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Management Science for *PAGTANAW 2050* Talent Development and Retention

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ABSTRACT

PAGTANAW 2050 unraveled Science, Technology, and Innovation (STI) Talent Development and Retention (TDR) decision-making challenges and implementing them for its four clusters to contribute to the end goal of an archipelagic marine nation within evolving national and global systems. The goals of the proposed Foresight Institute (FI) are viewed through two management science frameworks, input-process-output-outcome (IPOO) and Kotter's Leading Change model, with illustrative summary cases following six STI TDR steps. The approaches reflect the practical aspects of operationalizing efficiency, using experts, and empathy for people as the science itself adjusts to changing organizational environments. **(i)** Beginning with the end in mind, foresight-capable people for various roles must be lifelong learners (*Outputs*). Decision challenges of training (who, why, etc.) are analyzed with a data science use case on regional STI TDR supply-demand imbalance for high-skills future needs and a prospective information technology-business process management (IT/BPM) expansion into data-intensive markets to meet new challenges in climate change or information systems *(Outcomes).* **(ii)** The leadership and guiding coalitions (*Inputs)* need intangible ideas with science, technology, engineering, and mathematics (STEM) tools of emerging technologies like (AI) to transform people, e.g., the sense of urgency but patience for long-term foresight skills awareness, and the phronetic use of translational research for knowledge generation with multidisciplinary team for the overall good. **(iii)** Business Processes must consider where value is added highest in the IPOO, adjusting STI TDR activities to changing SWOT conditions - as shown in cases on process-induced learning in basic education, STEM retention through innovative first-year course design, and morphing problems in nursing STI. Foresight Institute failure may come from inputs/processes.

Keywords: behavioral science, benefit-cost analysis, brain drain, economic development, human resource development, innovation ecosystem, information technology-business process management (IT/BPM), knowledge management, management science, social science, talent war.

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Abbreviations: AI, artificial intelligence; AIM, Asian Institute of Management; CHED, Commission on Higher Education; DOST, Department of Science and Technology; FI, Foresight Institute; IPOO, Input-process-output-outcome; IT/BPM, information technology-business process management; LLL, lifelong learning; NAST PHL, National Academy of Science and Technology Philippines; PIDS, Philippines Institute for Development Studies; STEM, Science, Technology, Engineering, and Mathematics; SWOT, Strengths, Weaknesses, Opportunities, Threats; STI, Science Technology and Innovation; TDR, Talent Development and Retention; VUCA, volatility, uncertainty, complexity, and ambiguity.

SECTION I: INTRODUCTION

At the heart of *PAGTANAW* 2050 (NAST 2021), the Philippines, as a prosperous, archipelagic, maritime nation, pulled together the collective wisdom of the country's top scientists in a renewed recognition of the geographic dimensions of national development from a 21st-century perspective. Geo-politics and geo-economics have returned beyond the post-colonial, post-industrial, and post-competitiveness paradigms at both global and local levels, spurred by the relentless external forces shaping the search for solutions to improve holistic human welfare in a chaotic world (Macaranas and Garcia 2007b).

The "war" for mobile human resources/ talents (Bernido and Carpio-Bernido 2020; WEF Top 10 Job Skills 2023; WEF Global Risk Report 2023) is a major factor shaping the foresight document's continued acceptance by the larger public beyond the academic community. It responds to opportunities wherever and whenever they are needed regardless of geographic boundaries that electronic technologies have erased, or of the blurring industry lines that redefine new business opportunities (Michaels et al. 2001). The major science, technology, and innovation (STI) talent development and retention (TDR) problems are identified in *PAGTANAW* 2050 and elaborated by Padolina (2022) – the why and what of quantity, quality, and imbalances in human resource distribution by gender, region, sector, etc.; on the other hand, the need for lifelong learning needed for global positioning of STI talents and the products they produce, are at the subject of Republic Act No. 11293 also known as the Philippine Innovation Act.

In this paper, the three objectives of the Foresight Institute (FI) and the corresponding six steps in the STI TDR for *practical applications* to national objectives are examined:

- to inform policymaking so that *key actors are more aware of longer-term scenarios* [Step 1: developing good STI talent seeds, and Step 2: planting them in good soil — which are *inputs* for STI TDR and applications, covered in Section II here],
- *to help build networks* among the people centrally involved with shaping the future [Step 3: caring for the environment of STI Talents, and Step 4: harvesting their efforts with love—by applying their ideas and services in productive ways, including entrepreneurship, and in ways that care for the talents themselves, given the realities of political, social, and economic institutions — which are *processes* for STI TDR and applications, covered in Section III], and
- to develop *capabilities* that shape a *'foresight culture'* [Step 5: choosing good STI talent seeds to replant later, and Step 6: lifelong learning for STI talents and other stakeholders with foresight — which are *outputs and outcomes* respectively of STI TDR and applications, covered in Section IV].

Management Science approach

Management science is a broad, interdisciplinary study of decision-making and solving problems within an organization. Its evolution in overlapping eras focused on (i) execution (pre-1900s-1960s) to maximize efficiency,

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ensure production consistency, and predictability in enterprise operations, which are all process-oriented in contrast to the next two which are focused on people inputs, (ii) expertise (1916-2000s) to manage highly complex businesses with ideas from psychology and other social sciences, and (iii) empathy (1990s-current) to create value through employee, customer, supplier, and government regulatory and promotional engagements (Anderson 2020) already vividly lived through the lives of managers of the last century (Zimet and Greenwood 1979).

This paper explores and applies some of the evolving practical management science tools related to human resources to achieve the end-in-mind or final outcomes of *PAGTANAW 2050*: the unified and inclusive, sustainable, and innovative prosperous, archipelagic, maritime nation concept — thus embracing all three management eras in a complex economy with uneven regional development like the Philippines. Hence, even Kotter's approach has to be adapted to certain segments of the economy which are more amenable to tools of complex adaptive systems, a variant of chaos theory that falls under complexity area (Macaranas and Ubarra 2001).

The three objectives of the Foresight Institute are matched in this paper with the management science approach of solving problems within organizations especially in the STI TDR through decision-making informed by multi-, trans- or inter-disciplinary *studies*, viz.,

- economics as a social science but steeped in other analytic approaches like data science,
- engineering concepts that business administration recasts in terms of human motivations, and
- the Fourth Industrial Revolution confluence of biological, digital, and physical technologies applied to an archipelagic maritime nation, as goods and services are produced for more than its material requirements.

Two overarching management science concepts are used across this paper: (i) the inputs-processes-outputs-outcomes (IPOO) approach further described in Section II with details on *inputs* to introduce its linkages through Sections III processes and IV outputs and outcomes, (where other management science tools and ideas are introduced for STI TDR), and (ii) Kotter's "leading change" model (Kotter 1990) described below in incorporating organizational behavior in STI institutions. The two are mapped with each other in Table 1 to ensure long-term behavioral changes.

The Inputs-Processes-Outputs-Outcomes (IPOO) approach

This approach is helpful in **(i)** *combining tangible outputs* (talents, plans, products which are goods or services) *with desired characteristics* (results, outcomes) as the beginning points for understanding the end-in-mind of any leadership or management problem (Covey 1989). Beginning with the end-in-mind is the 2nd of Stephen Covey's *The 7 Habits of Highly Effective People* "which inspired millions of people to make better decisions and build better relationships" (Anderson 2020).

This is critical to a demand-driven rather than a supply-pushed STI TDR strategy for developing the natural and human resources of a marine archipelagic nation, which requires more sensitivity to future production activities in the "blue economy." The underutilization of STI must be differentiated across the *PAGTANAW 2050* clusters since the industry demand may vary greatly across sectors dynamically changing through time (e.g., local and global healthcare markets shown in Section III).

After clarifying outputs and outcomes, **(ii)** *matching the quality requirements of the inputs and processes* needed for such ends-in-mind becomes *the subject of transformational issues*; these include leaders and people with ideas on working with the digital component of the morphing Fourth Industrial Revolution technologies, e.g., Metaverse (2023) and ChatGPT (2023). This approach is true of critical thinking in long-term macro problems (planners dealing with aggregate demand of consumers, investors, governments, and international trade, to address inputs supply) as well as "wicked" micro problems in designing products of enterprises (to address inputs demand including STI TDR) in both public and private sectors (NNSI Editorial Team 2022).

Finally, the dynamic IPOO approach deals with **(iii)** *choosing the outputs of seeds to replant* for the purpose of multiplying the outcomes of STI stakeholders trained with a foresight culture through lifelong learning exemplified by some expatriate talents.

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The Kotter 8-step change model in Table 1 can be applied to operationalize the STI TDR in *PAGTANAW* 2050 by expanding it to include elements discussed in Sections II-IV but adapted to the new leadership demands of the 21st century, e.g., swarm leadership for complex systems dominating the sea- and landscapes of *PAGTANAW 2050*. A swarm leader is a systems builder (like bees), choreographer (coordinates networks), harvester (ideating to implementing), digital communicator, and connector (like bees pollinating ideas and energy across 'learning fields') (Kelly 2019).

Table 1 and Figure 1 groups concepts with the following logic:

People with ideas (*inputs in TDR*) are the leaders and guiding coalition members in Kotter's Stages K1-K4 who can empower ecosystem implementers in K5-K8. They result in *TDR processes* that reap short-term wins across the major areas of STI through a deeper understanding of problems using, e.g., data analytics and solutions from predictive and prescriptive analytics. K8 is the general long-term objective of an institutionalized foresight culture across the country. In whatever ways the leadership styles may change, the essence of service to a transforming group through collaboration remains, as in swarm leadership.

The *outputs* of the relatively *short-term wins* in K5 (*"short"* from the 2050-time horizon) are in the areas identified in the second layer of horizontal boxes in Figure 1, viz., (i) organizational culture in the lead agencies implementing the diverse *PAGTANAW 2050* clusters, for adapting to 21st century complex systems in a VUCA world (Bennett and Lemoine 2014), (ii) deeper Filipino diaspora engagement (from STI advice to the actual attraction of investments and institution building), (iii) reform of the Philippine STI talent market (information systems for knowledge management and wise decision-making), and (iv) ASEAN and international positioning in areas where Philippine competitive advantage may be threatened (e.g., segments in information technology-business process management [IT/BPM], nursing, maritime) and for cooperation in solving problems of global public goods (Macaranas and Ubarra 2001).

Table 1. Mapping TDR six steps into Kotter's Change Model to operationalize STI reform in *PAGTANAW 2050*

6 Steps in Talent Development and Retention (TDR) for STI	**Kotter's 8 Steps integrating behaviors into successful organizational change**
1. Develop good seeds	1. Create urgency: sense emergency
2. Plant in good soil	2. Form powerful coalition teams: convert others
3. Care for the STI Talent environment	3. Create a vision: set it clearly 4. Communicate the vision: convey to all stakeholders 5. Empower action: engage players creatively
4. Harvest STI Talents with love	6. Create quick wins: target incremental gains
5. Choose seeds to replant	7. Build on the change: improve small wins
6. Engage all stakeholders through lifelong learning	8. Make it stick: embrace change by all
Each of the 3 STI Foresight Institute goals corresponds to two successive steps above as **Inputs (Steps 1-2), Processes (Steps 3-4) and Outputs and Outcomes (Steps 5-6) of STI TDR**.	

Source: Kotter 1995. Kotter's 8 steps in leading change.

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The bottom layer boxes in Figure 1 are *medium- to long-term* institutional environment factors underlying the entire operationalization of reforms where simultaneous efforts happen in political governance, economic and social relations, especially education, technology/ ecology, and legal/regulatory areas (PESTEL), the latter being critical to the nature of appropriable ideas on STI (through complexity, copyright, document management, lead time, legal agreements, patents, and secrecy). These are medium- to long-term conditions when new resources (foreign investments, including those from the diaspora) are needed for inputs, processes, and outputs of both STI TDR and the industries they serve.

The focus of the *issues of the 2020s* above this last layer may change due to the many VUCA forces in the global ecosystem, e.g., how climate change and the way humans handle education and training may be addressed in the face of Generative Pre-Trained Transformers (GPTs) and large language models (LLMs) that utilize natural language processing. Other concerns are on the (i) *ambiguity* in the use of STI to reshape the geopolitical and geoeconomic landscape, including those resulting from the COVID-19 pandemic and the Ukraine crisis, (ii) *complexity* in the governance due to networked disinformation in an already complex world, (iii) *uncertainty* in the applications of artificial intelligence from more voluminous data, the new oil, and (iv) the *volatility* of policies as people see patchwork vs. systems solutions.

Other constraints on education and training programs are included in the PIDS Economic Policy Monitor 2017-2018 especially a scoping study on preparing the country for the Fourth Industrial Revolution (Dadios et al. 2019).

Figures 1 and 2 are the main frameworks for applying other management science ideas in the following sections.

Section II deals with the inputs of urgency-conscious leaders and managers with ideas for raising awareness of the longer-term chaotic Philippine environments in the two STI TDR markets of talent development and talent application/ retention. The education sector's role in the efficiency and expertise eras of management science of the 20th century as well as the 21st century empathy stage of people relations is expanded in a forthcoming article as the country adapted to global ICT developments from the 1920s through the 2020's.

Section III delves deeper into the processes of multidisciplinary networks for shaping future markets in the new data- and technology-driven knowledge economy in both markets of talent development and talent application/ retention. The responsibilities of the Foresight Institute are dissected with the possible sources of failure in inputs (people, ideas, soft and hard infrastructure) and processes.

Section IV finally looks at outputs and outcomes that support the general objective of fostering a foresight-capable Filipino people. This is illustrated by (i) the 'use case' study (a data science terminology) on the regional imbalance of STI demand and supply that require functional analysts, leading to (ii) the IT/BPM examples where new global markets may be developed in both service-oriented *manufacturing* or service-oriented *services* enterprises by multidisciplinary teams using the Stan Shih "smile curve of global value chains," and (iii) the two cases of Diosdado Banatao and Samuel Bernal from the diaspora who exemplify the phronetic or practical wisdom of STI talents, that require lifelong learning reforms in the entire Philippine education-life-work ecosystem.

For practical implementation of future programs related to *PAGTANAW 2050*, workshops are suggested at the end of this paper to inform all stakeholders on the 21st century management science approaches pertinent to the three Foresight Institute objectives. These stakeholders include cross-disciplinary planners and policy-makers, stakeholders, and shareholders of private and public economic production groups across industries.

SECTION II: INPUTS FOR STI TDR

The Foresight Institute's concern for urgent *long-term* scenario awareness to achieve the *vision* of *PAGTANAW 2050* is matched here with this paper's first two talent growth steps, choosing good seeds to develop and planting them in good soil. What leadership seeds are needed to address the STI skills shortage for the Philippines as it pursues national development in a fast-changing world? Should the search for solutions be confined within Philippine geographic soil, sourced from mobile Filipinos in technologically advanced countries, or from non-Filipinos with competencies in developing our human, physical, and natural resources, foremost for the nation's interest and then the world?

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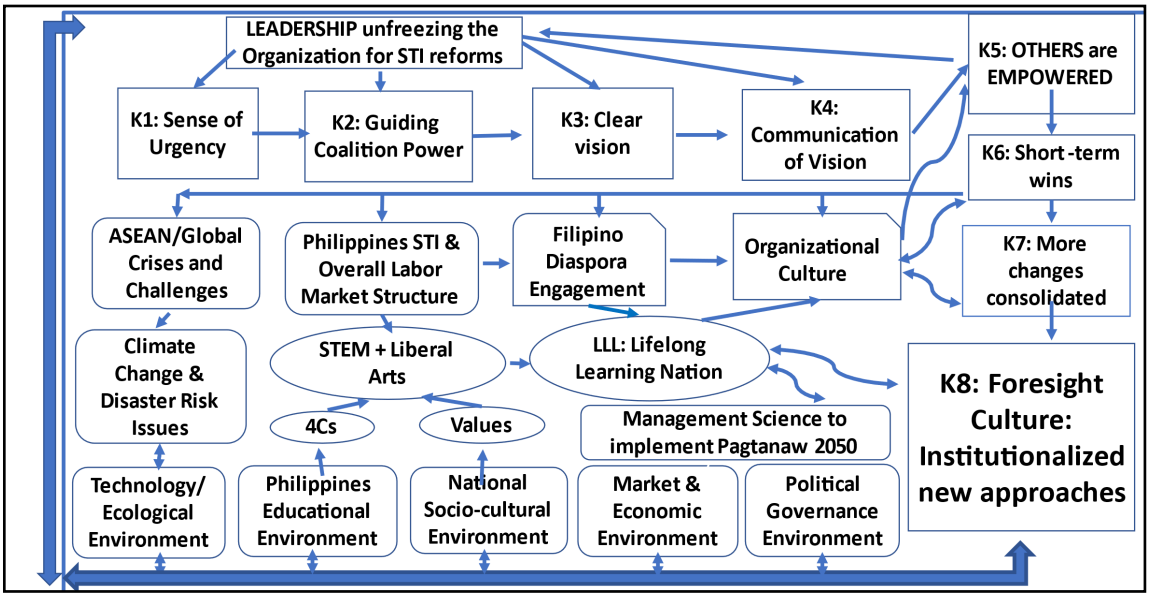

Figure 1. Operationalizing STI reforms: Kotter's 8 Steps Model of Leading Change expanded in a causal-loop framework.

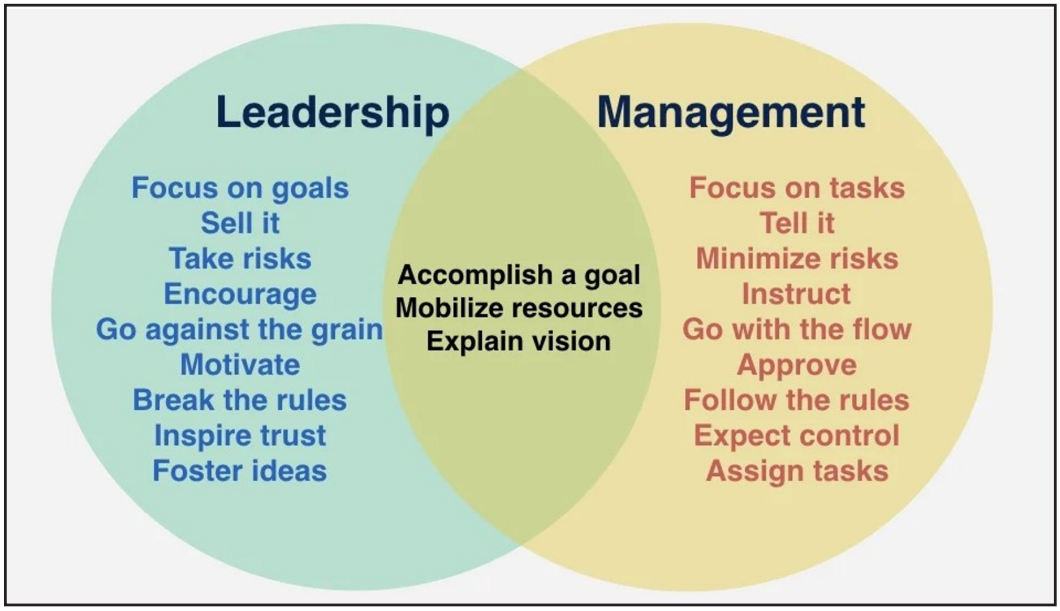

Figure 2. Distinctive roles of leaders vs managers.

Source: Ho 2023. LifeHack. Leadership vs Management: Is One Better Than the Other?

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Leaders begin with ideas vs. objects as the ends in mind

Kotter (1990) distinguishes leaders (from managers) in direction setting (vs planning and budgeting), aligning people (vs. organizing and staffing), and motivating (vs. controlling and solving problems) in an article included in the Harvard Business Review's 10 Must Reads on Leadership (HBR 2011).

On this first major seed of direction setting (vision, goals, outcomes), the pertinent management science concept for leadership is the re-defined concept of *inputs* in any economic activity by the 2019 Nobel Prize winner in economics Paul Romer (Romer 2018). *PAGTANAW 2050* views inputs in the foresight process, primarily as the "tools of STEM and emerging technologies." In the inputs being "utilized for production," Romer includes people, especially leaders *and* their "ideas," which are *non-rival* (or transferable to other firms or industries without being depleted, as in a service contemporaneously consumed by many users as in the World Wide Web on the Internet).

In contrast, human talent working with "objects" or "artifacts" — the old factors of production of land/natural physical resources, facilities, equipment, etc., as "produced means of production"— are subject to *rivalry* (once used as inputs "utilized or consumed" in producing goods for one firm, it is impossible to use them any longer for any other production of outputs, of both goods and services, contemporaneously). Hence, the inputs for the STI TDR are defined as follows:

i. *people inputs* in an STI-based long-term scenario awareness following the Kotter change model, especially the *leaders who will effect a transformation of people* in the organizations of the latter (industry-transferable *skills* in working with the tools of STEM and emerging physical, digital, and biological-based technologies, and applications in *competencies* across various industries requiring relationship capital based on attitudes and values of various system actors (Gleason 2018),

ii. *their ideas* for redressing imbalances in STI talent distribution across regions, industries, and age groups, with solutions in the market (*demand and supply adjustments)*, in administration (public and private sector governance approaches including self-regulation), and social institutions (culture-bound mix of resource redistribution), and

iii. the hard *physical facilities (objects) and software (mix of objects and ideas they work with)* (Jones 2019) as needed to effect the transformation journey, not necessarily owned by a school or an institute, but legally shared across entities on commercial or other payment terms, e.g., for intellectual property rights. "Objects" are also termed "artifacts" in a "new" definition of the innovation system (Granstrand and Holgersson 2020).

Kotter's K-1 (sense of urgency) and K2 (coalition teams): In this case of people with STI ideas as inputs for STI TDR, two essential skills and competencies of leaders are their abilities (i) to establish a sense of *urgency*, better reinterpreted as a sense of *emergency* in the climate change context of the 2020s, which combines the probability of loss of value of an asset (human, natural, or physical) and a metric of urgency described below; and (ii) to create a "powerful guiding coalition team" to address, in turn, the major problem of skills shortage in STEM.

Emergency is conceptually equivalent to a leader and his/her guiding coalition rushing a patient to an emergency room based on the *probability of loss in value* of human life due to an event, compared to the urgency of a life-or-death situation, which is further a ratio of reaction time vs. intervention time (https://www.arimetrics.com/en/digital-glossary/sense-of-urgency). Hence, "emergency" is technically definable as "the probable value loss due to an adverse event" divided by "a measure of urgency."

Urgency can thus be operationally defined as a *reaction time* to an adverse event relative to an estimated *intervention time* for bad outcomes to occur. The reaction time in the urgency numerator can be measured by behavioral scientists and development managers on how fast people respond, rationally or irrationally, in the face of the urgency denominator of intervention time, which is what climate scientists measure, in the case of climate change mitigation and adaptation strategies.

On the other hand, the risk of loss of assets valued by metrics of economics opportunity costs in social benefit-cost analysis is measured probabilistically by

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actuarial scientists with the help of organizational scientists, agricultural and other economists, biologists, etc. in estimating an adverse event like unabated GHG emissions, massive soil erosion from heavy rains, impacting the value of an asset (human, physical, natural, governance, and organizational systems, etc.) (Macaranas 2022b).

In 21st century shared leadership responsibilities, the guiding coalition created by leaders requires cross-, trans-, or multi-disciplinary collaboration, not in the perfectly competitive model of classical or neo-classical economics embraced by the execution efficiency focus of the first management science era (pre-1990s-1960s) noted in Section 1 above, but the union of 21st century economics with the talent expertise and empathy stages relationship variables of management science thereafter.

Urgency and patience: The new behaviors of a sustained foresight culture in the STI community must be carried over by successive leaders over a period long enough for change to be embedded in the governance ethos in both public and private institutions. This finding, based on long years of research on hundreds of major companies by Kotter a generation ago, still holds true today. Indeed, Kotter advises patience in changing behavior for sustained adoption of innovation through leadership in contrast to management, now widely popularized in Venn diagrams (Figure 2). This is reflected in later literature on two different systems of thinking, popularly labeled as slow vs. fast by psychologist Daniel Kahneman where the latter is instinctive and emotional while the former is more deliberative and logical (Kahneman 2011).

A forthcoming industry case note on the applications of Figures 1, 2, and 3 to the IT/BPM sector of the Philippines recounts how IBM's entry into Philippine markets continued through the 21st century market for service science management and engineering (SSMEs) and the ensuing data science field as the multidisciplinary responses to the talent shortage. As a driver of global economic growth, the dramatic rise of information products over manufactured goods and services hastened the Philippines academic sector as a player in the leadership and management of STI TDR, albeit later than that of government and industry. Section IV here introduces some of the ideas to pursue the new areas of engagement of the expanded BPO market in contemporary issues of climate change and information networks w ith negative externalities and public good elements.

This approach in STI TDR is needed for the Foresight Institute (FI) in the *PAGTANAW 2050* clusters as well — multidisciplinary, out-of-the-box thinking in line with trending areas in developing new markets. This may be what Albert Einstein referred to when he said, "The value of an education in a liberal arts college is not the learning of many facts, but the training of the mind to think something that cannot be learned from textbooks" (Frank 1948) which do not yet capture fast-moving events that the Internet provides.

The soil for such multidisciplinary engagement may already be present in some Philippine STI communities. However, both non-STI and STI managers of new areas of the economy must be trained in the 21st century need for 4Cs (critical thinking, communication, collaboration, creativity) incorporated in the CVIF Dynamic Learning Program since 2002 for basic education (Bernido and Carpio-Bernido 2021) with substantive content on leadership vs. management. This addresses the serious problem of teacher training institutions in the country for basic education, which begins the process for STI foresight culture (Cebu Normal University 2023; University of Southeastern Philippines 2023; Western Visayas State University 2023). More than the sense of markets and the sense of nation (concern for persistent social issues), the seeds and soil for STI TDR must include a sense of simultaneous cooperation and competition (cooperation between competitors or co-opetition) among stakeholders, and a sense of practical knowledge (diaspora connections, opening doors for new resources). These are discussed in the processes (Section III) and outputs and outcomes (Section IV) for STI TDR.

SECTION III: PROCESSES IN STI TDR

In Table 1, the first stage of STI TDR with Steps 1 and 2 involves planting good seeds in good soil as *inputs* to build national awareness in long-term scenarios of STI for national development (with leadership and empowered teams).

The second stage of STI TDR involves the *processes* which bridge inputs and outputs in education and

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markets, *and* in STI talent application to industries. The bridging happens with technology strengths (*inputs* in various organizations and firms in various *PAGTANAW 2050* clusters) are linked to market insights in various reports that contain anticipatory intelligence (for the different cluster industry *outputs*).

These processes include (i) Step 3, *helping build networks* among the people centrally involved with *shaping the future,* by ingraining translational research and multidisciplinary networks in the minds of STI talents (supply side of the talent market) *and* (ii) Step 4 harvesting with love such STI talents by *employing them in productive activities with care for their welfare as well*, given the realities of political, social, and economic institutions (demand side of the talent market) constantly modified by technology that also redefine faculty research assessment metrics (DORA 2011).

Harvesting talents with love refers to a form of "returns on caring for talent" in social reciprocation ("utang na loob" or debt of gratitude in the milieux of pre-colonial Philippines) (Jocano 2007) that are powerful in economic areas like social and private insurance that seek to mitigate the problems in the cases of the free-rider (benefit receiver does not pay for the cost of a good or service) and moral hazard (reduced incentive to exercise caution after buying insurance) (Stevenson and Wolfers 2013).

Both supply and demand sides call for inventories of STI talents for agile responses to national needs in situations of great urgency or even emergencies. LinkedIn-type databases of such talent banks, as practiced in Singapore, may be considered in the spirit of Labor Market Information Systems (Republic of Singapore 2023). Leadership foresight skills can be discerned from talent banks with AI given the accomplishment records of the subjects sourced from text, audio, video, photographs, etc.

Steps 3 and 4 (networks with productive activities) assure that two Figure 1 elements, K6 short-term wins and K7 further consolidation of reforms, are carried over to (i) both markets (of various organizations producing the *inputs* of labor and the *outputs* of goods and services where STI foresight is needed) and (ii) the nation's polity and society (where the *supply* of STI local and diaspora talents and ideas, and the *demand* for regional/ international solution to various VUCA challenges are to be engaged, e.g., disaster risk mitigation, combatting networked disinformation, or other global public goods with negative externalities (Buchholz and Sandler 2021).

The STI talent markets are found not only domestically but also in the diaspora due to (i) the global mobility increasingly engendered by various business models of transnational education after the decolonization of the last half of the 20th century and (ii) the imbalances in demand and supply of labor in the West coming from demographic changes and a production growth culture that encourages various models of brain gain and circulation vs. the brain drain phenomenon earlier observed (Macaranas 2007; Shin and Moon 2018).

The Foresight Institute's responsibilities in an IPOO framework

The analogy of living system processes of the six steps for STI TDR adopted in this paper illustrates the systems thinking more evident in the biological foundations for the education-life-work ecosystem than the physical machine analogies of ideas and models in the first era of management science. The living systems-type interaction within different sub-process operations is what *complex adaptive systems* deal with.

The old economics-physical engineering framework of inputs-processes-outputs (IPO approach) must therefore be reviewed and seen at various stages of a production-consumption construct with feedback typical of a living system like a circular economy. In the IPOO framework, the addition of *outcomes* to IPO results in *PAGTANAW 2050's* end-in-mind: the increased welfare of Filipinos in the broader context of the UN Sustainable Development Goals (SDGs) 2030 and beyond.

From Table 2, two STI FI outputs (tangible goods and services) are identified as (i) R1 output of "anticipatory" intelligence from a *talent development* market (trainees who demand the skills in research, writing, and presentation of results, and trainers who supply those skills), and another output of (ii) R10 regular progress reports from a market of *such reports* (students who demand skills supplied by communications experts). The IBM-inspired Karlsruhe Institute (Germany) version of SSME or service science requires such communication skills (IBM 2023).

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The talent development market in R1 leads to a separate market for *talents* themselves (*talent* buyers are decision-makers who need their anticipatory skills services directly). In R10, the market for *creating* progress reports is separate from the markets for *progress reports* themselves where the buyers are also decision-makers who need *outsourced information* other than what in-house talents provide – which is where recent espionage cases arise in China-US confrontations on stolen technology from universities (Lewis-Kraus G 2022) but which AI is also changing (Andrews EL 2021).

Distinguishing the two markets of talents or reports *development* and their utilization and *retention* in a second market leads to a "make or buy" option (involving decisions for in-house vs. outsourced talents/reports – the critical basis for the IT/BPM markets where the Philippines has made a name) which has a *sequential* or issue-tree logic (Besanko et al. 2007). The decision tree is based on the (i) benefits of economies of scale and scope vs. alliances or close-knit supply arrangements, (ii) costs of coordinating partners (due to location of assets, their customization, or dedicated use in some programs, human resources unique to routines or standard operating procedures of one party, etc.), and (iii) the writing costs of contracts vs. common ownership of assets, or joint ventures with shared services or facilities, including intellectual property, or vertical integration with in-house or in-country *organic* growth). These considerations have been applied to transnational education options of franchises or branch campuses, twinning, articulation, and other arrangements in Asia-Pacific (Macaranas 2010).

Separating two STI markets

Clarity in thinking through two markets of STI TDR: Table 3 groups Outputs/Outcomes separately from Inputs/Processes for clarity of thinking through strategies for solving problems related to STI TDR and STI applications. The chaotic context of the FI Responsibilities is indicated in R1, R4, R5, R6, R9, and R10. For example, Taleb's antifragility ideas in addressing ambiguity or "unknown unknowns" is where the least amount of information exists and predictability of impact of actions taken are at the lowest; hence, R1 anticipatory intelligence outputs are the most difficult areas to engage in but where his Black Swan-Robust Society principles can be explored, e.g., fragile should break while still small — no "too big to fail" syndrome, and avoidance of financial assets as repository of value in economic life (Taleb 2010).

However, Dixit's political economy view sees the policy process as "an evolving economic game" of transaction costs where, indeed, the technical route preferred by economists in this process has given way to their attention to history and institutions originally favored by politics, sociology, etc. for descriptive, historical, or philosophical approaches (Dixit 1996).

Table 2. Responsibilities (R) of the STI Foresight Institute: IPOO framework.

INPUTS and PROCESSES	More PROCESSES and OUTPUTS/OUTCOMES
• INPUTS	• MORE PROCESSES
R-5: Stakeholder Contributions	R-8: Benchmark checks progresses
R-6: Timely Benchmarks	R-9: Continued conversations
	R-11: Policy Implementation SFI availability to stakeholders
• PROCESSES	• OUTPUTS
R-2: Collaboration with similar STI Foresight Institutes	R-1: "Anticipatory" Intelligence
R-3: Communication linkages	R-10: Regular Progress Reports
R-4: Public Consultation on Results	
R-7: Documentation processes	
	• OUTCOMES → 17 UN SDGs 2030

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Such convergence has happened in recent years as management science embraced its third era of empathy, focusing on the relationship of economic actors.

Table 3 is presented for two purposes: (i) clarifying the value chain relating to STI TDR and its applications in the Porter model and (ii) demonstrating how a dynamic SWOT (iteration at different decision periods to address morphing problems in STI TDR), requires different skills and competencies with an example of the push-pull factors in the Philippine participation in global markets, e.g., nursing, discussed in Section III here.

For the first, consider the R1 output/outcomes of respectively "anticipatory" intelligence/useful for decision-makers for the UNSDG #3 (Good health and well-being) as the end-in-mind. There is a second market on output/outcomes here where the *buyers* are the decision makers applying STI in a particular industry, e.g., one of *PAGTANAW 2050* Cluster 2 food, nutrition, and health products like drugs, vaccines, traditional medicine, or diagnostics (and the *sellers* are the *talents* in biochemistry offering services produced from the first market of inputs/processes in the talent development market).

Inputs/processes failure in attaining outputs/outcomes: What factors will make for the success vs. failure of the outputs/outcomes in a VUCA world of the second market? The inputs/processes may turn out to be the causes — due to either or both — which in the R1 are, respectively, FI ***people*** (presumably already pre-trained/providing timely information), but working with inferior inputs of ***ideas*** (e.g., in a foreign context, hastily developed mRNA vaccines not yet fully vetted by protocols for vaccines development (Ali et al. 2021)) or ***facilities***, in turn, due to poor translational research skills or lack of sufficient multidisciplinary collaboration, including employing ethicists (Monrad 2020). Thus, the

Table 3. Foresight Institute (FI) responsibilities in a two-step Inputs/process → Outputs/outcomes. Mapping from *PAGTANAW 2050* document.

	Inputs/Processes	Outputs/Outcomes
R1	FI people/trained to provide timely information on future challenges	Anticipatory "Intelligence"/useful for decisionmakers, e.g., UN SDG #3 for the Food, Nutrition, and Health Cluster. (Taleb's antifragility issues in an ambiguous world)*
R2	Foresight institutions collaborate with others	People gain awareness of trends and drivers of change
R3	Stakeholders' representation in STI committees	Stakeholders represent community views for two-communication
R4	Non-FI People consulted in town hall meetings and other ways to discuss STII initiatives	(*clarity of desired results: Dixit's political economy options in VUCA situations*)**
R5	Specific stakeholders contribute to projects and initiatives	(*clarity of desired results: Dixit's political economy options*)**
R6	People *inputs* subject to Dixit's political economy issues, but *process* of setting timelines for Institute activities to be benchmarked against UN SDG goals is clear	(again, hopeful for the best but as per Dixit's political economy, there are more complicated reasons why success is not assured)**
R7	*Inputs* not clear - if Cluster program/project secretariat or professional staff, or a mix - will keep documentation to track activities	Policies and legislation resulting from Foresight activities
R8	Regular convening — of certain groups yet to be specified — to check benchmarks	Status of consultation, implementation, and results of Foresight initiatives determined
R9	Private and public policymakers continuously converse on STI proposals, etc.	Timelines for proposals reviewed (most likely to account for different constraints in a VUCA world of Dixit's political economy)**
R10	Some group or body to provide progress reports via different media	(Most likely for positive outcome which is not assessed for VUCA conditions that can be clarified with different analytic tools)**
R11	Foresight Institute accessibility to stakeholders	Stakeholder concerns on policymaking and implementation clarified

* Taleb, Nassim Nicolas, Antifragile: Thing That Gain from Disorder (Random House, 2012) ISBN 9781400067824
Taleb, Nassim Nicolas, The Black Swan: Second Edition: The Impact of the Highly Improbable (Random House, 2010)

** Dixit, Avinash K., The Making of Economic Policy, A Transaction Cost Politics Perspective (Cambridge, Mass. The MIT Press, 1996)

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failure in STI TDR (Table 1) may be attributed to Step 3 in failure to build robust networks, and not to Step 4 employing talents in productive engagements with their own welfare being cared for (including STI talent's reputational risks from burnout and stress) (Ali et al. 2021).

Modified Porter Value Chain: The two connected markets arise from a first market of *talent development* that leads to a second one on *STI talents for application in PAGTANAW 2050* clusters or in the industries of the Blue Economy. The modified Porter value chain framework (Figure 3) with a "make or buy" option for STI TDR illustrates how, e.g., outsourced talents (people with ideas) create values different from internally trained people inputs. "People with ideas" in the Romer-sense of STI talents may be found across Porter's horizontal segment of primary activities; they can be "made or bought" for the design, prototype, final production, marketing, and after-sales stages of a final consumer or even intermediate product (Gao et al. 2009).

Since the second market depends on the ***"make or buy"*** decision on how inputs (inbound logistics) of people, ideas, and facilities are sourced — internally (*"make"*) or from outside the firm (*"buy"),* an STI TDR market must exist in the first place where the supply of talent development must meet the demand for it. The lack of demand is explored in the data science use case in Section IV. Hence, regional STI imbalance is not on account of education institutions but more on the business applications in different activities across the country, in contrast to the IT/BPM case where the demand is from foreign investors for their global markets (Macaranas 2001; Kang and Francisco 2019).

What is true of the STI Talents market can be translated to outsourced intermediate inputs based on a firm's fixed and variable costs *plus* the transaction costs of coordination, writing contracts, etc. This is the basis of the Stan Shih "smile curve" of the value chain (also in Section IV here) that serves as justification for a Philippine focus on IT/BPM as one common area for the 4 clusters to consider for STI-type market for talent application (the BPO and ICT industry sectors having high innovation content that affects more employees, compared to food and other manufacturing (Albert et al. 2017).

The same Porter value-creating approach is applied to the care delivery value chain in three healthcare areas (Porter and Teisberg 2006) — kidney diseases, strokes

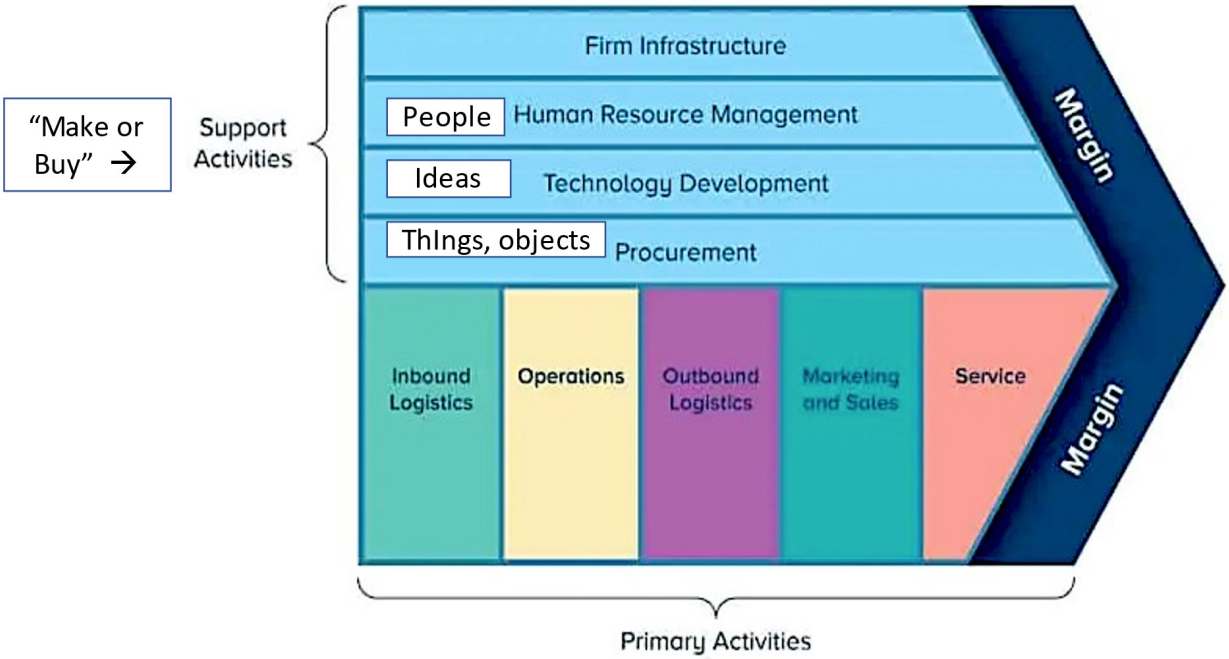

Figure 3. Modified Porter's value chain framework with "make or buy" inputs markets.

Source of original framework: Porter 2008

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involving a major blood vessel, and breast cancer, which can be the models for developing similar value chain ideas for tropical diseases of particular interest to the Philippines. On dengue, yellow fever, zika, chikungunya, and West Nile fever, the Philippines may "buy" from or "cooperate" with other ASEAN and Pacific Island test sites of the Bill and Melinda Gates Foundation research on Wolbachia-infected mosquitoes mating with *Aedes aegypti* to block transmission (Macaranas 2022c).

The inputs for the second market need not be people with ideas only but can be raw physical materials for an IPR- excludable tangible final good like a space satellite to produce intelligence data for civilian uses, e.g., improved weather forecasts for decisions related to agricultural crops — or military purposes, and detection of vessel movement in Philippine territorial waters to assert sovereignty (*PAGTANAW 2050* Cluster 1 on space science).

The inputs can also be non-rival ideas in STI TDR freely available to all to adopt or adapt, following Romer (2018), e.g., (i) the Central Visayan Institute Foundation-Dynamic Learning Program (CVIF-DLP) that reverses the time allocation of 70% teacher inputs to a revolutionary 70% process-induced student learning in senior high school STEM courses, and (ii) the retention of STEM talents from first year through graduation, and early career to retirement in the Freshman Research Initiative (FRI) at the University of Texas at Austin.

Process-induced CVIF-DLP for STEM in basic education

A systems approach is adopted by theoretical physicists Ma. Victoria Carpio-Bernido and Christopher Bernido (Bernido and Carpio-Bernido 2011) in a process-induced learning of STEM subjects that has dramatically proven more effective than teacher inputs-induced learning in rural and other challenged areas.

Addressing student issues: The Dynamic Learning Program (DLP) addresses learner dispositions applied from the educational psychology literature: bite-size learnings in the absence of expert teachers; handwritten answers to required worksheets to improve psychomotor, visual, and hearing faculties; more difficult STEM subjects in the mornings when learning is optimal; lighter courses in the afternoons and half day on Wednesdays when teachers can meet and consult with each other; no homework in the absence of tutoring at home, bad internet connection in pandemics and similar situations, and the need for children to help in some livelihood and house activities (Bernido and Carpio-Bernido 2021).

Addressing teacher quality problems: To alleviate the expert teacher shortage, there are no traditional lectures in the STEM subjects that usually take the whole class period by teachers of varying capacities. (Then as now, the quality of both Philippine teacher education institutions and graduates remains a problem. These are discussed in three papers prepared for a February 2023 national conference at the Philippine Normal University on the subject of pre-service teacher education research cited earlier in this paper).

At CVIF-DLP schools, the expert teacher controls classroom intervention by presenting ideas in only 30% of class time through co-designed Learning Activity Sheets (LAS) for students to work on independently during the remaining 70%. When the expert teacher is not in the classroom, a teacher facilitator simply monitors students in doing their work, individually and collaboratively, based on the LAS. Upon the return of the expert teacher to the classroom, students raise questions pertaining to the problems and various approaches to the solutions, a time when "the flash of insight or understanding" surfaces (Bernido and Carpio-Bernido 2011). Performance is assessed and tracked from individual student portfolios of worksheets from the various LAS every week during the grading period.

Innovation outcomes: For the greatness of their spirit in transforming education, the Bernidos were conferred the Ramon Magsaysay Award in 2010 (Ramon Magsaysay Award Foundation 2023). The CVIF-DLP process bridges the inputs (experts, teachers, facilitators, students, and Learning Activity Sheets or LAS) to the desired outputs (student learning) and effective outcomes evidenced by Bernido and Carpio-Bernido (2011) in improving passing rates in poor rural high schools and mean percentage scores for general scholastic aptitude at DPL schools.

The CVIF-DLP has been rolled out across the country in the Philippine Learning Physics as One Nation Project to some 200 high schools. The physical presence in the Visayas-Mindanao region has made possible the faculty development support that the Institute of Theoretical Physics in Jagna, Bohol set up by the Bernidos has

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extended for college faculty development in physics in several Universities in the southern regions of the Philippines (Bernido and Carpio-Bernido 2011). It has lessons for even tertiary education, where behavioral scientists like B.F. Skinner developed programmed learning across various fields in earlier decades, but not in more challenged poor developing countries (Seel 2012).

STEM in the STI TDR scheme at the University of Texas Austin

A second classroom management case illustrates an interesting STI TDR idea that can be adapted for training programs in Philippine schools, DOST councils, and NAST PHL *PAGTANAW 2050* clusters. The Freshman Research Initiative (FRI) was developed at the University of Texas (UT) at Austin to increase students' retention in science degree programs and careers by engaging them in multiple semesters of course-based undergraduate research experience (CURE) starting in the 1st year. As an alternative to entry-level laboratory courses, "research streams" of large numbers of undergraduate students are created to work on a common research problem, with mentorship and guidance from a PhD-trained research educator (RE) and a tenure-track or tenured principal investigator (University of Texas at Austin 2023).

The RE, which is necessary for FRI to scale up STEM interests, mentors over 35 students in a stream of his or her expertise that is not feasible in the structure of traditional research groups. REs create and implement a research program to support student learning in both core science concepts and research skills. STEM retention is made possible by the compelling research experience of mentoring and tutoring within learning communities.

Innovation outcomes: Participation in FRI increased overall graduation rates (83% for FRI vs. 66% for the comparison group, controlling for other factors affecting the graduation rates with propensity score matching). The STEM major graduation rates (vs. transferring to a non-STEM field) showed a dramatic increase (94% for FRI students vs.71% of the comparators.) This result on the *STI talent development* market supports the outcomes in the *STI applications market*. Using the benefit-cost analysis tool, lifetime potential earnings per student (3% discount rate, in 2014 US$) were estimated to be higher for STEM graduates ($1.425 M) vs. non-STEM graduates ($1.01 M) vs. those who leave college ($720K). Benefit/cost ratios are similarly impressive: lifetime benefit/cost ratios (BCR) range from 91 (high FRI cost scenario) to 561 (low FRI costs), with a baseline FRI cost yielding a BCR of 169 (Walcott et al. 2018).

Dynamizing SWOT analysis: from monopsonist to enlightened nurse employer

A second use of Table 3 is dynamizing the SWOT strategy tool for clearer thinking in identifying implications and strategies of any problem in the STI talent or its application to a second market. Consider the case of the Philippines as the major supplier of nurses to global markets. It has been supplying healthcare systems in the US since the 1950s but accelerated when immigration laws were relaxed in North America and the Middle East, and most recently, the Asian markets partly through new modes of trade in services, e.g., cross-border, consumption abroad, commercial presence, or presence of actual persons (Macaranas 2009; Macaranas 2010; Francisco and Macaranas 2015).

To explain this, Table 4 illustrates the logic of a dynamic SWOT table, a tool used in developing the four stages of the healthcare cluster in *PAGTANAW 2050* (as reported in the AIM CHED leadership program by Acd. Carmencita D. Padilla (2021)), from wise pandemic-responsive use of scarce resources in the short-term, to a revived economy in the medium-term, and, a high growth period, and finally a fully competitive player in the long-term.

The case of a complex morphing problem: This is best shown in the long-term nursing shortage in Philippine hospitals, which must address stages of deeper reflection by all stakeholders from the view of educational psychology (Paul and Elder 2020). A sample scenario below suggests new skills and competencies of nursing graduates and hospital owners that should be the subject of further lifelong learning and training in the 4Cs of the 21st century education, to meet the leadership, negotiations, and other lifelong learning needs of government officials and the private sector for the STI TDR ecosystem.

The dynamics of changing nursing markets involve new problems arising from an initial situation, e.g.,

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exodus of Philippine nursing talents with global post-pandemic needs in already human health resource-constrained countries.

Table 4 situates a hospital owner as a decision-maker to manage this problem, but the leadership issue goes deeper— as the Philippine government realizes that healthcare providers will be similarly challenged in the medium-term and that the other side of the market faces a monopsonistic labor market (local healthcare facility owners are able to demand "nurse trainees" to *pay* hospitals in effect for the "work" they render in exchange for the "training" they receive, documented in a study of Pampanga markets) (Macaranas 2009 and same database used in Francisco and Macaranas 2015 for more econometric analysis).

More enlightened owners and other nursing market players may, however, opt for alternative solutions. By engaging hospital owners to see the bigger picture of global nursing market shortages and the pecuniary motivations of Philippine nurses, the government can support more creative private sector responses, e.g.,

i. dialogue between Philippine hospital owners and foreign investors for return packages of temporary overseas work of nursing talents as Philippine facilities are simultaneously upgraded,
ii. offering of short-term micro credential negotiation courses for local stakeholders, including government officials who can link Philippine climate change onsite experiences in health, public works, education, etc., with Filipino internationally- shared human talents,
iii. long-term studies of nurse motivations with socio-economic and other variables.

SECTION IV: OUTPUTS AND OUTCOMES

In this final section, this paper now returns to the end-in-mind of an STI foresight-capable people in a broader talent ecosystem (*Outputs*) for shaping STI applications in new economy markets, strengthened by embracing a lifelong learning nation, especially at the regional level (*Outcomes*).

Step 5 is the stage when the harvest of STI bounty in agriculture, industry, and services is needed to *generate successor talents*. The social compact of who cares for these successor talents (government, private business sector, or social organizations) must be raised in the context of the Philippines through the next development plan periods which the National Innovation Council must address, with the assistance of the FI's hard science

Table 4. Dynamizing SWOT in Philippine nursing market.

(Problem: Nursing exodus creates shortages of healthcare workers in local hospitals. Decision maker: hospital owners in three time periods)

Internal Factors → / External Factors ↓	Strengths (S) 1. Many local graduates 2. LLL for nursing education leaders (add "government officials" in medium-term)	Weaknesses (W) 1. Young nursing grads prefer working abroad 2. Weak negotiating skills of owners vs. foreign hospitals
Opportunities (O) 1. High global regard for PH nurses 2. Foreign investment potential in PH education and hospital markets (add "nurses and disaster risk reduction management experts" in the long-term)	S+O Implications S1+O1: Strong negotiation point for PH government S1/S2+O2: Creative dialogues between PH hospital owners and foreign investors	W+O Implications W1+O1: Must satisfy growing global market segments to remain competitive W2+O2: Short-term micro-credentials needed by hospital teams to deal with foreign investor interests
Threats (T) 1. PH: low-trust society 2. Socia media negative impact on fact-driven analysis 3. Technology-driven workplaces abroad F. M. Macaranas, Lifelong Learning in the Philippines, for Pi Lambda Theta, 19Nov2022 (3mins)	S+T Implications S1+T1: Low credibility of gov't in Improving welfare of nurses and families→ study global trends S1/S2+T3: Fear of older educators to work abroad is formidable due to new technology demands Medium-term: Engage gov't.	W+T Implications W2+T1/T2: PH hospital management teams need to study global trends to gain trust of local stakeholders W1+T3: Hospitals partner with tech providers and test them with young nurses who are malleable learners Long-term: Engage disaster risk experts for reduction mgmt

Source: Macaranas 2022a. Lifelong Learning Frameworks and Implementation in the Philippines.

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members and from other disciplines that can redress the basic long-term management of the weakness of Philippine society, e.g., the perceived amorality and moral indifference to issues from an oligarchic feudal society in need of institutional reform including corruption at various levels (Milo 1984; Johnston 2005; Macaranas 2022a).

Step 6 is a lifelong learning nation for all. Here, all STI stakeholders include final end-users of their basic and translational research where the goods and services produced for the local or global markets generate the well-being of Filipinos everywhere, inside and outside the geographic map we currently associate a nation with.

Successor talents: Supply and demand

In Section II, it was noted that the Philippines' initial mover advantage in value creation for digital-age firms through industry and government leadership started around a century ago, and that as the services-oriented industries of the late 20th century called for new skills in data analytics for 21st century, the education sector caught up with programs in information technology and business administration around the first decade of the new millennium (Garcia 2021).

The latter responded to the liberalization of global trade in information technology goods and services and the local Filipinnovation strategy for the adoption of STI for national development to support, among others, the IT/BPM sectors that have become major employers of STEM and other talents, producing a comparative advantage for the country. The two other major global economic participation of Philippine human resources are in nursing (Reblando 2018) and the maritime sectors (Abutal 2021).

Macroeconomic considerations and the IT/BPM comparative advantage

A study on the macroeconomic demand and supply situation in five human resource/talent categories through 2025 presents data on where the Philippines can position itself in the supply chain of global industries in the medium-term (Albert et al. 2017). The supply for 2020 vs. 2025 talents in engineering, computing/IT, mathematics and statistics, physical sciences, and life sciences are estimated from the production rates of the education system and the survival rates in the labor market participation in these fields.

For future S&T human resource demand requirements, Albert et al. (2020) apply the most recent Philippine Statistical Authority input-output coefficients to 2020 vs. 2025 data projections from two alternative measures: a historic sectoral gross value added in Philippine national income accounts and a more optimistic Philippine Development Plan projection from 2017-2020 targets. These market- and plan-derived demands are also used later in the data science use case below.

Figure 4 shows the graphs from the extracted demand vs. supply numbers in the five fields. It is clear that for the 2020 and 2025 data, only in Computing/IT will there be any surplus supply in either demand scenarios of historic sectoral gross value added, or the PDP 2017-20 projections both for the ratio of demand to supply (relative gap) and the differences in the demand and supply (gap magnitude). This is in stark contrast to the increasing shortages of talent, especially in engineering, rather than in life sciences, physical sciences, and mathematics, generally reflecting global trends due to the PESTEL environment of advanced countries cited in various reports, viz., (The Institution of Engineering and Technology 2023; US Chamber of Commerce Foundation 2023; IEEE 2023; Hira R. 2022).

To capitalize on the computing/IT base generated in the earlier decades, the Philippines through 2050 must now look for applications in the other four STI fields. In the light of the IT/BPM comparative advantage of the country noted earlier, new global markets for outsourced services using the digital-physical-biological technologies of the fourth industrial revolution can be studied by the STI leaders in the various *PAGTANAW 2050* clusters for developing value-creation strategies. It will require a multidisciplinary understanding of both ends of the value chain which follow the Stan Shih “smile curve” model, a variant of the Porter value chain, with a “make or buy” framework (Figure 3). These efforts should be with the support of the National Innovation Council and within the FI’s responsibilities. These are the new seeds to be replanted in the 21st century Philippine soil of STI TDR.

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Fig. 4A: Ratio of Demand to Supply

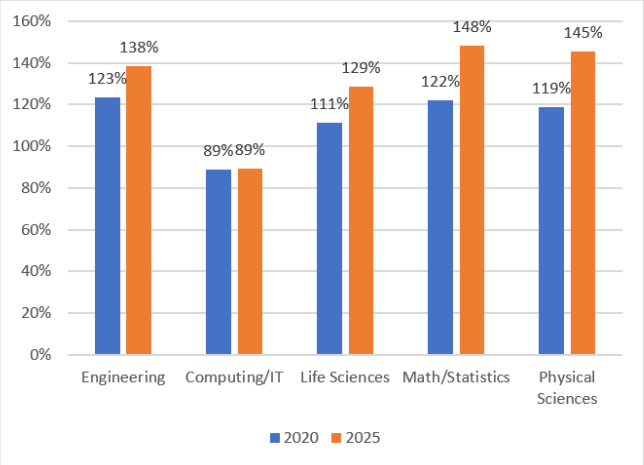

Fig 4B: Differences in Demand and Supply

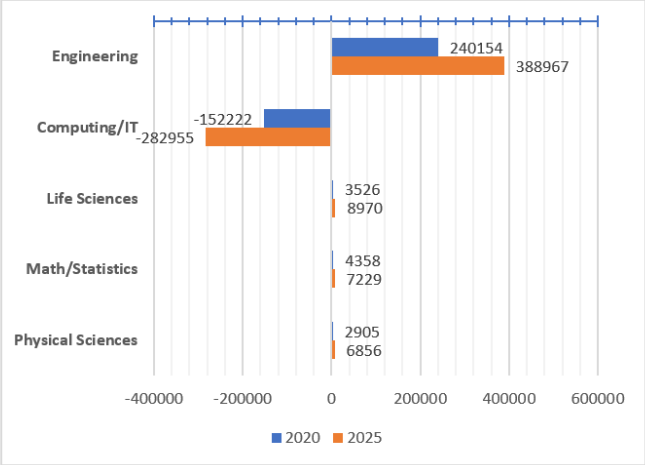

Figure 4. Philippine STI talents demand and supply medium-term projections, 2020 and 2025

Source of Basic Data: Albert et. al. 2020

Use case study on regional imbalance of STI talent

From the regional level view of the STI TDR problem, the data science use case approach (Caubalejo et al. 2021) provides some insights into potential new Philippine market sectors to develop for internal and global positioning (See Figure 5). This will stimulate long-term interest in STI foresight-consciousness among other stakeholders in the *PAGTANAW* 2050 clusters, and spur "ideating" and "insighting" steps in the innovation journey of the demand side in both current markets and government plans.

Focus on higher-level STI skills: The use case study focuses on the supply and demand for *higher-level STI skills* needed in the regions through the years. It applies data analytics tools to map regional imbalances on issues that domain or functional experts co-define with data scientists. Thereafter, implications are extracted from the specialized courses that are demanded both by current markets and future ones implied by the national and regional development plans. A distinction is then made between STI talent-ready and "hard-to-reach" markets that require new 4th IR skills for global competitiveness positioning.

The example of the data science use case study on the above subject distinguishes among three types of markets for STI TDR subject matters in the regions (see Figure 5B). It is on the market side of demand where STI talents applications can be expanded: where the supply of courses offered in tertiary education is met by current market demand only (labeled "regionally relevant courses"), by development plans only (future market demand labeled "supplied specialized courses"), or by both — which is the ideal larger market combination. Where there is no large market being served by the Philippines yet (some few current market demands elsewhere and future planned domestic demand increase, labeled here as "developing courses"), the challenge is for the comparatively successful sectors like the IT/BPM to lead once again in the new economy areas for Philippine positioning. This is discussed in the penultimate topic of this Output and Outcomes section of the STI TDR when the value-creation is contextualized.

The network science framework: The framework adopted in this use case relies on elements (job demand and supply parameters) or actors represented by nodes or vertices and their connections for computational analysis. Social networks (sociograms) have also been studied in this academic field and have been widely extended in understanding telecommunications, computing, biology, cognition, and semantics.

The use case approach focused on the regional tertiary education *strategy to align courses with the specialized needs of the various regions*; the common area of the three major circles in Figure 5B comes from the supply side and two sources of demand. Alternative

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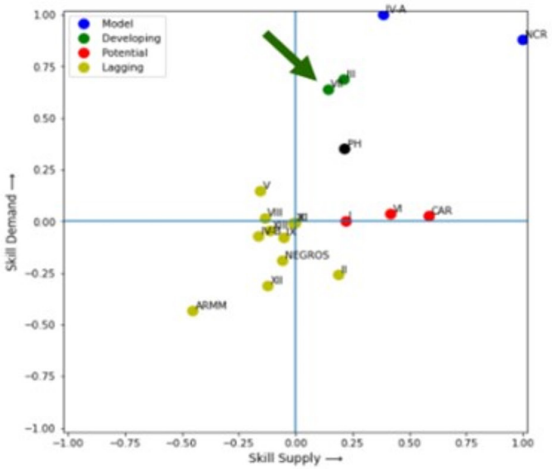
Figure 5A: Regional Positions in a Quadrant of Low vs. High Demand and Supply of higher skilled - talents



Source: Caubalejo et.al. 2021.

Figure 5B: STI TDR Courses Demand - Supply for a Use Case Analysis of Regiona Gaps (Jaccard Index)

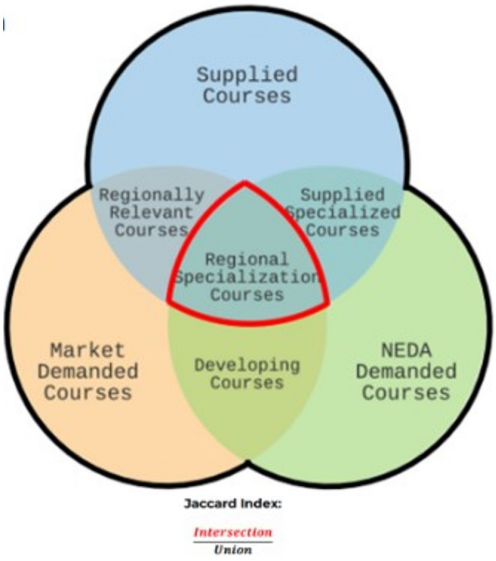


Figure 5. Data science use case figures on STI demand and supply analysis of regional gaps.

approaches on TDR at the national level of two ASEAN members are noteworthy. Indonesia's Critical Occupation List (World Bank Group 2020) of talent shortage in strategic areas was developed initially by the government but vetted with close industry consultation to confirm actual shortages through data scraping from job titles, skills, and sector strategies also demonstrated in the use case study here (Caubalejo et al. 2021). Talent Thailand (Office of National Higher Education Science Research and Innovation Policy Council) is a platform with a database of Thai and international experts who can analyze human resource data and distribute them to organizations involved in talent development. Its STI policies for Thailand 4.0 also link to regional science parks (Kingdom of Thailand 2021).

Both talent concerns of Indonesia and Thailand are in the 21st century fields and disciplines of interest to the Philippines and thus call for simultaneous competition and cooperation strategies, or co-opetition (Luo 2004) to be able to assert ASEAN's primacy as a regional player in many 21st century industries. For example, the large proportion of Southeast Asia's value creation in the information technology areas noted earlier creates a very important sub-regional cooperation between it and Northeast Asia (China, Japan, and Korea) in the global electronics industry (Macaranas 2017).

Differences in regional imbalances: Figure 5A is presented along with Figure 5B to identify the regions where STI TDR needs more attention in view of gaps in overall higher-skilled demand and supply likely to persist through the next decades if not properly strategized. Figure 5A shows the northeast quadrant with Models NCR and Region IV-A Calabarzon, and the Developing Regions III Central Luzon and VII Central Visayas with the arrow for new IT/BPM sectors in the Blue Economy. Although the borderline Potential Regions have average demand, their supply of higher-skilled labor is far ahead of the rest of the remaining regions; the hope is that learning programs in face-to-face *plus* the electronic presence of talents can be effectively delivered as the CVIF-DLP model of the Bernidos demonstrates (Bernido and Carpio-Bernido 2021).

The Central Visayas case: Data science tools illustrate how the IT/BPM for Central Visayas (Region VII) may be extended to new markets, especially of the marine archipelagic Blue Economy globally. Classified as a Developing region with respect to jobs of the future (behind only NCR, Regions III (Central Luzon) and IV-A (Calabarzon), it has high demand but only slightly above average supply for higher-level STI skills. The "hard to reach" jobs in the region are in professional

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and technical areas, common to other regions in the country, except BARMM where the challenges are more complex (lowest in high skills demand and supply). The "within-reach jobs" in Region VII are office supervisors, sales managers, accountants, and financial professional advisors.

Due to its higher skills presence, Central Visayas can work on its IT/BPM potential beyond the current focus on retail and agriculture (the "within reach" jobs). As already started in some cities there, more software development for the management of firms in manufacturing, property, industrial engineering, marketing, and professions are suggested from the data analysis for the "regional specialized courses." (These courses are where STI TDR in Region VII can be further promoted based on the Stan Shih value creation analysis for service industries, discussed in the penultimate section here). Non-STEM graduates who are unable to reach better-paying jobs can now be trained in new jobs for data-based decision-making support as functional analysts, a point raised in the use case study, working with data scientists (mainly computer science, mathematics, and physics graduates). These DSA-ready workers include industrial engineers mainly for data steward jobs, and computing/IT and library information science graduates for data engineering.

Data scientists and functional analysts: The imbalance in the production of data scientists and analysts and industry demands for more functional analysts was noted in a PIDS study (Quismorio et al. 2020). Of four job roles from data science and analytics-related programs, functional analysts demand-supply gap (66% of demand-7% of supply) is the widest. It contrasts strongly with the oversupply of data engineers (20%-72%), data scientists (8%-16%), and data stewards. The job roles for functional analysts can be handled by economics and industrial engineering graduates since they utilize data to leverage insights for improved decision-making in organizations.

This undersupply of functional analysts stimulated academe-industry discussion (MAP Dialogue with University Presidents in the AIM-CHED Global Academic Leadership Program) during the Covid-19 pandemic in September 2021 where several of the tertiary education leaders representing various associations proposed functional analysts in cybersecurity for the maritime industry (Abutal 2021), accountancy (Mallari 2021), health sciences for policy decisions and translational research in collaborative ventures of STEM disciplines with new fields in Computing/IT (Padilla et al. 2021), and engineering (Ronquillo et al. 2021). It eventually spun off to include indigenous culture preservation (Abansi 2021), food tourism technology (Ang et al. 2021), guidance counseling, and tracking of UN SDG implementation across curricular offerings..

Stan Shih "smile curve": Higher value added at the extreme ends of global value chain

The Stan Shih "smile curve" (Figure 6) is a way of seeing differentiated value-creation on different contributions to the total product at each stage of gathering inputs, operating processes, delivering outputs, and creating outcomes. Shih originally applied it to the electronics engineering markets as he shifted Acer's venture away from low value-added of manufacturing to *IPR-rich tangible* inputs to manufacture *tangible* electronic goods (Shih 1992; Gao et al. 2009), higher value-added on the left side of the "smile curve", and a deeper understanding of markets, with similar higher value-added on the right side of the same curve. The value creation model has been extended further to services inputs (of *intangible* elements from ideas of STI talents) linking to the 21st century production of *services* outputs with many intangibles, the new equivalent of "manufacturing" stage of the curve (Gao et al. 2009; Fu 2018; Best 2021).

Indeed, it is argued that the services sector firms are areas where Shih's curve persists today because Shih defined manufacturing to include standardized services (including project delivery in Best 2021). This may simply be a way of defining "projects" as a composite of "goods and services," further interpreted as goods with larger value shares from *service-based elements*, or *services* with larger value shares from tangible goods elements. This approach can lead classification taxonomists to identify *services embedded in service sectors* for the new economy. These are the areas that both the FI and IT/BPM groups within IBPAP, the industry association of IT and business processing in the country, and new economy businesses should study more closely for new market insights and ideas.

Foresight on changing industries: By data mining the changes in the ever-changing 5-digit-level industries defined by the Philippine Standards for Industry

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Classification (PSIC) and other countries' SICs, the IT/BPM sector can discover which STI-related activities can be the new service-oriented *manufacturing* firms (Gao et al. 2009) and service-oriented *services* enterprises.

Between 2009-2019, new economy areas that became 5-digit PSIC industries include manufacturing, where new Philippines 5-digit classifications now include, e.g., manufacturing sensors (26121), actuators (26122), oscillators (26123), ride-sharing vehicles (49325), post-production activities of traditional 2D animation (51921) as differentiated from 3D animation (59122), and gaming design and development (62011). There must be more sunrise industries in climate change (other than solar panels) and for combating networked disinformation (other than fact-checking services) among promising start-ups (Ronquillo et al. 2021). In fact, it is acknowledged that the reclassification is also the "basis for anticipating the emergence of new industries" which is what entrepreneurs in the IT/BPM sector should watch for (PSA 2019).

Redefining value-creation: Best (2021) dismisses the idea that intangibles (defined as things that cannot be touched, perceived by the senses, or exactly described or valued) are irrecoverable sunk costs that should not worry decision-makers. Shih argues that some intangibles, i.e, in what people add to their work environment, create more than goodwill; they may promote *business continuity within* and even *beyond one's organization* when thinking of their contribution to value added at other stages of the organizational operations, and not only where they are located for payroll purposes.

Indeed, if people in the manufacturing stage are evaluated from a job description only, then the pay-for-work concept does not reward creative people who see a larger picture of any organization. This is exactly what 21st century education and learning through the 4Cs promotes: (i) *critical thinking* of how to contribute in many ways to a business organization people care to believe they "own", (ii) *communication* and (iii) *collaboration* across other parts of the whole to maximize value for the entire system and not only to oneself in an industrial setting, and (iv) *creativity* in problem-solving and opportunity-seeking.

The climate change and networked disinformation impacts on society and human existence are 21st-century concerns that managers of particular enterprises need to review as they transform themselves into leaders as against managers also for the "common good" albeit for a smaller universe (see Figure 2 shown earlier). The STI foresight culture embedded in that value-creation setting will see worker value added as spread across units and stages of production. Institutional economists and behavioral scientists stress the non-appropriable intangible ideas (a la Romer) behind institutions as one area for innovation, for good or bad, that impact on skills-based technology (Acemoglu and Autor 2010) or informational cascades (Banerjee and Duflo 2019).

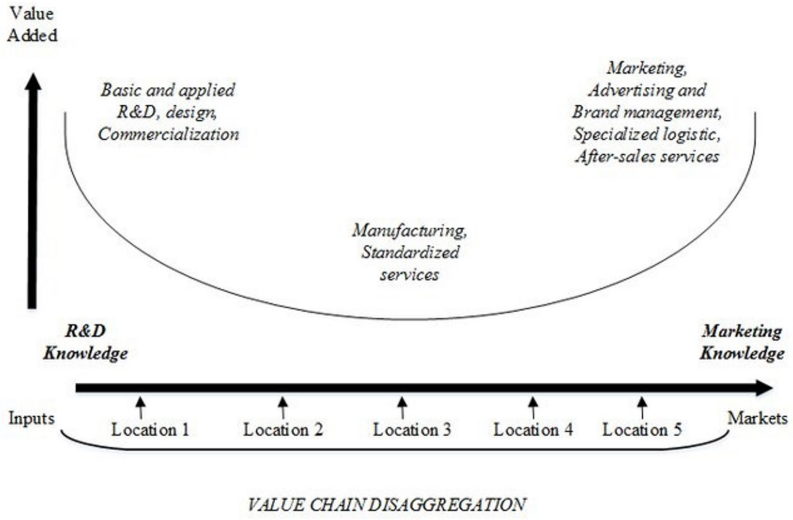

Figure 6. The smile curve of GVCs.

Source: Shih 1992. Empowering technology-making your life easier.

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Services-oriented service sector firms: knowledge management

Internal "markets" within firms add value along the inputs-processes stages as demonstrated in the responsibilities of the FI where in fact failure may occur at the inputs/processing stages of value creation. In services-oriented manufacturing, Stan Shih moved away from the low value-adding manufacturing of electronic products which had been outsourced to countries with "cheaper" labor inputs, but which also need work standards including management of processes that are efficient (first management era) or rely on expertise (second management era) or cost-effective when intangibles matter (third management era of empathy in relationships).

In the knowledge era, where services sectors generate more share in economic output measured by gross domestic product accounting, value creation from knowledge management (KM) is what makes for more productive and efficient economies (Drucker 2010).

In fact, by redefining knowledge management in an IPOO approach, as "*sourcing and deploying knowledge, workable practices and working relationships to improve organizational performance"* a Philippines KM champion (Talisayon 2006) is able to integrate human, structural and relationship capital which are new non – "objects or artifacts"- type inputs into 21st century processes of creating goods and services.

As noted earlier, a practical way of doing the foresight exercises by the IT/BPM in new service-oriented service sectors involves scrutiny of changing industrial classifications around the world; these will be the new economic areas that will reshape the potential businesses to target. A simple foresight study of the Philippines' own 2019 PSIC updates of the 2009 PSIC will be useful for both new customers and potential new competitors elsewhere for IT/BPM since it is patterned after the UN Industrial Standard Industrial Classification (ISIC). Many domestic industry changes in the Philippines may also be happening in other countries due to similarly situated economies structurally, geographically, and demographically (presence of large migrant populations regionally or globally).

This requires constantly adjusting education and training systems to a lifelong learning nation, Step 6 for STI TDR, the strategy that Singapore adopted less than a decade ago, after several countries earlier realized its importance to their own economic competitiveness and geopolitical standing. In this regard, foresight workshops for the various *PAGTANAW 2050* Clusters are suggested in Table 5 to implement future multidisciplinary programs for various stakeholders.

Lifelong Learning Nation: Outcomes-based education issue

Three reasons for continued employee training were found out to be critical among 11 variables in the 2007 International Labor Organization (ILO) study on the Philippines (Macaranas 2007a): 1) GDP growth relative to other countries; 2) flexibility (adaptability of people in the economy is high when faced with new challenges); and 3) educational system (meeting the needs of a country's universities). There are points for and against these, based on solid empirical evidence and good logical thinking with theoretical frameworks, but the institutional foundations of policy-making deserve critical thinking. Combined STEM and liberal education with practical applications on problems on the ground are propounded by many management scientists (Zimet and Greenwood 1979; Anderson 2020), including economists who have won the Nobel Prize (Brittanica 2023).

Three main issues on long-term GDP growth are raised by Alba (2007) in terms of the low Philippine growth trajectory interacting with its low steady state level of output per worker (low savings rate, low average year of schooling, high population growth) and low level of technology adoption). Yet, *PAGTANAW* 2050 points to the Philippine overall competitiveness ranking (Global Competitiveness Index of World Economic Forum) that *trended upwards from 2010 until 2016 and declined thereafter*, while the Philippine overall innovation index (Global Innovation Index of Cornell University, INSEAD, and World Intellectual Property Organization) *improved in the period after 2016.* One implication of the oppositely trending ranks in competitiveness vs. innovation readiness is the need for translational research and application, which in turn will come from the quality of general education that is weak on the practical knowledge aspect of outcomes-based education measured from a learner-teacher perspective and not from a learner vis a vis the recipient of the learner's services.

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Table 5. Mapping TDR six steps & Foresight Institute objectives for designing STI workshops to implement *PAGTANAW 2050*

TDR 6 Steps for Talent Development and Retention in the STI Foresight Institute	***PAGTANAW 2050* Foresight Institute Objectives and Suggested Training Workshops**
A. INPUTS	**A. STI actors' awareness of longer-term scenarios:** from ambiguity to complexity to uncertainty (reverse UVCA, Taleb's anti-fragility → for Kotter's urgency and coalition building)
1. Develop good seeds	Designing longer-term scenarios: Bloom's Taxonomy Workshops for critical thinking, crossdisciplinary communication/collaboration, and creativity → developing talent databases
2. Plant in good soil	
B. PROCESSES	**B. Building networks to shape the future:** Cross-disciplinary, cross-specialty translational research; crossborder (diaspora); knowledge management → for Kotter's version, communication, empowering, and quick wins
3. Care for the STI Talent environment	
4. Harvest STI Talents with love	
C. OUTPUTS and OUTCOMES	**C. Foresight-capable Filipinos:** STI teacher training; STI for corporate universities; STI adult education courses →for Kotter's building upon incremental changes, and stickness
5. Choose seeds to replant	
6. Engage all stakeholders through Lifelong Learning	

Through translational research, actual investments in high-quality jobs can be generated. High-quality jobs correlate well with the productive knowledge of any nation (Harvard Growth Lab), as gauged by the Economic Complexity Index (ECI) which measures the number and complexity of the products successfully exported (Hidalgo 2021; Shaw 2010).

A positive correlation between per capita GDP and Economic Complexity Index data is observed in many studies. Hence, ECI is now used as a new predictor of economic development, based on the theoretical literature that links diversification of production and trade to economic development. Further, a new data analytics study (Mealy et al. 2018) shows that the earlier focus of ECI studies on *what type* of exports a country is competitive in (ubiquity) should also be understood versus the measure of *how many* exports a country is competitive in (diversity). This fits the earlier literature that countries diversify at early development stages and start to specialize at higher per capita incomes (Mealy et al. 2018).

A whole-of-nation LLL approach from cradle to grave, in both formal and informal systems, was suggested by the ILO study cited earlier but never addressed. The low GDP growth relative to dynamic Southeast and Northeast Asian neighbors in 2007 is a long-term development issue that is explained in complex adaptive systems where swarms move in different directions based on local information as processed by distributed swarm leaders in empowered groups (Kelly 2019).

Seeds from the diaspora for lifelong learning (LLL): Two STI TDR champions from the Philippine diaspora, Diosdado Banatao (Computer History Museum 2013) and Samuel Bernal (Research Gate 2023), are excellent case studies for their passion in promoting the country's STEM human reservoir through advice, education, and investments. They were attracted to the new directions of the country in the late 1980s as the nation institutionalized science and technology as an Executive Cabinet office. They headed the Science and Technology Advisory Councils (STAC) chapters in Silicon Valley/ San Francisco and Boston, respectively, set up by the Department of Foreign Affairs during the administration of Pres. Corazon Aquino to harness Filipino STI talents for national development in partnership with the DOST (Tible-Caoyonan 1994). They are still actively engaged in their STI TDR advocacies.

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Disodado Banatao, an engineer by training fondly called "the Philippines' Bill Gates", is best known for developing "the first 10-Mbit Ethernet CMOS with silicon coupler data-link control and transceiver chip, the first system logic chip set for IBM's PC-XT and the PC-AT, and the local bus concept and the first Windows Graphics accelerator chip for personal computers. A three-time start-up veteran, he co-founded Mostron, Chips and Technologies, and S3 Graphics'' (Wikipedia). Honored in a Philippines, philatelic stamp as one of the icons of the diaspora, he has set up joint research programs between the Philippines and US universities, provided scholarships for Filipino-American engineering students and educational programs through PhilDev, a non-governmental organization also supporting start-ups. The AIM STI incubator is named in his honor, after sponsoring several years of training engineering faculty across the country in summer training programs with experts from Silicon Valley at AIM for entrepreneurship ventures. It has led to several start-up competitions in the country and many successful STI start-ups, especially in resource-based products, and encouraged other governments to partner bilaterally with the country in STI education and entrepreneurship endeavors (Barns 2003).

Samuel Bernal, Ph.D., MD, LLB, JD, MBA, taught and researched at Harvard Medical School, continues to obtain patents for his work, and is now Professor Emeritus of Medicine at UCLA, among others. Interests in both management and liberal arts led him to set up agriculture-, education- and health-related companies in the United States, Europe, and the Philippines. He is among the pioneers of stem cell therapy research and the application of personalized medicine in the country, after training many young Philippine medical doctors in Boston. Among his Philippine-based entrepreneurial ventures are a private STEM-oriented senior high school with projects for organic products (food and clothing) and assistance in biochemistry laboratories that serve needs of the healthcare community; consultancy firms for personalized medicine, government regulatory issues, and legal aspects of trade and investment; and agricultural farms that form part of his education supply chain but also serve exports markets (Ekvator Vodka based on local *lambanog*, and formal suit wear from organic plant-based *hablon* for the upscale European consumers). He teaches at AIM in various top-level executive programs for lifelong learning.

LLL as a global strategy**:** Lifelong learning has been recognized in national laws as early as the 1970s in France and the USA, and in the following decades in Japan, Germany, Sweden, Canada, etc. The 1976 Nairobi Conference adopted the expansion of education to "all aspects of life and all areas of skills and knowledge" even in developing economies. The Philippines committed to LLL only with ILO Recommendation 195 in 2005 for economic and employment growth. It nevertheless led to a working paper on LLL in the Philippines in 2007 but no system-wide integrated policy was formulated to pursue "an integrated action plan (for lifelong learning which is) … multi-sectoral, multi-period, and go beyond the boundaries of the nation." (Macaranas 2007).

The UN Millennium Development Goals 2015 was succeeded by UN SDG 2030, where indicator No. 4 was set to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all." By June 2020, the "right to lifelong learning" was reiterated at the 5th UNESCO Conference on Adult Learning and Education (ALE) and the ensuing Marrakech Framework. The global reports on ALE do not capture the essence of individual country challenges because of the paucity of LLL system-wide data, including the Philippines. The recently legislated Education Commission can now pursue what was proposed in the ILO study in 2007: (i) building legal, policy and institutional LLL framework, (ii) building LLL foundation through learning to learn skills, (iii) developing policies and institutions for all forms of learning, (iv) mobilizing resources for wider access to LLL opportunities, (v) ensuring collaboration among LLL partners and stakeholders, and (vi) designing guidance and counseling for LLL.

CONCLUSIONS

The value-added of management science in embracing long-term foresight culture can be gauged from the weak foresight skills in the spread of global pandemics. The Philippines, as early as 2013, promoted the ASEAN Network for Drugs, Diagnostics, Vaccines and Traditional Medicine Innovation (ASEAN-NDI) as part of a global WHO strategy (ASEAN NDI 2013; Montoya et al. 2014). In championing a Strategic Business Plan (SBP) for ASEAN-NDI, no less than the Philippine Health Secretary in 2013 focused on the issue of future pandemics, globally neglected despite previous infectious disease spread

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from Asia (ASEAN-NDI 2013). The issue of scientists vs. professional non STI-managers leading STI programs, as the SBP suggests, is a matter for management science to address in interdisciplinary collaboration with translational applications. With the Covid experience, it now includes innovative education programs especially management science topics (for efficiency, phronetic use of expertise, and empathy in relationships-based leadership). Governments and large business groups around the world failed to heed the warning of future pandemics based on the last century's global experience, as noted in studies in pre-Covid 19 pandemic years (Office of the Director of National Intelligence 2023; New York Times 2020) but for which academics also failed to get support in part due its distance from industry. Change requires patience, but must focus on urgent issues long ahead of other system actors which is the bedrock of the FI of *PAGTANAW* 2050.

Some case stories face complex dynamic factors unforeseen by government and business that center on the technology-dictated efficient scale (Shilov 2021). In the IT/BPM case on the exit of Intel from the Philippines, this is partly due to the lack of qualified people in advanced fields, e.g., to sense the economic scale of operations of new fabrication plants the size of a small city with its own power plant, and besides a university (Teves 2009; Shilov 2021). However, this could have been improved with more academic inputs from management science in decision-making from here and abroad – but requiring the leadership and empowered groups to form intelligence swarms for programs in *PAGTANAW* 2050 clusters, informed by the systematic steps in new areas of the Blue Economy, mostly through data science, especially with more functional analysts. Indeed, STI talents in computing/IT can be further developed and retained in those industries related to high value-adding services inputs in the services sectors of knowledge management on technology and market matters, including those for climate change and networked disinformation threatening the well-being of 21st century people in our fragile planet.

Contributions of the author:

The sole author formulated the six steps of the Science, Technology, and Innovation (STI) Talent Development and Retention (TDR), and fit them to the 3 purposes of the Foresight Institute and the Kotter model expanded to include PESTEL business environment forces. All the succeeding analyses are those of the author, including the tables and graphs, except where cited for original sources. The three regional NAST presentations benefited from successive discussions with National Scientist Carmencita D. Padilla, Academicians William Padolina, Fabian Dayrit, Christopher Monterola, and Alvin Culaba.

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The three training programs for advancing the Foresight Institute and *PAGTANAW 2050* reported in the article are open to implementation by any researcher from any institution to improve Philippines tertiary education in STI, including the AIM, BIG, CHED, and the Management Association of the Philippines which have run related programs on education reform where the author participated.

Additional information:

The author advised the students who prepared the job readiness use case on the imbalance of supply and demand for 21st century employment in the various sectors and regions of the Philippines. The author also advised the participants, mostly university presidents, in the AIM CHED-GALP course reported in the article, who

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prepared reports on academic leadership programs and projects for 21st century tertiary education; the same participants also discussed the University of Texas at Austin Freshman Research Initiative and the Dynamic Learning Program of the Central Visayas Institute.

The two expatriate STI Talents described towards the end of the study are personally known to the author as champions of the Science and Technology Advisory Councils in Boston and Silicon Valley/San Francisco, formed when he served as Assistant Secretary, and later Undersecretary, at the Department of Foreign Affairs. His STEM, and HRD interests spun off from DFA's responsibility in helping formulate regional policies, programs, and projects of the Asia Pacific Economic Cooperation for the 1996 Summit; the agenda of that 1996 Summit continues today with economic-technical cooperation in addition to trade and investment liberalization and facilitation.

An extension of the write-up concerning the Philippine IT/BPM sector is the subject of ongoing research at BIG to supplement the current paper on new ideas to reform Philippine higher education through lifelong learning activities. These benefit from many programs of Philippine higher education institutions related to the *PAGTANAW 2050* ideas, e.g., the 3-year EU Erasmus + PATHWAY Project for the Philippines ending in 2024 on employment and entrepreneurship structures, the AIM CHED-Global Academic Leadership Program for State Universities and Colleges and Local Universities and Colleges on 21st-century smart universities, and the MAP-AIM Management Educators Workshops for new academic-industry linkages including faculty immersion in specific industries and student project-based internships under the MAP Education Committee programs through 2025 with the cooperation of other training institutions.

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