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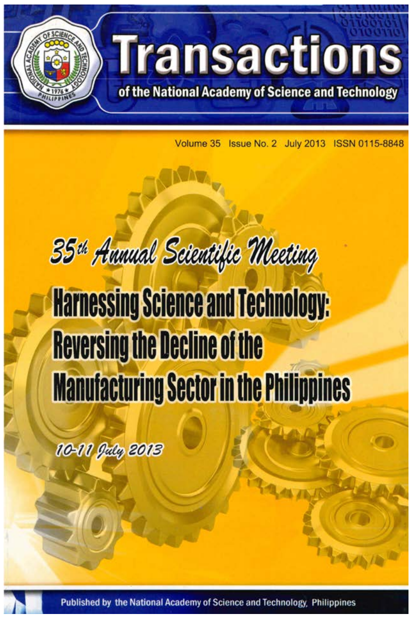

An Integrative Approach for Developing our Flexible and Sustainable Manufacturing Industry

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AN INTEGRATIVE APPROACH FOR DEVELOPING A FLEXIBLE AND SUSTAINABLE MANUFACTURING INDUSTRY

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Abstract

In many countries, manufacturing is seen to play a critical role in the economy. From the social science, science and engineering perspectives, various literature have pointed out that the positive effect of manufacturing goes beyond the output and the employment that it creates. In addition to the direct results of manufacturing, there is an indirect impact specifically in terms of supporting the jobs in the other sectors. With the importance of manufacturing from many perspectives, all with the aim of developing manufacturing for national progress and economic prosperity, a question pertinent to explore is, "what will it take for a country to have a competitive and sustainable manufacturing industry?"

The main proposition of this research is to look at the manufacturing industry as analogue of its smaller counterparts of manufacturing organizations. Specifically, this research proposes (1) to manage our country's manufacturing industry as a large chain of institutions and organizations that have the aim of providing products or component goods to the local and global market; (2) to structure the internal chain within the manufacturing industry such that the industry will possess the characteristic of flexibility to arrive at different products that will be demanded by the market at any time; and (3) to highlight that the manufacturing industry should be "self-supporting" which can be done if the profits or rewards of manufacturing at the different points of the supply chain can be re-invested for generating scientific and practical knowledge that will be the seed resource, i.e., raw material, for future manufacturing.

Through case studies, this paper illustrates how different countries that possess characteristics reflective of integrated activities for manufacturing, are able to direct their manufacturing industries to highly contribute to their national development.

Keywords: Integrative, Flexible, Sustainable, Manufacturing Supply Chain

Introduction

In many countries, manufacturing is seen to have a critical function in the economy. For instance, statistics from the World Bank shows that in China, value-adding manufacturing industry contributed an average of 31.67% of the GDP for the years 2008 to 2010. For the same period, the average contribution of the manufacturing industry to Malaysia's GDP was 24.67%. For Vietnam, where manufacturing GDP was seen to have striking growth, specifically within the period of 1994-2004, the average contribution of manufacturing to the GDP for the years 2008 to 2010 was 20%. Furthermore, for the Philippines, where in recent months analysts have said Japanese manufacturers are predicted to move to because of high-quality labor with lower cost and more stable growth compared to China or Vietnam (Olchandra 2012), the average contribution of manufacturing to the GDP for years 2008 to 2010 was 21.67%. Just recently, early in the month of June 2013, the 7.8% growth of the Philippine GDP for the first quarter of 2013 is reported to be largely due to the growth of the industry of 10.9% (Batungbakal 2013). According to the National Statistics and Coordination Board, manufacturing grew by 9.7% in the first quarter of 2013, an improvement to the 6% growth of the same quarter in 2012.

The figures above show the importance of manufacturing from the standpoint of economics, specifically as a contributor to the GDP. From the social science, science, and engineering perspectives, various literatures has pointed out that the positive effect of manufacturing goes beyond the output and the employment that it creates. In addition to these direct results of manufacturing, there is an indirect impact, specifically in terms of supporting the jobs in the other sectors (Hettinger and Gordon, 2011). As economists' Stephen Cohen and John Zeeman wrote in the late 1980s, the manufacturing sector does not just include the group of employees who *work on the factory floor*. Instead, the manufacturing sector has "direct linkages" to high-level service jobs throughout the economy: *product and process engineering*, *design*, *operations* and *maintenance*, *transportation*, *testing*, and *lab work*, as well as, sector-specific payroll, accounting, and legal work (Cohen and Zysman 1988). The importance of the manufacturing sector is, moreover, reflected in the findings of the Philippine Institute for Development Studies, which has arrived at the computation that in the Philippines for the Year 2009, the ratio of the productivity, i.e., real value added per worker, of the manufacturing sector is 2.5 times that of the service sector (Yap 2012).

1. The Objective of this Paper: To Propose a Methodology for Moving Towards a Competitive and Sustainable Manufacturing Industry

With the foregoing discussion on the importance of manufacturing to create jobs and to build the nation's wealth, an interesting question pertinent to explore is "What will it take for a country to have a *competitive* and *sustainable* manufacturing industry?"

2. The Proposition of this Research: An Integrative Approach

The main proposition of this research is to have an integrative approach towards developing the manufacturing industry, involving the building and strengthening of the supply chains of manufacturing resources to work for the creation and continuous growth of the nation's wealth. The integrative approach involves the iterative series of research, development, innovation, and *reinvestment.* This implies that to continuously create compounding wealth, a process that includes reinvestment of the proceeds from the manufacturing activity is necessary. Figure 1 shows this iterative process.

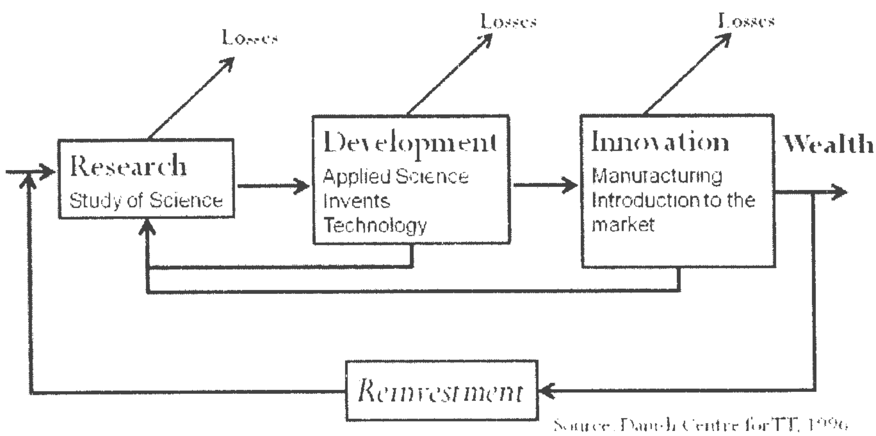


Figure 1. The Manufacturing Industry as an Iterative Process of Research, Development, Innovation and Reinvestment for the Continuous Creation of Compounding Wealth.

Sub-proposal of this Research: The Manufacturing Industry as an Analogue of its Smaller Counterparts of Manufacturing Organizations

Furthermore, the proposition of this research is to look at the manufacturing industry as an analogue of its smaller counterparts of manufacturing organizations. Specifically, this research proposes:

(a) To manage our country's manufacturing industry as a large *chain* of institutions and organizations that have the aim of providing products or component goods to the local and global market;
(b) To structure the internal chain within the manufacturing industry such that the industry will possess the characteristic of flexibility to arrive at different products that will be demanded by the market at any time; and,
(c) To highlight that the manufacturing industry should be "self-supporting," which can be done if the profits or rewards of manufacturing at the different points of the supply chain can be re-invested for generating scientific and practical knowledge that will be the seed resource, i.e., raw material, for future manufacturing.

Figure 2 illustrates a model of the manufacturing industry as a chain of suppliers and resources.

To manage the manufacturing industry as a value chain or interconnected set of organizations ultimately resulting to different products or component parts, we need to have a common understanding of the critical resources that must be provided by the value chains. In 1976, Daniel Bell proposed to distinguish three kinds of societies commonly passed through by different countries. These are: (1) Pre-industrial, (2) Industrial, and (3) Post-industrial. Bell said that these three kinds of society develop one after the other, although a newer society such as an industrial one does not displace the older one, which is the pre-industrial or the agrarian sector. Figure 3 shows the Bell's characterization of societies–.

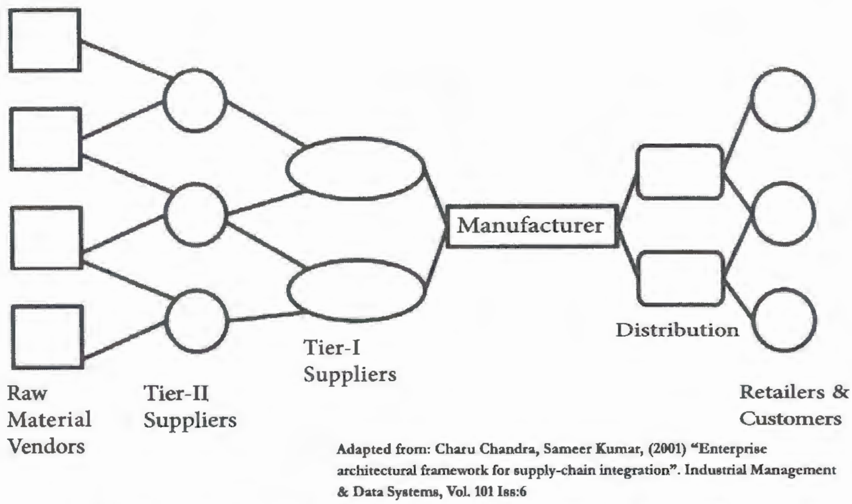


Figure 2. The Manufacturing Industry as a Large Chain of Institutions and Resources ALL Aimed at Providing Goods and Component Parts to the Local and Global Markets.

Table 1. Daniel Bell's (1976) Characterization of the Pre-industrial, Industrial, and Post-industrial Societies

The Post-Industrial Society: A Comparative Schema

MODES	PRE-INDUSTRIAL	INDUSTRIAL	POST INDUSTRIAL
MODE OF PRODUCTION	Extractive	Fabrication	Processing; Recycling
ECONOMIC SECTOR	Primary *Agriculture* *Mining* *Fishing* *Timber* *Oil and Gas*	Secondary *Goods-Producing* *Manufacturing* *Durables* *Non-durables* *Heavy Construction*	Services Tertiary: *Transportation*, *Utilities* Quaternary: *Trade*, *Finance*, *Insurance*, *Real Estate* Quinary: *Health*, *Research*, *Education*, *Government*, *Recreation*
TRANSFORMING RESOURCE	Natural Power *Wind, Water, Draft animals, Human muscle*	Created Energy *Electricity—oil, gas, coal* *Nuclear power*	Information[1] *Computer and data-transmission systems*
STRATEGIC RESOURCE	Raw Materials	Financial Capital	Knowledge[2]
TECHNOLOGY	Craft	Machine Technology	Intellectual Technology
SKILL BASE	Artisan, Manual worker, Farmer	Engineer, Semi-skilled worker	Scientist, Technical and Professional occupations
METHODOLOGY	Common Sense, Trial and error, Experience	Empiricism, Experimentation	Abstract Theory: *models, simulations, decision theory, systems analysis*
TIME PERSPECTIVE	Orientation to the past	Ad hoc adaptiveness experimentation	Future orientation: forecasting and planning
DESIGN	Game Against Nature	Game Against Fabricated Nature	Game Between Persons
AXIAL PRINCIPLE	Traditionalism	Economic Growth	Codification of Theoretical Knowledge

For the industrial society, the critical resources are the following: (1) The transforming resource is created energy; (2) the strategic resource is money or financial capital; (3) the required skill base is the engineer and semi-skilled worker; (4) the critical technology is machine technology; and (5) the methodology is empiricism or experimentation. For the methodology, it is interesting to note that various authors, including Bell, have pointed out that *innovations that contribute to successful manufacturing industries are largely results of empiricism or the "tinkering" of people.* Steel, automobile, electricity, and aviation industries of the industrial society, according to Bell, "were founded and created by talented tinkerers, men who worked independently of scientific establishment and were ignorant of many theories of basic science."

If we are to agree with this, then do we have a value chain for producing those "tinkerers" or "experimenters" who use primarily their hands to innovate? Does the Philippines have a continuous, sufficient, and reliable supply of the *strategic capability of the manufacturing industry, which is its human resource* (*Prahalad* 1983)*?*

3. The Required Supply Chains

If we superimpose the required resources for manufacturing on the proposition of this research to look at the manufacturing industry as a supply chain, the resulting figure will that be as shown by Figure 3. This resulting figure shows that strong supply chains of (1) the human resource or the engineers and semi-skilled workers who we said are supposed to be tinkerers, (2) the machine technology which is the required technology for driving the industrial society, and (3) the created energy which is the transforming resource needed to power the machines are critical.

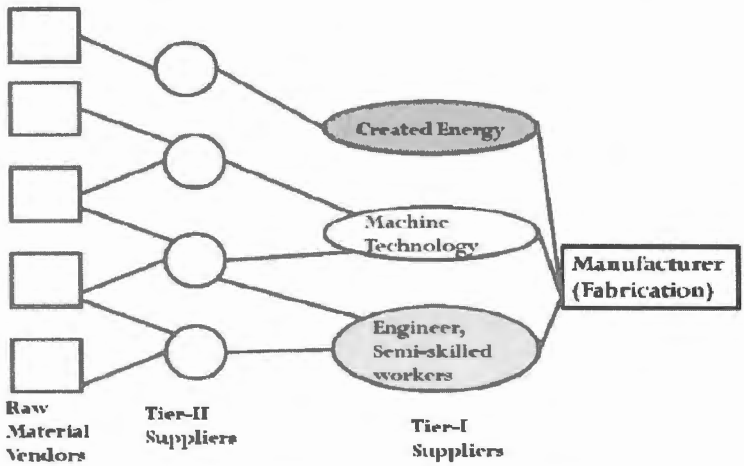


Figure 3. The Supply Chain of the Critical Resources for Manufacturing: The Chains of Engineers and Semi-skilled Workers, Machine Technology, and Created Energy.

These critical resources named by Bell in 1976 are also the same factors that were cited by the Deloitte and US Council on Competitiveness as the Drivers of Global Manufacturing Competitiveness in 2010. With the similarity between the critical resources for manufacturing as named by Bell in 1976 and the drivers of global manufacturing competitiveness as identified by the Deloitte and the US Council on Competitiveness in 2010, this research takes these critical resources/drivers of competitiveness of (1) *human: engineer and semi-skilled workers,* (2) *machine technology,* and *(3) created energy,* as the primary factors needed for building, strengthening, and sustaining our country's manufacturing industry.

3.1 Engineers and Semi-skilled Workers Supply Chain

In terms of producing our engineers and semi-skilled workers, according to the statistics of the Department of Education for 2010–2011, out of 100 children who enter Grade 1, 49 children proceed to secondary education. Out of those 49, 19 proceed to tertiary education. Among the top college programs of Business Administration, Medical and Allied education, Education, and IT, those who choose to take Engineering Technology are about 2 to 3 students out of the 19 who enter tertiary education.

Perhaps, we may say that the insufficiency of our manufacturing capability is due to the small number of students who go to Engineering Technology. We may be graduating too few in the said programs. However, if we look at the proportion of estimated engineering graduates, in 2011, the Philippines graduated an estimate of 325,443 students, i.e., about eight times as many as the engineering graduates of Germany of 40,000, when the population of the two countries in 2011 differed only by 15%.

Table 2. Comparison of the Philippines and Germany in terms of Population and Estimated Number of Engineering Graduates in 2011.

2011		
Country	Population (World Bank Statistics)	Estimated Number of Engineering Graduates
Philippines	94.8M	325,443 (source: Phil TVET Stat, 2011)
Germany	81.8M	40,000 (source: IEEE, VDI)

We recognize that we have losses in the supply chain of engineers and semi-skilled workers, such those due to drop outs, inability to enroll in the next part of the supply chain, and that we have some of them not utilized for manufacturing as they eventually go to services, or agriculture by which we also need to do. Nevertheless, we also *lose a great number of our resource to overseas work.*

Figure 5 shows that the magnitude of number of those trained by our technical vocational institutions from 2005–2011 are just about the same as the magnitude of deployed overseas Filipino workers. Those who are trained are not exactly the ones who go, however, to retain a critical mass of technically vocationally trained individuals, it will be safer to have the number of trained much greater than the number of deployed. Furthermore, an irony is, many of those we deploy do blue collar work in other countries even when they are unwilling to perform blue-collar work in our country.

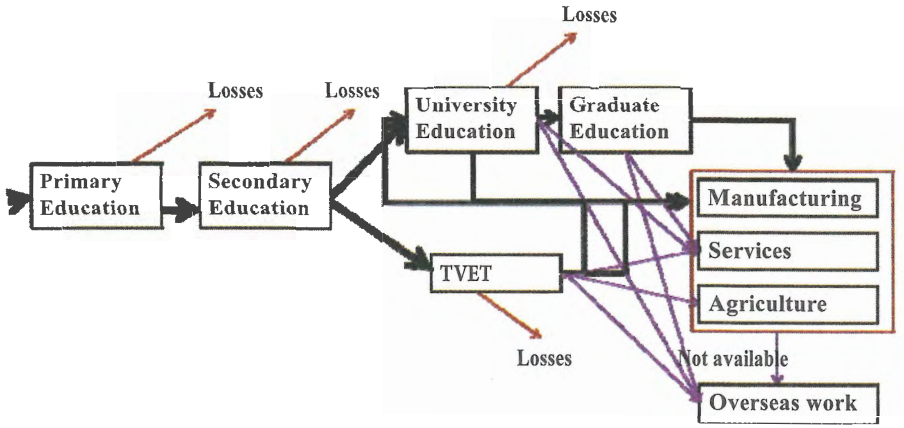


Figure 4. Losses in the Supply Chain of Engineers and Semi-skilled Workers.

- Losses to other countries: Deployed Overseas Filipino Workers (2005-2011)

Year	Total
2005	988,615
2006	1,062,567
2007	1,077,623
2008	1,236,013
2009	1,422,586
2010	1,470,826
2011 *	966,353

Source: 2005-2011 Current Labor Statistics, DOLE
* Preliminary

- Number of Graduates of TVET institutions (2005-2011)

Year	Graduates
2005	1,154,333
2006	1,340,620
2007	1,702,307
2008	1,812,528
2009	1,903,793
2010	1,344,371
2011	1,332,751

Source: Philippine TVET Statistics, 2005-2011

Figure 5. Deployed Overseas Filipino Workers and Number of Graduates of TVET Institutions (2005-2011).

In the previous section's comparison of Germany and the Philippines in terms of the number of engineering graduates, it is apparent that the strength/weakness of the manufacturing industry does not lie in the number of Engineering Technology graduates. Can the *quality* of Engineering

Technology education and training be the crucial factor? In providing the proper knowledge and training to our human resource for manufacturing, we must take note that technology or knowledge is composed of *explicit*, i.e., those that we learn through codified theory, and *implicit*, i.e., those that we learn through *practice* or experience from extended contact with a mentor. As mentioned by Bell and other researchers, the *practical* education in Engineering Technology is particularly significant to create the *tinkerers* needed for the Industrial Society.

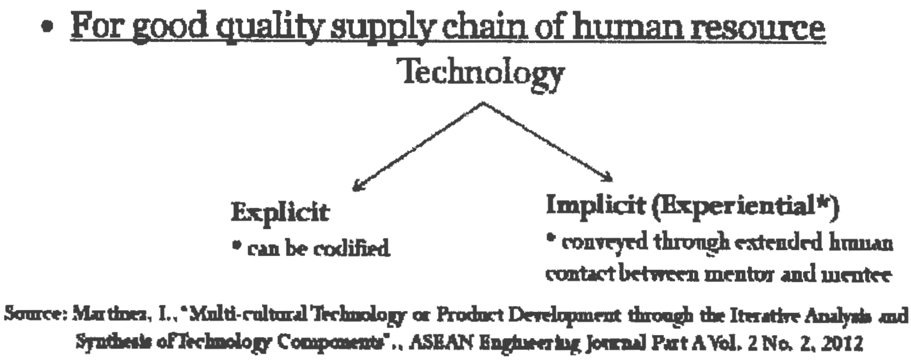


Figure 6. The Two Components of Technology (or Knowledge): Explicit and Implicit.

Aside from reducing the losses in the supply chain, we must strive to improve the quality of the supply chain by educating our human resource to get them ready for manufacturing. We must make sure that we teach "transferrable skills" or knowledge of how to deal with unexpected problems that may arise in the manufacturing factory floor and communicating those to other people. Concretely, we must have a critical mass (inventory) of vocationally-educated individuals to successfully carry out manufacturing. The supply must be provided with sufficient explicit and implicit, i.e., experiential, knowledge and training. With this, the present study recommends the following to improve the human resource supply chain:

(1) Reduce the losses.
(2) Improve the quality of education by making secondary education more prepared for manufacturing:
    - Lower secondary: common curriculum containing core skills

- Upper secondary: strike a balance among technical, vocational and general subjects

It is said that "to be successful, an integrated curriculum needs to offer a wide enough range of subjects". Studies of Botswana, Ghana, Kenya, and Mozambique show that adding only a few vocational subjects to the curriculum of secondary general education brought no benefits to the labor market. In Mozambique, it was only when vocational subjects made up at least 30 to 40% of the total hours in the curriculum that tangible benefits became apparent (Lauglo 2005).

Indeed, continuous practice makes us improve. In a recent study conducted at the UP Diliman Department of Industrial Engineering and Operations Research, it has been confirmed the learning remission or that the non-performance of a manual work makes the worker "forget" (Revilla 2012). A contractual worker then, whose work is cut before the six month, and does not do that work for the next six months, goes back to the top of the graph and will consequently need a longer time to do the work again upon resuming the job. Figure 7 shows this behavior.

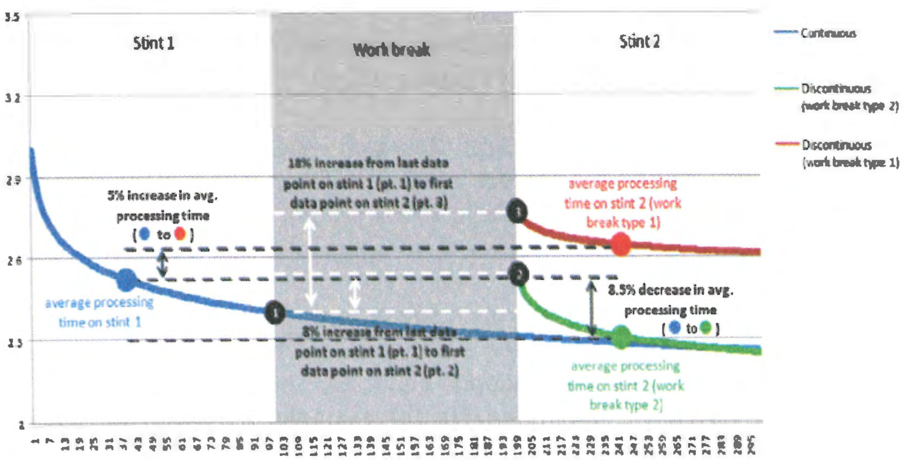


Figure 7. Learning and learning remission in manual work.

3.2 Machine Technology Supply Chain

Discussion of machine technology raises the following question: "Does the possession of machine technology that is required for a successful manufacturing industry imply the presence of a machine tool industry?"

Figure 8 shows the top 10 countries in terms of manufacturing, specifically for 2010. The same 10 countries are in the top of the list of the top producers or top consumers or top consumers & producers of machine tools.

Machine Tools, 2013
(Source: Gardner Survey)

	Top Producers	Top Consumers
1	China	China
2	Japan	United States
3	Germany	Japan
4	South Korea	Germany
5	Italy	South Korea
6	Taiwan	India
7	United States	Italy
8	Switzerland	Brazil
9	Spain	Taiwan
10	Austria	Mexico
11	France	Turkey
12	Czech Republic	Russia
13	India	Canada
14	Canada	France
15	United Kingdom	Switzerland

Figure 8. Top Manufacturing Countries are also Top Countries in terms of Machine Tool Production and Consumption.

In 2009, the Metals Industry Research and Development Center (MIRDC) surveyed 955 shops out of the 1,350 existing machine shops nationwide. A big proportion of these shops are not involved in production but in repair services. Figure 9 shows some figures for this.

Looking at the supply chain of machine tools, it can be remarked that there is a long way to go before the Philippines can have, or at least, be part of a supply chain. Given the supply chain for the grinding machine of Okamoto Co. as shown by Figure 10, for example, the chain is globally deployed. Our close neighbor, Thailand, has been part of the chain by providing cast metal, doing machining, painting, assembly, and testing. Thailand has domestic production of casted parts being provided by its metals and mold and die industries.

Service	No. of Shops
Repair Services	641
Industrial Parts Fabrication	451
Engine Reconditioning	214
Machine Rebuilding	127

Figure 9. Types of Services Offered by Machine Shops.
Source: Fudolig A., "The State and Development of Machinery and Equipment for the Manufacturing Industry of the Philippines

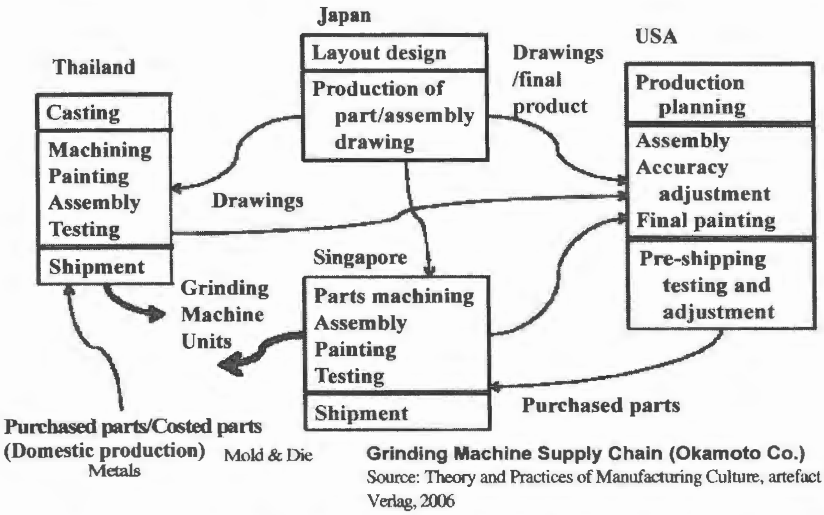


Figure 10. An Example of the Global Supply Chain for a Grinding Machine.

3.3 The Created Energy Supply Chain

The manufacturing industry is said to be driven by the transforming resource, which is the created energy, such as electricity, oil, gas, and coal. Energy is needed to power the machines that we need for manufacturing. In developing economies, highly reliable and efficient energy is needed to serve increasing demand. Figure 11 illustrates this.

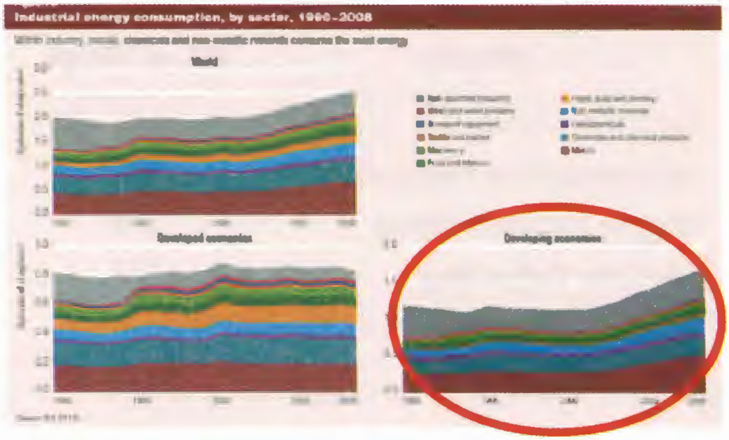
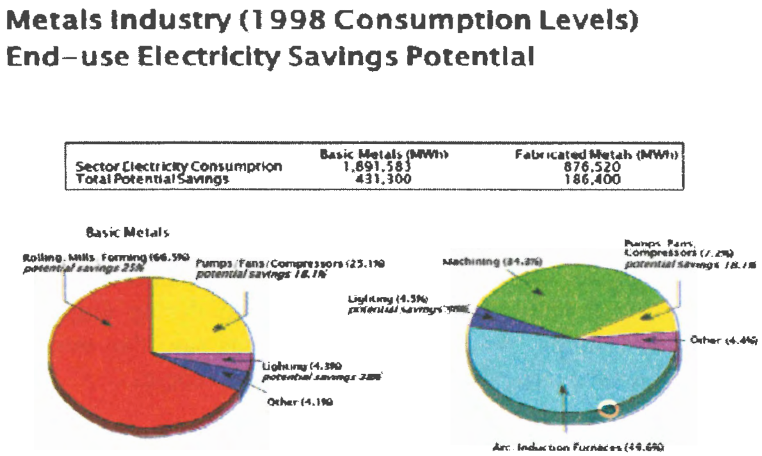


Figure 11. The Growing Consumption of Developing Economies such as the Philippines. (Source IEA 2010)

In April 2013, in a Roundtable Discussion organized by the National Academy of Science and Technology, Department of Energy Director Jesus Tamang showed the total demand for energy in 2012 to be at 6.1 Metric Tonnes of Oil Equivalent, 93.2% of which is for the manufacturing industries.

Furthermore, Director Tamang stressed the need to understand how to save on energy, to minimize losses in the supply chain, by understanding how much energy is used by our machine tools. Again, this is about saving energy by looking at the machine tool as a system or as a chain of different components.

Figure 12. Energy Demand by the Industrial Sector in 2012.



Source: Tamang, J., "RTD on Human, Machine and Energy Resources for Manufacturing, NAST", April 2013.

Figure 13. Understanding Consumption Breakdown to Minimize Losses.

In summary, the proposition of this research is to manage the manufacturing industry as an analogue of individual organizations. This research suggests managing the manufacturing industry similar to how supply chains of its smaller counterpart organizations are managed. Specifically, this research proposes that the manufacturing industry be: (1) managed as an interrelated chain of organizations and resources, (2) made flexible to be able to produce different kinds of products and component parts by postponing specificity as such "specific skills", "special-purpose machine tools" as much as possible, and (3) made self-sustaining by making sure that proceeds from the manufacturing activities are reinvested into the supply chain.

4. Case Studies: A Brief Look at Other Countries

4.1 Japan

As case studies to show the validity of the proposal, we can look at Japan whose manufacturing industry ranked 3rd in 2010 and whose machine tool industry was the 2nd largest producer in 2013. Specifically, let us look at the supply chain of engineers and technical vocational educated human resource. In Japan, out of 100 who enter the primary education, all of them go to the lower secondary education, which is offered in the same location. Out of these 100 individuals, 95 eventually try to obtain upper secondary and 37 of them go to higher education. In the upper secondary education, although there are options of (1) general education, (2) vocational education, and (3) other specialized programs, contrary to typical opinion, Japan does not really provide narrow vocational training. Instead vocational education is provided and even in vocational educational institutions, 50% of the curriculum is general education. Thus, the students who take vocational education may streamline back to higher education. Again, vocational education is more general than specific. Specific trainings are provided during employment through in-company training. As a matter of fact, it is said that companies prefer graduates who have basic and fundamental competencies.

4.2 China

In the case of China, there is a slight difference. While like in Japan, there is a high output of the lower secondary education it being mandatory and like Japan, there is a significant number of individuals taking vocational education, specific training is part of vocational education. In vocational education, like Japan, there is a wide range of specializations and there is a good percentage of general academic programs. Unlike in Japan, there is company internship on the last year for one year to teach the individual commitment to the workplace and good relationship with employers. However, though specific training is provided earlier than in Japan, like in Japan, specific training is not provided by the school but by the private companies.

Thus, we can compare Japan and China. Common characteristics include:

1. General/core education by the government until before the last year of secondary education.
2. Technical vocational is hands-on or apprenticeship.
3. Specific technical vocational education is provided by private company.

5. Discussions

Having stated and discussed the proposal of this research for an integrative approach to developing our flexible and sustainable manufacturing industry, the challenge to our country is this: "If we take on the proposition of this research on developing the engineers, semi-skilled workers, machine tool industry and efficient and reliable energy supply chains, it will take us a long time. Are the Filipinos capable of possessing the required patience to wait for the long number of years for the engineers and semi-skilled workers who have hands-on training, which will certainly take many years from now given the time required to plan the shops, to set them up and to actually provide the training? Will we have the perseverance to build a strong machine tool industry that takes the whole chain from the basic metals to mold and die to machine tools? We do have these industries at present but have they reached the critical mass of production needed to sustain the manufacturing industry?" This is a great challenge.

According to Geert Hofstede, the influential Dutch researcher, who pioneered research works on cross-cultural studies, Filipinos are relatively short-term in orientation, or we can say "impatient for achieving quick results". Thus, this research proposes a long wait which is something challenging for us. However, perhaps, we can take advantage of our country's high Power Distance Index (PDI), similarly proposed by Hofstede, which implies that The Philippines is a *hierarchical society*. This means that people accept a hierarchical order in which everybody has a place and which needs no further justification. Hierarchy in an organization is seen as reflecting inherent inequalities, centralization is popular, subordinates expect to be told what to do and the ideal boss is a benevolent autocrat. Then, we just need our leadership to be determined to take this approach for the success and sustainability of our manufacturing industry for all of us to follow. The validity of that hypothesis is just part of this discussion and is just a suggestion but is not for which this research has found proof.

6. Conclusions and Policy Recommendations

In conclusion, this research recommends some policies for education, the machine tool industry, and the energy industry.

6.1 Policies for Education

The recent decision of the Philippines to move to the K12 curriculum can be a good starting point for strengthening the supply of engineers and semi-skilled workers. *However, the implementation must be done correctly, with no regard for interests for the self-promotion of the implementers, but with the purest intention of providing more knowledge and skills to the next generations.* Following the restructuring of primary and secondary education, this research recommends the following:

1. Offer the lower secondary education in the same location as the primary education and remove school fees to decrease student dropouts, which are the losses to the supply chain of engineers and semi-skilled workers.
2. Offer vocational education tracks that are:
    - Going to provide skills needed in manufacturing. Tracks must promote machine technology or the use of machine tools, i.e., basic industrial processes such as casting, machining or joining (welding)
    - Relevant to the manufacturing industry. Consult key manufacturing industries about long-term skills that they require. Then:
        1. Consolidate these skills and identify the most common long-term skills requirements and translate them into upper secondary school vocational education.
        2. In the last year of upper secondary school training, allow two options for students:
            - vocational education offered within the school
            - vocational education through apprenticeship in accredited companies
        3. Vocational tracks must be carefully selected:
            - It should be "needs-based" not based on what is "easy to teach" or based on the "available resources". Financial investment on the *relevant* machines and tools will be necessary.
            - It should not be too specific to one company unless the company is willing to sponsor the vocational education through apprenticeship
        4. A government unit must be in charge of linking the trade and industry unit, labor unit, vocational education unit and finance unit of the country.

6.2 Policies for the Machine Tool Industry

Develop the following industries that make up the supply chain of the machine tool industry.

1. Metals industry
2. Tool and die industry
3. Machine tool fabrication, assembly and repair industry

6.3 Policy on Energy

Set up infrastructure for sustainable technology collaboration within the country and between Philippines and other countries for the aforementioned industries and their impacts on energy utilization. Furthermore, implement measures for utilizing alternative and renewable energy sources but also *efficiently* utilizing all these, most especially those that are non-renewable.

7. References

Batungbakal. 2013 June 10. Manufacturing grows by 9.7% in Q1-2013. *Philippine Manufacturing Revisited.* Available from: http://philippinemanufacturing.wordpress.com/tag/nscb/

Bell D. 1976. Welcome to the post-industrial society. Physics Today, 29(2): 46-49.

Carlsson B. 1984. The Development and Use of Machine Tools in Historical Perspective. Journal of Economic Behavior and Organization, 5(1): 91-114.

Chandra C, Kumar S. 2001. Enterprise architectural framework for supply-chain integration. Industrial Management & Data Systems. 101(6).

Cohen S, Zysman J. 1988. Manufacturing Matters: The Myth of the Post-Industrial Economy 1st ed. Basic Books.

Danish Centre for Technology Transfer Kfu. 1996. Technology Transfer and Development Effect. Retrieved from: www.um.dk/danida/evalueringsrapporter/1996-9/

Ettlinger M, Gordon K. 2011 April. The Importance and Promise of American Manufacturing: Why It Matters if We Make It in America and Where We Stand Today. Available from: http:www.americanprogress.org

Fudolig A. 2013 April. The state and development of machinery and equipment for the manufacturing industry of the Philippines," NAST.

Hofstede G. 1984. Culture's consequences: International differences in work-related values 5. Sage.
Houlihan JB. 1983. June/July. Supply Chain Management- The Modern Approach to Logistics. BPICS Control.
Lauglo J. 2005. Vocationalisation of Secondary Education Revisited. In Lauglo J, Maclean R, editors. Vocationalisation of Secondary Education Revisited Dordrecht: Springer.
Martinez, I.A.G. 2006. Modularizing Decision Support Systems in Manufacturing to Facilitate Technology Transfer. Theory and Practices of Manufacturing Culture (Chapter 7). Ito Y. and Ruth K. (eds.) artifact Verlag.
Organization for Economic Cooperation and Development. 2010. Vocational Education and Training in China: Strengths, Olchondra R. 2012 September 17. Japanese Manufacturers Move to Philippines. Philippine Daily Inquirer - Business.
Péano S., Vergel de Dios B., Atchoaréna D., Mendoza U. 2002. Investment in Technical Vocational Education and Training (TVET) in the Philippines. Retrieved from: http://unesdoc.unesco.org/images/0018/001804/180405e.pdf
Philippine TVET Statistics. (2005-2011). Retrieved from http://www.tesda.gov.ph/uploads/File/Planning2012/TVETSTAT/Philippine%20TVET%20Statistics2005-2011final%20%28cleandata%29revised9-25-12a.pdf
Prahalad CK. 1983 Developing strategic capability: An agenda for top management. Human Resource Management 22.3: 237-254.
Revilla A. 2012. A Comparative Study of Performance between Workers with Work Discontinuity and without Work Discontinuity, MSIE Thesis, UP Diliman.
Shibazaki, Hiroshi, Kim SH. 1989. Learning systems for manufacturing automation: Integrating explicit and implicit knowledge. MIT.
Usui N. 2012. Taking the right road to inclusive growth – industrial upgrading and diversification in the Philippines. Asian Development Bank.
Yap J. 2012 October. Regional Economic Integration and Inclusive Growth. Talk during the Inception Workshop on the Formulation of the Manufacturing Industry Roadmap, PIDS.