

Technology Commercialisation in Indonesia: Current Condition and Its Challenges

Wawan Dhewanto¹, Khamdan Khoirul Umam²

¹Department of Management, Faculty of Buseco, Monash University, Victoria, Australia

²Center for Research on Energy Policy, Institut Teknologi Bandung, Indonesia

ABSTRACT

Innovation is considered the main engine of economic growth in both developed and developing countries. Innovation refers to the first commercial application of a technological invention. Despite the importance of this topic, little has been understood on how a technology transferred and developed into a commercial success especially on Indonesian context.

The purpose of this paper is to identify technology commercialization activities in Indonesia. Based on secondary data sources, we constructed an analysis on the current state regarding the issue. The findings in this paper suggest that technology commercialization could be tracked down to university laboratories, government laboratories, and business organization laboratories.

This study provides insights to policy makers, business leaders, and university administrators on the appropriate roles of institutions and organizations in promoting and assisting technology commercialization activities of their respective inventors.

Key words: commercialization, innovation,

1. Introduction

In the globalization era, the challenge faced by Indonesia has become a tremendous issue due to the fact that we should be able to compete with other countries in all fields. As one of the sectors expected to be the backbone of national economy, our industries still found themselves in a condition which is difficult due to the economic crisis that occurred in mid-1997 and the recent global financial fraud. Therefore, we need to put efforts and try to use all the benefits of partnership to be able to survive in the era of the free market. In an increasingly tight competition, industries must be able to improve the quality of products and continue

to make innovation through research and development (R&D). Knowledge based economy (KBE) has become dominant in the 21st century and has been proved to increase a nation's competitiveness.

KBE refers to the use of knowledge and technologies as the main driver for growth and sustainability to produce economic benefits. The degree of KBE in a particular country is reflected on its *Knowledge Economy Index* (KEI). One of the main indicators for KEI is the economic regime and its performance (Ristek, 2008). Table 1 shows that although Indonesia's Poverty Index steadily declining, the people of this republic are still in behind their neighbouring

countries. Table 2 exemplifies the fact further. Though recorded average economic growth achieves more than 4% each year, 9.9% of Indonesian workforce is unemployed.

Table 1. Poverty index

Country	2001	2002	2003	2004	2005
Indonesia	21.3	18.8	17.9	17.8	18.2
Malaysia	10.9	n/a	n/a	n/a	8.9
Philippines	14.7	14.6	14.8	15.0	15.3
Singapore	6.3	6.5	6.3	6.3	5.2
Thailand	14.0	14.0	12.9	13.1	10.0
Vietnam	29.1	27.1	19.9	20.0	15.2

Source: Human Development Report (2007/2008)

World Bank Institute has developed a methodology known as *Knowledge Assessment Methodology* (KAM) which can be used as a mean to do a benchmark among countries, to identify potential strengths and weaknesses on transition towards KBE. Four pillars of KAM are similar to those on KEI, namely i) regime and economic performance, ii) education and human resources, iii) information and communication technology, and iv) national innovation system (NIS). Based on this methodology, we could draw an early observation that Indonesia's regime and economic performance slump can be attributed to the lack of the next three pillars, especially on the last pillar (innovation). Indonesia's budget for research is not more than 0.07 percent from its GDP, this alone enough as evidence¹. A study by Levit (2001) concludes that there is no doubt that NIS is an important factor which determines national competitiveness. Functioning

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www.mediaindonesia.com/read/2008/08/08/24310/45/7/Menristek_Anggaran_Riset_Perlu_Ditambah

NIS in a country could be evaluated from intensity and effectiveness interaction and interconnection between the elements of NIS i.e. R&D institutions, universities, and industries, and also performance of supporting organizations such as venture capitals.

Table 2. Unemployment growth

Country	2000	2001	2002	2003	2004
Indonesia	6.1	8.1	9.1	n/a	9.9
Malaysia	3.0	3.5	3.5	3.6	n/a
Philippines	10.1	9.8	10.2	10.2	9.0
Singapore	n/a	3.4	5.2	5.4	5.3
Thailand	2.4	2.6	1.8	1.5	1.5
Vietnam	2.3	2.8	2.1	2.3	2.1

Source: KAM World Bank (2008)

The present study was primarily based on a desk research of relevant existing studies, statistics, selected articles, policy documents, and expert opinions. We focused our search for data regarding current Indonesian condition on technology commercialization by means of the internet with various keywords². Organisation websites which might relate to technology were reviewed. Collected data were organised on the basis of key players as their activities related to technology commercialisation in Indonesia. Analysis was undertaken to describe the current state of technology commercialisation in Indonesia and its challenges. This followed by description of technology commercialisation in India and China as a benchmark. We try on making reference to the original information sources

² The main keywords we have used to screen the articles were: tech* start*, tech* spin*, academic spin*, academic start*, academic start*, entrepreneur* tech*, tech* commercialisation, universit* ntb, academic* ntb. The asterisk stands for finding all combinations of a word or word fragment. E.g. spin* finds spinouts as well as spinoffs.

wherever possible. The following key questions were addressed:

- Who are the key players of the technology commercialisation in Indonesia?
- What are the main relevant initiatives/activities in Indonesia?
- What are the challenges of technology commercialisation activities in Indonesia?

2. Technology Commercialisation as a Proposed Solution

Does advancement in technology lead to a nation's economic development? To some great extent, the answer is: Yes! Nevertheless this answer needs to be taken with some qualification. Technological catch up by industrial latecomers such as Japan, South Korea and Taiwan exemplifies cases of technology-led economic development. Neo-classic thinking in economics also sees technology as a freely available "public good," that facilitates development as long as markets are liberalized.

A closer view into the relation between technology and economic development is offered by the so-called *Schumpeterian perspective*. From this perspective, innovation is conceived as a creative destruction process. Competition among agents not only generates variety through innovation, but also reduces this variety through selection mechanisms, which depend on market institutions. Thus, innovation is the result of a process of creative destruction which transforms the routines of firms and institutions through formal and informal learning, and integration of tacit and codified knowledge. The creative destruction process determines, among other things, the level of development of an economy (Kadiman, 2009).

One popular perception of innovation (that can be seen in media every day) has to do with developing brand new, advanced

solutions for sophisticated, well-off customers, through exploitation of advance technologies. Such innovation is normally seen as carried out by highly educated labour in R&D intensive companies, with strong ties to excellent research centres. Hence innovation in the above sense is a typical "first class" activity, and is directly relevant to wealthy nations in the West. To those at the "third class", the developing countries, that notion of innovation is only indirectly relevant.

However, there is another way to conceive technology and innovation that goes beyond the above 'high-tech phobia'. In this broader perspective, innovation – the attempt to try out new or improved products, processes or ways to do things – is an aspect of most, if not all, economic activities. In this alternative view of innovation, the outcomes are not necessarily as fantastic and luxury as that in developed countries. Nevertheless, the cumulative social and economic impact of such 'moderate class' innovation could be no less-significant. Even in the so called 'low-tech' activities, there may be a lot of innovation going on, and the economic effects may be very large and sustainable.

3. Indonesian Technology Commercialisation Map

The "Science and Technology (S&T) Vision 2025" aims to establish "S&T as the main force for sustainable prosperity". The National S&T Strategic Policy 2005–2009 focuses on strengthening the linkage and partnership among R&D institutions, university and industry. For the first time the Industry Development Policy (2005-2009) is following a similar approach.

The 2004-2009 National Midterm Development Plans' "Chapter 22 Innovation" provides only a rather vague policy framework for innovation with its four "Development Programs in S&T Capability Enhancement".

The “Presidential Degree on the National Midterm Development Plan” defines fields of research priority (food and agriculture, security, renewable energy, transportation technology and management, ICT, defence technology, and health and medicine technology). The new research priorities seem to be better selected than in the past (earlier: strong focus on aeronautics and nuclear science).³

In 2006, the Ministry of Research and Technology (RISTEK) launched five incentive programs to implement its policy directions. The programs provide incentives for basic research, applied research, enhancement of the “S&T capacity production system”, acceleration of R&D result diffusion and utilization and “National Strategic Priority Research”. However, experts of the Indonesian Institute of Science (LIPI) question the funding for the incentive programs, as government spending on R&D and S&T infrastructure has seen a rather declining trend for a long time.⁴

Wrong S&T policy and priority setting should be corrected. All mechanism to bring R&D results to the market has to be tested. Based on our review of literatures, we could identify three main sources of innovation think-tank as described below.

3.1 Universities

One of the general policies of Indonesian universities is conducting research to develop knowledge in areas that are prospective and universal in order to improve the welfare of mankind. More particularly, the research conducted to develop technology that can be applied to build the strength of

³ Tatang, T. (BPPT): “Indonesia’s Sub-national Innovation System Policy and Programmes”

⁴ LIPI: “Policy Approaches and Support Mechanisms to Develop, Nurture and Promote Innovation in Indonesia”

national economy. Aside from their ‘Tri Dharma’ mission (education, research, society empowerment), universities are now expected to produce *technopreneurs* who are able to develop industries in the country competitive in the era of globalization.

Four of Indonesia’s leading universities, which are University of Indonesia (UI), University of Gajah Mada (UGM), Bogor Institute of Agriculture (IPB) and Bandung Institute of Technology (ITB), have already started their technology commercialisation activities⁵. IPB and ITB have established their office of Intellectual Property Right (IPR) office, while UGM includes IPR activities within their Institute for Research and Society Empowerment (LPPM) office and UI includes these activities within their office in the Directorate for Research and Society Empowerment (DRPM) office. IPB, ITB and UGM also have their business incubator for accommodating their students, alumni and staff who are challenged to start their own businesses. Furthermore, UI started to realise its long-term vision of developing science parks since 2007. The science park will integrate all of its research, development and commercialisation activities.

Table 3 Departmental Research Institution (DRI)

Institution	Number of DRIs
Department of Agriculture	31
Department of Communication and Informatics	4
Department of Energy and Mineral Resources	4
Department of Forestry	19
Department of Industry	27
Department of Health	14
Department of Marine and Fishery	15

⁵ IPB (www.ipb.ac.id), ITB (www.itb.ac.id), UGM (www.ugm.ac.id), UI (www.ui.ac.id)

Figure 1 below shows a particular project carried out by LPPM ITB and Department of Industry on the development of biodiesel technology, its commercialisation and its supporting policies.

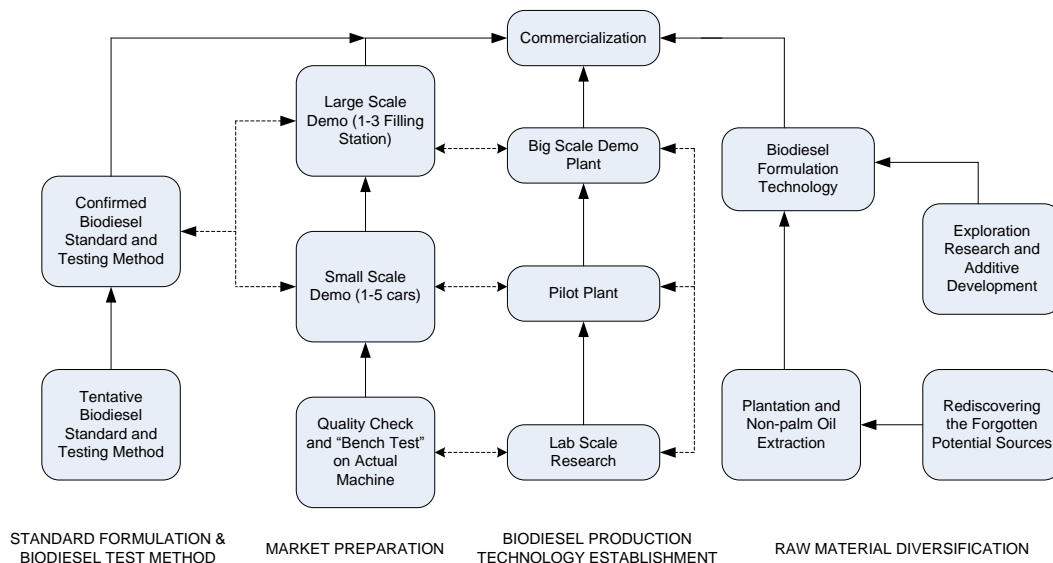
3.2 Government Research Institution

RISTEK appears as the key government player, with responsibilities including the formulation of relevant national policies and coordination of their implementation. Some other ministries have their own research institutes (Table 3). A clear coordination mechanism among ministries has not yet been developed. It is also important to note that the research priorities formulated (see above) are only partly reflected in the performing research landscape, i.e. it will be difficult to follow the political directions, if research capacities are limited in certain fields.

Based on a president's resolution, a National Innovation Centre for Small and Medium Enterprise (SME) was initiated in mid 2007. Under the supervision of the

ministry for economics all relevant other ministries as well as important research ministries have developed a guideline for this centre. Regional diversification is one key component. It is planned that the centre will have a staff size of 130. A proper budget has been allocated for 2009.

Generally Indonesian research has something to offer, its GCI (Global Competitiveness Index) being ranked 39th among 134 countries world-wide for quality of research institutions (World Economy Forum, 2008, p. 204). Among the most relevant research institutions reporting directly to the President, LIPI appears most involved in innovation-related activities. It holds a "Centre for Innovation", is responsible for the SME support program IPTEKDA (Implementation of Science and Technology at Regional), organises the "National Young Innovator Awards" and conducts S&T research for sustainable development.



Source: Department's websites

Figure 1 Indonesian Biodiesel Commercialisation Plan (LPPM ITB, 2006)

One of the most notable innovation from LIPI is Marmut Listrik LIPI or to be short, “Marlip”. Marlip is a battery-powered car which resulted from extensive research at Centre for Research for Electricity and Mechatronics (P2 Telimek) since 1998. This patented innovation has more than 80% of local content and available in 8 variants⁶.

Other than LIPI, there are 6 Non-Departmental Research Institutions (NDRI) that directly report to the President:

- LAPAN: National Aeronautics and Space Institute
- BPPT: Technology Assessment and Application Agency
- BAKOSURTANAL: National Coordinating Agency for Surveys and Mapping
- BATAN: National Nuclear Energy Agency
- BSN: National Standardization Agency
- BAPETEN: Nuclear Energy Regulatory Agency

The Agency for Agricultural Research and Development under the relevant ministry has traditionally received considerable R&D resources and has employed a majority of Indonesian R&D personnel. Due to previous research priorities, the National Nuclear Energy Agency and the National Institute for Aeronautics and Space still exist.

3.3 Corporate

Although Indonesia has transformed slowly from its agricultural base to become industrially prominent, industrial development still depends on foreign direct investment and foreign R&D. The majorities of foreign companies in Indonesia only develop its manufacturing factories or setup its distribution office using Indonesia as its market. Only a few of them develop its R&D in Indonesia. At the same time only few

Indonesian entrepreneurs develop technology based companies which have their own R&D facilities. In the automotive sector, no Indonesian national cars are in the market, all being foreign branded cars whose companies build their factories in Indonesia. While in the personal computer and notebook sector, no Indonesian brands are in the market. In the electronics sector, only one Indonesian manufacturer has its product in the market which is PT Hartono Istana Teknologi under the Polytron brand. Whereas in the software development sector, some software house already exists in Indonesia to supply Indonesian internal need.

The Indonesian Chamber of Industry and Commerce (KADIN) has also developed into a rather active player, however, their budget is limited. Impact is being generated when individual members actively promote certain areas/technologies/cooperation. Figure 2 shows the organisational structure of R&D Network’s relationship in Indonesia. This figure summarises the key players of R&D activities in Indonesia.

4. Lessons From Other Countries

Best lessons regarding technology commercialisation arguably came from the United States. Commercialisation of R&D and its results has become an important mechanism for economic growth in the U.S. as well as providing them with strategic advantages (Liu and Jiang, 2000; Wayne, 2003). However, this study will focus on its benchmark countries, China and India. These two countries have been selected because they are developing countries which share similar characteristics to Indonesia, having huge number of population and share rapid economic growth over the last ten years.

4.1 China

China used to have a very pragmatic approach: Attracting Foreign Direct Investment (FDI) for cheap mass production, gradually establishing indigenous R&D

⁶ <http://www2.kompas.com/kompas-cetak/0305/24/inspirasi/329243.htm>

capabilities, launching pilot operations and scaling up operations in case of success. China was virtually trading market access for technologies. However, China is currently losing its competitive advantage of being a “low cost country”. If the country wants to maintain its economic growth, it will have to improve own innovation capabilities. Being fully aware of the threats, China has taken steps towards building a high-performing innovation system. It has mobilised resources for S&T exceptionally rapidly and on an unprecedented scale and is now becoming a major R&D player.⁷ Fast growth and high savings rates enabled the country to do so. Weaknesses are still there at the institutional and policy level.

Already in 1998 China has established a comprehensive National Steering Group for

⁷ OECD: “Reviews of Innovation Policies - China”, 2007

S&T and Education⁸ in the State Council as the highest coordination mechanism of the innovation system. Nevertheless, this steering group does not seem to work efficiently, potentially hindering the realisation of the ambitious goals. There are first indications that the insufficient inter-ministerial cooperation may be improved via the establishment of a “supra-ministerial office for S&T” (Wang, 2007).

After the State Council as the prime source for innovation-related policies, the Ministry of Science and Technology (MOST) takes a lead position in innovation policy making and coordination with other ministries. Other active ministries include the Ministry of Education with increasing importance for R&D activities in universities and S&T human resources, and the Ministry of Finance for fiscal policies (promotion of R&D activities in enterprises).

⁸ The National Steering Group is comprised of the Premier of the State Council and Ministers of nine member ministries.

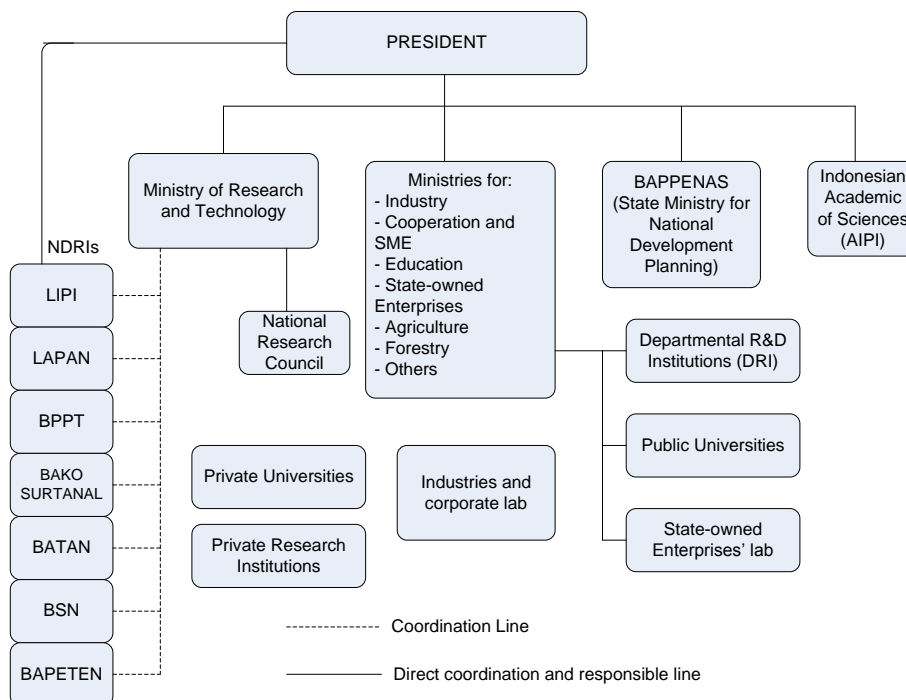


Figure 2 Indonesia’s R&D Network (from multiple sources)

The public research system has been downsized, rebalanced in favour of universities and modernised to a considerable extent. However, government research institutes still play a key role in supporting basic and strategic research. Together with the universities, they take the lead in cutting edge basic and even applied research, leaving research initiatives of local enterprises far behind. The Chinese Academy of Sciences (CAS), the country's most prestigious research institution, has undergone a tremendous internal reform process, aiming at transforming the previously overstaffed and inefficient institution (60,000 staff, 120 research institutes) to a centre of excellence, with 30 internationally recognised research institutes by 2010. Currently, 89 CAS research institutes are in operation (OECD, 2007).

The State Council has already established more than 50 S&T Industrial Parks to enhance international competitiveness in selected research priorities, filled with research centres, incubators and mainly foreign-funded businesses. In China, universities have been given considerable freedom to engage in profit seeking businesses. Such university-run enterprises can be either scientific/engineering businesses or non-scientific business such as shops. The number of scientific university-run enterprises is around 2,000, employing 238,000 workers, of whom 78,000 are scientific researchers. Technology transfer and licensing from universities is also on the rise. The number of patent transfers, for example, went up from 298 in 1999 to 532 in 2002. During the same period, technology transfers also increased from about 4000 to 5600.

In addition to technology transfers, contractual research, consultancy and enterprise incubation are widely seen as a means for university researchers to work with private businesses. During the three-year period between 2000 and the end of 2002,

326 establishments were created in cooperation with Chinese or foreign enterprises. What is remarkable about the funding of scientific research in Chinese universities is the high proportion of funding from private companies, a total of 40%. This shows a very high level of readiness on the part of Chinese businesses to pursue University-Industry collaboration.^{9,10,11}

4.2 India

India wants to be a “knowledge super power” by 2020 and has fair chances getting there. After the IT revolution, the intellectual capital of India has attracted Multi-National Company (MNCs’) R&D centres. 225 of the “Fortune 500 companies” today have their R&D centres in India. The biotechnology revolution could be next. It is undoubted that India is increasingly becoming a top global innovator for high-tech products and services. Growth has been driven by rapid expansion in export-oriented, skill-intensive manufacturing and services, and has seen further rise by increased local demand due to rising incomes.

There are however many challenges: The availability of work force with the right skills is increasingly becoming a problem. This results in rapidly rising costs. Also, infrastructure at most levels remains weak. Finally, one should not forget that especially in India innovation mostly takes place in a few selected “islands of excellence”, leaving large numbers of companies in other sectors behind.

Various policy level bodies have been set up to coordinate S&T programs, such as the Committee on S&T, the high-level

⁹ http://168.160.153.227/areas_two.htm

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http://www.most.gov.cn/eng/newsletters/2007/200706/t20070611_50331.htm

¹¹ Yujian, J. (2006), *Development of University-Industry Partnerships for the Promotion of Innovation and Transfer of Technology: China*

Scientific Advisory Committee to the Cabinet and the National Committee on S&T for the development of S&T plans. In addition, the National Knowledge Commission (a high-level advisory body to the Prime Minister) is supporting the transformation of India into a knowledge society and monitoring innovation related developments. Role distribution within the advisory and coordination landscape appears unclear.

At the ministerial level, the Department of S&T under the Ministry of Science and Technology (MOST) plays the leading role. Government entities responsible for commercialisation of R&D results so far have had limited success in meeting their mandates. The Technology Development Board (TDB) is facilitating the commercialisation of indigenous technology internally via seed funding to technology-based companies, but has only supported 100 initiatives within 5 years (2001-2006). The National Research Development Corporation (NRDC) under the MOST is the only public enterprise wholly dedicated to transferring technologies from R&D labs to the industry. Although it is a profitable public enterprise, it has not been successful as measured by the low overall commercialisation of publicly supported R&D.

The public sector dominates the Indian R&D landscape, with approx. 70–80 % of India's total R&D budget/investment. However, the public R&D system is extremely fragmented. A vast number of central government structures, organisations, instruments, and programs have emerged in response to specific needs and challenges. The Council of Scientific and Industrial Research (CSIR) of the MOST is India's main producer of scientific and technical publications and patents, with 39 laboratories and more than 5,000 researchers. Over the past 20 years, it has gone through a major restructuring, from producing technology for the domestic market to helping Indian industry become globally competitive. The

number of patents filed and granted from CSIR doubled or tripled every year after 2001. This is a result of an aggressive and systematic IPR policy as well as the benefit of 39 networked laboratories. This points to the importance of attitudes and policies taken by individual research organizations in advancing the protection of inventions.

India's innovation infrastructure is further growing. Main institutions include the prestigious and very successful Indian Institutes of Technology (IIT), which have been doubled this year with 8 new IITs. Together with the Indian Institutes of Sciences (IIS), the Indian Institute of Science

(IISc) and the recently created Indian Institutes of Information Technology (IIIT), they have largely benefited from the rising investment of MNC in R&D in India through industry-university partnerships, mainly in the field of electronics and IT. Indian academic institutions became aware of the importance of protecting and disseminating their knowledge through patents rather recently and the trend seems to be continuing. In 1995, only 35 applications were filed, but it rose to 96 in 2001 and 79 in 2002. Out of the more than 300 Indian universities, the number of academic institutions that filed patent applications during the last four years was in the range of 22 to 29 per year (a total of 62 over the four-year period), and this was still too small compared with the high number of educational institutions in India that engage in R&D activities.^{12,13,14}

¹² World Bank: "Unleashing India's Innovation", 2007

¹³ GTZ India

¹⁴ Ganguli, P. (2006), *Development of University-Industry Partnerships for the Promotion of Innovation and Transfer of Technology: India*

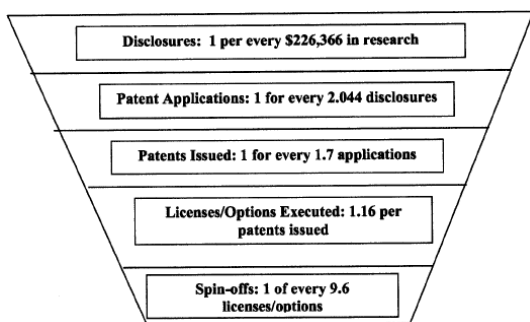


Figure 3. Yields in the Technology Commercialisation Process (Renault, 2003)

5. Challenges

Transfer of technology from Public R&D Institutions to industry, especially by means of commercial mechanism, is a challenging task. Recent studies (Higgins, 2001, Aiman, S, 2002, and RAMP-IPB, 2006) show that weaknesses in internal organization need to be overcome in order to increase utilization research results by industry commercially. Lack of clarity in R&D marketing direction and policy, weakness in design of research, lack of R&D marketing capability, limited research budget to conduct market testing, in addition to very limited incentive from government to industry which exploit local R&D results are the obstacles.

Many researches conducted by public R&D institutions, including what so-called applied research, are not yet designed and aimed to fulfil the market / industry needs. The activity designed and proposed by a group researcher appears more to satisfy the researchers want rather than to support industry development or to solve industry problem. A schematic of the technology commercialisation is shown in Figure 3. It takes an average of \$226,000 in research to produce a disclosure. This is because inventions are rare and most intermediary institutions are limited by budgets and staff and cannot search out all inventions on their lab networks. Therefore, not all inventions are disclosed. Of the disclosures that are

made, about one-half merit patent protection and only one-half of those patents are licensed. Of those patents that are licensed, 66 percent are commercialised via license to small companies and only one out of ten are licensed to spin-off companies (Renault, 2003).

Note that Figure 3 above illustrates condition in the US, but the trend and characteristic are not that different when viewed from Indonesian perspective. Table 4 shows raising trend of patent commercialised from public R&D although the relative percentage is still far lower than those in the U.S.

Another obvious problem is that marketing was not designed from beginning of research neither become program of the institutions. It is conducted only at the end research activity; so that marketing is become a kind of burden for researcher since marketing is not competency of the researcher. Many of researchers do not aware about industry need related to their activities, since very limited contact between researcher and industry/market. R&D Marketing should be responsible for all level of managements in the R&D organization; it is not only responsible of researchers who produced the technology or the results (Luxmore, 2000).

Table 4 Patent Commercialised from Public R&D Institutions

Year	Patent Filed	Patent Commercialised
2000	24	2
2001	62	7
2002	45	6
2003	47	8
2004	65	21

Source: LIPI (2006)

The effort to protect intellectual property yielded from research activities are very limited, most of research results are published only for benefit of the scientists. Those things

finally cause difficulties to market the research results. Lack of government incentives for industries causes them, especially large industries, do not willing to attempt to utilize local research results and local technology, furthermore they have no incentive to make investment to conduct research by themselves. They do more willing to buy available technology from other country (Spurling, 2002, RAMP-IPB 2006). Small and medium industries are more enthusiastic to utilize local technology and research results, unfortunately they have limited budget to buy a license, so they are more willing to use free technology. This cause a limited collaborative research fund or limited royalty that could be received by public R&D organizations. At the end, these cause most of R&D budget should be provided by the government.

6. Concluding Remarks

Indonesian technology commercialisation has already occurred in some organisations in Indonesia. However its performance is relatively low key, in term of quantity or value, when compared with that of India and China. The R&D budget available is small; therefore Indonesia should focus on very limited sectors as occurs in India where the current focus is on IT with the future having biotechnology as its focus. Indonesia should also encourage its corporate sectors to have its own R&D or outsource its R&D needs to an Indonesian university or a government laboratory as has been achieved in China which has successfully established Industry – University partnerships. The government should give incentives to industries which show a willingness to outsource R&D to Indonesian universities or government laboratories. On the other hand, universities and government laboratories should concentrate on researching industry's needs, than researching the preference of particular scientists.

The commercialization of the research results involves many stakeholders and is not

a static process. For more than last 10 years, literatures have been suggested two main streams for this activity, market-based or resource-based. Various different models appear from both approaches, those are the technology push, market pull, coupling model, interactive model, and network model. The obsolete linier model has become non-linier. Each R&D institutions have specific issues and uniqueness when viewed from the structural side and R&D programs and activities conducted. This condition requires them to be more adaptive and flexible in tackling every potential issue which could hinders commercialization of the research and its results.

The question posed should not be how to attract so-called high-tech activities from abroad, but *how to unleash the creative potential of innovation actors* (firms, bureaucracies, research organizations, financial institutions and the rests) that are already there, in a broad range of sectors and activities. This naturally leads to a focus on the quality of the environment in which the various innovation actors operate.

7. Future Directions

Various approaches have been used to study the technology development process. Ravasi and Turati (2005) recently used a case study approach to investigate the development of two inventions –one successful and one unsuccessful– by the same corporate entrepreneur. Cooper and Kleinschmidt (1986) also analysed a successful and an unsuccessful new product case study relative to 13 generic development activities. A next step in this research would be to investigate the technology development process and its commercialisation on two groups of inventor –academic (university and government) and corporate. To what extent are the steps similar? How do they differ? Can we use them to better understand the similarities and differences of processes followed by corporate and academic inventor? In general, how does the effect of

the various elements differ between the academic and corporate arena, since clearly the barriers, challenges, and drivers to create and commercialise innovative technologies also appear to be different?

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Agent-Based Simulation of School Choice in Bandung, Indonesia: The Emergence of Enrollment Pattern Trough Individual Preferences

Dhanan Sarwo Utomo, Utomo Sarjono Putro and Pri Hermawan
School of Business and Management, Institut Teknologi Bandung, Indonesia

ABSTRACT

This study is motivated by the reality that school choice programs that is currently implemented in Bandung that, always resulting student deficit (lack of student) in some schools. In this study, a mechanism that can describe how the enrollment pattern in a school choice program emerge as a result of individual preferences of the prospective students, is constructed. Using computer simulation, virtual experiments are conducted. In these experiments, the enrollment patterns and the number of student deficit that were resulted by various school choice program configurations are analyzed. Based on the experiment results, modification of the current program that can minimize the number of student deficit can be purposed.

Keywords: agent-based simulation, school choice, computer simulation

1. Introduction

1.1 School Choice Problem in Indonesia

As an impact of the implementation of Indonesian Republic Law No.32 2004, each local government has an obligation to design suitable education policy for their region. One of the obligations that should be met is to design a school choice program that is suitable to be implemented in their region. School choice program is a program that facilitates the parents and their children to select schools (Brown, 2004; Betts, Rice, Zau, Tang, & Koedel, 2006). In Indonesia this kind of program is also known as the acceptance of new students program (is abbreviated as PSB in Bahasa).

From year to year, school choice program in every region, especially for senior high school, is vary in the term of:

- The information technology that is used to manage applicants administration data. For example, central data base that can be accessed via internet is used to manage applicants administration data in Jogjakarta and DKI Jakarta (Rusqiyati, 2008).
- They way the schools are classified or clustered. For example, in Bogor the schools are categorized or clustered based on their achievement from previous year experience while in Takengon the schools are clustered based on their geographic location (Muisman, 2003).
- The number of school to which the prospective students may enroll. For example, students in Yogyakarta may enroll to three schools while in Bandung, students is only allowed to enroll to two schools (Kompas, 2007).
- Admission criteria that is used to determine whether an applicant is accepted or not.

For instance, a number of regions in Indonesia use national examination score as the admission criteria. In another region like Bekasi a combination between national examination score and test score that held by each school is used as admission criteria (Pos Kota, 2008).

Education experts and practitioners in Indonesia argue that, there are two criteria of a good high school choice program, namely:

- Fair and free from corruption, collusion and nepotism practice (Junaidi, 2008; Suwarja, 2003; Vardhana, 2008).
- The incoming students are distributed evenly to all public and private school in that region (Suryadi, 2008; Fathoni, 2008).

Unfortunately, school choice programs that are currently applied in many cities in Indonesia still cannot meet these criteria. There are many schools that suffer from lack of students (Antara, 2008; Radar Cirebon, 2008; Banjarmasin Post, 2009). On the other hand, many prospective students were rejected because the schools to which they enroll have lack of space (Kompas, 2007; Sumatera Ekspres, 2007; Surya, 2009). In addition, there are gaps in the quality of incoming students between the favorite schools and less favorite schools (Siahaan, 2008).

To improve the performance of school choice program, the city governments continuously modify the program that is applied. These modifications are usually made based on the evaluation of the program's performance in the previous year (Suara Merdeka, 2008; Radar Bogor, 2009). This mode is no other than an experiment that is conducted in real system. Experimentation in real system was very risky because a school choice program involves a complex social process. A complex social process consists of many non linear interactions among elements, in this case human (Gilbert, Agent-based Social

Simulation: Dealing with Complexity, 2004). This non linear interaction is caused by human societies characteristic that can recognized and changed their behavior (adaptive) in order to respond to (Gilbert, Emergence in Social Simulation, 1995) the new implemented system. Because of this human society characteristic, the impact that will occur from the experiment will be very hard to predict (Agar, 2004).

1.1 Purpose of the Study

This study aims to purpose a mechanism that can describe how the enrollment pattern in a school choice program, can emerge from the individual preferences of prospective students. The case that is selected in this study is the school choice program in Bandung in 2008. Using computer simulation, experiments with various system configuration and agent's characteristics are conducted. Specifically, these experiments aim to show the enrollment patterns and the number of student deficit that may occur. Based on the experiments results, school choice program that can minimize the number of student deficit can be purposed.

2. Modeling Process

2.1 Description of School Choice Program in Bandung

In 2008 there are 26 high schools in Bandung that participate in the school choice program. All of these schools are public high school. The rest of the high school and the private high schools have obligation to hold their own selection process.

26 high schools that participate in the school choice program are clustered into five. These clusters were made based on the school's previous achievement. Prestigious high schools are placed in the first cluster and less favorite schools are placed in the last cluster. Each applicant may only choose two schools from different cluster. They have seven days to consider and submit their application to the selected school. Each applicant was able to access daily information about the number and

national examination score of all applicants that already submit their application.

There is no specific standard that have to be met by an applicant. The lowest national examination score of a student that was accepted in the previous year (known as passing grade) usually become guidance for the applicants to select a school. Schools with high passing grade usually interpreted as a prestigious schools, which is commonly avoided applicants with low national examination score.

2.2 Applicant Decision Making Process

There are three general steps that are usually taken by an applicant to decide schools to which he or she will apply. In the first step, an applicant will gather information about the schools (Tatar & Oktay, 2006). There are six kind of information that usually gathered by the applicants in this step, namely:

- Applicant's residence location (Henrickson, 2003)
- Distance travelled to school (Henrickson, 2003; Tatar & Oktay, 2006)
- The number of application that have been sent, represent the number of competitors they will face.
- Applicant's achievement represent by the national examination score.
- Applicant's expectation about the school's quality (Henrickson, 2003; Tatar & Oktay, 2006), that is based on the school's previous achievements.
- The minimum qualifications that are accepted in that school (Tatar & Oktay, 2006).

Applicants have autonomy to determine the importance of each school attributes.

In reality, the applicants will not have complete information of all available schools. But, in order to simplify the problem at hand the simulation that will be constructed is based on the assumption that, all applicants (agents) are able to gather complete information about

all school and, they will update this information regularly.

In the second step, the applicant will consider the school that is most appropriate for them. This process can be represents by the process of maximizing school's aggregate benefit according to applicant (Belfield & Levin, 2002).

In the last step the applicant will consider whether he or she will be qualified in the selected schools (Belfield & Levin, 2002). This process can be considered as the process of comparing applicant's national examination score to the school's passing grade.

2.3 Purposed Agent-Based Simulation

The purposed simulation is constructed using SOARS (Spot Oriented Agent Role Simulator) that was developed by Deguchi Laboratory in Tokyo Institute of Technology. There are two types of object in SOARS, spot and agent.

In this model an agent represents an applicant in the school choice program. The total number of agents is 2850, that represent 6% of the total applicants in 2008. Agents are categorized into three types:

- Neutral agents: represent applicants who believe that the minimum score they should have to be qualified in a school can fully be described by the previous year passing grade. Therefore, they will apply to a school only if their score is higher than the previous year passing grade of that school.
- Pessimistic agents: represent the applicants who disbelieve that the minimum score they should have can be fully represented by the previous year passing grade. Therefore, they make some adjustment to anticipate in case the minimum the minimum score needed to be qualified increase.
- Optimistic agents: this type of agent also disbelieve that the minimum score they

should have can be fully represented by the previous year passing grade. But, they dare to make speculation and apply to the top school of their choice.

There are two types of spot that are defined in this model. The first is the home spot in which the participants stored all information during the simulation and the second, school spot to which the applicants enroll. The number of school spot is 26 (equal to the number of schools that participate in the school choice program in 2008) and the number of home spot is 2850 (equal to the number of agent). The next section describes mechanisms and attributes owned by each spot and agent.

1) Attributes of School Spot

The first attribute for the schools is x and y position in a grid of Bandung City. In order to assign schools position, Bandung city is divided into 6 X 4 grids. Then, the x and y position for school spot is assigned based on the actual position of the given school in the real world.

The second attribute of the schools is passing grade score (PG_j). A passing grade score indicate the lowest national examination score that was accepted in a certain school in the previous year. In this study, passing grade score of each school is assign based on the result of the school choice program in 2007.

The third attributes of the school spot is capacity (C_j). School's capacity indicates the number of student that can be admitted by a certain school. The capacity of each school spot is assigned based on the data in 2008.

The fourth attributes of school spot is image score (IM_j). Image score indicates the expected education quality of schools based on the perception of the agents. This attributes is assigned as a real number from 0 to 100. The higher image score, the higher the expected education quality of the given school. Although there is no research that directly measure image of the schools in Bandung city, some research

in Indonesia revealed that there is a linear relationship between the passing grade score and the school's expected education quality (Muisman, 2003; Purnawan, 2005; Priyanta, 2008; Rijanto, Hadi, & Relisa, 2008). Therefore, the following linear relationship is used to assign image score to each school spot in the simulation.

$$IM_j = 7.651PG_j - 114.765 \quad (1)$$

The fifth attribute of the school spot is the number of applicants (NA_j^t). This variable is an integer counter of the agents who enroll to school j at each time step. At the beginning of the simulation, this variable is initiated as zero.

The sixth attribute of the school is the cluster number (CL_j). This attribute is put into the simulation as integer based on the school's cluster data in 2008.

The seventh attribute of the school is the minimum applicant's score (MS_j^t). This variable indicates the lowest national examination score of all agents who enroll at school j at time t . At the beginning of the simulation, this variable is initiated as zero.

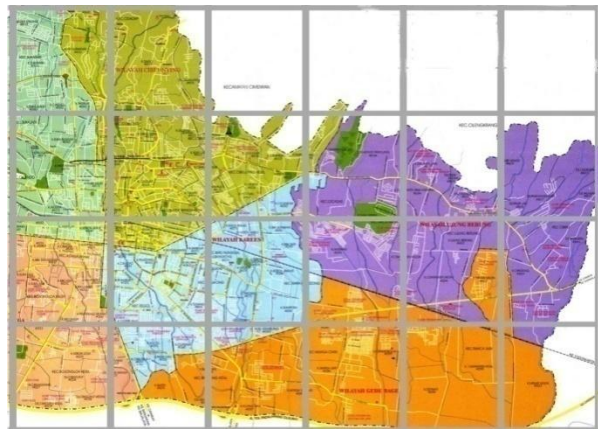


Figure 1 6 x 4 grid of Bandung city

The eighth attribute of the school spot is the competitor score (CS_j^t). Competitor score is a real number that range from 0 to 100. This variable indicates the degree of competition that will be faced by agents if they enroll to school

j . This variable is inserted in the simulation as a function of the capacity of school j and, the number of applicants in school j in the previous day.

$$CS_j^{t+1} = \frac{100 * (C_j - NA_j^t)}{C_j} \quad (2)$$

The last attribute of the school spot are two arrays to store the indexes (AI_j) and national examination scores (AS_j) of the agents who have enroll to school j . At the beginning of the simulation both of these arrays are initiated as .

2) Attributes of Home Spot

Just like the school spots, each home spot is also equipped with the x and y position. To assign the x and y position of home spots, the population densities at each point on the grid are calculated. The population densities are calculated by dividing the population in each point by the total population in Bandung. After that, the coordinate of each home spot is assigned using roulette wheel method in which, the population density serves as the probability.

The second attribute of the home spot is its distance to each school (r_{ij}). This attribute is calculated using Euclidean distance formula as the following:

$$r_{ij} = \sqrt{(x_j - x_i)^2 + (y_j - y_i)^2} \quad (3)$$

Where, r_{ij} is the distance from home i to school j , x_j is the position of school j in x axis, x_i is the position of home i in x axis, y_j is the position of school j in y axis and y_i is the position of home i in y axis.

The distance to each school is then converted into a score (D_{ij}) from 0 to 100. Score of 100 is assign if the $r_{ij} = 0$ and score

of 0 is assign if r_{ij} is equal to the diameter of the grid (7.211). In order to assign the distance score of each school the following equation is used.

$$D_{ij} = -13.867 * r_{ij} + 100 \quad (4)$$

The third attribute of the home spot are two arrays to record index of the schools that are chosen by agent his or her first ($CH1_i$) and second ($CH2_i$) choice. At the beginning of the simulation, both of these arrays are initiated as .

The last attribute of the home spot are two arrays to record cluster code of the schools that are chosen by agent as his or her first ($CL1_i$) and second ($CL2_i$) choice. At the beginning of the simulation, both of these arrays are initiated as .

3) Agent's Attributes

The first attribute of the agents is their national examination score (S_i). The minimum national examination score that should be achieved in order to be graduated from junior high school is 22 while, the maximum national examination score that can be achieved is 40. Therefore, in this study the national examination score of each agent is assigned as a random number from 22 to 40.

The second attribute of the agents is the weights for each school attribute namely, distance weight (WD_i), image weight (WIM_i) and competitor weight (WCS_i). All of these weights are assigned as a random number from 0 to 1 but, the total of all weights may not exceed 1. In order to fulfill this constraint, the following steps are taken.

$$WD_i = random[0,1] \quad (5.a)$$

$$\Delta = 1 - WD_i \quad (5.b)$$

$$WIM_i = random[0,\Delta] \quad (5.c)$$

$$WCS_i = \Delta - WIM_i \quad (5.d)$$

The third attribute for the agents is agent's tolerance (T_i). Agent's tolerance indicates agent's boldness to speculate on the fluctuations of passing grade score that may occur. For neutral agents, tolerance value is set as zero.

$$T_i = 0 \quad (6.a)$$

For optimistic agents, tolerance value is initiated as a negative random number with restriction that, the total of tolerance value and agent's national examination score may not less than 22 (since there will be no school which passing grade is less than 22).

$$T_i = \text{random} [0, (22 - S_i)] \quad (6.b)$$

For pessimistic agents, tolerance value is initiated as a positive random number with restriction that, the total of tolerance value and agent's national examination score may not greater than 40 (since there will be no school which passing grade is greater than 40).

$$T_i = \text{random} [0, (40 - S_i)] \quad (6.c)$$

4) Simulation Process

At every time step, from the 1st day until the 7th day, as long as $CL1_i = \emptyset$ or $CL2_i = \emptyset$, agent i will visit all school. Agent i then will record the passing grade score (PG_j), competitor score (CS_j^t), image score (IM_j), cluster code (CL_j) and the minimum applicant's score (MS_j^t) from each school. These variables are then stored in agent i 's home.

In each home spot, agents calculated the aggregate benefit of all school using additive model (Goodwin & Wright, 2004).

$$AB_{ji} = WD_i D_{ij} + WIM_i IM_j + WCS_i CS_j^t \quad (7)$$

Where, AB_{ji} is the aggregate benefit of school j according to agent i .

The aggregate benefit scores of all schools are then sorted from the school with the highest aggregate benefit to the school with the lowest aggregate benefit. Agent i then determines the school to which he or she will enroll. The evaluation process is started from the school with the highest aggregate benefit to the school with the lowest aggregate benefit. In this process agent i will calculate the difference between his or her national examination score and the passing grade of school j plus agent's tolerance.

$$d1_{ij} = S_i - (PG_j + T_i) \quad (8)$$

If $d1_{ij} > 0$ then, agent i will chose school j . If $d1_{ij} < 0$ then, agent i will not chose school j and, will continue the evaluation process to the next best school. If $d1_{ij} = 0$ then, agent i evaluate whether he or she has better chance to be admitted than the applicant with the lowest national examination score at school j .

$$d2_{ij} = S_i - MS_j^t \quad (9)$$

If $d2_{ij} > 0$ then, agent i will chose school j else, agent i will continue the evaluation process to the next best school.

Every time an agent chose a school, he or she will check whether he or she is able to enroll to the chosen school. If $CL1_i = \emptyset$ and $CL2_i = \emptyset$ then, agent i will store the index of school j in array of first choice index ($CH1_i = \{j\}$) and, the cluster code of school j in the array of first choice cluster ($CL1_i = \{CL_j\}$). If $CL1_i \neq \emptyset$ and $CL2_i = \emptyset$ and $CL_j \notin CL1_i$ then, agent i will store the index of school j in array of second choice index ($CH2_i = \{j\}$) and, the cluster code of school j in the array of second choice cluster ($CL2_i = \{CL_j\}$). If school j cannot satisfy these conditions then, agent i will chose new school.

After the evaluation process, agents will enroll to the schools whose index is stored in

array $CH1_i$ and $CH2_i$. Each agent who enrolls to school j will increase the number of applicant at school j (NA_j^t) by 1. Agent's index and national examination score then will be stored in array of applicant index (AI_j) and array of applicant score (AS_j) at school j .

After agents enroll to the schools of their choice, each school then will update the competitor score (CS_j^t) and the minimum applicant's score (MS_j^t) for the next iteration. The new competitor score in each school is calculated using (2).

To update the minimum applicant's score in each school, both AI_j and AS_j are sorted based on the applicant's score, from the highest score to the lowest score. If $NA_j^t \leq C_j$ then, the MS_j^t is equal to the applicant's score who is in the NA_j^t rank. If $NA_j^t > C_j$ then the MS_j^t is equal to the applicant's score who is in the C_j rank. After these processes are finished, the iteration counter is increased by 1.

At the end of the school choice program, both AI_j and AS_j in all schools are sorted based on the applicant's score, from the highest score to the lowest score. If $NA_j^t \leq C_j$ then, the school j will admit all agents who enroll to school j . If $NA_j^t > C_j$ then, the school j will admit agents whose rank is less than or equal to C_j .

3. Experiment Process

In this study three experiments are conducted. The aim of the first experiment is to test the performance of the current program (five clusters with two choices) under various population variations. The second and third experiment aimed to test the performance of the school choice program using different number of cluster.

In each experiment, four kinds of scenarios are carried out. The first scenario involve only neutral agents, the second involve

only pessimistic agents, the third involve only optimistic agents and in the last scenario all types of agents are involved with equal proportion.

In the first experiment observed that in the current school choice program, student deficit are always occurred in every scenario. The number of student deficit increases drastically in the second scenario, when all agents are pessimistic. This is happened because pessimistic agents tend to avoid competition, indicated by a low total number of applicants in each cluster.

In the second experiment, the number of cluster is reduced into three clusters. This program performs better in eliminating the number of student deficit in the second and fourth scenario. But, this program performs worse than the current school program in the first and third scenario.

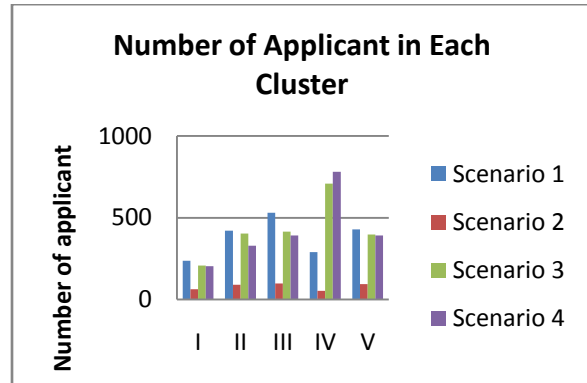


Figure 2 The enrollment pattern in the first experiment

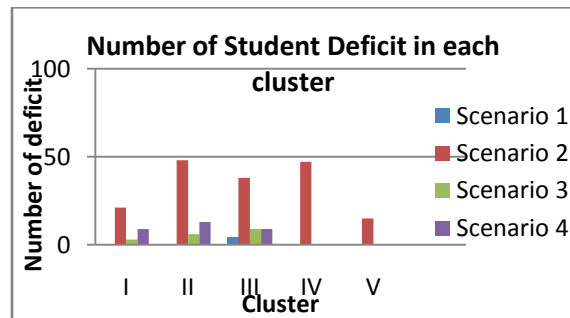


Figure 3 Student deficit in each cluster in the first experiment

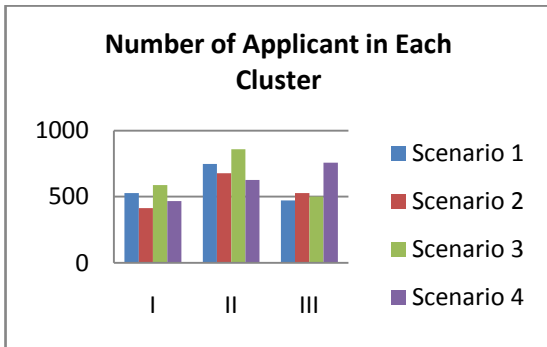


Figure 4 The enrollment pattern in the second experiment

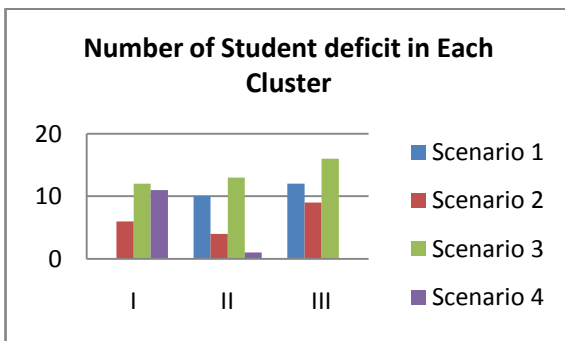


Figure 5 Student deficit in each cluster in the second experiment

In the third experiment, the number of cluster is increased into six clusters. This program performs better in minimizing student deficit in all scenarios. The deficit only occurred in the third scenario, with less number compare to the two previous programs.

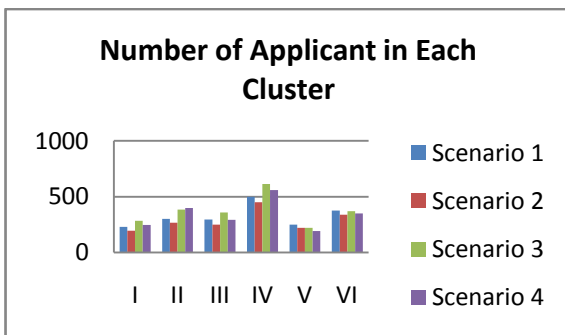


Figure 6 The enrollment pattern in the third experiment

4. Conclusions and Further Research

4.1 Conclusions

In this study mechanism that can describe how the enrollment pattern in a school choice program can emerge from the individual preferences of prospective students is purposed. Using computer simulation virtual experiments can be conducted. These experiments can give insight to the decision maker about the enrollment pattern and the number of student deficit in each cluster under the variation of population proportion and number of cluster.

From the experiment results it can be concluded that the current school choice program is very sensitive to the variation of population proportion and the number of cluster. The current school choice program is vulnerable in resulting high number of student deficit especially, when the number of pessimistic agents is high. In order to minimize the number of student deficit in each cluster, the decision maker in Bandung can increase the number of cluster that is used, from five clusters to six clusters.

4.2 Further Research

This study has several limitations that should be improved in the future. The first limitation is that the experiment result is still not yet validated externally. In the next study, we aim to compare the enrollment pattern and the number of student deficit in each cluster, to the data taken from the real world.

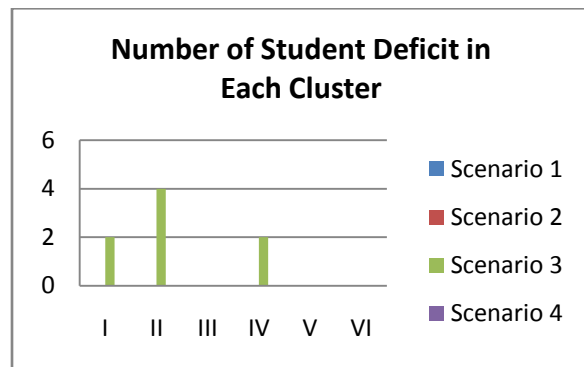


Figure 7 Student deficit in each cluster in the third experiment

The second limitation of this study is that, the agents are only interact each other through the school spots. The agents are also assumed to have complete information about all schools attributes. Studies have revealed that in a school choice program, agents have incomplete information about the school's attribute. Agents will rely on their social networks (for example: ex-schoolmate, parent's co-worker, or family member) in gathering more information about the school attributes (Holme, 2002; Ramsay & Sanchez, 2006; Dougherty, et al., 2007; Dillon, 2008). In the next study we aim to improve the purposed mechanism, in order to facilitate these behaviors.

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Government Intervention to Encourage the Increase of Innovation Activities: The Case of Automotive Component Industry

Erry Ricardo Nurzal, Pudji Hastuti
Researchers in the Centre of Technology Innovation Assessment, BPPT

ABSTRACT

The increasingly globalizing and very tight competition in the world market nowadays requires companies to increase their competitiveness to maintain and strengthen their position. One of the efforts has to be taken into consideration by companies is innovating sustainably. Evidence shows that companies characterised by innovation have above-average productivity and become leader in the industry. Firms innovate either to produce technologically new products or services, or to produce technologically improved products or services. To produce technologically new and improved products or services, firms need to undertake some innovation activities. Innovation activities are all those scientific, technological, organizational, financial and commercial steps, including investment in new knowledge, which actually, or are intended to, lead to the implementation of technologically new or improved products or processes. Small and medium enterprises face some problems to innovate. Government intervention is needed to manage the problems, and is expected to increase innovation in the industry.

Innovation activities discussed in this paper are focused on those occurred in small and medium enterprises in the automotive component sector as one of the sectors will be developed by the government. In the first part is the introduction which presents problem background. Then, the explanation about methodology and followed by the purpose of the study. The next part is results and discussion. Finally, the paper provides recommendation on intervention necessarily to be taken by the government in order to increase innovation activities in the industry.

Key words: Government Intervention, Innovation Activities, and Automotive Component Industry

1. Introduction

Amidst the increasingly tight and globalizing competition, industries are required to acquire competitiveness in order to raise and sustain their business. The efforts conducted by companies to produce the products with high quality and competitive price have led them to innovate. Some studies revealed that the innovative firm is the one

that can survive and even take a lead in the industry.

Innovation activities performed by companies can be with the purpose to sustain company's competitiveness to protect their market share, or to pursue company's competitiveness to have a strategic position towards their competitors. For those reasons, companies carry out product and process innovation. The manufacturing of

technologically new products or products with significant technological improvements and the implementation of technologically new process or process with significant technological improvements are called technological product and process innovation (OSLO MANUAL, 1997). To implement technologically new or significantly technologically improved products or processes, firms undertake innovation activities.

Maintaining and increasing the competitiveness of small and medium enterprises (SMEs) have become the focus of many countries around the world. It can be seen through their efforts to introduce innovation activities to these enterprises and encourage them to perform the activities. The growing attention to SMEs is based on some reasons, i.e. the number of SMEs as the biggest part of the businesses in a country, the employment of the huge amount of workforce by SMEs, and the SMEs significant contribution on the country economic growth.

Similar to the condition commonly occurs in the other developing countries, the technological capability of the Indonesian industry, small and medium enterprises specifically, is very low. Under this poor condition, the automotive components manufactured by the local small and medium enterprises have to compete with the products, which can be easily found in the market, from neighboring countries such as Taiwan, China and Thailand. For this reason, some efforts need to be taken to increase the innovation activities in order to foster the local firm technological capability. Government, through the implementation of the policies, plays important role to encourage the increase of innovation activities in the enterprises as well as their own efforts. Government intervention by formulating and implementing the appropriate policies is expected to create an innovative and very competitive industry.

This paper discusses the innovation activities conducted by industry/firm, one of the innovation system elements, with the focus on automotive component SMEs as one of the industries the government intends to develop. In the first part of the paper is the introduction which provides the problem background. The explanation on the methodology used comes in the next part and followed by the explanation on the purpose of the study. Then, the result and discussion will be presented. Finally, this paper will propose a recommendation on the intervention the government need to be considered in order to promote the increase of innovation activities in the automotive component industry.

2. Methodology

To discuss the innovation activities and the supporting government policies, primary and secondary data are required. Primary data is needed to track the innovation activities carried out by small and medium automotive component enterprises and the influence of the government policy on these activities. The data were collected by interviewing the champion companies of automotive component. These firms are spread in some automotive component industrial centers in Bandung, Tegal and Sidoarjo. While the secondary data is very useful to recognize the policies implemented by the government in order to promote innovation activities. Policy analysis method was used to get the policy alternatives on promoting the innovation activities. It was first started with the problems identification requiring the government intervention. Then, it's continued further by finding the source of the problem. Analysis on the existing policies and determination of policy alternatives to solve the problems come next. The implementation of this method involved the related stakeholders.

3. Objective

The objectives of this study are:

- 1) To identify and analyze the innovation activities in automotive component industry,
- 2) To identify and analyze the existing policies, technology policy in particular, to urge innovation activities, and
- 3) To provide policy alternatives to urge the innovation activities.

4. Results and Discussion

There are several things that will be discussed in this part. Firstly, there will be the explanation on the innovation activities and the problems faced. Next, it is the analysis on technology policies related to innovation activities. The policy alternatives to urge the innovation activities will be presented in the last part.

4.1 Innovation Activities and Problems

As defined in the OSLO Manual by Organization for Economic Cooperation and Development (OECD, 1997), technological product and process innovation activities are all those scientific, technological, organizational, financial and commercial steps, including investment in new knowledge, which actually, or are intended to, lead to the implementation of technologically new or improved products or processes. Some may be innovative in their own right, while others are not novel but are necessary for implementation (OSLO Manual, 1997).

Seven types of innovation activities mentioned in the OSLO Manual are:

- a. Research and experimental development.
The detail of research and experimental development is discussed below.
 - Research and experimental development comprises creative work undertaken on a systematic

basic to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications (as defined in the Frascati Manual, 1993).

- Construction and testing of a prototype is often the most important phase of experimental development. A prototype is an original model (or test situation) which includes all the technical characteristics and performances of the new product or process. The acceptance of a prototype often means that the experimental development phase ends and the other phases of the innovation process begin (Frascati Manual, 1993).
 - Software development is classified as R&D as long as it involves making a scientific or technological advance and/or resolving scientific/technological uncertainty on a systematic basis.
- b. Acquisition of disembodied technology and know-how.
Acquisition of external technology in the form of patents, non-patented inventions, licenses, disclosures of know-how, trademarks, designs, patterns and computer and other scientific and technical services related to the implementation of technological product and process innovations, plus the acquisition of packaged software that is not classified elsewhere.
 - c. Acquisition of embodied technology and know-how.
Acquisition of machinery and equipment with improved technology performance (including integrated software) connected to technological product or process innovations implemented by the firm.
 - d. Tooling up and industrial engineering.
Tooling up and industrial engineering include the changes in the production and quality control procedures, methods and standards and associated software

required to produce the technologically new or improved product or to use the technologically new or improved process.

- e. Industrial design
Industrial design includes plans and drawings aimed at defining procedures, technical specifications and operational features necessary to the production of technologically new products and the implementation of new processes.
- f. Manufacturing start up
This may include product or process modifications, retraining personnel in the new techniques or in the use of the machinery, and any trial production not already included in R&D.
- g. Marketing for new or improved products
It's defined as the activities in connection with the launching of a technologically new or improved product. These may include preliminary market research, market tests and launch advertising, but will exclude the building of distribution networks to market innovations.

the technical change both in product and in process, there were not, in fact, many innovation activities carried out by firms. The only innovation activity undertaken by small enterprises was the most modest one, i.e. tooling up (improving the equipment's technological performance) and industrial engineering (making some changes or engineering on the existing equipment or machinery). Such technical change on product and production process was not something new to firms. It occurs very often to adapt with the recent development and to make the process of production go faster.

Some medium enterprises carried out the higher level innovation activities like performing research and experimental development and purchasing (acquisition) of machinery with improved technological performance. But the latter was conducted only by one or two biggest enterprises with the highest amount of workers and the highest sales volume among the surveyed enterprises.

From the survey on some small and medium enterprises, it is found that despite of

Table 1. Innovation Activities in Small and Medium Automotive Component Enterprises

Firm	Innovation Activities						
	Experimental research and development	Acquisition of disembodied technology	Acquisition of embodied technology	Tooling up & industrial engineering	Manufact. start up	Industrial design	Marketing
MP1				√			
KL1				√			
KL2				√			
MK1	√		√	√			
MK2	√			√			
KL3				√			
KL4				√			
KL5				√			
KL6				√			
KL7				√			

Source: Survey Results on Innovation Activities (2005)

Tabel 2. *Obstacles to Innovation Activities*

Perusahaan	Kendala
MP1	Knowledge gap, cost too high, lack of sources of finance, demand risk
KL1	Cost too high, lack of finance, partnership, demand risk
KL2	Economic risk, lack of skilled personnel, lack of finance, partnership
MK1	Knowledge gap, cost too high
MK2	Cost too high, lack of finance
KL3	Lack of skilled personnel, knowledge gap, lack of finance, partnership, demand risk
KL4	Cost too high, lack of finance, knowledge gap
KL5	Knowledge gap, cost too high, cost too high
KL6	Lack of finance, knowledge gap
KL7	Economic risk, cost too high

Source : Survey Results on Innovation Activities (2005)

From Table 1, it can be seen clearly that the innovation activities in the industry are still too low. There are some main reasons for this condition as shown in Table 2. First, the low technological capability of the firms, including the know-how of the personnel to support the innovation activities. Second, the investment required to perform innovation activities is so high that firms are not able to make it due to lack of financing. Third, there is a risk of the low demand on innovated product. If these things take place, innovation is not resulted in the appropriate return on investment to firms.

On the subject of innovation sources that encourage firms to undertake technical

changes, almost all of the enterprises mentioned fairs/ exhibition and buyers. Other information sources mentioned by some enterprises were supplier and competitors. An interesting fact revealed from the survey is that no single firm considered research and development institution or laboratory as the important innovation sources for the company. Two enterprises that used the service from laboratory for their innovation activities were those belong to medium enterprises.

The low amount of innovation activities performed by small and medium enterprises also occurs in some other countries, including in the European countries. According to the data on European Trend Chart on Innovation (2004), firms in this group usually do not invest much in research and development. Factors hampering innovation activities faced by firms come from the internal and external of firms. Some external obstacles often mentioned by firms are financial factor like lack of seed capital to innovate, lack of skilled personnel or lack of relevant training schemes or subsidies to hiring innovation manager, and lack of technological capability. While the reluctance to innovate and lack of learning attitude were the internal obstacles that hamper innovation in SMEs. These can be in the forms of the resistance to change, to learn and to cooperate, inability to cope with the uncertainty, result and time of innovation, and lack of awareness to identify opportunities on new technology and cooperation, and the benefit resulted from them.

The fact that there were only small amount of innovation activities in small and medium enterprises was used by the government as the argument for an intervention. This intervention is taken by formulating the policies to encourage firms to innovate and to assist them to overcome the obstacles to innovate. For this reason, the government in European countries has designed three types of innovation program

for small and medium enterprises, i.e. innovation program for SME based on their sectors and technology fields, innovation program in accordance with SME technology competences, and innovation program in accordance with the SME business development phase. In addition, programs designed to overcome the obstacles for the firms to innovate are especially aimed to: 1) encourage the industry awareness on the importance of innovation and identify their innovation potential, 2) increase their expertise and competence to innovate, 3) assist the industry in acquiring human resources required to innovate, 4) increase market intelligence to make new product and technology developed by industry to be accepted by market, 5) reduce the obstacles to cooperate with public R&D institution and universities, 6) ease the cooperation with other firms.

Policy to arise the awareness on the importance of innovation can be in the form of award presentation to the most innovative firm (implemented by Czechoslovakia and Greece), or by holding a national competition to select the firm with the best performance (implemented by French, Ireland and England). The bottom up programs to increase the capability to innovate includes training and consultancy service or financing program focused on knowledge transfer between R&D institution and SMEs. These programs may also help to provide the industry with reliable human resources to carry out innovation activities. The difficulty faced by SMEs to develop new products being accepted in the market can be encouraged through the program of providing free consultancy service and market information (Czechoslovakia), market research subsidy scheme (Cyprus), and on-line business providing information on market and improvement of performance and competitiveness (UK). Policy can be used reduce barriers for industry to cooperate with research institution includes incentive to promote cooperation between research

institution and industry (Norway and Slovenia), bottom up financing program to support the cooperation between industry and research institution (Switzerland), or the establishment of science park (Romania and Slovakia). Cooperation among the existing research institutions, public R&D institution and universities in particular, may also overcome obstacles to innovate due to the low technological capability owned by industry. Research institutions, with their pool of knowledge, qualified human resources and facilities, may become one of critical innovation sources to the industry. Study on the researches financed by public funding (Nelson, 1986; Acs et al, 1992; Mansfield, 1991; Mansfield, 1995; Senker, 1991; Faulkner & Senker, 1994; Pavitt, 1991; Nelson & Rosenberg, 1994; Beise & Stahl, 1998) revealed that researches carried out in the Research and Technology Organization have positive effect to firm innovation.

4.2 Government Policies

In the national medium term development plan (Rencana Pembangunan Jangka Menengah Nasional) 2004-2009, science and technology programs are focused on six priority fields, i.e.: 1) food self reliance, 2) health and medicine technology, 3) new and renewable energy sources, 4) transportation technology and management, 5) information and communication technology, and 6) defense and security technology. It can be concluded that among these six focuses, technology development in automotive component industry is under the field of transportation technology and management.

Realizing that there were some weaknesses on the national medium term national development plan, either in the side technology producer and user or in the side of intermediary, the Office of State Ministry for Research and Technology introduced five incentive programs, i.e. incentives on basic research, applied research, science and technology capacity improvement on

production system, acceleration of science and technology diffusion and utility, National Strategic Priority Research (RUSNAS). The aim of these incentives is to accelerate the growth of technological innovation, to stimulate research in order to produce commercially high value innovation, to encourage the acceleration and enlargement of innovative product commercialization, and/or to strengthen the domestic technological and industrial competitiveness.

Technology policy related to the encouragement of innovation activities in automotive component industry, the instrument that can be used is the incentive for the improvement of production system science capacity, that is all the efforts to improve the potential of adoption, adaptation, and technology development for the high value competitiveness of the products and/services by optimizing input, process and industry management. The introduction of this incentive is directed to stimulate investment in research, development, and engineering in the industry with the purpose to facilitate the interaction between science and technology supplying institution and industry. This incentive is also able to help industry coping with financial obstacle and

low technological capability in undertaking innovation.

If it is analyzed further, this incentive is also aimed to increase public research and development institutions. It can be seen clearly from the definition of ‘instrument’. In the guidance on incentive program, it is stated that the term of incentive defined as policy instrument introduced by The Office of State Ministry for Research and Technology to accomplish its mission to provide the opportunity and to motivate the research and development institutions and researchers in carrying out their research, managing the problem systematically hampering innovation growth, and stimulating the adoption of innovation results by business practitioners/industry/society. Based on this definition, it is clear that the research institution meant here is the state/public institution. In addition, this incentive is directed more on researches to solve problems that hamper innovation growth. However, the problem faced by the automotive component industry that really requires special attention is the development matter to encourage innovation activities.

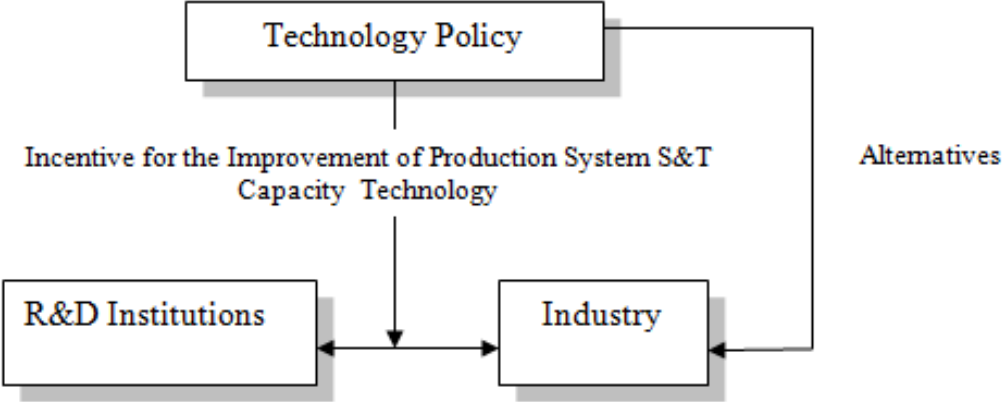


Figure 1. Target of policy alternative to encourage innovation activities

4.3 Policy Alternatives

As already known publicly, all the activities starting from technology design and production to technology marketing are carried out in the industry. Therefore, in order to promote and encourage innovation, it would be much better if the incentive is aimed directly to the industry, since the sources of innovation are on the industry, not in public R&D institution.

Moreover, innovation activities in automotive component industry may be occurred unscheduled basis. On the other hand, the existing incentive is based on certain schedule starting from March and has to be accepted on November. This situation may hamper innovation activities in firms. For this reason, it is necessary to arrange this incentive similar to bank financing where fund may be available at any time it's needed.

The improvement work of the similar policy has been carried out by Greece as the effort to formulate innovation policy in a user-friendly manner. The change is made on the proposal application from industry which previously with fixed deadlines into open deadlines, and the time reduction of the evaluation and proposal approval. The steps in the improvement of incentive application were also carried out by Sweden. The process perceived previously as complicated and time consuming was changed into the simpler and shorter one, with the purpose to attract the attention of more participants.

5. Recommendation

In order to increase technology innovation in industry, government through the Office of State Ministry for Research and Technology, in fact, has introduced five incentive programs with the aim to accelerate the growth of technology innovation, to stimulate research in producing commercially high value innovation, to encourage the acceleration and broadening of innovative product commercialization, and/or to strengthen domestic competitiveness of

technology and industry. For the case of automotive component industry, incentive for the improvement of production system science and technology capacity is the most appropriate one. But, if it's analyzed further, this incentive has the purpose more on enlarging the public R&D institution, not on the industry, while, in fact, the innovation sources of small and medium enterprises are generally in the industry itself.

To encourage the innovation activities in automotive component industry, it is perceived that some adjustments are required:

- The time period of the incentive distribution needs to be more flexible – can be applied at any time
- It would be better that the incentive is aimed to raise the industry capability, not the public research and development institution as the innovation sources are available in the industry.

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Technology Transfer Challenges in Indonesia: An Experience from Industry Turbine Overhaul

Subiakto Soekarno, Sylviana Maya Damayanti, Putri Maharani Samsu Wibowo
School of Business and Management, Institut Teknologi Bandung

Abstract

This paper discusses the problems and challenges that Indonesia faces in the process of its technology transfer. Matters discussed in this paper are based on the lead writer's personal observation and experience of the technology transfer taking place in Indonesia's turbine maintenance and overhaul industry.

The first challenge faced is the lack of basic skills on the part of factory workers. The next challenge is the lack of supporting industries. Furthermore, the low level of English proficiency of the workforce has contribution to the technology transfer problems. Final challenges are the low credibility of the government entities that oversee the turbine maintenance industry in Indonesia. The steps undertaken in the technology transfer in the turbine maintenance and overhaul industry in Indonesia is done through several complex stages.

Keywords: challenges in the transfer of technology, technology transfer in Indonesia, turbine maintenance and overhaul industry.

1. Introduction

In 1984, General Electric won the tender competition of aircraft turbine election (GE CT7) for new CN 235 aircraft designed jointly by the PT Nusantara Aircraft Industry (a state owned company) from Indonesia and CASA of Spain. As part of the agreement, General Electric shall establish facilities Turbine Overhaul of Aircraft in Indonesia as well as carrying out the process of technology transfer so that the facility is fully functional, according to the standards set by the factory and run by local personnel.

Keep in mind at that time there has been no overhaul facility turbine aircraft operating in Indonesia, except commercial facilities owned Garuda Indonesia (Indonesian flag

carrier). Facilities owned by Garuda Indonesia at that time are only to serve the needs of internally, so that the operators must send their engine abroad for overhaul maintenance.

Step PT Nusantara Aircraft Industry that would build a turbine maintenance overhaul that includes the ability to turbines aircraft commonly used in Indonesia as it is a strategic step in building the capability within the country, so the flight operators no longer need to send overseas turbine besides course to prepare the product support for the CN-235 aircraft.

After solving various problems and challenges, the process of building the turbine

aircraft overhaul facilities and transfer of technology / skills to local workers had successfully done. This paper finally discusses the problems and challenges that Indonesia faces in the process of its technology transfer. Matters discussed in this paper is based on the lead writer's personal observation and experience of the technology transfer taking place in Indonesia's turbine maintenance and overhaul industry.

2. Turbines Overhaul Processes

Turbine motor used for aircraft power consisting of various static and rotating components that have different thermal cycle according to usage in aircraft. The various components of the turbine after use for some time will experience damage (corrosion, wear and tear).

Turbine manufacturers have made many good maintenance schedule and the level of light weight (overhaul) to ensure performance in accordance with the standard turbine feasibility of flying and flight safety (airworthy and water safety). Timed in light treatment can be done without removing the motor from the wing turbine aircraft (on wing maintenance). Treatment weight (overhaul) is done by sending a turbine motor to an overhaul facility that has been in the factory authorization.

An overhaul facility turbine aircraft must obtain authorization from the manufacturer (OEM authorization) and the state air agencies local fitness (Airworthiness authority). To obtain authorization, a turbine overhaul facilities must have a complete tool, skills / competencies that both of the employees, adequate shop operation procedures, and spare part supplies a complete and adequate. From time to time overhaul facility will be audited by the factory inspector and Airworthiness authority to determine whether the facility can operate either to provide flight safety guarantee. When the overhaul facility can not demonstrate a good standard of operation, the

Airworthiness Authority may revoke the approval of the garage because it was considered would endanger flight safety.

Overhaul process at a treatment center are steps taken to ensure the performance of new turbines to be like again. Basically, the steps performed in an overhaul process are as follows:

Receiving Inspection: the process of initial inspection of the turbine is sent to the workshop. In this process will only be seen visually, checking the completeness of components or record things that are not normal (the signs of corrosion, overheat, foreign object damage / FOD, etc.).

Disassembly: the process of dismantling the turbine up to the smallest form. The whole part of this turbine will be inspected one by one in accordance with the turbine manual.

Cleaning: all turbine components will be cleaned so as to facilitate inspection process. This cleaning process is done or the mechanical and chemical.

Inspection: all components of the turbine will be checked to ensure the condition. This inspection process is the heart of the turbine overhaul process. All turbine parts will be grouped into three namely: scrap (can not be used again), repairable (to repair), and serviceable (can be used again). Error in determining the condition of this part can be fatal where the turbine does not operate optimally or even fail to operate. Various sophisticated inspection techniques used in this process include: visual inspection, dimensional inspection, non destructive inspection to determine crack (may use Fluorescent Penetrant inspection, magnetic particle inspection, x-ray, eddy current inspection etc).

Repair / refurbishment: All components of the entry categories will be repairable refurbishment process to restore the initial

conditions. Various sophisticated repair techniques performed here by using processes such as machining (conventional and unconventional), the coating material (all kind of welding and plasma spraying), the process of heat treatment, shot peening, corrosion treatment and coatings, chemical plating. The more complete the repair process has the overhaul facility will be more able to reduce the cost of increasing the competitive overhaul advantage. Various techniques refurbishment of turbine parts can be independently developed by the overhaul facility, so that some parts are in scrap condition can be returned in accordance with repair technological developments owned.

Accumulation / Kitting: In this process the process of completing all turbine parts that should be done there. Parts are in the scrap replaced with new spare parts. Repairable parts will be used again after completing the necessary repair. The serviceable used parts will surely again. The kitter will make sure that all parts are complete for reassembly.

Assembly: All parts that have been checked in the process of accumulation trimmings will be sent to the assembly and the turbine assembly whole again. Assembly process also involves activities requiring precision and accuracy.

Performance Test: After the assembly, the turbine is sent to the testing center (engine test cell) to test its performance. Performance test results compared with reference data that must be achieved so that the engine passed the test and ready to operate in accordance with factory standards.

Shipping: Engine after passed the certification test will be airworthy and ready to be sent back to the customer.

From the above processes it seems that the overhaul process is complex, involving many high-tech processes, requires high

competence of its employees, and became one of the factors to ensure flight safety.

3. Technology Transfer Challenges

Lead writer were recruited as one of the trainees that will be employed in the overhaul shop. He had the opportunity to observe the whole process of the development of the overhaul shop and was involved in the technology transfer processes to develop the local talent capabilities. The technology transfer was not easy back then and had to overcome several challenges.

The first challenge faced is the lack of basic skills on the part of overhaul shop workers. Education in Indonesia does not emphasized vocational training, which is a critical requirement in industry. Generally, the output produced by the education institution (namely STM and SMA) is not ready for use by the industry. Often the industry must create its own vocational/practical training to meet their own needs. As you have read above, the industry needs certain specific skills such as: disassembly/assembly, chemical cleaning and plating, inspection (visual, dimensional, non destructive inspection), machining (conventional and unconventional), welding and plasma spraying, and special processes (heat treatment, coating, painting, and shot peening). The Overhaul Shop has to develop its own training center in order to provide basic skills to its workers, technical high school graduates, and requires at least 18 month apprenticeship training before the workers are ready for the real job.

Another challenge is cultural in nature. A technology based industry requires certain attributes such as : planning ahead, the timeliness/punctuality, accuracy, and compliance. Unfortunately, these attributes are not widely practiced in the society. Back then, it required a special effort for emphasizing these attributes to all workers. There were many findings during early year

operation which were due to repeated inaccuracies and incompliance by its workers.

A third challenge is the lack of supporting industries. Often times small and medium industries have to build the whole capabilities from A to Z because of the absence of other small scale industries needed to support it. Ideally the overhaul shop concentrated on the basic overhaul processes such as: receiving inspection, disassembly, cleaning, inspection, accumulation, assembly, and performance test. The repair process of the repairable parts should be contracted out to the supporting industries nearby. Since the whole processes had to be developed by the overhaul shop, some processes do not achieve economies of scale; this will ultimately reduce the competitiveness of the industry. Back then, the supporting industries were only available overseas mainly in Europe and United States of America.

The fourth challenge is the low level of English proficiency of its workforce. Most sources of technology come from Western countries, and utilization of resources such as shop operation manual, engineering/technical documentation, and communications with technology licensors require a basic mastery of the English language.. Technical high school and senior high school graduates spend at least 6 years in studying English, but in our experience this is inadequate due to ineffective way of teaching method. Unlike the neighboring countries such as : Singapore, Malaysia, and Philippines, the English language is not widely used in the daily life in Indonesia. The lack of language skill hinders the technology transfer process.

Last but not least is the low credibility of the government entities which oversees the turbine maintenance industry in Indonesia. Foreign customers are not satisfied with local airworthiness certification. Eventually the local overhaul shop will seek additional certifications from the foreign authorities such as FAA (Federal Aviation

Administration of USA) and/or EASA (European Aviation Safety Agency). It requires a regular audit from FAA or EASA to maintain the overhaul shop authorization which was costly and needed a great deal of effort.

Technology transfer in the turbine maintenance and overhaul industry in Indonesia occurs in stages. The technology licensor in the case we study is General Electric and the recipient of the technology (technology licensee) is Universal Maintenance Center (UMC), a workshop owned by PT Dirgantara Industries (previously known as PT Industri Pesawat Terbang Nusantara, The Indonesian Aircraft Industry). The first step begins with the recruitment of a number of technical high school, senior high school, and university graduates. High school graduates are given basic apprentice training that lasts approximately 1.5 years. University graduates are given basic management training that lasts 6 months. The second step is on the job training in a work shop owned by General Electric with assignments based on job title and specialization. The On the job training (OJT) is conducted for approximately 6 month for both technical and managerial work. After completion of the OJT, the workforce is considered ready to work with closely supervision. The following step is what it is called “ shadow management”, in which workers shadow technical assistants from the licensor. After certain time based on the comprehensive evaluation of the licensor’s technical assistant, the trainees and technical assistants will switch roles. The Indonesian worker then perform their full duties assisted by the licensor’s technical personal when needed. After some time, the technology transfer process is considered complete and the operation of this overhaul shop can be carried out by the Indonesian worker only with limited assistance from the licensor. In the turbine overhaul industry, the whole process of technology transfer was completed in approximately 30 – 36 months.

4. Conclusions

We need technology transfer in developing the domestic capabilities. Based on the experience in doing technology transfer in turbine overhaul industry in Indonesia, there are several challenges that can impact the process of technology transfer. Such challenges worth considerations are lack of basic skills, requirements of certain attributes, lack of supporting industries, requirements for English language mastery, and low credibility of the authority who oversees the industry.

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Holonic Business Process Modeling in Small to Medium Sized Enterprises

Nur Budi Mulyono, Tezar Yuliansyah Saputra, and Nur Arief Rahmatsyah
School of Business and Management (SBM), Bandung Institute of Technology (ITB), Indonesia

ABSTRACT

Holonic modeling analysis which is the application of system thinking in design, manage, and improvement, is used in a novel context for business process modeling. An approach and techniques of holon and holarchies is presented specifically for small and medium sized enterprise process modeling development. The fitness of the approach is compared with well known reductionist or task breakdown approach. The strength and weaknesses of the holonic modeling is discussed with illustrating case example in term of its suitability for an Indonesia's small and medium sized industry. The novel ideas in this paper have great impact on the way analyst should perceive business process. Future research is applying the approach in supply chain context.

Key words: Business process, holonic modeling, operations management, small to medium sized enterprise

1. Introduction

In unpredictable change of business environment, enterprises have to continuously introduce innovative programmes to remain competitive. Their continued competitiveness will depend on their ability to respond to internal pressures and external environment change (Porter and Ketels, 2003). This, in turn, require effective design of enterprise's processes through effort such as business process reengineering (BPR), enterprise integration (EI), and enterprise engineering (EE). All of these efforts normally incorporate three components namely: the theories of management, the process and implementation methodology, and the process modeling techniques of the enterprise.

BPR is concerned with radical, all or nothing approaches that cannot be accomplished in small steps. EI defines as the task of improving the performance of large

complex processes by managing the interactions among participants (Petrie, 1992). EE attempts to take a more holistic approach than the often more narrowly focused BPR and EI approaches (Liles, Johnson, Meade, 1996).

Business process modeling (BPM) can be defined as the process of building functional activities of the whole or part as either current situation or a proposed situation (Tam, Chu, Sculli, 2001). BPM has the principal aim of helping identify critical processes and improve the overall performance of the business. There are three goals of BPM namely: form a tool for business process reengineering, help to identify appropriate strategies for software package implementation, help with software development.

There are several business process modeling techniques established today such

as: IDEF0, data flow diagrams, flow charting, and Structural Analysis and Design Technique (SADT). Those techniques require an understanding of the systems thinking fundamentals.

A system usually have a name, inputs, feedback loops, elements, relationships between those elements, and a system boundary defining it from its environment. Figure. 1 shows the fundamental properties of a system. These fundamental properties can be applied to any system whether it is physical, social, or a combination of both.

This paper will present modelling methodology that supports a process centered approach to the design of enterprise especially small and medium sized. The methodology includes a modelling scheme for representing the enterprise and a technique prescribing the set of steps used to create a model. The scheme uses a holon based approach to enterprise modelling and adapts concepts from research in the object oriented and agent modeling areas.

The modelling scheme described in this paper uses a holon based approach to identify

and represent the activities and resources of an enterprise. This approach uses abstraction and enrichment rather for building hierarchy of business process models, rather than using aggregation and reduction which used by reductionism approach. The purpose of this unique approach and techniques is to be able to build process models that can be nested within hierarchy but do not adopt reductionistic principles.

2. Theories Background

2.1 Shortcomings of Current Methods

Current modelling methods are not fully supporting the needs of enterprise engineering (Giaglis, et al. 1996). In inter-organizational setting, process modelling becomes more difficult. Business process modelling should have the ability to: (1) represent multiple views of the enterprise, (2) support and integrate multiple means of analysis, (3) support top down design of business process and enterprises. Multiple perspective of an enterprise are required due to various questions and viewpoints of the end customers of a design effort. Most modelling method currently available focus on one or a few aspects at a time.

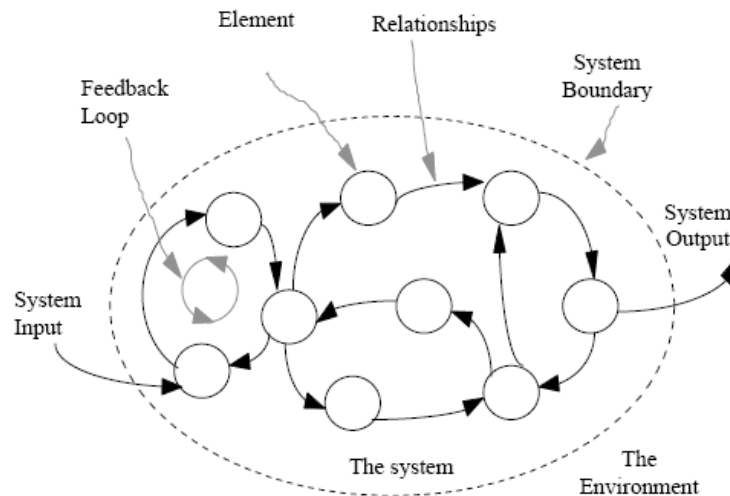


Figure 1: System Properties

2.2 History of Holon and Holarchies

The term “holon” was first proposed by Arthur Koestler (1989) as the basic unit for modeling biological and social systems in his book *The Ghost in the Machine*. The term is intended to describe any entity that is at the same time “a whole into itself and a part of other whole(s)”. A holon is taken to be a human activity system such as business process that contains all the fundamental systems thinking principles; it is considered to be part of larger system, and may itself contain other systems.

Holons belong to structures called holarchies that consist of self contained units capable of functioning independently but nevertheless are dependent on other units. The holarchy is a temporary assembly of holons with a specific set of temporal goals and objectives. The strength of a holarchy lies in its ability to construct highly complex, resource efficient systems which are highly resilient to internal and external disturbances

and are adaptable to changes in the environment.

The concept of holon and holarchies can be applied to social structures such as enterprises. A manufacturing enterprises can be considered to be a holon consisting a sets of holons representing various functions or organization of the enterprises. For example, a factory could be specified as five level of holons: facility, shop, cell, workstation, and equipment. Higher level holons set goals for lower level holon and coordinate overall control; the lower level holons are granted autonomy in their class actions and controls. The characteristics of holarchies are as followed:

- *Bi-directionality*: each holon can receive signals as well as send signals.
- *Level behaviour*: the holon at one level is not necessarily the sum of its subordinates. The characteristic of holons at one level are not representative of the characteristics of the level above or below them.

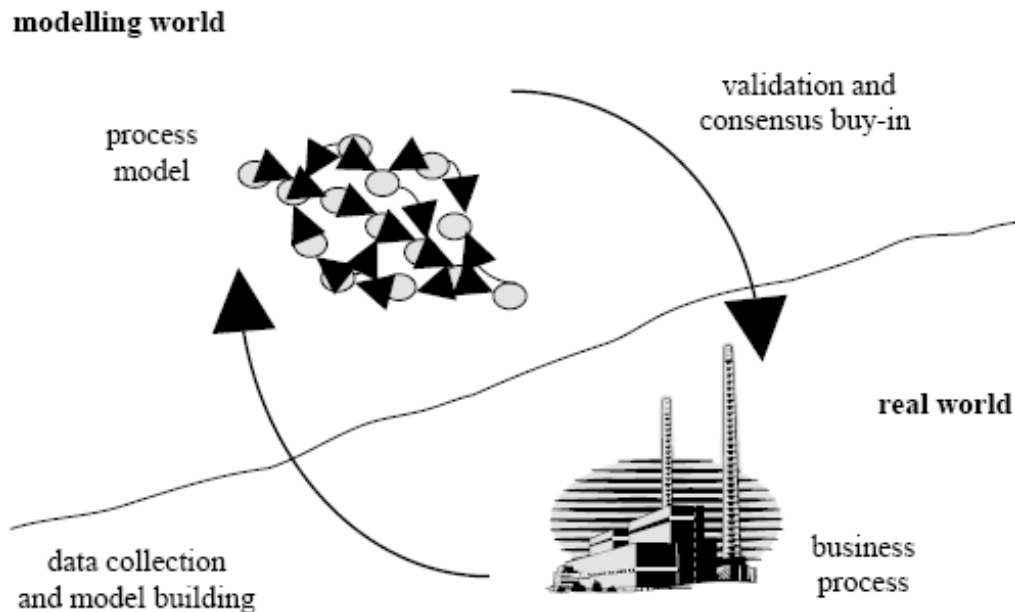


Figure 2. Division Between the Real World and Process Model

- *Flexibility*: holarchies are not rigid structures, they allow modification and adaptability. A holon can be part of multiple holarchies.
- *Open ended*: the top and bottom of the holarchies are not absolute. A holarchy can be augmented or interwoven with another holarchy.

3. Holonic Business Process Modeling

Business process modeling is only simple reflection of the actual business process represented. A process model is merely constructed to provide an insight into the behaviour of the real world process, see Figure 2 (Cleg, 2006).

Business processes are not purely physical systems and involve more than just lists of tasks to perform. They required people to make decisions about complex issues involving the use of tangible and intangible transformational resources used to transform a huge range of inputs (e.g. people, information, material) to outputs that fulfill the objectives of the process (e.g. finished products) (Johnson and Scholes, 2002). In order to investigate complex issues in processes that are characterized by low volume, high variation and long lead time (e.g. small medium sized enterprise), enrichment is a better way of building a hierarchy of models. The reductionism principles reduce core business process into sub-task, sub-sub-tasks and so on. This approach may be suitable way to proceed for producing product breakdown structures or task lists for chronological project plans but it is not considered suitable for explaining complex causal relationships within business processes. The core business process description is enriched by either adding supporting activity or by building a hierarchy of models to detail specific aspects of the model.

Business process model typically requires a mix of graphics, language, and

codification. The language should describe the process in familiar terms to those operating it, explaining relationship and behaviours of the process as an integral part of the model. Codification for numbering of task, sub task, and people; should be used in minimum number. Graphics can be the key to reach the right balance between natural language and codification.

Each individual business process model should be given an objective and should be reflected in its name. It is the purpose why the process exists. For example, consider a process called “product design”: all the fundamental properties of the process should contribute to the objective of delivering a product design by being either part of the core business process or supporting activities.

4. Business process modeling methodology

The modeling methodology embeds both creative systems thinking and the logic of input-transformation-output process analysis which is loosely based on Deming’s plan-do-check-act cycle.

- *Plan*: scope process model and define process.
- *Do*: gather data, retain original language, define logical dependency, reflect not recreate.
- *Check*: build, enrich and abstract model as part of validation, minimize codification.
- *Action*: implement process model findings within business process.

5. Business process modeling template

The template of business process modeling as shown in Figure 3, reflects one business process holon which includes the rigors of input-transformation-output type process analysis. The application and interpretation of this is the bases of every business process model which in turn can be built into a non reductionistic and

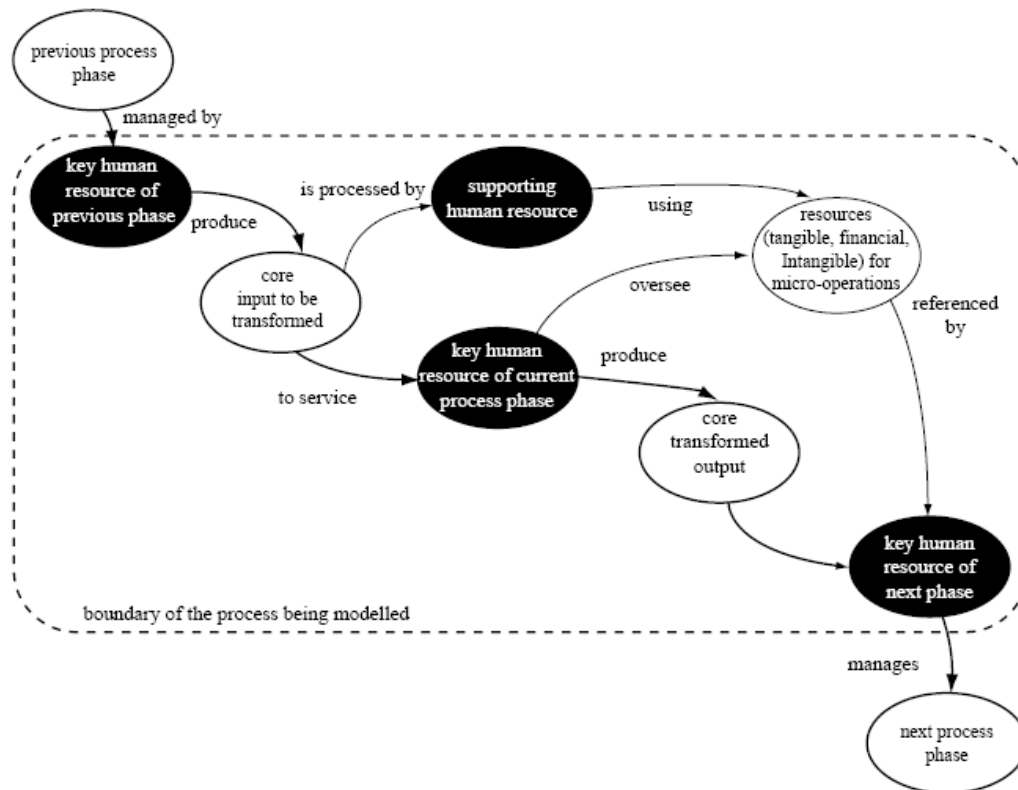


Figure 3. Holonic business process

aggregational hierarchy. The explanation of each element inside the template is as follow:

- *Previous key human resource and activity:* input from previous process phase, key human resource of previous phase produced core inputs.
- *Input:* core input to be transformed.
- *Key human resource:* key human resource of current process phase, oversee resources, supporting human resource.
- *Performs an activity:* produces core transformed output, oversee processing of resources for micro operations, uses resources in essential for producing core transformed output.
- *Output:* core transformed output, resources for micro operations.
- *Next key human resource and activity:* output to next process phase: key human resource of next phase manages next phase.

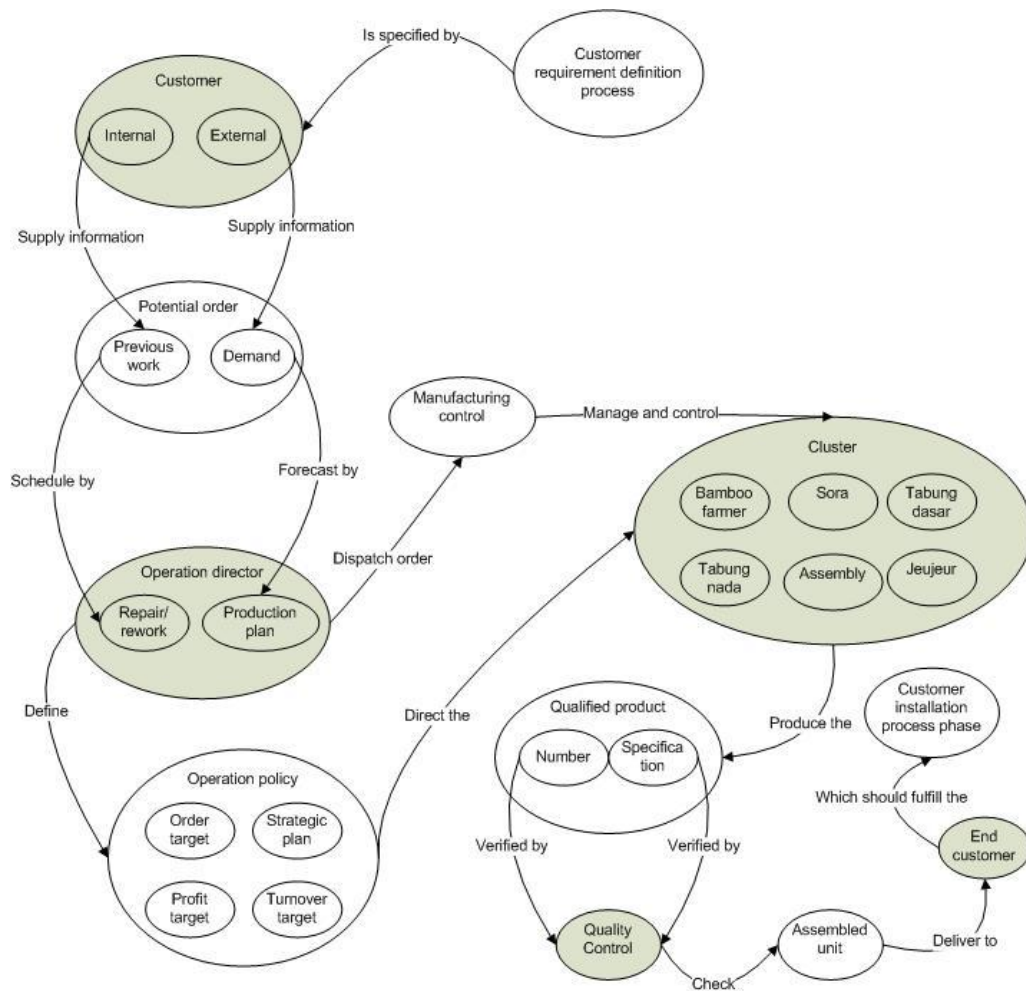


Figure 4 Holonic business process representation of production unit of medium sized company

6. Application

The company concerned is medium sized company based in West Java Indonesia. The major business of the company is performing West Java (Sundanese) traditional entertainment (e.g. music, dance) and producing a famous music instrument made from bamboo called “Angklung”. This company has cultural workshop consisting of performance venue, bamboo handicraft centre, and bamboo instrument workshop. Apart from that, it has an honourable function as an educational laboratory and training center to preserve the Sundanese culture.

The main problem of interest of this company is capacity of “Angklung” production which is still incapable to meet demand. Business process example of the production unit of this company is presented on Figure 4.

7. Conclusion

Holonic business process modeling has been developed using test cases from medium sized company having main business in culture’s products. It has been found to have better description of business process that are hard to define, which typically having low volumes, high product variation, and lengthy

period of time to complete. Standard techniques for process modeling often focus on well-defined processes with high volumes, low variation in delivery and short lead times.

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