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System Dynamics Model and Policy Scenario Analyses on International Movements of Indonesian Scientists and Engineers

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Abstract. *The necessity to face technology challenges in industrialization in Indonesia causes the current condition to be not preferable. Conditions in higher education which relates closely to the research and development in Indonesia trigger questions of what future holds in Indonesia's technology development in the future. This paper looks back at the previous literatures on international movements of scientists and engineers abroad and proposes to apply a causal loop diagram model. This paper also analyzes the relationships based on Indonesia's context and set a parameter for each variable. The relationships were checked through interview with representation from Indonesian research institutions and Ministry of Foreign Affairs. The result of this paper confirms that the diagram is able to symbolize the circumstances in Indonesia's context. Second important finding is that based on simulation and policy scenarios implemented, the policy to increase the number of scholarships by the government is predicted as the most effective to all important parameters for future development in Indonesia in relation to education and technology development, which will eventually lead to economic development.*

Keywords: *Engineers, international students, policy scenarios, scientists, system dynamics*

1. Introduction

In 2000 – 2006, seven major universities in Indonesia were becoming Badan Hukum Milik Negara (BHMN), which meant that universities were becoming autonomous in the management, including financially. Therefore, those universities were lack of government subsidies and resulted in increasing of tuition fees for enrolled and current university students. Because there were a lot of protests that the tuition fees were not affordable from lower to middle-class families, then the previous Badan Hukum Milik Negara (BHMN) had transformed into Perguruan Tinggi Negeri Badan Hukum (PTN BH) and would receive government's financial aids for universities' expenses. The most recent Peraturan Pemerintah Nomor 6 Tahun 2015 stated that higher education institutions receive government subsidies extracted from Government's annual budget (APBN) and from society dedicated to operational expenses, university lecturers' expenses, academic staff expenses, investments, and development. Moreover, Indonesian government is targeting to increase gross enrolment ratio for higher education in Indonesia in order to grow capable human resource; hence the budget for higher education increases.

The relationship between higher education and research and development is very close. Higher education produces talented human capital for research and development that will increase economic development in the long run. Scientific publications and patents applications are often considered as quantitative measurements for not only higher education achievements but also research in STEM and medicine fields. Therefore, the relationship is very close. Considering the circumstance of higher education in Indonesia, Universities ranks, even the best ones, cannot compete with

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other countries, including top neighboring countries' universities. As an addition, the enrolment rate for universities is considered low since Indonesian government's program is to make education compulsory until high school. The more disturbing number is from the percentage of students from science and engineering major: according to OECD (Organization for Economic Co-operation and Development) (2015) only 16 percent of total tertiary students are in engineering, manufacturing, and construction. This causes the lack of innovation that can be aroused by increasing the number of students in this area. Research and development condition in Indonesia is also not favorable. Major research institutions in Indonesia are run by the government; but, the Government only spent 0.08% of Gross Domestic Product in 2009 and 0.09% in 2013.

This number is very low compared to Malaysia and the Philippines. The amount spent by the government may indicate attention to research and development in general is not the focus of Indonesian government's current policy directions; and one result is scientific publication and patents have not been achieved optimally considering facilities and equipment are not compatible for further technology innovation. This is also supported by the management of research funding in research institutions (including in government's research institutions) that implies complicated and long bureaucracy, thus causing many research must be abandoned mid conducting in order to be able to finance other research. Nevertheless, the government is not the only source to fund research and development. Private sectors should play role in funding research and development in Indonesia; but this alternative for research and development funding is not yet considered for policy implementation by Indonesian government.

The still-developing universities and low level of research and development budget has led to the increasing number of students who choose to study abroad. Students are not only looking for good universities as a place to study, but also looking for better employment abroad or in Indonesia. The number of Indonesian mobile students has been increasing for the past years. For example, before monetary crisis in 1998 Indonesia sent many students to United States (Project Atlas), the number decreased since 9/11 yet has rise again for the last few years but not as many as previous trends. This is due to globalization that has triggered many countries to compete with one another to become the host countries for the talented and high skilled for the sake of their development, hence trying to attract as many students as possible.

All submitted articles must be written in good English. Problems mentioned above are not the only factors that attract students to study abroad; many deciding factors involved here. Factors such as the gap in economic condition, scholarships and financial aid for students, and policies from both countries regarding this matter also need to be considered. This movement event occurs because there are causal relationships involved and there is a need to address this problem; so one relationship to be explained is not adequate. The return of graduates from abroad is also being suspected since nowadays the global world is inevitable: graduates from abroad have better access to international jobs rather than graduates from Indonesia though not impossible.

The implication of policies from the government abroad may indicate that the demand for high-skilled workers is needed there, especially in STEM (Science, Technology, Engineering, and Mathematics) and medical fields. This is the time when countries abroad absorb new 'brain' from source countries. This paper proposes to address the causal model of movement of Indonesian human capital particularly in STEM and medicine fields, starting from the decision to study abroad. This holistic approach is expected to explain the relationships concerning factors influencing students to pursue their tertiary education abroad and the factors influencing graduates to apply for work abroad. The proposition to include only students and professionals in

STEM and medicine fields is because the authors would like to focus on the technology development in Indonesia. Technology development may influence Indonesia in terms of economy in the long run. Moreover, to be focus more on the science and technology area can generate more descriptive model. Since there are a lot of factors involved in the real world, focusing more to one area or field is better and simpler.

The second purpose is to identify the background of causal relationships and analyze the relationships of variables in the model. Authors propose this model as evidence in Indonesia because other countries may have differences in determining the relationships and there may be other factors that are more important. To analyze whether this model is also applicable for other countries as well, further research is necessary. Another limitation is the available numerical data for variables may be scarce; hence this paper also provides the lack of data available hoping that in the future the completion of data for simulation will be achieved.

2. Literature Study

This chapter discusses about relative studies about students mobility and international labour market because both contexts are highly related in this topic.

2.1. Students Mobility

In general, the mobility of students has been an interesting topic to discuss. This phenomenon has already happened for decades, and the trends seem to emerge; students from developing countries seek for the better education than in their home country to developed countries. United Nations had been analyzing the pattern of movement by looking on the amount of incoming students to developed countries. It seems that the number increases throughout the years; nevertheless, the distribution of international students that was initially centered in some countries, but nowadays the distribution has spread more, although several countries are still the top destinations for international students.

Bhandari et al. (2011) stated that six countries hosted more than 60% of international university students all over the world in 2009; those are: USA (20%), Great Britain (13%), France (8%) and Australia, Germany, and China (7%). While in 2013, OECD (2013) noted that over 50% international students pursued their education in Australia, Canada, France, Germany, United States, and United Kingdom. There are common grounds of motivation on choosing where to go studying.

A study by Novak et al. (2013) on motivating factors of international students going to three higher education institutions in three countries (Norway, Germany, and Slovenia) using statistical analysis, generated the results that the international experience, improving foreign language skills, academic reasons, career opportunities, and new acquaintances are the motivations for students to participate in a mobility program. They also found that there is a correlation between satisfaction and length of the mobility period. There is another interesting view that according to authors a large percentage of the surveyed students will have better chances for finding work abroad after completing a mobility program.

Kim (1998) modelled the process of foreign education and stated that the import of knowledge is essential to economic growth in source countries when students return with knowledge gained from abroad. Also, the number of students abroad in host countries especially with higher technology level is associated positively with the growth rate of income per capita in the sending countries. Thus, it is important for students who studied abroad to return home and it is also significant to develop technology in order to build more advance economic development.

Motivating factors mentioned above have clearly helped push students to go abroad. However, there are some benefits that students will gain if they pursue their

education abroad. Languages of instruction and quality of education have been very important factors that attract students. Another statement by Bourke (1997) and Park (2009) claimed that multiculturalism, safety, weather, and the friendliness of the people in the country are important factors for students to study in a country.

A salient study Kahanec and Králiková (2011) by using data from MIPEX (Migrant Integration Policy Index), ARWU (Academic Ranking for World Universities), and OECD statistics discovered that: (1) even excluding the outlying USA, mobility is increasing, but at a decreasing rate, in the share on higher education institutions in the ARWU top 500; (2) International students are more likely attracted to countries whose universities have English as language of instruction; (3) countries where fees for international students are higher than those for domestic students have more international students; and (4) it appears that there is no distinct relationship between higher education mobility and the MIPEX ranking.

In 2009, 21.5% of Australia's all tertiary degree students were international students, which makes Australia the highest percentage of international students among OECD countries and supposedly the world. Australia is the top destination and most well-known for international students, especially from Indonesia, as mentioned in the previous chapter. Australia is the closest English speaking country to Indonesia; and historically, the flow of Indonesian students studying in Australia has been rationally large. Therefore, Australian and Indonesian government construct bilateral cooperation especially in education. According to one of education-related Australian government website, the tuition fees for tertiary degree range between: AUD 15,000 and AUD 33,000 for undergraduate bachelor degree; AUD 20,000 and 37,000 for postgraduate master degree; and AUD 14,000 and 37,000 for doctoral degree (http://www.studyinaustralia.gov.au).

Australian government alone also provides scholarships for international students, which cover not only tuition fees but also living cost. Indonesia and Australia have managed to have education collaboration; for instance, the Australia Awards program for Indonesia is the biggest and longest running scholarship program offered by Australian government to any of its development partner countries (http://www.dfat.gov.au/). Another example is by BRIDGE program (Building Relationships through Intercultural Dialogue and Growing Engagement) that links education systems and facilitators between Australians and Indonesians.

Australia is very concerned in managing its research and development, especially in science and technology fields. Expenditure on Australia research program in 2002 was above AUD 3 billion in all fields of study. In the natural science and engineering fields, the expenditure was over 70% of the total of all fields (www.innovation.gov.au), and that was not to mention the business resources devoted to research and development. Australian government issued a new visa category in 2001 that allowed university graduates in Information and Communications Technology (ICT) to apply for permanent residents in Australia (Tremblay, 2004). This is one of supporting policies of Australian government to welcome the settlement prospective foreign students. Since then, the stay rate of foreign students in Australia will grow over the years, for example, in 2003/2004 the rate increased 28.8% from the previous year's report. United States has been the top destination for studying abroad, the country has hosted millions of students from around the world. The cause of this is because the quality of its education institutions is top notch. However, since September 11 incidents, the number of international students' enrolment have become decreasing, this is due to the strict visa acceptance procedures. This condition improved with the changing of political circumstance, better improvement of education system, and the cooperation with education institutions in other countries.

As mentioned by Tremblay (2004): "the reliance of the US industry, academia and even the Federal government on foreign highly skilled workers has reached such a large extent in the Science and Engineering fields over the last decade that it has become a source of concern related to security implications and sustainability in the double current context of post September 11 security concerns and fierce global competition for skills and talent." Among all fields of study in the United States, sciences and business and management are the popular choices for international students. The natural sciences receive a great deal of funding from national agencies such as the National Institutes of Health and the NSF.

These affect the opportunities to conduct research with highly sophisticated and cutting edge equipment that may not be found in other countries. (Goodman & Gutierrez, 2011). Japan is one of the leaders in science and technology innovations. Since technology innovation is one of primary assets for Japan, the government spends a large amount of budget for research and development. In 2010, the gross domestic expenditure on research and development in Japan was USD 128,581 million (http://www.oecd-ilibrary.org/).

The research main condition in Japan is very hospitable, despite the fact that Japan's primary language is not English. The environment of Japan is also a convenient place to study, and it attracts international students to pursue their tertiary degree studies there. While fluently Japanese language is the first requirement to be able to study in Japan, recently many universities had opened the English programs without Japanese language requirements. Similar to Australia, Japanese government also provides incredible amount of scholarship for Japanese and international students.

Japan is one of many countries that take serious concern on its education and research development, one main reason was on 1995 Science and Technology Basic Law, the development of a new research system throughout the 1990s had led to new systems of innovation emerged explaining that universities had the role as economic resources which is very important for the country (Kitagawa & Oba, 2010). As a result, the emergence of Toyama Plan in 2001 led the support for top 30 universities in Japan in terms of research, which was later called COE (Centre of Excellence) Program. However, the implementation of the program has become more flexible for any departments and research units in any university to apply (Eades, 2005).

Government policies are important on deciding whether to be a good host for international students, or otherwise. With emphasizing on education policies, countries can attract international students; creating a good academic environment, as one of many attractive factors, to enhance the amount of international students and to elevate the quality of higher education institutions.

Kahanec and Králiková (2011) claimed that in the short run policies should increase the number of programs with English as the language of instruction and simultaneously increasing marketing of the education in that country and transparency of measurement and evaluation of the quality of higher education institutions.

Süoğlu (2012) drew several conclusions in his paper, one of them is that immigration and education policies along with visa and labour market regulations will have an ever-increasing role in the process of students' decision making for their future. In other words, the government has important roles in implementing policies in education, immigration, and labour market. These policies are considered the main policies in attracting students and professionals. In the same reasoning, those policies are also considered important for students in science and engineering major who look for future employment in the host countries.

2.2. International Labor Market

International education is closely related with the number of international high skilled workers. Finn (2003) mentioned that based on data collected in 2001, 56 percent of foreign doctoral recipients in the United States who started in 1996 still lived there using temporary visas. Since the relationship between international higher education and the number of highly skilled people in a country is highly related, it is difficult to discuss or separate discussion between the flow of international students and international graduates working abroad or at home; when we conduct a research on the international students only, we will always ask "what's next?" There are many factors influencing graduates whether to return to their home country or remain abroad. Grogger and Hanson (2013) indicated that the gap of Gross Domestic Product between source and destination countries is one of the factors that influences return/remain decision for international graduates. This statement links to the types of occupations that returnees have: The returnees did not consider salary that they would receive, a fast and promising career, and close relationships with institutions and people in their home country (Baruffaldi and Landoni, 2012; Gupta et al., 2003).

Specifically to Scientists and engineers in United States, unemployment rate and research development expenditure can be used as prediction for international doctor recipients to remain in United States (Roh, 2015). This is in line with people working in this area anywhere, because if they are able to be hired (enough employment opportunity in their field) and enough funding for doing their work, it is logical that if the source country cannot provide supports for them then scientists and engineers tend to work where those needs are fulfilled.

Tremblay (2004) also confirmed that the level of technology has major influence on the situation of scientists and engineers abroad. Immigration policies also play important role of the international migration of scientists and engineers (Docquier, 2011; Slatinšek, 2011). Better compensation and economic condition are essential for how international migration works (Thorn, 2009). Many previous researches also suggest that to retain people from going abroad is to increase the quality of education in the source countries; this result implies that education policies need to be emphasized (Süoğlu, 2012; Kitagawa & Oba, 2010).

3. Research Methodology

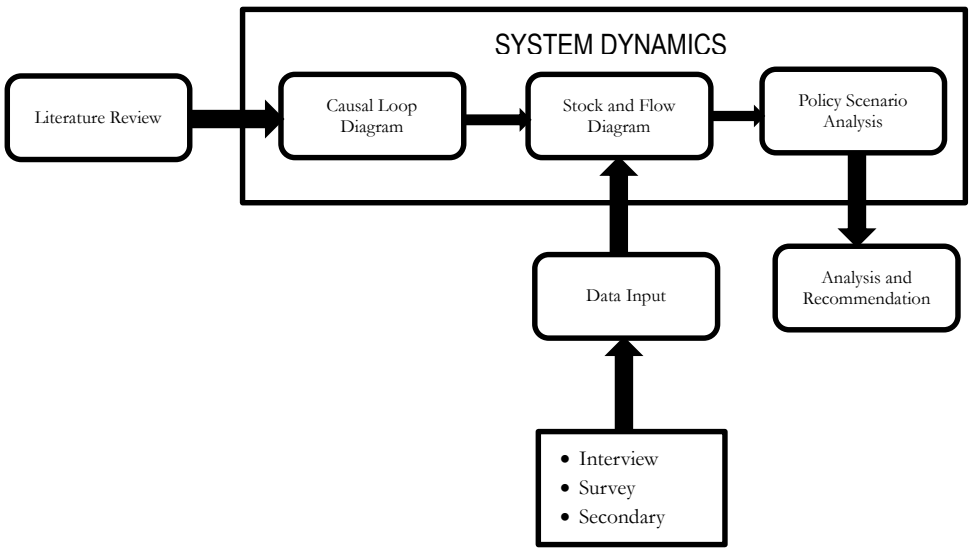

Figure 1. Research Methodology Flow

There are several methods that we use in this paper. First, by referring to previous literature review, authors have managed to construct causal relationship for this phenomena; and by that, we are using Causal Loop Diagram (CLD) based on system dynamics approach. After creating CLD, we construct Stock and Flow Diagram (SFD) in order to be able to conduct simulation, create policy scenarios, and finally give recommendations to Indonesian government based on simulation results.

The CLD itself is used as a base of mental model of what is going on in the real world. Literature review is utilized to objectify the model by connecting the relationships. CLD also means that the relationships will influence variables that are set in the beginning, causing looping process of an event. To strengthen the power of the model, relationships set in the CLD must be analyzed. CLD is typically utilized as the first step before Stock and Flow Diagram for simulating the model more precisely, and it mainly consists of existing variables, causal relationships between variables whether the effects appear directly or with time delay, and the relationships loop (balancing or reinforcing).

The relationships between variables also have positive and negative effects. In order to utilize good causal loop model, we need to consider several parts: Theme selection, time horizon, behavior over time charts, boundary issue, level of aggregation, and significant delays (Kim, 1992). Theme for CLD was already explained clearly in the first chapter, as well as boundary issue. It is impossible to map exact variables to demonstrate real world, but by using CLD the image will be clearly generated in simpler way. As for behavior over time, we cannot predict that yet since this paper could not gather enough data for simulation. Although, knowing from previous trends might help to indicate what will occur in the future.

The level of aggregation is also an important consideration in making the model, but possibly the most significant factor because we need to consider how detailed the model is. If one is discussing about social phenomena, the model clearly consists of complex particles; so, we should be very careful with which variables to include in the model. Meanwhile, this paper will discuss what appears in the surface, because CLD is just the beginning of the process in system dynamics (thus what is also this paper's limitation). Significant delays exist in the model and will be explained further in chapter 4. After creating CLD, then SFD should be undertaken. In this stage, data needed to run a simulation are compiled and hence, creating running model.

Data availability for Indonesia is still incomplete; however the results from several analyses are valuable as starting point to understand the circumstance, mainly in Indonesia. Therefore, first of all, we will hypothesize the available explanation concluded from previous literature review, and then cross checking with Indonesia's condition – whether those variables are indeed highly correlated. The gap in the data is filled with assumptions or flat numbered data when time series data are not available.

4. Finding and Discussion

4.1. Causal Loop Diagram

Based on the preliminary research, we managed to construct a causal relationship model shown in Figure 1.

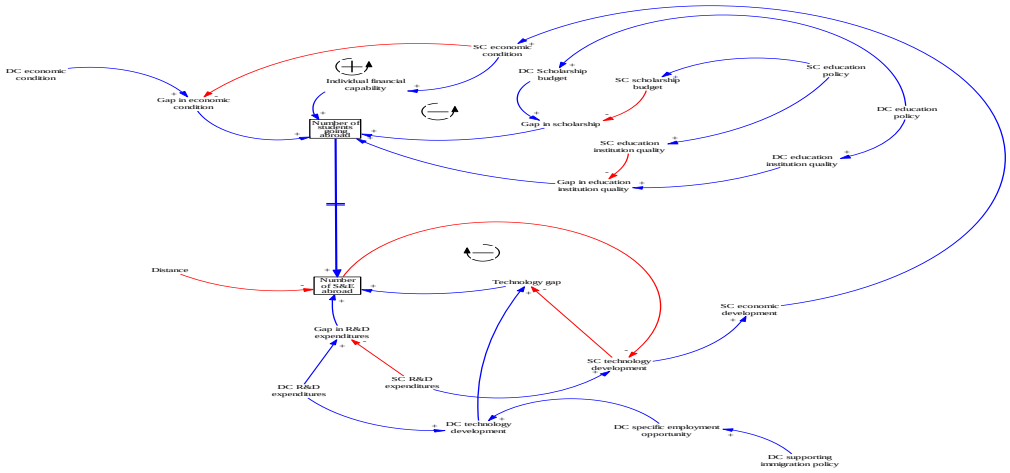

Figure 2. Causal loop diagram

Our proposal to causal loop diagram was based on existing literature. There are several things that we need to point out according to this diagram. First, previous literatures were conducted in another country's contexts. Hence, it is important that we compare to Indonesia's characteristics to see whether the theories are compatible in Indonesia. To do that, we need to set a parameter to each variable. Secondly, a limitation for this paper is that there is a need to explore further whether there are additional variables that may affect variables drawn in the diagram. This is where interview and observation play important roles because we need perspectives other than number available.

Lastly, what we conclude in this diagram which influences the decision of students to study abroad and graduates to return home is based on difference of circumstances between source and destination countries. The concept was adapted from Lee's push-pull theory (1966) that modelled the interaction between source and destination with intervening obstacles in the middle. This theory was implemented in many cases of international migrations between countries, such as Roh (2015), Güngör and Tansel (2008), and Tansel and Güngör (2002), and Parkins (2010).

There is one balancing loop (represented by (-) mark) and one reinforcing loop (represented by (+) mark). Balancing loop shows that the relationships how economic condition in the source country can reduce or stretch economic gap and that will affect to the number of students abroad, while reinforcing loop is when economic condition can push individual financial capability to pay for school by themselves.

1. Economic Condition

Economic condition can be explained by several parameters; but to show the correlation we will include one parameter: GDP per capita. Since Indonesia is still considered a developing country, the difference with OECD countries is high. Therefore, we suggest differentiating the growth of GDP per capita each year and the result of the number of students abroad. Indonesia's economic condition also influences the individual capability of a person or family to send students abroad, aside from the scholarship or financial support programs provided by the government (host and source countries). However, individual capability cannot be calculated by data available, so we will use categorical number.

2. Education Policy

Education policy can influence the number of scholarships provided by the government. Although the economic condition may also influence the education policy by the government, usually it is evaluated in some period of time since the government have mid-term plans relating to education. Another reason why we do not give any

relationship between economic condition and education policy is because we would like to simplify the model first by separating economy from education.

Education policy also encourages the quality of education institutions not only in general but also particularly in universities. Therefore, we hypothesise that not only education policy influencing the number of scholarships or financial aids given, but the quality of education institutions as well. Since education policy is difficult to quantify or given the level of policy, we suggest that Education policy's parameter can be determined from the categories of budget for education especially in tertiary education.

3. The Number of Students Abroad

The number of students abroad is influenced by variables mentioned above, and it also relates to the number of scientists and engineers abroad. With some delay in time (studying period), students will graduate eventually and they will face a decision whether to have a career abroad or in Indonesia. When they decide to have a career in Indonesia they will return, and vice versa. Hence, it will influence the number of scientists and engineers abroad. According the data collected, two sources show different results. Based on Ministry of Foreign Affairs the number is very small compared to the data from other sources. For example, the number of Indonesian students abroad is 3,341 people (Ministry of Foreign Affairs, 2016). The number of Indonesian students in Australia only according to Project Atlas in 2014 was 8,525 people. This number gap can be explained due to whether or not Indonesian students register to Indonesian embassies abroad.

4. Distance

The distance measured in this model means two folds: physical and emotional distance. Physical distance can be interpreted as the geographical distance between source and host countries. The bigger the distance, the less attached people are to their home country. Emotional distance means the psychological distance that one feels with their country, or sense of belonging with one's home country. This is a very difficult to measure because the human factor is difficult to measure or generalized. From interviews conducted, many feel close emotion with Indonesia and others do not. Therefore, parameter for distance can be measured from interviews and questionnaires on their sense of belonging to their home country, because the geographical distance is not necessarily important for Indonesians for making decision whether they will return or not after graduating. For example, in one forum in a website called *Quora*, the decisions for Indonesians to return after studying abroad were mainly based on personal perspectives and personal opinions: how much they feel about their home country.

5. The Number of Scientists and Engineers Abroad

Graduates will have two main choices: to remain abroad or return home. Their choice is not only based on the personal factor (the unexplainable factor), but also the gap of conditions created by the government from both sides. Since we discuss mainly about the future of scientists and engineers, there are several main factors that are considered important to them and obvious for people who work in STEM and Medicine area. Two major factors are the gap of technology development and concerns in research and development in a country. In this case, the data gathered from Ministry of Foreign Affairs cannot provide complete all fields, the existing data (real time data) is from information technology and education (university and schools). The parameter for number of scientists and engineers abroad is none other than the number of scientists and engineers abroad. However, it is very unfortunate that not all countries' government have this kind of data available through public access. In Indonesia, there is no data available with this specification.

6. Research and Development

Research and development support from the government is also essential in convincing

science and engineering graduates abroad to return home. The condition to make advanced innovation is influenced not only by the funds provided to support research and development, but also the capable and qualified human capital. Hence, research and development focus in a country may be determining factors of the number of scientists and engineers. In the model, research and development expenditure will influence technology development in a country hence influencing the number of scientists and engineers who will stay to implement their knowledge and improving further. Parameter for research and development is the research and development financial support from the government only, since the research and development funded by private companies are difficult to track and not all countries have the data. To include the data from private companies can be used as further research.

7. Immigration Policies

Although there are many highly skilled people who would like to work in the host countries, it will be less comfortable if there is not supporting immigration policies from the host countries. The difficulty of getting work visas and less kind working and life environment can reduce the number of foreign workers in general and scientists and engineers in particular. The supporting immigration policies for foreign workers contribute to the specific job opportunities in the host countries. Slatinšek (2011) also stated that traditional host countries had tried to make policies to be intermediates between higher education and labour market for international students to enter host countries' labour market. The globalization makes the movements inevitable and many natives are concerned that their jobs filled with foreign workers, so countries are carefully implementing immigration policies. The parameter for this variable can be represented by whether a country is supporting people from other countries to work there or not. This variable can be represented by 0 (by not supporting) and 1 (by supporting fully). Data can be searched through reviews from other sources about host countries.

8. Specific Job Opportunity

In this model, we include specific job opportunities because we would like to focus in particular fields with people with particular capabilities, thus the number of jobs concerning with highly skilled workers will influence the development of technology in a country. Süoğlu (2012) claimed that employment opportunity was an important factor to influence the decision made by students to return after they graduate. Slatinšek (2011) also claimed that policies to ease the employment process in International graduates in science and technology field had been conducted in many host countries. In one of government's research institutions in Indonesia, the number of engineers recruited is based how many retirees there. Therefore, considering today's condition, it is difficult for Indonesia to increase the capacity for human resources. As parameter for specific job opportunities, the number of researchers, scientists, engineers, and even academics in related fields can be utilized. It is also possible to assume that the number of specific job opportunities in reality is higher than the current number or highly skilled people.

9. Technology Development

Technology development has been a critical measurement on how a country's ability not only to absorb new technology but also to improve existing technology. It is mainly supported by the support of research and development (by the government or private sector) and qualified human capital. Support of research and development creates a good research atmosphere in the sense of equipment and incentives, and qualified human capital is the key of research conducting. Technology development is also difficult to measure quantitatively; however, according to previous research on the measurement of technology development had been registered patents that were accepted. Scientific publications are often considered the parameter of research, but they are also considered as parameter for university's quality. Therefore, it is more suitable for technology development's parameter to be patents accepted.

10. Economic Development

Economic development is considered an important output aside from the number of high-skilled people abroad. Economic development is indeed important but the impact of the development habitually appears in time, because the development of technology also cannot be seen in an instant. Another thing with the development is there are many variables or parts. However, since one of the advantage of using system dynamics as a tool is that we can simplify the complex problems in the real world; thus the model will seem simple. The parameter for economic development can be seen from the increase of GDP per capita or GDP in general in a country.

4.2. Simulation Analysis

After designing causal loop diagram and stock and flow diagram, simulation is conducted in order to comprehend of policy scenarios provided in this particular topic. There are five scenarios applied in the simulation: (i) Government support for university, (ii) increase in scholarship funding, (iii) incentives for returning students, (iv) increase in R&D expenditure from the Government, and (v) incentives for patents produced in the country.

The results that we would like to see and analyse is the trend and changes in the future; those changes are: (i) The number of undergraduate students, (ii) the number of postgraduate students, (iii) the number of high skilled workers in Indonesia, (iv) the number of high skilled workers abroad, (v) the number of patents, and (vi) GDP growth. The data collected are from secondary and primary data in the forms of survey and interviews. The time range that we set is 20 years times (2010 as year 0 and 2030 as year 20).

Table 1.
Comparison of policy 0,1, and 2

Changes from year 0 to year 20			
	Policy 0	**Policy 1**	**Policy 2**
Undergraduate abroad	5.433251	5.433251	*20.97133*
Undergraduate Indonesia	1.059497	*1.06810*	*4.608189*
Postgraduate abroad	23.78889	23.78889	*95.31778*
Postgraduate Indonesia	0.391128	0.391128	*1.71819*
High-skilled abroad	43.095	*43.315*	*169.625*
High-skilled Indonesia	56.21909	*56.4850*	*162.2292*
Patent	1.390567	*1.39680*	*3.836443*
GDP growth	1.4	1.4	*4*

As seen in Table 1, the first scenario, government support for university, results show that compared to zero policy (where there is no additional policy involved) increased trends or number of changes are the number of undergraduate students in Indonesia, high-skilled workers both abroad and in Indonesia, and the number of patents. Second policy, the increase of scholarships provided by Indonesian government, has significant influences in all areas. The third policy, incentives for returning students, has only affected the number of high-skilled workers both in Indonesia and abroad, also it influences to the productivity of patents; however, it the effect is decreasing rather than increasing. While fourth policy scenario, increase in R&D expenditures, has major influence to the number of patents and GDP growth. Lastly, the incentives for patents produced has no influence whatsoever, resulting in the similar trend and number compared to zero policy (refer to Table 2 for detailed numbers).

Table 2.
Comparison of policy 3,4, and 5

Changes from year 0 to year 20			
	Policy 3	**Policy 4**	**Policy 5**
Undergraduate abroad	5.433251	5.433251	5.433251
Undergraduate Indonesia	1.059497	1.059497	1.059497
Postgraduate abroad	23.78889	23.78889	23.78889
Postgraduate Indonesia	0.391128	0.391128	0.391128
High-skilled abroad	42.48	43.095	43.095
High-skilled Indonesia	56.21425	56.21909	56.21909
Patent	1.390464	*2.98273*	1.390567
GDP growth	1.4	*3.2*	1.4

5. Conclusions

The number of Science and Engineering students in Indonesia has been a concern, especially with the addition of fluctuating number of students abroad. Also, the performance of Indonesian scientists and engineers abroad shows higher than in Indonesia, hitherto causing low production of patents. This research is questioning on the mechanism of the movements of Indonesian scientists and engineers since the beginning of pursuing higher education abroad. Second objective is to analyse possible scenarios presented to Indonesian government and see which policy scenario(s) optimal for this problem.

Using System Dynamic method, there are five policies applied in this simulation: (i) Government support for university, (ii) increase in scholarship funding, (iii) incentives for returning students, (iv) increase in R&D expenditure from the Government, and (v) incentives for patents produced in the country. Four out of five policy scenarios have impacts on the condition compared to policy zero, where there will be no additional policy included in 20 years. Although some policy scenarios only have direct effects to some aspects, it is considered that increase in government scholarships will have significant effects to all aspects due to large influence of sending Indonesian students to pursue higher education abroad and in Indonesia.

Research Implications, Limitation and Further Study

This research implication has several targets for the future of Indonesia's technology and education condition, especially in Science and Technology areas. In education, the increasing number of engineering students indicates that Science and Technology areas in Indonesia will have vast stock of scientists and engineers. Second, is that if most of Indonesian students abroad return after they graduate, it will increase the number of scientists and engineers in Indonesia, which leads to increasing performance of technology advancement in Indonesia. Higher education and scientists and engineers as professions cannot be separated; they will create a loop that will force the government to make a policy that is able to enhance both sectors (education and specialized professions).

The research shows that increasing scholarship is proven to be the best policy scenario because it has direct effect to not only higher education, but also to the technology development in Indonesia. However, if the government would like to increase the interests for students to take S&T majors, then support for higher education will raise the result of the number of undergraduate students in Indonesia, besides high-skilled abroad and in Indonesia and also patents. Increase in R&D expenditures will increase the number of

patents and GDP growth, this is due to the direct impact of monetary support from the government to the patents production. However, if it is considered difficult to increase the expenditure based on nation's expenditures, the government should be creating policies that industries and private companies to share their Corporate Social Responsibility by supporting R&D activities in Indonesia.

The limitation of this study is three folds: First, the data provided to this study are very limited. However, we tried to make the best of it by effectively insert the variables based on the available data. Second, time series data are often not available, concerning the census does not occur every year. Hence for some variables the data are constant rather than dynamic, and it limits the result of the simulation itself. Third one, is this study does not consider sudden changes, such as political structure or revolution, disaster, and so on. The assumptions for this simulation will follow if no sudden changes occurs in Indonesia.

Further study should be directed at the availability of the data and the completeness of the data itself. When the data for variables are available, then simulation will become more sensitive, as a part of model testing in System Dynamics. The last one, the boundary of the model can be expanded or detailed further depending on the focus of the study despite of concerning the similar topics. More improvements can be conceived if sudden but radical changes in the future can be included as considerations for more accurate simulation.

References

Australian Government. *Study in Australia.* http://www.studyinaustralia.gov.au (accessed 22 April, 2016).

Australian Government. *Department of Foreign Affairs and Trade.* http://www.dfat.gov.au (accessed 22 April 2016)

Australian Government. *National Innovation & Science Agenda.* http://www.innovation.gov.au (accessed 22 April 2016)

Baruffaldi, S., & Landoni, P. (2012). Return mobility and scientific productivity of researchers working abroad: The role of home country linkages. *Research Policy, 41*(9), 1655–1665.

Bhandari, R., & Blumenthal, P. (2011*). Global student mobility and the twenty-first century silk road: national trends and new directions.* In International Students and Global Mobility in Higher Education: National Trends and New Directions, edited by Rajika Bhandari and Peggy Blumenthal, 1-23. New York: Palgrave Macmillan.

Bourke, A. (1997). The internationalisation of higher education: the case of medical education. *Higher Education Quarterly 51(4)*, 325–46.

Docquier, F. (2011). Globalization, brain drain and development. *IZA Discussion Paper No. 5590.*

Eades, J. (2005). The Japanese 21st center of excellence program: Internationalisation in action? In J. S. Eades, R. Goodman, & Y. Hada (Eds.) *The 'big bang' in Japanese higher education: The 2004 reforms and the dynamics of change.* Melbourne: Trans Pacific Press.

Goodman, A. E., & Gutierrez, R. (2011). The international dimension of u.s higher education: trends and new perspectives. In R. Bhandari, & P. Blumenthal (Eds.), *International Students and Global Mobility in Higher Education: National Trends and New Directions,* 83 – 106. New York: Palgrave Macmillan.

Finn, M (2003). Stay rates of foreign doctorate recipients from U.S. universities. Oak Ridge, TN: Oak Ridge Institute for Science and Education. In Tremblay, K., 2004. *Links Between Academic Mobility and Immigration.* http://www.wes.org/ (accessed 19 November 2013)

Gungor, N. D. & Tansel, A., 2008. Brain drain from Turkey: the case of professionals abroad. *International Journal of Manpower 29*(4), 323 – 347.

Gupta, D., Nerad, M., & Cerny, J. (2003). International PhDs: Exploring the

decision to stay or return. *International Higher Education 31(*8), 31–38.

Kahanec, M., and Králiková, R. (2011). Higher education policy and migration: the role of international student mobility. *Centre for Economic Studies and The Database for Institutional Comparisons in Europe Report* . 4/2011.

Kim, D. H. (1992). Guidelines for drawing causal loop diagram. *The Systems Thinker 3(1)*, 5 – 6

Kim, J. (1998). Economic analysis of foreign education and students abroad. *Journal of Development Economics 56*.

Kitagawa, F., & Oba, J. (2010). Managing differentiation of higher education system in Japan: connecting diversity and excellence. *High Educ 59,* 507 – 524.

Lee, E. S. (1966). A Theory of Migration. *Demography 3*(1), 47-57.

Migrant Integration Policy Index. http:// http://www.mipex.eu/ (Accessed 03 February 2016)

Novak,R., Slatinšek, A., & Devetak, G. (2013). Importance of motivating factors for international mobility of students: empirical findings on selected higher education institutions in Europe. *Organizacija 46(6)*, 274-280.

OECD online library. OECD ilibrary. http://www.oecd-ilibrary.org/ (accessed 01 April 2015)

Park, E. L. (2009). Analysis of korean students' international mobility by 2-d model: driving force factor and directional factor. *Higher Education* 57(6), 741–755.

Parkins, N. C. (2011). Push and pull factors of migration. *American Review of Political Economy 8(2)*, 6 – 24.

Project Atlas. http:// http://www.iie.org/. (Accessed 04 February 2015)

Quora. https://www.quora.com. (Accessed 11 May 2016)

Roh, J. (2015). What predicts whether foreign doctorate recipients from u.s. Institutions stay in the united states: foreign doctorate recipients in science and engineering fields from 2000 to 2010. *High Educ 70,* 105-126.

Slatinšek, A. (2012). Mobilnost študentov v visokem šolstvu. [Students' Mobility in Higher Education]. *Master Thesis*. University of Primorska, Faculty of Management, Koper.

Süoğlu, B. B. (2012). Trends in student mobility from Turkey to Germany. *PERCEPTIONS, 17 (2),* 61 – 84.

Tansel, A. & Gungor, N. D., 2002. "Brain drain" from Turkey: survey evidence of student non-return. *Career Development International 8*(2), 52-69.

Thorn, K., (2009). The relative importance of motives for international self-initiated mobility. *Career Development International 14(5),* 441-464.

Tremblay, K. (2004). Links between academic mobility and immigration. http://www.wes.org/ (accessed 19 November 2013)

UNESCO Institute for statistics. http://data.uis.unesco.org/Index. (Accessed 01 April 2016)