TOKYO UNIVERSITY OF SCIENCE

A Research on the International Movement of Scientists and Engineers and Its System Dynamics Modeling: Case of Indonesia

TUTIK INAYATI

1/24/2017

Table of Contents

1 INTRODUCTION 6
1.1. Background and Problem Identification 6
1.2. Indonesia 10
1.2.1. General context 12
1.2.2. Tertiary level education context 14
1.2.3. Research and development context 16
1.3. Significance of the Study 18
1.4. Research Objectives 19
1.5. Scopes and Limits of Research 19
1.6. Research Contributions 20
2. LITERATURE REVIEW 22
2.1. International migration 22
2.2. High Skilled Workers 25
2.3. Higher education 28
2.3.1. Science and Engineering 32
2.4. Brain Drain and Brain Gain 33
2.5. Repatriation and Diaspora Networks 35
2.6. Government Policies Related to Migration 38
3. SURVEY AND STATISTICAL ANALYSIS 42
3.1. Descriptive statistics 42
3.2. Importance of variables 45
3.3. Return Intention and future plans 48
3.4. Binary Logistic Model 50
4. INTERVIEWS 54
4.1. Interviews from perspectives of governments and Indonesian scientists and engineers in Indonesia 54
5. SYSTEM DYAMICS MODEL AND SIMULATION 59
5.1. Causal Loop Diagram 59
5.2. Stock and Flow Diagram 61
5.3. Policy Scenarios 74
5.3.1. Policy 0 (no policy implemented) 74
5.3.2. Policy scenarios 77

5.3.3. Validity and Verification 86
5.4. Sensitivity Analysis 89
6. CONCLUSIONS AND TENTATIVE RECOMMENDATIONS 117
References 122
APPENDICES 126
APPENDIX A. SURVEY RESULTS 126
APPENDIX B. Data from Ministry of Foreign Affairs, BPPT, and LIPI 130
APPENDIX C. SYSTEM DYNAMICS (STOCK AND FLOW, FORMULAS) 134
APPENDIX D. SIMULATION RESULTS 143

List of Figures and Tables

Figure 1-1. Human and financial resources devoted to R&D 7
Figure 1-2. Outward mobility of Indonesian students 10
Figure 1-3. Indonesia GDP growth (in percentage) 12
Figure 1-4. High-technology exports 13
Figure 1-5. Productive age (15-24 years old) of total population 14
Figure 1-6. Outward mobility of Indonesian students, destination proportion 16
Figure 1-7. Gross expenditure of research and development (% of total GDP), ASEAN countries 17
Figure 2-1. Emigration rate from regions to OECD countries based on Docquier and Marfouk (Docquier & Marfouk, 2004) data 26
Figure 2-3. Government's expenditure for Research and Development (2008-2012 40
Figure 3-1. Respondent's gender 42
Figure 3-2. Range age distribution of respondents 43
Figure 3-3. Education background of respondents 43
Figure 3-8. Students: return intention 49
Figure 3-9. Students: Future plans 50
Figure 5-1. Causal loop diagram (Inayati et. al, 2016) 61
Figure 5-2. Process of enrolment 63
Figure 5-3. Stock and Flow of Indonesian undergraduate students in Indonesia 64
Figure 5-4. Stock and flow of Undergraduate students abroad 65
Figure 5-5. Stock and flow diagram for Postgraduate students in Indonesia 66
Figure 5-6. Stock and flow diagram of postgraduate abroad 67
Figure 5-7. Returning or remaining flow of students abroad 68
Figure 5-8. Stock and flow diagram of high-skilled workers abroad 70
Figure 5-9. Stock and flow of high-skilled workers in Indonesia 71
Figure 5-10. Stock and flow of patents in Indonesia 72
Figure 5-11. Stock and flow diagram of economic development 73
Figure 5-5-18. High-skilled workers (policy 0) 76

Figure 5-21. Undergraduate students in Indonesia (policy 1) 78
Figure 5-22. High-skilled workers in Indonesia (policy 1) 78
Figure 5-23. High-skilled workers abroad (policy 1) 79
Figure 5-24. Patents (policy 1) 79
Figure 5-25. Undergraduate students in Indonesia (policy 2) 80
Figure 5-26. Undergraduate students abroad (policy 2) 81
Figure 5-27. Postgraduate students in Indonesia (policy 2) 81
Figure 5-28. Postgraduate students abroad (policy 2) 81
Figure 5-29. High-skilled workers in Indonesia (policy 2) 82
Figure 5-30. High-skilled workers abroad (policy 2) 82
Figure 5-31. Patents (policy 2) 82
Figure 5-32. GDP growth (policy 2) 83
Figure 5-33. High-skilled workers in Indonesia (policy 3) 83
Figure 5-34. High-skilled workers abroad (policy 3) 84
Figure 5-35. Patents (policy 3) 84
Figure 5-36. Patents (policy 4) 85
Figure 5-37. GDP growth (policy 4) 85
Figure 5-38. Patents (policy 5) 86
Figure 5-39. High-skilled workers in Indonesia (parameter 1) 91
Figure 5-40. Patents (parameter 1) 91
Figure 5-41. Undergraduate students in Indonesia (parameter 2) 93
Figure 5-42. High-skilled workers abroad (parameter 2) 94
Figure 5-43. High-skilled workers in Indonesia (parameter 2) 94
Figure 5-44. Patents (parameter 2) 95
Figure 5-45. GDP growth (parameter 2) 95
Figure 5-46. High-skilled workers in Indonesia (parameter 3) 97
Figure 5-47. Patents (parameter 3) 98
Figure 5-48. GDP growth (parameter 3) 98
Figure 5-49. Patents (parameter 4) 100
Figure 5-50. GDP growth (parameter 4) 101
Figure 5-51. Postgraduate students in Indonesia (parameter 5) 103
Figure 5-52. High-skilled workers abroad (parameter 5) 103
Figure 5-53. High-skilled workers in Indonesia (parameter 5) 104
Figure 5-54. Patents (parameter 5) 104
Figure 5-55. GDP growth (parameter 5) 105
Figure 5-56. Patents (parameter 6) 107
Figure 5-57. GDP growth (parameter 6) 107
Figure 5-58. Undergraduate students in Indonesia (parameter 7) 109
Figure 5-59. Undergraduate students abroad (parameter 7) 110
Figure 5-60. Postgraduate students in Indonesia (parameter 7) 110
Figure 5-61. Postgraduate students abroad (parameter 7) 110
Figure 5-62. High-skilled workers in Indonesia (parameter 7) 111
Figure 5-63. High-skilled workers abroad (parameter 7) 111
Figure 5-64. Patents (parameter 7) 111
Figure 5-65. GDP growth (parameter 7) 112

Figure 5-66. Undergraduate students in Indonesia (parameter 8) 114
Figure 5-67. High-skilled workers in Indonesia (parameter 8) 114
Figure 5-68. High-skilled abroad (parameter 8) 114
Figure 5-69. Patents (parameter 8) 115
Figure 5-70. GDP growth (parameter 8) 115

Table 1-1. Educational attainment of the population aged 25 years and older 15
Table 2-1: Inflows of foreign population by nationality (OECD countries) 25
Table 3-1. Classification table[a,b] 52
Table 3-2. Classification table (2)[a] 52
Table 3-3. Variables in equation 52
Table 5-1. Tests for assessments for dynamic models (Sterman, 2000) 87
Table 5-2. Elasticity of best scenario (parameter 1) 92
Table 5-3. Elasticity of worst scenario (parameter 1) 92
Table 5-4. Elasticity of best scenario (parameter 2) 96
Table 5-5. Elasticity of worst scenario (parameter 2) 96
Table 5-6. Elasticity of best scenario (parameter 3) 99
Table 5-7. Elasticity of worst scenario (parameter 3) 99
Table 5-8. Elasticity of best scenario (parameter 4) 101
Table 5-9. Elasticity of worst scenario (parameter 4) 102
Table 5-10. Elasticity of best scenario (parameter 5) 105
Table 5-11. Elasticity of worst scenario (parameter 5) 106
Table 5-12. Elasticity of best scenario (parameter 6) 108
Table 5-13. Elasticity of worst scenario (parameter 6) 108
Table 5-14. Elasticity of best scenario (parameter 7) 112
Table 5-15. Elasticity of worst scenario (parameter 7) 113
Table 5-16. Elasticity of best scenario (parameter 8) 116
Table 5-17. Elasticity of worst scenario (parameter 8) 116
Table 6-1. Parameters sensitivity analysis 121
Table A-1. All respondents response 126
Table A-2. Students responses 127
Table A-3. Students' responses based on level of education 128
Table A-4. Professional respondents 129
Table B-1. Data derived from annual report of BPPT 130
Table B-2. Data derived from BPPT annual report 131
Table B-3. Data on Indonesians abroad (Ministry of Foreign Affairs) 132
Table B-4. Data on Indonesians abroad (Ministry of Foreign Affairs) continued 133
Table C-1. Description of variables 135
Table D-1. Policy 1: Increasing Government Funding for Universities 143
Table D-2. Policy 2: Increasing Scholarships 144
Table D-3. Policy 3: Incentives for Returning Graduates 145
Table D-4. Increase in R&D Expenditures 146
Table D-5. Policy 5: Incentives for Patents Produced 147
Table D-6. Parameter 1: Sensitivity analysis on high-skilled abroad return rate 148

Table D-7. Parameter 2: Sensitivity analysis on GDP for education 150
Table D-8. Parameter 3: Sensitivity analysis of high-skilled workers input rate in Indonesia 152
Table D-9. Parameter 4: Sensitivity analysis on patents produced per high-skilled workers in Indonesia 154
Table D-10. Parameter 5: Sensitivity analysis on postgraduate program enrolment rate in Indonesia 156
Table D-11. Parameter 6: Sensitivity analysis on R&D expenditures..... 158
Table D-12. Parameter 7: Sensitivity analysis on Scholarships 160
Table D-13. Parameter 8: Sensitivity analysis on undergraduate program enrolment rate in Indonesia 162

1 INTRODUCTION

1.1. Background and Problem Identification

Technology has been an essential part in our lives. It has been moving so fast that sometimes it is difficult to adjust to the new technology appropriately. Technology has so many impacts that nowadays, people cannot live without technology. Science, technology, and globalisation have become major engine to the world it has become today. And science and technology area now have vast role to support the economic development of a country, as Capello (1994) mentioned : "Since the 1980s productivity, continuing innovation and technological changes have been considered as the main local catalysts for regional economic development, thus abandoning the standard classical concept of technology as a given resource and explaining both the development of mechanisms of single regions and the general evolution of inter-regional disparities." (p. 60)

Adding the globalization, world market has become more open than ever, causing gaps of development between countries. These gaps affect countries to compete, especially in science and technology in order to push technology development and then receive benefits from it. However, one must keep in mind that they should not forget the brilliant brains producing these advanced science and technologies. Therefore, in conclusion, the need of capable human capital in order to produce new technologies is desperately high, whether it is in developed or less developed countries.

The real demand of scientists and engineers in the world is high, hence countries put great effort to search for scientists and engineers to work in their countries to generate changes. Or, at least they should. Less developed countries are also concerned about this matter, but science and technology are not their main concern in the moment. Therefore, many scientists and engineers in several less developed countries choose to migrate to developed countries where their talent and skills are appreciated. This dissertation sees the condition where less developed countries have less concern to support the advancement of science and technology in their countries. One identification can be seen from the government's budget for research and development coming from Gross Domestic Product (GDP) and the human capital for research and development, as seen in Figure 1-1.

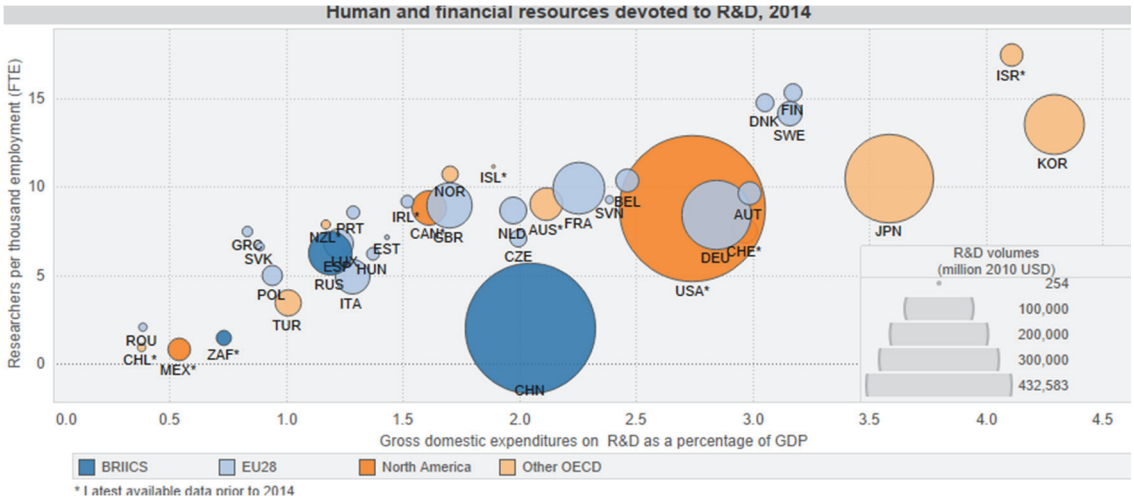

Figure 1-1. Human and financial resources devoted to R&D
Source: OECD, 2014

In most developed countries, the proportion for human capital and financial resources tend to be in optimal position. Developed countries seek scientists and engineers from other countries to develop their skills there, because not only there will be more jobs available, but also developed countries provide better facilities, incentives, and supporting policies in research and development. The governments also support innovation in their countries with policies such as R&D tax initiatives to support R&D activities by private companies to generate innovation (OECD, 2013). With this background, mobility of scientists and engineers is inevitable. This situation is often called 'brain drain' when high-skilled people move internationally to another country (often developed countries) and causing the lack of highly skilled people in their source country. Brain drain has been a major concern in the migration topic for, more or less, 60 years. The context of brain drain and brain drain has changed over the years. While brain drain is considered as a phenomenon that usually developing countries experience, brain gain occurs in developed countries. Nowadays, the brain drain does not occur only in less developed countries; but it also happens in developed countries. Another recent development is the term brain circulations was introduced describing temporary movements of high skilled workers from a country to another, spending several years in the host country, and then return home to the home country. This movement occurs mainly in China and India where scientists and engineers who previously had career in countries such as United States return to their home country. Thus, even though brain drain tends to have detrimental effects, many research also concluded that brain drain actually has positive impacts to the source country in terms of knowledge transfer and foreign investment in the source country.

Developed countries so far have managed to induce scientists and engineers to stay in their countries and help develop technology, for instance the H1B visa in United States. United States uses this policy to attract high-skilled migrant through this visa in order for them to work in United States, while high-skilled immigrants can improve their life quality in the United States rather than in their home. This is also one of the problem in less developed countries.

Less developed countries (or developing countries) produce relatively small amount of scientists and engineers as professions. Even if there are professionals in science and technology areas, small opportunities of employment in science and engineering area or the lack of research area will be the next problem; students who are expected to be working in the same major in which they graduated look for job opportunities in managerial positions in corporations due to the level of salary and, again, the small opportunities in the area where they study. In this circumstance, it is not surprising that many scientists and engineers from developing countries who would like to deliver and gain more knowledge in their fields move abroad to other countries that are able to offer excellent facilities and incentives for them.

Another problem arises from education system and education quality, especially tertiary education. As mobilization occurs, international mobility of students are also inevitable. The movement of students abroad in order to pursue higher education abroad is also critical because students will be exposed with more career options and better quality of life there. Good infrastructure and more stable economic and political condition in developed countries are some of the factors influencing people to move abroad, or for students to not return home after finishing their studies abroad.

These days, Asia takes part contributing in science and engineering area. Today, countries such as Japan, China, India, and South Korea have become the pioneers in technology. More importantly, these countries support the advancement of science and technology including promoting the number of science and engineering students. With the increasing amount of science and engineering graduates, the demand of scientists and engineers in developed and developing countries is fulfilled by nationalities from Asia. Indonesia, as a part of it, is also one of contributors in sending highly skilled people throughout the world.

However, the rate of brain drain is considered small compared to other countries. The closeness to family and friends has been a strong determining factor for Indonesian scientists and engineers to return. However, with the advancement in ICT geographical boundary is not a problem anymore.

In conclusion, development in science and technology is essential for economic development in a country. While this is an important issue, it seems that not all countries are concern, especially in Indonesia. How Indonesia is not very much concerned about this matter can be apparent from very few research and analysis about the movement of scientists and engineers abroad. There is also a large number of research trying to analyse international migration by their own methods of choice. Migration models have been discovered by many experts in each of their specialty of areas, such as Michael Todaro, Frederique Docquier, and so on. However, their model consists of mainly econometric models, and the character of the model is only one way (separated relationship). Despite the model has been verified with available data, writer thinks that there is a necessary to look at this problem in holistic manner.

When one variable or one condition changes, then it will influence another variable. It is not enough only to look in one way manner, hence to look for the many relationships is required. Another reason why more holistic approach is considered more appropriate is because there will be looping effects. Technology development affect positively on economic development, but economic development also has major influence for the government to implement policies that in the end will influence technology development. Another thing is that it is essential to understand what kinds of reality that we are facing and try to make a simplified, but realistic model in order to understand the condition. The model that should be formed is based on not only quantitative perspective, but also qualitative perspective because social phenomenon is more often than not explained by narrative values which are evidenced by numerical values.

The key to economic and technology development is the policies stated by the government. The more supportive and distinct policies implemented by the government, the more advance the development. Also, with the addition of skilled human resource, the development can move forward faster. Facilities provided by the government in need for research purposes also need to be organized. A model that can provide the

simulation of real condition and suggestions for policy making based on data and facts for the government is what Indonesian government needs now.

1.2. Indonesia

This research utilises Indonesia as empirical evidence of this social phenomenon. Indonesia is chosen because of many reasons. First, Indonesia has rather small number of high-skilled international migration – from international student's mobility or self-expatriation. The small number, however, does not have trends. Therefore, it is interesting to understand the factors behind fluctuating trend of outbound of students abroad. As for self-expatriate, the number is still unknown so we cannot conclude anything from the trend.

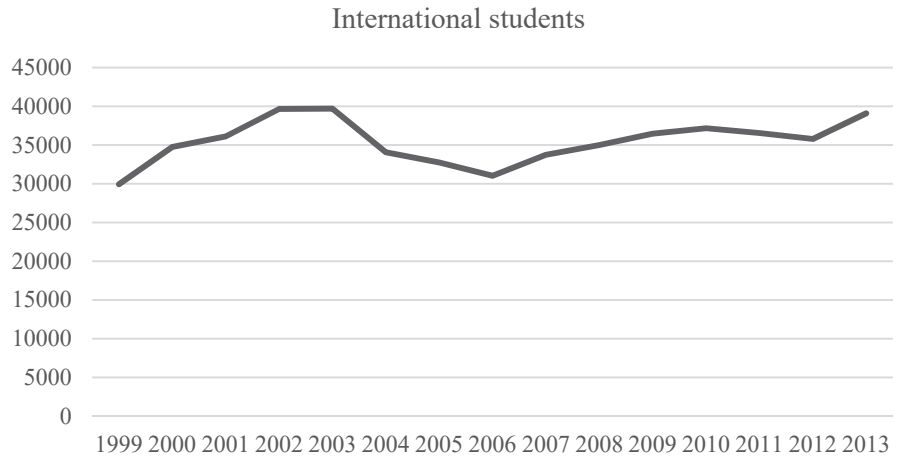

Figure 1-2. Outward mobility of Indonesian students
Source: UNESCO (2016)

Second, Indonesia's political condition and condition in general cause the uncertainty of future prediction. For example in 1998 when the change of government regime, caused instability in almost all areas, such as decline in GDP change and currency exchange. Third, in relation to research and development, Indonesia does not ambitious target of what technology improvement to achieve in the future. Changing head of the state also means change in science and technology policies, hence the government still has no consistent implications. The budget for research and development is managed by the Ministry of Finance: one government research institution mentioned that it got the budget for incentives and research budget from Ministry of Finance. This can be a problem when the government follows how much can a country earn, and even then the percentage of GDP spent for research and

development is considered very low. Therefore the research activity in Indonesia is not going well. Research activity has close relation to the number of graduates in science and engineering area. The number of students taking natural science and engineering majors is very few compared to social science and humanities. The percentage of graduates from natural science, engineering, manufacturing, and construction, agriculture, health and welfare were 11.3, 9.2, 3.4, and 12.1, respectively (UNESCO, 2014). This can be a problem in supplying qualified scientists and engineers in the future, since Indonesia needs approximately 65,000 additional engineers per year while currently it is in shortage for 30,000 engineers. Even though Indonesia has 750,000 engineers, but only 40 percent of them work in engineering fields (Tempo, 2016).

Fourth, the leaving of Indonesian scientists and engineers has long term effects on Indonesia's development. Indonesia is currently run by a new president and his government implements the infrastructure development all over Indonesia since Indonesia is an archipelago and to have equal development in infrastructure and construction is important in order to have equal economic development that so far has only centralised in Java Island. With the infrastructure development it is hoped that Indonesia manages to move from early stage to the next stage, which is industrialisation and it needs improved innovation and development. If this policy runs smoothly, in a decade or two Indonesia will need more high-skilled workers more than ever. If the productive and qualified human capitals leave Indonesia, then Indonesia will have difficulty to keep improving itself. Writer sees this gap and would like to send Indonesia's government caution of what will happen in the future if they do not do anything now.

The last one, Indonesia, when considering policy making, does not use concrete evidence. Mostly, policy making process is generated through qualitative approach rather than quantitative. It only seeks opinions from experts and observation, and habitually continuing previous policies without considering reality and facts. Another problem is the data management in Indonesia whose quality is doubtful and often missing may become the reason why the government rarely uses facts as solid backgrounds and evidence for policy making. Therefore, it is important to suggest the government about policy making process using a combination of data and narrative approach.

1.2.1. General context

Indonesia itself, as a developing country, has a promising development in terms of Gross Domestic Product (GDP). In recent years, Indonesia has stable GDP growth in 6 percent annually and is predicted to keep stabilizing in the future. The only negative growth was only when the recession happened in 1998 when the government regime changed and reformation occurred. Since then, the growth became more consistent. However, in terms of technology development, Indonesia lagged behind, even from its neighbouring countries.

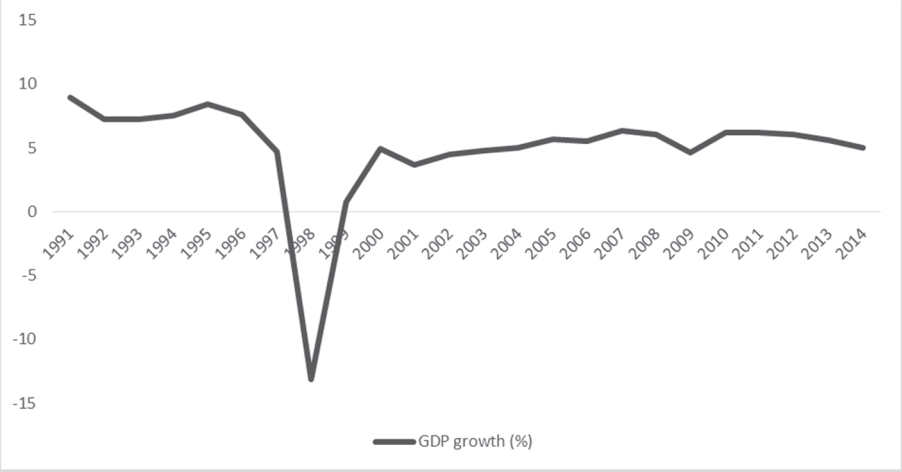

Figure 1-3. Indonesia GDP growth (in percentage)
Source: Worldbank (2016)

According to (Frankema & Lindblad, 2006), Indonesia was lagged behind Thailand in many aspects; especially in per capita GDP growth, value-added in manufacturing, exports of capital goods, and application of medium or high-level technology in manufacturing production. And a critical point in this study was that "technology policy in Indonesia needs to address institutional weaknesses and, above all, shortcoming in the capacity of the labour force to absorb new technology." (p. 321). The arrival or existence in advanced technology cannot be used effectively if it is not coupled with the presence of capable human resource. Another resource stated that Indonesia lagged behind on the use of high technology products on 1992 – 1994 (Lembaga Ilmu Pengetahuan Indonesia, N.A)

In figure I-3, the proportion of high-technology exports compared to the total manufactured exports is relatively small. In the last data (2013), high-technology exports was only around 7 percent of the manufactured exports. The technology

condition even for the industry has taken impacts on the economic circumstance in Indonesia.

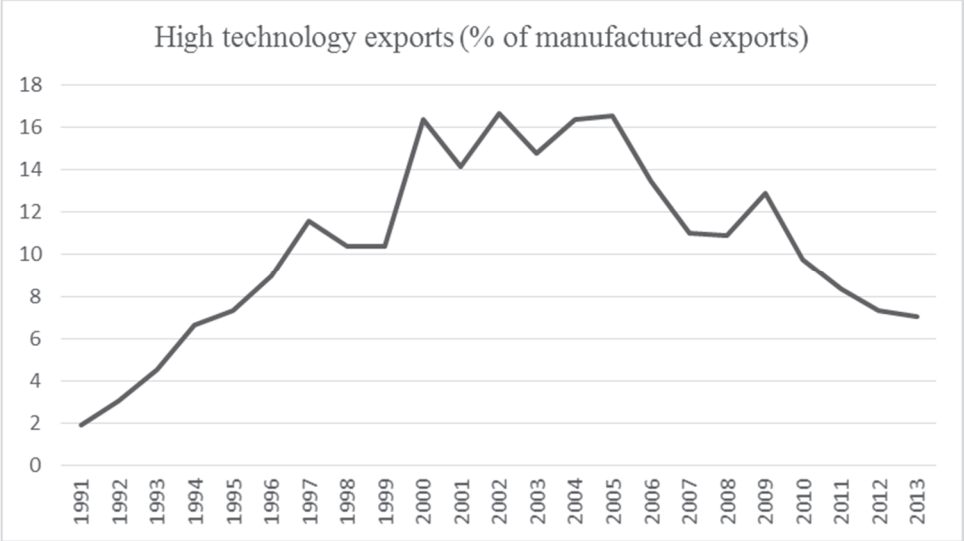

Figure 1-4. High-technology exports
(Source: World Bank data, 2015)

Information is not only instrumental in facilitating migration by increasing people's migratory capabilities, but new ideas and exposure to new life styles conveyed by migrants may also change people's cultural repertoires, preference and aspirations [Castles, et al., 2014]. The increase of high-technology and ICT service exports over the years is a significant indicator that the technology development in Indonesia has progressed. However, if compared to other developing countries, Indonesia still lags behind. According to Fatah et. *al,* Indonesia needs to formulate policy that will attract and benefit more from FDI inflows and greater openness. Using ordinary least square regression, FDI has a positive relationship with economic growth and statistically significant especially for Indonesia (Fatah, Othman, & Abdullah, 2012). As mentioned before, FDI allows a country to speed up the development, especially technology development. Therefore, in the long term, economic stability will be achieved when supports from technology advancement and financial stability occur.

Indonesia's large population has positive and negative impacts. The positive impact is that Indonesia has a large number of human resources to be employed in industrialisation process; hence it does not need to seek human resources from abroad. The down point is the education system is not evenly distributed, as seen in not so low

unemployment rate and illiteracy in rural areas. Even with the increasing number of population, it can be a caution that unemployment rate can also increase if Indonesia does not try to create new job fields. Therefore, hopefully with the development of infrastructure, the government can reduce unemployment rate and create new jobs opportunities and increase its GDP.

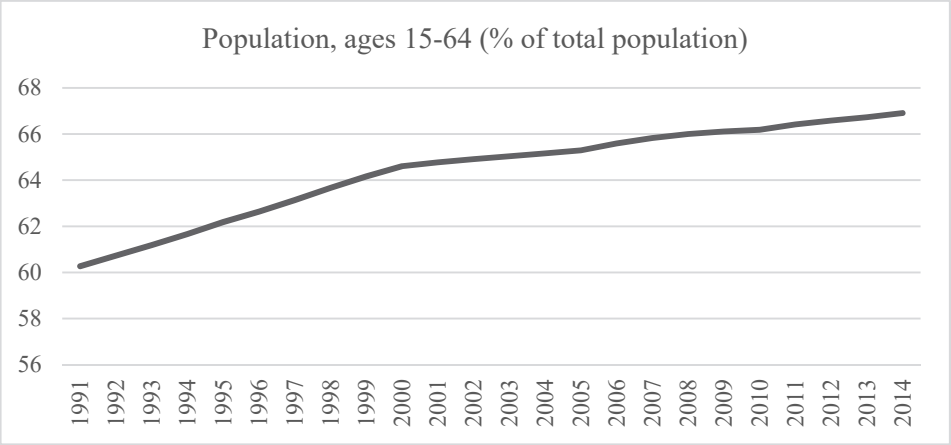

Figure 1-5. Productive age (15-24 years old) of total population (Source: World Bank data, 2015)

1.2.2. Tertiary level education context

Two pillars of Indonesia's focus are education and health. This is true as this is the basic for a human being to be productive. For Indonesia, education is still not evenly distributed due to the geographical condition. The good education institutions is also centred in Java Island, just as infrastructure, economy, and demography.

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 26 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 (a copy of *Peraturan Pemerintah Republik Indonesia Nomor 26 tahun 2015*) (Universitas Gajah Mada, 2016).

The government is still focusing on 12 years of schooling (primary and secondary), but recently tried to raise the quality of tertiary education as well. This can be seen from the number of the percentage of population achieving education degrees. In 2014, the percentage of population 25 years old and above with no schooling was 6.8, the population that finish primary, lower secondary, and upper secondary are 29.3, 16.2, and 22.4 respectively. While 7.4 percent has bachelor or equivalent degree and only 0.6 percent has master or equivalent degree. These numbers are very alarming because so little have tertiary level education. However, the percentage is promisingly increasing even though very slow that in the future there will be more tertiary educated people.

Indonesia's universities quality is very low. Three universities had been in the top 500 world ranks, but recently none of them was. Domestically, accreditation of universities by Indonesian government showed that only almost three percent of total higher education institutions in Indonesia generate excellent performance academically (Badan Akreditasi Nasional Perguruan Tinggi, 2016). Therefore, despite of a large amount of higher education institutions in Indonesia, the quality of those institutions is still poor. While realizing that Indonesia's higher education institutions' quality is still poor, students have the alternative to pursue tertiary education abroad.

Table 1-1. Educational attainment of the population aged 25 years and older
Source: UNESCO, 2016

Year	No schooling (%)	Incomplete primary (%)	Primary (ISCED 1) (%)	Lower secondary (ISCED 2) (%)	Upper secondary (ISCED 3) (%)	Bachelors or equivalent (ISCED 6) (%)	Master's or equivalent (ISCED 7) (%)
2006	6.1	13.7	36.9	16.9	19.5	6.9	N/A
2007	10.9	17.4	31.3	14.4	18.9	4.5	N/A
2008	10.5	17.7	30.5	15.2	19.6	4.3	N/A
2009	9.5	17.7	30.6	14.4	20.3	7.5	N/A
2011	8.0	17.6	30.0	15.5	21.1	7.9	N/A
2014	6.8	16.6	29.3	16.2	22.4	7.4	0.6

There are two clusters of students who pursue their education abroad: students who are excellent in their academic achievement and then receive scholarships from government (abroad and Indonesia's) and students who feel that they cannot be accepted in Indonesian universities or persuaded by their parents (or themselves) to study abroad. The second type students are financed by their parents partly or even fully.

Figure I-2 showed the outward mobility of Indonesian students abroad. Approximately 0.2 percent of population in tertiary age are abroad, but compared to percentage of total enrolment of tertiary students is 0.6 percent (UNESCO, 2016).

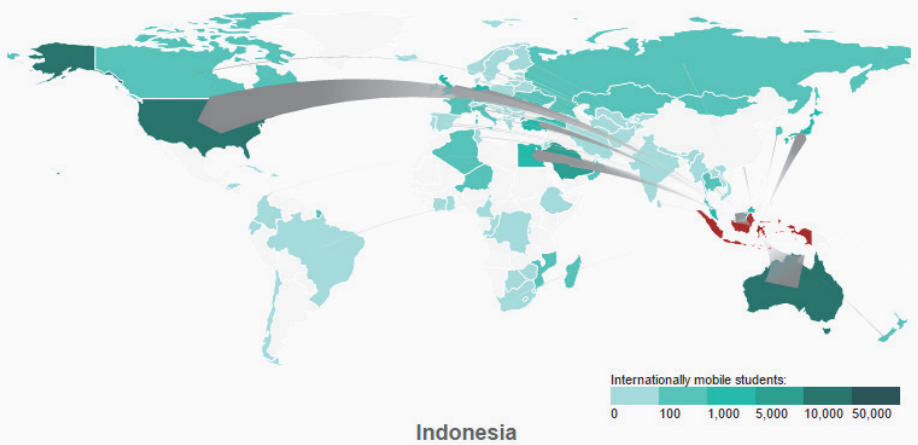

Figure 1-6. Outward mobility of Indonesian students, destination proportion
Source: UNESCO, 2016

While the number of tertiary students is small compared to the population, the number of students who study natural science and engineering in Indonesia is lower. As mentioned previously, the total percentage of students who study natural science and engineering comprises under 50 percent. The technology to support excellent research activities in Indonesia's universities is 50 to 100 years behind developed countries; in other words, Indonesia cannot compete globally unless it changes its policies in technology.

1.2.3. Research and development context

Research and development in Indonesia is also in similar condition with the quality of higher education institutions. Facilities provided by the government in need for research purposes also need to be organized. However, according to Wie (Wie, 2006), "the performance of the public research institutes, including the laboratories of the Department of Industry and research institutes of the Indonesian Institute of Sciences (LIPI) and the Agency for the Assessment and Application of Technology (BPPT), in technology development has also not been satisfactory. The laboratories of the Department of Industry are poorly staffed and poorly funded and mostly equipped with obsolete equipment."

Indonesian government's budget spent for research and development tends to be low, at least compared to its neighbouring countries.

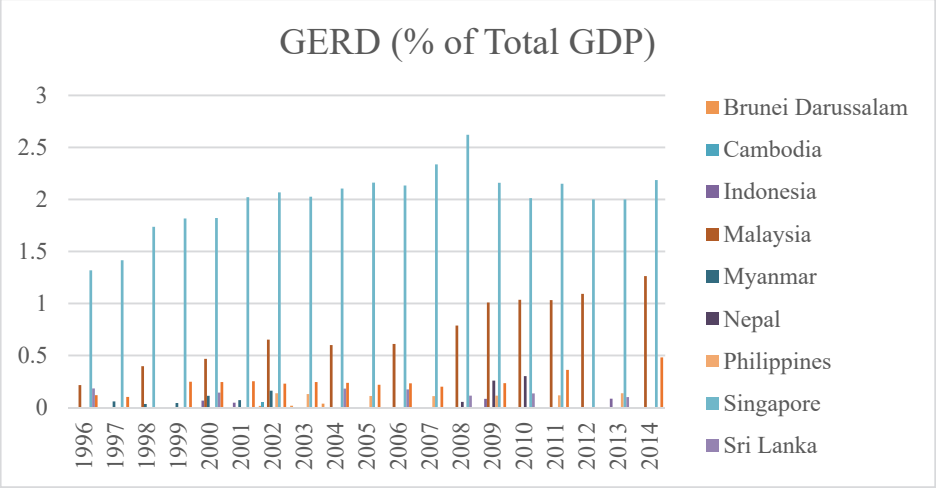

Figure 1-7. Gross expenditure of research and development (% of total GDP), ASEAN countries
Source: (UNESCO, 2016)

In figure I-6, Singapore has the most complete data and highest number on gross expenditure on research and development as percentage of GDP. The second biggest is Malaysia. Even Philippines, Thailand, Nepal, and Srilanka spent more from their GDP for research and development than Indonesia. These showed that neighbouring countries already realise how important it is to increase the quality of research and maximizing research activities in their countries. Research and development budget can be delivered to public universities and government's research institution. Even in Government's research institutions, the amount delivered to them in reality is smaller because the budget is not only for financing research, but also for paying for operational expenses. Therefore, it seems that scientists and engineers in government's research institutions feel that they do not have sense of flexibility and completeness in their research activities; and they have to be prepared to be cut from their research because of inconsistent budget management.

Indonesia, as one of exporters in scientists and engineers begins to see the gap of demand and supply of scientists and engineers. And many who leave Indonesia indicate that the demand of scientists and engineers is so limited that Indonesia has oversupplied in the area. On the contrary, according to Andrianto Handojo (the head of National Research Council of Indonesia, Indonesia has more than enough research institutions: 114 in public universities, 301 in private universities, 8 in government owned companies, 8 in private owned companies, 76 department research institutions, 91 non-department research institutions, and 24 regional development research institutions. However, He also claimed that regulations and research coordination needs to be cleared out in order for research to develop, including the way of thinking by the government about government expenditures on research (Kompas, 2010). The problem

indicated here is that the support of Indonesian government on the development of technology is still considered small compared to other several Asian countries. Therefore, policy analysis needs to be conducted to evaluate what Indonesian government is missing in its objectives and policies.

1.3. Significance of the Study

First of all, we need to state the stakeholders in this matter. The first stakeholder is the Indonesian students. As it is identified that the international mobility starts at education phase, Indonesian students, whether to choose Indonesian universities or universities abroad influence significantly the mobility and the next phase of mobility. However, in this study particularly, Indonesian students are only the ones who study in science and engineering or technology fields. Also, the next choice that Indonesian students make after they graduate, whether they want to have a career in Indonesia or abroad, also contribute significantly on the future trends of scientists and engineers.

The second stakeholder is Indonesian scientists and engineers, who are the extension of Indonesian students in science and engineering fields after they graduate. They have options whether to have career abroad or in Indonesia. Personal and external factors generally influence their decisions. However, which factor is considered more important for this stakeholder is still unknown. The development of technology in Indonesia and economic development depend on scientists and engineers who have careers working in similar fields, since they are the labour support of technology development.

Third and fourth stakeholders are Indonesian government and destination countries government. As mentioned before, personal considerations are not the only ones influencing decisions for this the first and second stakeholders; supports and challenges from the government also give significant contributions. The government (sending or receiving) has its own policies concerning this topic – sending on policies about the outmigration of scientists and engineers abroad and receiving on policies about employment and immigration of foreign scientists and engineers. The government also is a decision maker on the tertiary education policies, especially science and engineering areas that link to the research activities and eventually the technological advancement in the country. And on the basis of push and pull theory,

the policies that sending government create pushing people to move abroad and receiving government create pulling people to move to destination country.

Discussing about the stakeholders hopefully can give readers an image that international mobilization of scientists and engineers involves several stakeholders and how important it is to involve all stakeholders in one model and research. The significance of this research is how to manage these relationships into one holistic view, in general, and to give caution to Indonesian government on what happens and help them make policy based on the result of this result, in particular.

1.4. Research Objectives

Therefore, with background and problem identifications explained above, there are several objectives in this research.

1. The first objective of this research is to model the mechanism of Indonesian scientists and engineers mobilization that can collect perspective of shareholders. To understand the impacts of these movement to in terms of technology and economy development. The produced model is a model of prediction that will forecast the condition in the future.
2. The second objective is to understand and analyse the decision making process and factors affecting people's decision regarding their choices of studying abroad and their choices to return. This is essential to be acknowledged because this research is about human capital hence it involves human factor besides the macro view condition of a country. Additionally, this study will also
3. Finally, to analyse current policies in Indonesia related to the stakeholders, especially in education and technology policies; and next is to provide realistic policy recommendations for Indonesian government on the education and technology policies and adjusting to Indonesian government's objectives.

1.5. Scopes and Limits of Research

As a study, this research also has several limits and scopes. First, this research is conducted in Indonesia, further research needs to be done in order to whether this model can be applied in other context. Another limitation is that the lack of Indonesia's data available may make the model simulation not to be optimal; however, with the help of narrative perspectives, optimistically the missing data can be fulfilled. And this

is an important step for Indonesia's policy making decision's approach that it needs to be done in Indonesia's context.

Third, result of the simulation is only explaining the mobility in science and engineering occupation areas. Therefore, this research excludes the mobility of other occupations outside fields mentioned above. Even if the pattern is similar with other occupations, again further research needs to be done. Fourth, the narrative perspectives are coming from representations for the groups. The number of scientists and engineers abroad is also unknown, so writers do not know whether the data collection is enough to represent whole population. However, it is an important findings that the writer will collect primary data for this research. The similar limitation works the same way with surveys or questionnaires, in the hope that it is reliable to represent large amount of Indonesian scientists and engineers abroad.

Last scope and limitation is that destination countries included in the model is not all countries in the world, considering lack of data from other countries as well and a representation of a group of countries is only needed, then OECD countries will be the benchmark for destination countries, since more than 60 percent of Indonesian students are residing in OECD countries (Education New Zealand, 2015).

1.6. Research Contributions

There are several points of research contributions, which include the originality of this research. They are:

1. Viewed from stakeholders, the target respondents that will be approached in this research are students and professionals who have educational background in science and engineering or technology areas, mainly abroad. Therefore, the result may be different from respondents with different educational background. The data collection, different from secondary data collected from formal international institutions, will be primary data. The originality of this research is collected individually by the researcher, which is able to represent the behaviour, and in the end compliments future prediction of the model and policy analysis.
2. Holistic view about the problem that Indonesia is facing. Because the model is a prediction model, then it can show Indonesian government if the policies implemented will have positive or detrimental effects in the future. If it has

detrimental effects for the development, then this research can serve as a precaution for the government to act now.

3. This research also provides policy analysis and recommendations for Indonesian government; since Indonesia's mobility research is still rare, the contribution of this research is considered significant because it specifically focuses on the technology development, in which not many researchers conduct research in this topic in Indonesia's context. Also, this study can be a fundamental basis and methods for policy recommendations which so far the government has lacked in order to generate and analyse policy decision making.

2. LITERATURE REVIEW

In this chapter, the basic theories and previous research findings are discussed. This chapter will discuss the general concept of this research and how previous findings help to construct a concept of international mobilization of scientists and engineers in Indonesia.

2.1. International migration

Historically, there were several main factors influencing population movements during the period 1987-2006, such as: increased urbanization in emigration-inducing countries, consumerism or freedom attraction offered by rich countries, expansion of free-circulation space, encouragement by successful migrants, growing facility of exit from disadvantaged or deprived countries, and family and development-association stimulus. (Richardson, 2007)

Migration is one of the most common phenomena in the world today and it has occurred since post World War I. There are many causes to migration: searching for better quality of life, looking for the more decent occupations, or even to search for better political stability and security in countries. Migration does not occur only from developing countries to developed countries, but also between developed countries (as reported in OECD annual report in 2001) and between developing countries. A theory shows the influential costs of migration: geographical distance between the host and home country, barriers to the migration, and bilateral migration agreements and the free movement of workers (Brucker & Defoort, 2009). Therefore, the subjective choice and also the exogenous factors relatively influence people to migrate. As for scientists and engineers, or people who work in research institutions, few of many reasons to migrate are “the opportunities for high technology entrepreneurship, access to leading clusters of research and innovation, employment opportunities in public and private research and the globalization of the R&D activities of national firms.” (Guellec & Cervantes, 2002)

Research on migration is interdisciplinary. Researchers from different research background look migration in different perspective. The term migration is so general, that researchers from sociology, political science, history, economics, geography, demography, psychology, cultural studies, and law are able to study this phenomenon

accordingly to their fields. (Brettel & Hollifield, 2007). There are two basic theories about migration: Functionalist theories that explain about push-pull models and neoclassical theory and historical-structural theories, which include segmented labour market theory and globalization theory. Each approach has its own gaps and disadvantages. For instance, the neoclassical theory fundamentally sees migration as a function of geographical differences in the supply and demand for labour. However, according to Castles *et al.*, neoclassical theory and push-pull models do not have enough or no explanation for human agency, which is a real ability of human beings to make independent choices and to change structural conditions. Historical-structural theories criticized neoclassical approach and claimed that individuals do not have free choice because they are fundamentally constrained by structural forces. However, historical-structural theories view people migrating as if they are the victims of global capitalism who have no choice but to migrate in order to survive. (Castles, de Haas, & Miller, 2014)

In conclusion, both approaches underline important point of views on migration. Neoclassical approach suggests that the internal factors that depend on the choice to migrate or not, hence the free will of people who want to mobilize is the main cog. Meanwhile, according to historical-structural approach claimed that external factor decided whether people move. That is, the urgency and the inhospitable environment people live in that push people to move. Both structures have each essential point and some disadvantages too. There is, however, another approach called migration transition theories.

Every year, OECD countries have thousands (even millions in United States) incoming migrants from all over the world. The data shows that migration is inevitable, no matter how strict the regulation policies for migration in those countries are. The increasing number of migration in countries each year proposes that the many immigrants look for ways to have their acquaintances and families to the host countries. A study conducted in Hong Kong showed that family and friends are more important factors to bring expatriate engineers to Europe, Australasia, and North America (Findlay & Li, 1998). This was linked by Garrick's statement that in migrations motivated either by a desire for permanent settlement or to gain citizenship of another country, networking through friends and family remains of very great importance as a means of securing employment (Garrick, 1991).

The migration channel framework needs to be modified: the research found much evidence that migrants are not passive players in international migration system; the relation between migration channels and the conception of how space is structure and emphasis which needs to be given to the meaning of both place and of migration. One counter theory by Mountford (Mountford, 1997) is that the emigration under immigration controls result that in general emigration if the chance of emigration is long-lasting then the return will raise and productivity will be permanently greater in the source country. However, it has no relation to the return intention by the migrants, and in his study the effect will become clear in the long term period of observation. The similar statement is contributed by Docquier and Rapoport (Docquier & Rapoport, 2006) who argued that "If migration is probabilistic in that people are uncertain about their chances of future migration when they make education decisions, then under certain circumstances described in a series of recent theoretical papers, this can be turned into a gain for the source country."

There are several critical points taken from previous literatures on migration. First, the literature reviews on migration so far show the pros and cons of the effect of migration. Although this phenomenon is considered normal especially as one of many effects on globalization, the different way of seeing this needs to be further explored. Second, it is clear that internal and external factors influence the urge to migrate. However, comparing between internal and external factors, the more important cause is still unknown. Therefore, to put it at ease, the comparison of the relatively importance of factors needs to be conducted; and to do that, different methodologies need to be used in order to overview the personal and external factors. In addition, the overview can later be utilized the view of macro and micro movements. Third, some methodologies used previous literatures, such as economic model by Docquier and Rapoport, suggest that main methodologies of research in migration are by using mathematical equation to determine the value of migration and effects it follows. Meanwhile, the simpler and more understandable for general viewing methodologies have not been used. Therefore, by using methodologies such as agent based modeling and system dynamics are best put to use in order to map the pattern of migration.

Table 2-1: Inflows of foreign population by nationality (OECD countries)
Source: OECD [OECD, 2009-2010-2011]

	2009	2010	2011		2009	2010	2011
Country				**Country**			
Australia	222.572	206.714	210.704	Japan	297.092	287.071	266.867
Austria	91.818	98.262	114.936	Korea	232.844	293.07	307.249
Belgium	102.714	113.582	117.948	Luxembourg	14.635	15.814	19.108
Canada	252.179	280.685	248.75	Mexico	23.852	26.18	21.464
Chile	57.059	63.92	76.337	Netherlands	104.41	110.235	118.457
Czech Republic	39.973	30.515	22.59	New Zealand	43.575	44.345	40.796
Denmark	31.957	33.442	34.572	Norway	56.682	65.065	70.759
Estonia	2.229	1.199	1.675	Poland	41.277	41.061	41.336
Finland	18.087	18.212	20.416	Portugal	33.791	30.032	33.038
France	126.169	136.057	141.98	Slovak Republic	14.438	12.659	8.224
Germany	606.314	683.529	841.695	Slovenia	24.078	11.225	17.972
Greece	46.534	33.368	23.206	Spain	469.342	431.334	416.282
Hungary	25.582	23.884	22.513	Sweden	82.384	79.036	75.852
Iceland	3.392	2.988	2.754	Switzerland	132.444	134.171	142.471
Ireland	50.7	23.9	33.7	Turkey	..	29.905	..
Israel	14.574	16.633	16.892	United Kingdom	430	459	453
Italy	392.529	419.552	354.327	United States	1130.818	1042.625	1062.04

2.2. High Skilled Workers

In a report by The World Bank, Schiff (Schiff, 2005), Docquier and Rapoport (Docquier & Rapoport, 2004) report that the number of migrants residing in OECD countries increased by 50% between 1990 and 2000, with the increase in the number of skilled migrants equal to 2.5 times that of unskilled ones. The arrival of highly skilled people to developed countries is not always the same expectations accordingly to their occupations. Many high skilled workers take jobs outside or even lower than their specifications. This may be due to the urgency of their situation or the less available

occupations in their fields. And since the migration's causes differ in one country to another, this situation is inevitable and in the end causes the brain waste.

Nevertheless, data shows that the emigration of worker with tertiary education tends to be higher than for the general population in developing countries, and the worst part is the rate is bigger for scientists, engineers, and members of medical profession (Burns & Mohapatra, 2008).

> "Many of the graduates during the period could not be absorbed in the domestic economy with some finding their way into the overseas market either as temporary or permanent migrants. And with data available, it showed that professionals who left the country had longer and mature experience, hence produced great loss for the economy." (Alburo & Abella, 2002)

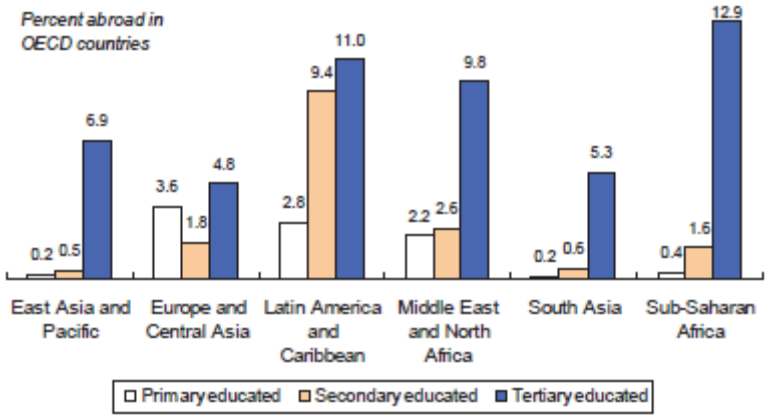

Figure 2-1. Emigration rate from regions to OECD countries based on Docquier and Marfouk (Docquier & Marfouk, 2004) data
Source: (Burns & Mohapatra, 2008)

The movement of high skilled people to developed countries should be viewed not only in negative ways, but also positive ways. According to Sahay [Sahay, 1999], developing countries should take the advantage of training opportunities in the developed world. The training opportunities – such as research and development may result in the non-returning of scientists and engineers, or even the effort of developing their home countries by gaining skills and knowledge in the developed countries to be applied in their home countries.

Push and pull factors are the common terms used to describe the factors influencing why people migrate. Push factors are the factors that "push" people to leave

their home countries, while pull factors are factors “pulling” people to come to host countries. In some cases for students, the push factors that influence them to remain the host countries are economic instability, bureaucratic obstacles, lower expected income, and little possibility for advancing in career. Meanwhile, the pull factors are better prospects for career advancement, greater opportunity for further development in the specialised area of study, and the existence of a more organised and ordered environment in general.

For professional, another survey conducted by Gungor and Tansel (Gungor & Tansel, 2008) showed that the push factor for professionals to remain abroad was the economic crises in Turkey. Therefore, the return intentions for Turkish professionals abroad vary depending on the length of stay abroad. Those who received their tertiary degree abroad have less definite intention to return, while those receiving their tertiary degree from Turkish Universities have likely intention to return home definitely. To be personal, working climate can be influenced by the national culture or relevant regulations. This may affect the condition of a person to stay in a country or return because he or she does not feel comfortable to work in particular countries (Forstenlechner, 2010). Another important empirical finding is the increasing of returns to education in the receiving country as well as in the sending country has an ambiguous impact on the self-selection of migrants. While increasing the difference in labour productivity between the host and the home country has a negative impact on the self-selection of migrants (Brucker & Defoort, 2009).

The process of migration is never conducive all the time. For example, France, as receiving country, has policies for people who chose to work in medicine, law, or in the public sector jobs. They faced the institutional barriers of regulated professions and actions guaranteeing fair access to employment for migrants are missing. Migrants in France have to deal with political institutions that are often "unhelpful" in offering them support for developing their careers. The management of immigration in France permits inflows of skilled migrants and yet presented strong barriers to their employment and career advancement (Ariss, 2010).

Different types of occupations in science and engineering fields have caused tendency of which occupation has the highest rates of movements, and what causes it. The gap is that even some studies explain which occupations have the highest rates of

migration; the information is limited only to some countries. Indonesia, which is the subject of this research, has very limited information and to some extent cannot be compared to other countries. With the lack of information, only few researches about the movement of talented or highly skilled people on Indonesia have been done.

2.3. Higher education

The skill and knowledge of a person come from the education one received. Education has been an important factor for determining a person's position in his or her job and in the society. With development of technology and globalization around the world, it is essential for people to have appropriate education in order to gain their skills and knowledge. Also with the same reasons, the education system is now open for all students who are willing (and also capable) to pursue wherever they want. The student mobility is now a common phenomenon around the world and it has both incremental and detrimental effects on sending and receiving countries.

The trend of students studying abroad, according to Bhandari and Blumenthal (2009), has increased significantly over the years. The emergence of new destination countries for international students, such as China, has begun to appear in the surface. Many organizations, such as UNESCO and OECD collect data on international students in several countries, but the limitation of these data is that the collection mainly involves in public universities. Private universities, as the fast growing education institutions, are difficult to be explored. The second limitation is that the time of data release and data collected have experienced time lag. Therefore, researchers cannot depend only on data from international organizations to generate significant results. However, since the data collection is almost impossible to collect by oneself because of the complexity of data gathering with limited time (usually the data is deducted every year). To overcome this problem, Project Atlas was established to synchronize the data from several organizations on student mobility (Bhandari & Blumenthal, 2011).

Countries are in competition with one another to develop their technology advancement. The pattern is now clear about where students are going to pursue their educations. In OECD countries itself, United States, United Kingdom, Germany, Australia, and France are the top five countries whose the amount of foreign students is the largest in the world become the top destination for international students. Many foreign students realize that by pursuing study abroad they increase the likeliness to get

appropriate jobs suitable with their qualifications, whether it is abroad or in their home country.

Students' mobility is not always smooth in the process. Barriers such as language, culture, and environment affect the decisions where students go. Although those barriers can be anticipated and taken into precautions, the length of stay of students during or after graduation is still considered by students.

International graduates from tertiary education are the source for knowledge transfers, especially in the source countries. However, the effects of return and non-return are still questionable. For some countries, whether international graduates return or not to their home country still does not influence the development of a country. Thankfully, with the advancement of Information and Communication Technology (ICT), the physical existence of high skilled workers is not needed in their home country as long as they keep communication for knowledge transfer (Diaspora networks will be further explained in the subchapter Diaspora Networks).

The level of schooling across countries is an important factor for explaining differences in growth rates (Barro, 1991). This implies that education is one of the biggest determining variables in development of a country. Evidence showed that education has a positive impact on the prospect and speed of engagement in the labour market. And the higher the education one owns, the more likely he or she gets better employment. The supply of highly educated students abroad is beneficial for the host countries due to the average performance that they have is above native students. The performance here means that they generate more publications, the empirical findings for companies related to their research, and more areas of research found with the insights of international students. And looking from the education, the gap between destination and source countries standard compensation will positively affect the self-selection of migrants (Belot & Hatton, 2008).

A study conducted about Turkish students who gain education abroad are mostly in science and engineering major with proportion of engineering and technical sciences (44%) and in math and natural science (11%) respectively. Most Turkish students' reason in choosing current institution of studying abroad is that the institutions that they are in provide the most suitable programme for their field of specialisation, while others are the respondent's ability to obtain acceptance, better financial support

or scholarship opportunities offered by the university, recommendation of the adviser or other professors, and the possibility of greater job opportunities (Tansel & Gungor, 2002).

Another example in The Philippines is that the recent supply trends are number of students earning a college degree had been on the rise, but not in major and vital disciplines such as engineering, medical, and education or teacher training (Alburo & Abella, 2002). Mountford (1997) claimed that temporary shifts in the proportion of educated people in the economy may result in permanent effects on the long run productivity level, thus may result in the increase of productivity if only the educated people contribute to their home countries.

There are many effects of student mobility for the host countries, such as: (1) the increase of national funding for education by the contribution of financial source of foreign students; (2) the economic contribution by foreign students, such as lodgement and living purchases, while they stay in the host countries; and (3) the knowledge and skill contributions by foreign students adding the development of host countries (Tremblay, 2004). Also some benefits of students mobility from the viewpoint of source countries according to Tremblay (2004) are quantitatively student mobility helps expand participation in tertiary education when the demand for skilled workers is not met in the developing countries, and qualitatively by having students get their education abroad the transfer of technology has been easier and stronger when it comes to technology related.

Literatures for education sector are mainly discussed about students who migrate from less developed countries to developed country, and the rest talk about the movements of students between developed countries. The effects for both source and host countries also have been explained by Tremblay. Tremblay reviewed by using statistical data on students who pursued their education mainly in OECD countries. While the methodology and target areas are reasonable, the further condition for both as a validation point in both source and host countries have not been described. Again, the future of students who pursue their education in specific degrees purposefully in this research is unknown, that is, whether students who pursue education in science and engineering areas stay within the area after they graduated. Therefore, further research

needs to increase the possibilities that graduates will stay to work in such specific areas, hence as one way, the elimination of undergraduates who pursue their degree abroad.

Students who pursue their education abroad and remain there have reasons to live abroad. One of many reasons for them to do so is because the supply of scientists and engineers is higher than the demand in the home countries. Therefore, there needs to be significant policies from the government on how to handle the oversupplied scientists and engineers and effectively generate performances on technology development.

China has its own history. Previous trends for Chinese students were the pursuit of studying abroad. However, the government applied effective policies in education and generated satisfying results. First of all, China's government established China Scholarship Council (CSC) which involves in giving scholarships to Chinese citizens to study abroad. The next step is the establishment of good working and living conditions and necessary funds in China to assist Chinese students from abroad after they graduate. The next strategy would be to build the connections between Chinese people employed abroad with their home country. China's strategy on education does not only to bring back graduates to build China's economy, but also to attract foreign students to study in China. China was ranked 13th place in 2005-2006 as the top host destination country for international degree students. One of the strategies by the government was building agreements with developed countries on mutual recognitions of academic degrees. The addition of Chinese people who work in universities abroad encouraged the agreement to run more smoothly. Scholarship provided by Chinese government for international students is also a booster to attract international students. The government is not the only one striving to attract; the willingness of educational institutions in China to upgrade their quality by increasing the quality of teachers, staff, and facilities also attracts international students (Xinyu, 2011).

In The United States, the trend of incoming students each year does not always increase. This is due to the increasing number of destination countries for foreign students besides USA. On the record, it was known that large part of students in Science and Technology fields was international students; also in 2008/2009 year enrolment, Indonesia ranked 17th of the top origin countries whose students studied in USA. The large amount of international students in Science and Technology fields is affiliated by the more than adequate source funding by national agencies, which has made USA

equip with state of the art laboratories and facilities in the world. One point that needs to be taken is that The United States will keep on supporting its public and private sectors to encourage the exchange of students and scholars because there is essential capacity for enhancing this type of mobility (Goodman & Gutierrez, 2011).

What Indonesia can learn from two major examples by China and The United States is the support not only from the government, but also the strong commitment from scholars and students abroad to build mutual relationships between home and host countries. Second, is that Indonesia should not just be the sending country for students to pursue education abroad, but it should also be the receiving country for international students as well. This way the transfer of knowledge, especially in Science and Technology fields, can be achieved optimally without Indonesia losing its talents to other countries.

2.3.1. Science and Engineering

Science and engineering seem to be two words that cannot be separated. Many people misunderstood that science equals engineering, and vice versa. And, with a little deep research, there are slightly differences in definition. According to Prausnitz, the simple definition of engineering is "the application of science for human benefit." (Prausnitz, 1991) Engineering's fields include electrical, chemical, materials, biological, environmental, and computer engineering – which explain that not all science fields are in engineering fields. Besides Prausnitz, Holtzapple and Reece define an engineer as someone who "combines knowledge of science, mathematics, and economics to solve technical problems that confront society." (Holtzapple & Reece, 1997)

As we seem to understand that engineering is a part of science that contributes and be a service to the society, next we need to understand the relationship between engineering and science. Terminologically, science comes from the Latin *scire* "to know", while engineering or engineer also comes from Latin *generare* "to create". The distinctive definitions help us to know further about the difference and the relationship between science and engineering. The creations from engineering attempt are determined mainly by whether they are useful and beneficial (to the society),

meanwhile the knowledge resulting from scientific endeavour is determined mainly by whether it is correct and consistent with former knowledge.

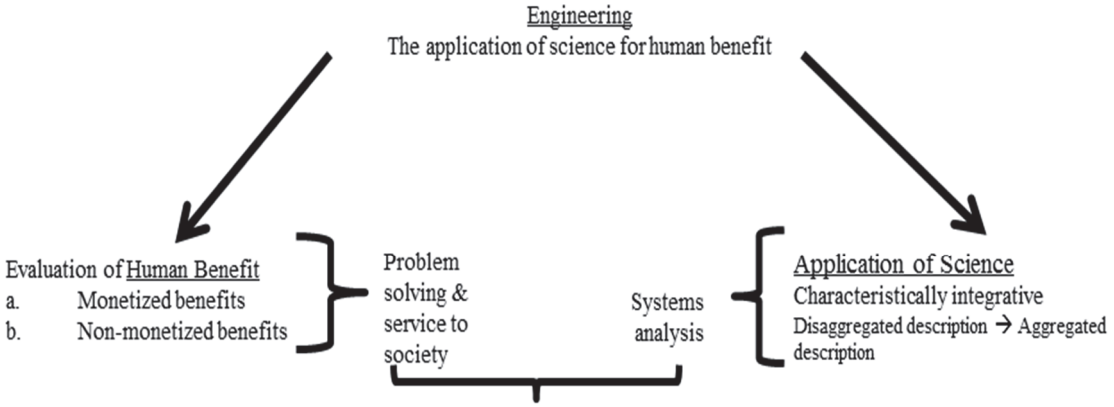

Figure 2-2. Perspective on Engineering Endeavour and its Relationship to Systems Analysis and Science (Lynd, n.d.)

2.4. Brain Drain and Brain Gain

Over the years, many specialists have analysed brain drain with various methods and outcomes. Brain drain can be described as "A one way flow of qualified human resources from poor to rich countries, or from the periphery to the core nations in the world economy that led to a net permanent loss for the origin country (p. 71)." (Solimano, 2010) However, with the high number of foreign born high skilled workers in the developed countries especially scientists and engineers, native born high skilled workers face difficulties in searching jobs in their areas. The benefit for using foreign workers is the cost for incentives are cheaper than paying native workers, but more expensive if they work in their home countries.

The new brain drain literature implies that the education benefit is subject to a high degree of uncertainties, and also the cost of education. (Schiff, 2005) Also, the new literature suggests that the brain drain raises the expected return on education; the raise, hence, will induce additional investment in education (a brain gain); then it may result in a 'beneficial brain drain' or net brain gain (in a brain gain that is larger than the brain drain; and a net brain gain raises welfare and growth. The new brain drain literature assumes that education is the only sector that generates positive externalities. However, according to Schiff, there are several factors that give positive externalities, such as healthcare provision, investment in R&D, and the provision of many other

public goods where the "presence of very large externalities and the temptation to free ride explains why these are provided publicly rather than privately."

Schiff (2005) formulated a formula of stock of educated people in period *t* in a country as shown below:

$$S_t = S_{t-1} + \Delta S_t = S_{t-1} + (BG_t - BD) = S_0 + \sum_{t-1}^{t} (BG_t - BD). \quad \textbf{1}$$

Where *S* represents the stock of human capital, *BG* reflects the brain gain and *BD* reflects brain drain which is determined by the host-country quota, and that the variable is the brain gain.

So, how big is the brain drain? Docquier and Rapoport (2006) stated that the magnitude of the brain drain has increased dramatically over the last few decades. However, if relating to intensity (or emigration rates), the picture is less clear as one must factor in the general progress in educational attainments observed all over the world.

According to Gibson & McKenzie (Gibson & McKenzie, 2011), the general idea of brain gain theories is that "decision of individuals to invest in education react to the prospect of future migration, and that not all those who choose to increase their education because of the chance they may migrate actually end up migrating." While many argue about brain drain and brain gain, finally researchers found the balance of both extreme conditions: brain circulation. Brain circulation may help solve demographic and economic problems in home countries. While many high skilled workers move to host countries, many also leave the host countries to return. The international mobility of the highly skilled is changing nature, and rather than a permanent emigration (brain drain), is increasingly characterised by a circular flow of human capital (brain circulation) between the countries of origin and destination.

The use of brain drain and brain gain terms is not as relevant as compared to 40 years ago. Brain drain and brain gain are not considered to have detrimental effects on the source countries and benefits for host countries anymore because as time goes by, alternatives were discovered to cope with the detrimental effects, such as brain circulation and diaspora networks. Statistically, Indonesia is one of many countries that have high return of students who previously studied abroad. However, concerning the

return of professionals especially in science and engineering areas, the number is unknown. Moreover, the performance of Indonesian scientists and engineers abroad produce significant contribution to technology development. This condition needs to be embraced by Indonesia government since the talents that Indonesia actually needs are abroad. Brain circulation can be a good solution to brain drain, where it works for India and China. It is not supposed to be a large constraint since more Indonesians choose to return after spending some time abroad than to remain. However, as mentioned earlier that factors influencing the movements are not only internal but also external, so the government, source or host country, stimulate the movements of people.

2.5. Repatriation and Diaspora Networks

The extension of brain drain and brain gain topic is the returning of high skilled workers. Scientists have willingness to return home because of cheaper living costs and challenges that they will face in their home country. In The United States approximately half of all foreign doctoral recipients leave United States to return immediately after they graduate, while some spend several years in advance to their return (Gwynne, 1999). This is what happened recently that scientists and engineers are actually leaving from where they study to return home. Subjective choices are mostly influential to decision whether high skilled people return or remain in their host countries. Some are looking for experience first in the host countries while some choose going home directly because of the contract from the government or institutions that give them scholarships, or they feel the lack of sense of belonging in host countries. In this case, no matter how prospective their jobs in the host countries, they will still choose to return. While this condition, in some ways, is detrimental to the host countries, home countries gain a lot of benefit by the returning high skilled people. Therefore, we cannot ignore the subjective element of a decision making especially concerning subjectivity of a human being.

Despite of the worse condition in the home countries compared to host countries, the amount of repatriation is still there, and it keeps increasing every year. For students, the reasons for them to return home are mostly reaching academic and work experience and goals and family reasons.

A diaspora is relatively defined as a dispersion of people throughout the world. The word is a combination of *speiro* (to sow) and *dia* (over) from Greek. Mahroum, et al.,

refers diaspora as “Any people or ethnic population forced or induced to leave their traditional ethnic homelands, being dispersed throughout other parts of the world, and the ensuing developments in their dispersal and culture.” (Mahroum, Eldridge, & Daar, 2006) Diaspora is caused by many reasons, and there are many types of diaspora itself; however, the closest characteristics that reflect diaspora nowadays are:

- The belief that all members of the diaspora should be committed to the maintenance or restoration of the original homeland and to its safety and prosperity;
- The continuation in various ways to relate to that homeland and the ethno communal consciousness and solidarity are in an important way defined by the existence of such a relationship. (Safran, 1991)

Finally, Butler, (Butler, 2001) states five dimensions of diaspora networks:

1. Reasons for, and conditions of, the dispersal;
2. Relationship with the homeland;
3. Relationship with host lands;
4. Interrelationships within communities of the diaspora, and
5. Comparative studies of different diasporas.

Many researches have discussed about diaspora networks, and they took different types of diaspora and samples of different countries. One of the most famous diaspora is Chinese people (although historically this term was used to picture the Jews movements) and Indian. Not only China and India, but also developed countries, such as United Kingdom, also experienced diaspora because it also underwent the outmigration of its people to other countries.

Chinese movements historically started in two periods. The first one was due to the conquest of China by Mongols; so many Chinese refugees went to the neighbour countries in 12th century. The second was in the governance of Deng Xiaoping who opened China market to the world after some period of retracting itself from the world. At the time China opened itself to the world, Chinese people who already lived outside played important roles to help China’s economy. Foreign Direct Investment supported China’s private sector to grow. Foreign Direct Investment came from the Chinese people outside China, and it contributed $307.6 billion of utilized Foreign Direct Investment from 1979 to 1999 (Smart & Hsu, 2004).

Related to the diaspora in science and engineering fields, Chinese abroad create a community or association of scientists and engineers all over the world to gather information, hold conferences, and knowledge sharing. The community also helps scientists to search for research funds to scientists in need. This proves the technology improvement in China is strengthened by the bond of Chinese scientists and engineers worldwide.

The British, on the other hand, was initiated by the purpose of domination. The relationship between British and its dominions (New Zealand, Australia, India, and others) was based on kinship and the transfer of culture. Not only that, the interdependence in economic trade and trades also rooted in the relationship. However, since the colonial countries gained freedom from Britain, the relationship began to wear out, especially since Britain joined European Union (Cohen, 1997). This has led countries to independence but weakening ties with Britain. "In recent years, however, some expatriate engineers and scientists from what we now call 'countries of the South' working in 'the North' have been organising among themselves – for mutual aid and information sharing, but also to help their home countries' institutions and scientists in various ways." (Barré, Meyer, & Valéria, 2003)

Diaspora Knowledge Networks (DKN) has been an interesting subject to discuss among policymakers and researchers around the world, and this subject is relatively new. The DKN usually exist in the science and technology communities where the communities' members spread networks and sharing of knowledge among them throughout the world. The networks aims to develop scientists and engineers in the source country by the aid and networks from their fellows abroad. In a matter, DKN even the detrimental effect of brain drain.

Diaspora networks can contribute to technology transfers and adoption by strengthening trade and investment linkages. Therefore, not all diaspora networks results in cooperation of scientists and engineers around the world who come from the same home countries, but also it will affect to the increase in investment and other aspects in the home countries. This statement is supported by Burns & Mohapatra (2008 and Agrawal et *al*. (2004) Who stated that "technology appears to diffuse more efficiently through culturally and nationally linked groups, and shared ethnicity appears

to counteract the kind of home bias effects that underpin the geographical network or the cluster effects that give high-density R&D zones and innovation advantage."

A study by Meyer and Wattiaux generated a stunning result of 158 online networks used to connect high-skilled people abroad with high-skilled people inside their country, and until by the time the research was published, 101 networks were still active. This research can be utilized by government and other public supports to gather information and in the end benefit developing countries (Meyer & Wattiaux, 2006). Another example of DKN is the existence of Virtual Laboratories; and these are expanding in some areas such as international human genome collaboration, the association of astronomical facilities (whole-earth telescope), the planned construction of long-baseline interferometry laboratories, and global observation networks for the environmental sciences (Turner, 2003). In The Philippines, the active diaspora network is the Brain Gain Network which covers many disciplinary networks of professionals in engineering, science, and organizations in the field of science and technology. The knowledge transfer is inevitably useful for countries; however some boundaries such as language may decrease the level of transfer. Nevertheless, migration has become a significant alternative or media for knowledge transfer regardless the boundaries in the process (Williams, 2006).

It is clear that repatriation and diaspora networks generate positive effects towards the movements of talented people especially, in this research, scientists and engineers. Effects from repatriation and diaspora networks are also explained by previous literatures. The management of diaspora networks in every country depends on the active participation or communication between scientists and engineers in the home country and host countries. In the example of Indonesia, only few are established without formal organization which is needed in order to run effectively. To understand the effects of repatriation and diaspora networks, certain methodologies need to be utilized. Therefore, this research will explain deeper knowledge about repatriation and diaspora networks especially on Indonesian scientists and engineers.

2.6. Government Policies Related to Migration

Government has significant roles in relation to the quality of education and the exodus of high skilled workers. Although the personal preferences indicate location and the length of stay in one country, government policies concerning the migration and

support on foreign workers, especially high skilled workers, also have important role to the decisions of foreign people to move to a certain country.

In some developed countries, immigration policies are main concern in filtering the inflow of high skilled workers. Therefore, the increasing population is balanced by the contribution that immigrants generate. In United States, the settlement of a foreign student is not encouraged by the government. So, for the United States graduates, there is no distinctive measurement. And the incident of September 11 has raised concerns of security that United States needs to further select immigrants in strict manner. As for high skilled workers, the government provides specific types of working visas: H1b for people with specialties (such as scientist and engineers) and H1c for nurses who are willing to work in area in need for health professionals. The increasing proportion of overall tertiary educated worker in science and engineering and the doctoral graduates of science and engineering have been increasing from 1990 and 2000 (14% to 22% for overall science and engineering field and 24% to 38% for doctorates in science and engineering) (Tremblay, 2004).

In case of Australian government foreigners get points for pursuing education in Australia. After foreign students graduate, they are granted permanent residence for six months. One policy made by the government is the visa category for students who have a degree in Information and Communication Technology (ICT), and this new visa category will ease the process of immigration. Due to these policies, the number of immigration has increased; in 2002/2003, 61% of permanent residence visas were held by skilled immigrants. The point system is also applied by Canadian government and New Zealand's concerning immigration (Tremblay, 2004).

Schiff (2005) mentioned that policies including increase in tax, a reduction in educational subsidies, and a reduction in other public expenditure affect the amount of emigration or quality of education in the home country. Increase in tax and a reduction in educational subsidies will lead to the low demand for education, while a reduction in other public expenditures will reduce the level of human capital. He recommended some policies suggested are host countries supporting education in source countries in the areas where they expect to need skilled labour in the future and instituting programs of temporary migration.

Other suggestions are the scholarships that the Government give to its citizens should be in a shorter period, scholarships given should be in areas that the countries are in need and suitable for labour market condition in the home countries. Also, one of many important things that the Government should consider is the support from the Government on public and private R&D centres. Some developing countries do not have enough subsidies on R&D in universities or institutions, and it causes lack of incentives to scientists and engineers, and hence, causes them to search for appropriate jobs abroad. This statement is supported by Gonzales (Gonzalez, 2010)who stated that the Government need to ensure adequate compensation and job opportunities.

However, in New Zealand, a desire for better remuneration and raise in economic situation are the only largest reasons that can be influenced by government's policies (Thorn, 2009). The decision of moving abroad or remain at home is still mostly influenced by individuals; however, government also contributes to the decisions that people make.

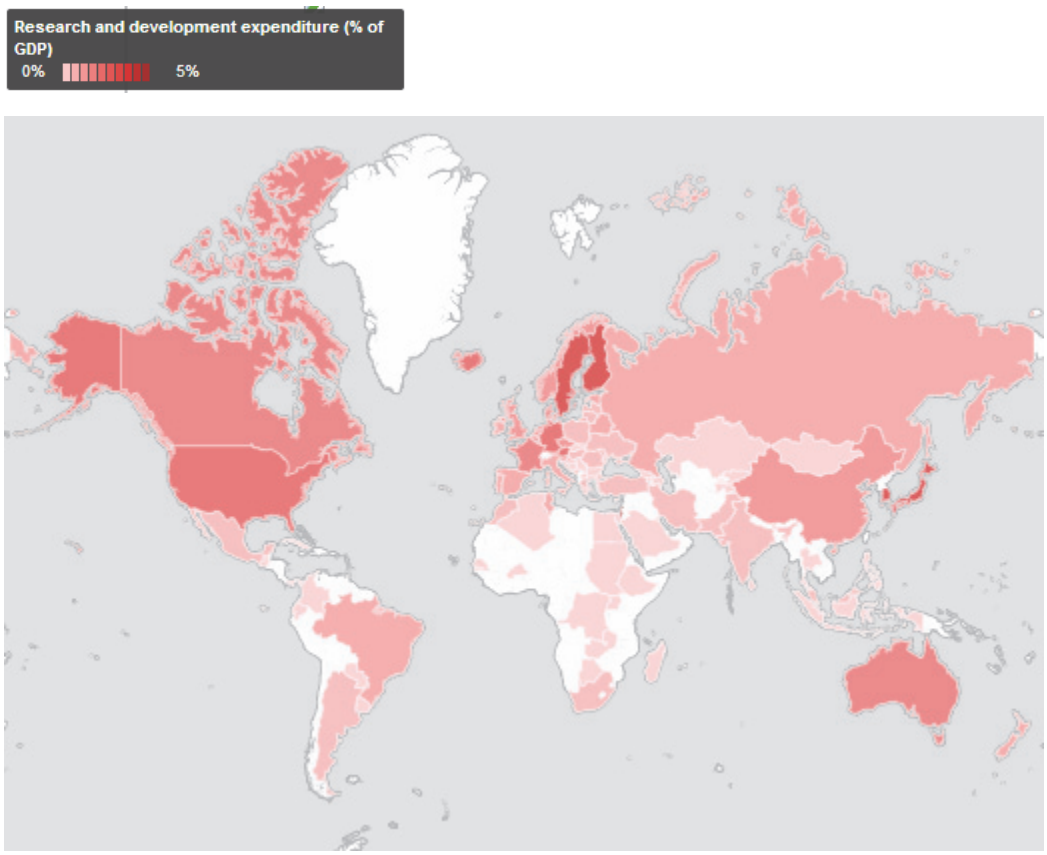

Figure 2-3. Government's expenditure for Research and Development (2008-2012
Source: (World Bank, 2014)

Governments cope with problems of migrating talented people in different ways. Adjusted to Indonesia's condition, not all policies from literature reviews can be applied in Indonesia considering the different political, economic, and social circumstances differing from other countries. Second, not all literature reviews considered the effects of the policies, whether it will achieve objective of their studies, and if so, again the circumstances cannot always be compared to Indonesia. It is clear that Indonesia government spent less on research and development expenditure compared to other countries, even Malaysia. The acknowledgment that research and development need in Indonesia exists, but with many specialists living abroad makes the optimal situation of government policies not met. Therefore, in this research, Indonesia government needs to review its policies and then simulate to know whether they will generate optimal effects on the movements.

3. SURVEY AND STATISTICAL ANALYSIS

This research conducted surveys on Indonesian students and professionals abroad in 2014. This survey was conducted in order to see things from the perspective of students and professionals abroad, which are two stakeholders in this research. Respondents were asked questions about themselves to know the demography of respondents, then they were asked about how important several elements are. Twenty elements were provided to the respondents. The last one was about their return intentions after graduation – for students, and eventually will return for professionals. Additional question about the reason of their decision was also asked. The total of respondents is 51 people consisting of 41 students and 10 professionals. More detailed information about respondents will be explained soon.

The statistical analysis in this chapter will be discussed in two parts: descriptive statistics and analysis of return intention.

3.1. **Descriptive statistics**

In this part, descriptive statistics is enlightened; it is important to understand the characteristics of the respondents in order to understand further of their answers. As previously mentioned, respondents consist of 41 students and 10 professional; the number of groups is not proportionate so there will be separated analysis – students and professionals. Overall, there are 37 males and 14 females and with different education background.

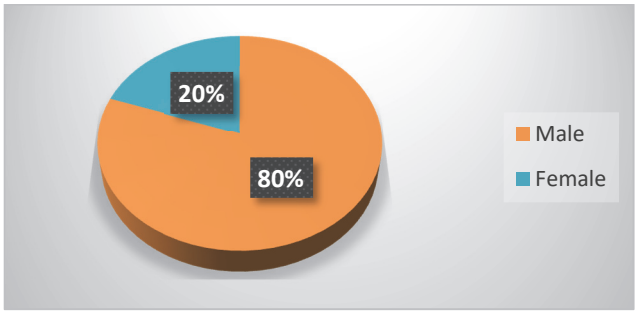

Figure 3-1. Respondent's gender

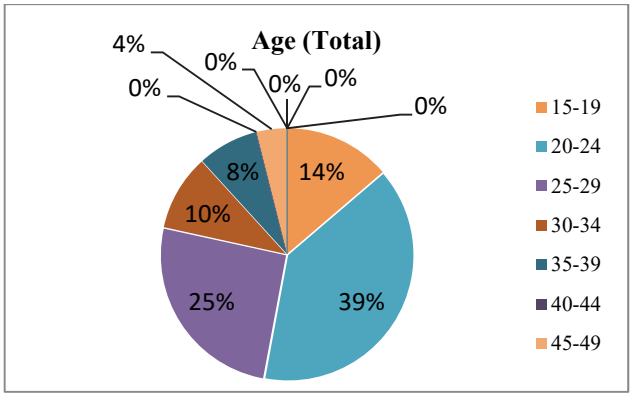

Figure 3-2. Range age distribution of respondents

The majority of respondents are between range of 20 to 24 years old, which explain that students hold the majority and most students are currently in bachelor programs, also leads to the status of marriage: almost 60 percent of respondents were not married. Most respondents also have hold bachelor degree, or currently pursuing bachelor degree studies, followed by masters and doctors. The country that respondents resided currently was in Indonesia, Japan, and Germany. The data collection was using purposive sampling, where respondents were currently pursuing or had been pursued higher education or tertiary education abroad (Bachelor, Master, Doctor). Not only that, the degrees that respondents must have were in science and technology area. That include science, engineering, medical research, and agriculture. Therefore, even though the countries were centered in several countries, it is hoped that it can represent the whole population. And since the exact population of Indonesian science and engineering students abroad and scientists and engineers abroad were unknown, this survey could be the foundation of opinions that respondents have.

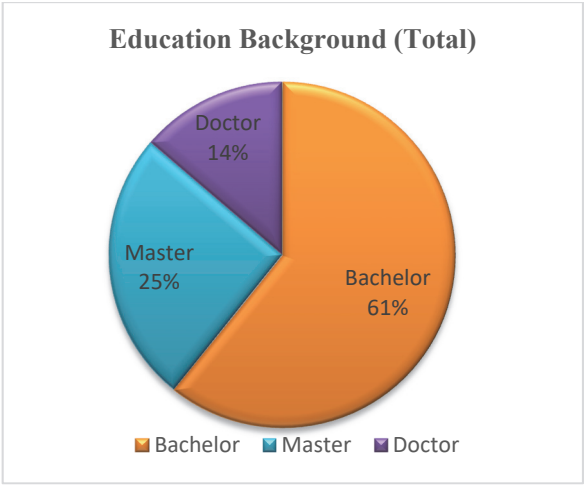

Figure 3-3. Education background of respondents

As explained previously, due to the different proportion between students and professionals, the writer separates explanation for students and professionals. For students, 70 percent of respondents were in bachelor students, followed by master students (16%), and the last were doctor students (14%). As for professionals, the largest respondents were graduated from master degree, followed by bachelor and then doctor. For professionals, this survey asked about their occupations. Large amount of professional respondents claimed they were not in the science and engineering occupations, since they put 'other'. Hence, even though they had education background from science and engineering but they did not work in their areas. The second major respondents claimed to be researchers, followed by academics, engineers, and no one claimed that the respondents were scientists. As how the background of this research enlightened, people who had graduated from science and technology fields choose to work in management level that have nothing to do with what they had learned, or being entrepreneurs. Most professional respondents had less than 3 years' experience; this also supported the overall respondents' age was mostly between 20 and 24 years old.

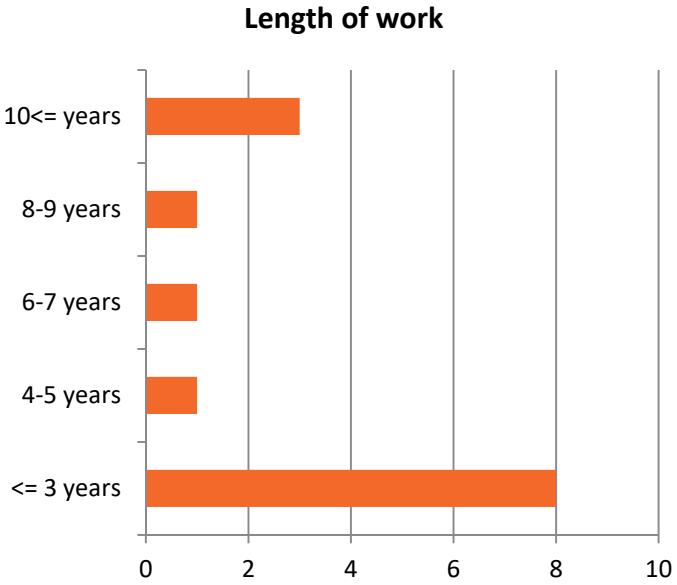

Figure 3-4. Length of work (Professionals)

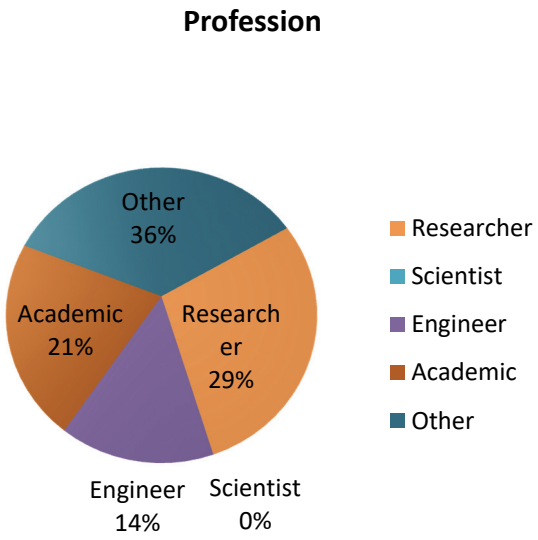

Figure 3-5. Respondent's occupations

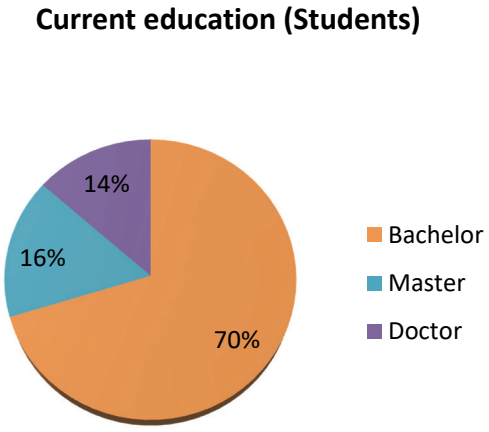

Figure 3-6. Education background (students)

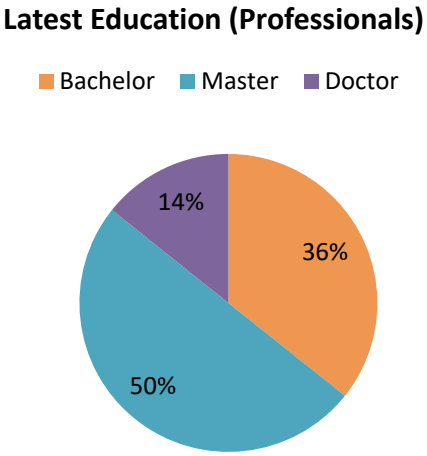

Figure 3-7. Education background (professionals)

3.2.Importance of variables

Aside from demography, the survey also provided twenty variables to be asked on their importance according to respondents to live in a country. There are twenty variables represent the condition in working or employment, a country's condition, and personal relationships. Respondents were obliged to fill in the number between 1 and 5 instead of put ranks because those variables might have similar weight to the

respondents. ‘1’ is the least important and ‘5’ is the most important. To analyse the data, the writer use simple descriptive statistics measuring the average of each variable from respondents. The 20 variables asked were:

1. Opportunity to work in suitable fields;
2. Surrounding's or general country's safety;
1. Easy communication with colleagues;
2. Equal opportunity for every religion;
3. Opportunity to work in desirable fields;
4. Distinct career path in workplace;
5. Financial and health support from employer;
6. Easy communication with family and friends;
7. Health support from the Government;
8. Equal opportunity for every race;
9. R&D budget;
10. Supportive community or neighbourhood;
11. Research field's variety;
12. Scholarship availability;
13. Area of specialization's variety;
14. Equal opportunity for every gender;
15. Political stability;
16. Average salary;
17. Strong culture or tradition; and
18. 20. Foreign investment / the amount of multinational companies in a country

First of all, top five variables (5 is the maximum value) were: opportunity to work in suitable fields; surrounding's or general country's safety; easy communication with colleagues; equal opportunity for every religion; and opportunity to work in desirable fields with values of 4.56, 4.44, 4.44, 4.42, and 4.42, respectively. As suspected, surrounding’s or general country’s safety and easy communication with colleagues have similar value of importance; as well as equal opportunity for every religion and opportunity to work in desirable fields. Meanwhile, this survey also listed down five least important variables for all respondents: Equal opportunity for every gender; political stability; average salary; strong culture or tradition; and foreign investment / the amount of multinational companies in a country. The number of the

values was 4.16, 4.06, 3.8, 3.44, and 3.38, respectively. Surprisingly, political stability and average salary did not reach top or at least middle range of importance. Thus, although it is too early to make any conclusion, to get high standard salary is not very important for respondents. The surprising part as well was when surrounding's or general country's safety and political stability were usually close related because the political stability in a country determines the country's security condition. Therefore, it is assumed that if people think political stability is important, then so is country's safety. Equal opportunity of every gender is low since the major respondents were male hence they do not have any problem with gender discrimination. The opportunity to work in suitable fields and the opportunity to work in desirable fields show that respondents have ambition to apply the knowledge that they received in the workplace. However, considering professional respondents did not have the occupations in science and technology fields, it can be concluded that since the majority of respondents were students, they still have idealism about their future. Communication with family and friends is important, but not as important as communication with colleagues. This may due to the advancement of Information and Communication Technology where people are easily connected with their loved ones through this technology. For bachelor students, important points were

The result from student respondents was slightly different from overall result. The top five variables were: Opportunity to work in suitable field; financial and health support from employer, easy communication with colleagues, surrounding's or general country's safety, and health support from the Government whose values were 4.55, 4.53, 4.48, 4.48, and 4.37, respectively. Financial and health support from employer, and health support from the Government indicated that students had concern of the support that their employer and their Government provide, especially in health issues (insurance or policies). Meanwhile, five least important variables for students were: Research field's variety, political stability, average salary, foreign investment / the amount of multinational companies in a country, and strong culture or tradition with the value of 4.08, 4.05, 3.82, 3.5, and 3.3, respectively. Research field's variety and foreign investment / the amount of multinational companies in a country were part of the least important. The logical reasoning behind this was presumably because it did not matter if students already know which field they were interested in. Also, if foreign investment / the amount of multinational companies in a country was not important, then the

assumption drawn from this result was that students might want to work in the domestic companies wherever they were planning to stay.

To be further broken down, for bachelor students, Opportunity to work in suitable field, Financial and health support from employer, and equal opportunity for every religion had highest value equally. While for master students opportunity to work in suitable field had the highest value, and for doctor students, health support from the government and financial and health support from employer had the highest values.

Viewpoint of students and professionals is supposedly different. As for professionals, the results were also different from students. The top five variables were: Equal opportunity for every race (4.8), research field's variety (4.67), opportunity to work in suitable fields (4.67), equal opportunity for every religion (4.67), and opportunity to work in desirable fields (4.6). Professionals were more concerned of the wellbeing of their families and themselves. Second, they preferred to be comfortable by working in their specialized fields and fields that they wanted. While five least important variables were: Financial and health support from employer (4.07), health support from the Government (4.07), average salary (3.87), strong culture or tradition (3.87), and foreign investment / the amount of multinational companies in a country (3.27). Similar to students, professionals thought that foreign investment / the amount of multinational companies in a country was the least important variables, which is surprising considering professionals had more experience and exposition of working and country's condition. Opposed from students, professionals thought that health and financial support from employer and health support from the Government were not so important. However, the values were still above 2.5, which were the median of the level, but among all provided variables these considered bottom five.

3.3.Return Intention and future plans

The third part of the statistics analysis is the about the return intention and future plans of the students. According to the survey, Indonesian students abroad had tendency to return to Indonesia by 55%. Although the tendency was to return home, students choose to remain abroad consisted almost 40% of the total sample. Therefore, it is likely for students to change their decision from returning to Indonesia to remaining abroad after they graduated.

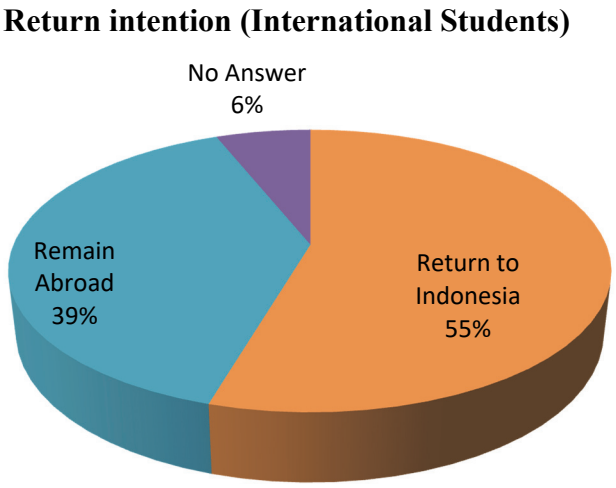

Figure 3-8. Students: return intention

Moreover, when they were asked about their future plan, the survey provided several options:

1. Working in a university according to specialization;
2. Working in a government institution according to specialization;
3. Working in a private company according to specialization;
4. Working in a government institution in the management or administration department;
5. Working in a private company in the management or administration department;
6. Continuing studies, and;
7. Other

The result showed that largest proportion of students would like to work in a private company according to their specialization. The second largest showed to continue their studies, then work in a government institution according to their specialization, 'other' option, working in a university, working in a government institution in the management or administration department, and the last was working in a private company in the management or administration department. Especially for science and engineering students, how they would work and which position determined their plans. Students would like to be able to practice the knowledge and skills that they gained while pursuing their studies. Only small portion chose to work in management or administration department, which showed that if many graduates work in the

management or administration department, it was because either they want to or they have no choice but to search for managerial position. Many respondents also chose to continue their studies; this linked to the fact that most respondents were in bachelor level, and then it was likely for them to continue their studies then searching for jobs. As for 'other' option, some respondents chose to continuing their parents businesses or being an entrepreneur.

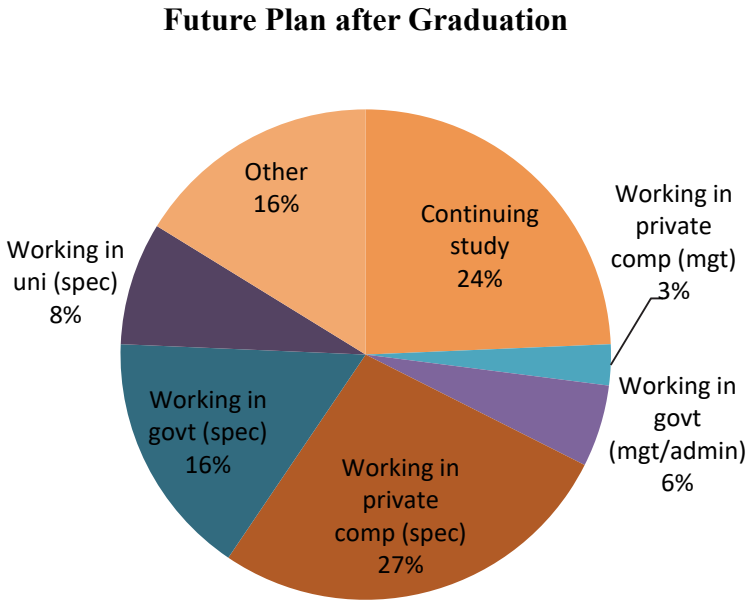

Figure 3-9. Students: Future plans

This survey also asked why they choose to remain or return. From the side of respondents who planned to return, the reasons mainly were because of their families and to help develop Indonesia. Another claimed that it was the right thing to do, and some claimed that it was easier to search jobs in Indonesia with education background abroad. The last reason was because of scholarship caused the obligation of respondents to return home. While there were reasons to return, there were reasons to stay. Most respondents would like to have working experience abroad or to continue their studies. Others said that the country they studied had good working condition and overall good country's condition in which they felt comfortable.

3.4.Binary Logistic Model

In order to be able to further analyse the result of questionnaire, binary logistic model is used as an appropriate tools. Binary logistic model is utilised as a reason to

understand what makes our respondents return to Indonesia or not, whether they finish their studies or as a professionals. We linked our respondents on their answers whether they have intention to return home with what factors that are important for them to live in a country. Here, we tried to analyse how importance factors to them actually influence their decision making. However, to conclude all 20 factors is difficult to manage; therefore, we included two variables: career path and political stability (represented by general country security). Although, according to the survey, political stability is in the bottom five of importance to live in a country, political stability is a strong factor for people to migrate internationally (Fatah et *al*. (2012), Bertocchi & Strozzi (2008)). Aside from that, top five factors indicate that health support from the government is important, which cannot be supported if the stability of political condition is not strong. Meanwhile, according to the support social and economic development internally, career path is considered as the most important variables. Career path is also listed in the least important variables. However, career path is considered to be important more to professionals than students. In conclusion, why career path and political stability (or general safety) were chosen was because those two factors have direct impact on someone's life, academically and professionally. Technically, when we computed the correlations, those two factors emerged as the most independent; as a preliminary test before conducting the binary logistic model, independent variables are required to have low correlations.

As for the returning intentions, in this model, the dependent variables, 0 (zero) is indicating as staying in Indonesia while 1 (one) is indicating to stay abroad. Choices to stay in Indonesia or abroad are characterised by these rules:

1. For students abroad, the choice is whether to return home or remain abroad after they graduate.
2. For students in Indonesia, the choice is whether to remain in Indonesia or move abroad after they graduate.
3. For professionals abroad, the choice is whether to return home or remain abroad for their future plan (the next 3 - 5 years).
4. For professionals in Indonesia, the choice is whether to remain in Indonesia or move abroad for their future plan (the next 3 - 5 years).

To analyse this, we use SPSS software. Table 3.1 shows the classification table of step 0 when variables are not yet included in the calculation. It shows that overall percentage is 66 percent, which means that the choice of people staying in Indonesia will be correct 66 percent of the time. Next, we will see the comparison between Table 3.2 where variables are not included and Table 3.3 where variables are included to see whether the adding of variables will increase the percentage of accuracy, with choice to stay in Indonesia (indicated by 0) by 93.9 % and choice to stay abroad (indicated by 1) by 17.6%; and results the overall percentage of 68%. Therefore, these designate that the model is better than not having variables included at all.

Table 3-1. Classification table[a,b]

Observed			Predicted		
			Staying intention		Percentage correct
			0	1	
Step 0	Staying intention	0	33		100
		1	17		0
	Overall percentage				66

a. Constant is included in the model.
b. The cut value is 0.500

Table 3-2. Classification table (2) [a]

Observed			Predicted		
			Staying intention		Percentage correct
			0	1	
Step 1	Staying intention	0	31	2	93.9
		1	14	3	17.6
	Overall percentage				68

a. The cut value is 0.500

Table 3-3. Variables in equation

							95% C.I for EXP (B)	
	B	S.E	Wald	df	Sig.	Exp (B)	Lower	Upper
Career path	1.096	0.602	3.321	1	0.068	2.993	0.921	9.73
Political stability	-0.551	0.35	2.481	1	0.115	0.576	0.29	1.144
Constant	-3.42	2.646	1.671	1	0.196	0.033		

a. Variable(s) entered on step 1: Career Path, Political Stability

-2 Log Likelihood scores 57.682; Nagelkerke R square indicates that the model has 16.7 percent relationship between predictors and prediction. Based on chi-square test (p = 3.950 with degree of freedom 5), the model shows that variables in this model

is not independent. However, the correlation between political stability and career path is small and negative. The Hosmer and Lemeshow test shows that this predicted model is not significantly differ from the observed case (Significance = 0.557). The result still indicates that there is almost certainty that students and professionals choose to stay in Indonesia when they are educated or living in Indonesia, or moving to Indonesia after they are educated or living abroad. Although the significance test is not what is expected, this result will be essential on the relationship between career path and political stability, and the decision of respondents to stay in Indonesia. For career path variable, the odds for people to move or stay abroad are almost 3 times. Meanwhile, the increase of one unit of political stability will increase the chance of people to stay abroad by 50% (Inayati et *al.*, 2014).

4. INTERVIEWS

Survey analysis in the previous chapter was explaining about the condition and preferences from the view of students and professionals. While from the point of stakeholders in the form of institutions, survey or quantitative approach seems to be inappropriate. To understand from their side, qualitative approach is suitable. Therefore, in this chapter, approach in the form of interviews, observation, and several online forum that can be considered as the narrative foundation of this research as well. This chapter will be divided into several parts: (1) Interviews, (2) online forum, and (3) observation. Besides interviews, writer also collected statistical data in annual the report from The Ministry, The agency, and the academy.

4.1. Interviews from perspectives of governments and Indonesian scientists and engineers in Indonesia

In order to understand the condition of a country, opinions from the people who actually work for the government is needed; it will help understand the current condition, plans, and policies that cannot be explained by numerical data, aside from the lack of data that Indonesia has related to this topic. In this part, interviews with Ministry of Foreign Affair, Agency for Assessment and Application of Technology (BPPT), and Indonesian Institution of Science (LIPI) will be clarified and concluded.

The interviewee from The Ministry of Foreign Affairs was the representative of Service and Protection of Indonesian citizens & Indonesia's Legal Advisory Abroad (*Pelayanan dan Perlindungan WNI & BHI di Luar* Negeri). The first thing to know when interviewing with The Ministry of Foreign Affairs was that according to them, there is no specific policy aiming at the outmigration of students and professionals. So far, because the outmigration of Indonesians was mostly of blue-collar workers (domestic help and factory labour), the outmigration of white-collar workers was not the main concern because they were thought to be more independent and could take care of themselves. Problems usually arose regarding blue-collar workers, such as illegal migration and human trafficking. Second, The Ministry did not know well how many Indonesians were abroad. To get the real data, they must access immigration data in destination countries, which is impossible unless given by destination countries since it is the matter of nation's confidentiality. Therefore, the data that can be provided by

The Ministry is only how many people register to Indonesian embassy abroad. The Ministry also does not have historical data; they only have current or real time data so that the increase or decrease of Indonesians who go to the country or return home from that country is unknown. The lack of data even The Ministry has is horrendous, given that it is impossible to decide which policies to make if there is no concrete data that can back up the policy making.

The only available data that The Ministry has was also divided into areas of the world instead of each country: East and South East Asia, South and Central Asia, Middle East, Africa, North and Central America, South America, Western Europe, South East and East Europe, Oceania, and Caribbean. Also, the categories of Indonesians abroad's occupation are also limited to certain types of occupations: (1) Non-labour (university students), (2) domestic helper, (3) mining (oil, gas, gold, etc), (4) health, (5) manufacturing industries, (6) information technology, (7) education, (8) international organization, (9) hotel and tourism, (10) finance, (11) legal/law, (12) fashion industry, (13) entrepreneurship, (14) art and culture, and (15) electronic media. It was unknown why those categories were the only categories that The Ministry had; rational excuse was because Indonesians registering in Indonesian embassies abroad were working in those areas only. That is why, to know the exact number of Indonesians abroad based on their occupations and countries of residence are still impossible for the moment. One example, The Ministry had data of current university students 3341 people, while according to UNESCO there are almost 40,000 Indonesian students abroad. This leads to a very large discrepancy between data.

As explained previously, since the outmigration of white collar workers, especially scientists and engineers, was not considered harmful by the Government, so far there is no plans or policies to attract them home. One policy was to introduce dual citizenships, but it is still a plan. Second policy is if scientists and engineers who were previously holding Indonesian nationality but change their nationality would like to conduct a research in Indonesia, they would receive a privilege by permitting their stay longer and easing research permit than scientists and engineers who were not. As for Indonesian students abroad, although The Government supports Indonesian students abroad, how to allure them to return home is in question. So far, The Ministry annually go to destination countries where there are a big proportion of Indonesian students there. They give seminars to Indonesian students that hopefully can make students interested

to return home, despite of destination countries able to offer more than Indonesia. There has not been a research or conclusion whether this way is effective or not, but eventually The Ministry realised that there are so many Indonesian students abroad who are not registered because they study using personal financing. And this might be a problem in the future if there is more Indonesian students remaining abroad than returning after they graduate. Even when Indonesian scholarships require Indonesian students to return to Indonesia or they will face a large amount of fine if they do not, this policy is not considered important, since employers where they work often pay for the fine. The Ministry also mentioned diaspora Indonesia, however the effects are unknown.

The second object of interview is an Indonesian institution called Agency for Assessment and Application of Technology (BPPT), which specialised in science and technology. There are three people interviewed in this agency, henceforth are the conclusions drawn from the interviews. In this agency, there are more engineers than scientists; scientists are mainly positioned in Indonesian Institution of Science (LIPI). According to the interviewee, how researchers decide whether to return or remain was only by personal experience, and evidently more of those who return than remain. One engineer mentioned that he, at that time, was not thinking to remain because he already has a family and he thinks that his family would be happier in Indonesia. And why he went abroad to pursue his doctoral degree was mainly because of 'prestige' studying abroad even though the university was not as good as in Indonesia.

Meanwhile, the number of engineers in BPPT does not have significant escalation. This happens for two reasons. First, the agency cannot propose the increment of human capital because of the provided budget by the Ministry of Finance to it. Second, the recruitment of new human capital is not to actually increase the number of engineers, but to substitute retired or deceased engineers. And speaking of recruitment, the process of the agency to recruit new employees is similar to any government's departments. The difference is only the education backgrounds for recruits have to be compatible with the research fields; and so far there was no difficulty in recruiting new engineers aside from physics.

The allocation of R&D budget is equal and according to the application for extra funds needed for each research field. Thus, so far there is no research field that excels more than others. Looked from the perspective of a scientists and engineers in this

agency, R&D budget is very small. Even with the small budget for the agency, the budget for the actual research and development is even smaller because the budget was not fully funding the research but it was also for operational costs (electricity, water, etc). The current government is not considered supporting research activities; instead it is focusing more to the infrastructure, which a scientist said it is okay as long as the infrastructure can be equal. However, government's R&D expenditure was not the only source of R&D, international collaboration with other international research institutions. However, scientists and engineers think that the government should make a policy about how to receive more funds for research activities that in the end will increase the technology development in Indonesia. They suggested that the Government should make a policy to require private industries and companies to set aside companies' profits for Indonesia's research activities as part of their corporate social responsibility program. However, this is a problem because the relationship between agency and industries is not built strongly; therefore, this can be the way to increase research productivity in Indonesia.

A scientist in this agency mentioned that another reason why research productivity was not as good as other countries was because of language border. It is more difficult and longer for scientists to create scientific papers with English language and compete internationally. As for engineers, most patents were produced in this agency. However, only two to four percent of applied patents are accepted.

The last one is from interview with one of scientists in LIPI and who are currently studying abroad. He continues his doctoral studies abroad while his bachelor and master studies were in Indonesia. He studied in The Netherlands by the scholarship from Ministry of Research and Technology and Higher Education (*KEMENRISTEK*). The academy supports its scientists to study abroad. When asked if the fine if graduates do not return home, he explained that this policy is not effective, which support the statement from The Ministry. He thought that students who study abroad when returning to Indonesia is possibly could not apply his knowledge and skills because the facilities were not advanced enough. Or even worse, does not exist. He also thought that Indonesians should bring Indonesia's name abroad when they would like to create scientific publications, hence do not have to directly contribute to Indonesia's development, because until now the science institution has little effect to the development of Indonesia. He personally thought that if the academy allowed him to

not return as soon as he graduated, he would like to work abroad first. He also complained about not having opportunity to work in the field that he desired, this is due to the narrow options of research fields in the job market in Indonesia.

5. SYSTEM DYAMICS MODEL AND SIMULATION

After Conducting surveys and interviews, writer seeks for secondary data that cannot be found through those methods in order to complete the simulation of the model, which is the final research step. System dynamics is one of simulation tools that can be used for simulating real condition by using constructed model. One of the advantages of using system dynamics is to combine quantitative and qualitative data in one model. This research cannot use only quantitative approach because it relates to the policy measurements. It includes levels and parameters that can be answered only by the involving authorities. Therefore, The policy is an important part of the model and the simulation, because simulation only is not useful without what policies to be suggested, at least in this research. Also, why this research uses system dynamics is because Indonesian government almost had never made policies based on a visible results. This research can be utilised as an example of how to used model and simulation to help generate public policies.

System dynamics fundamentally has three steps: constructing causal loop diagram, constructing stock and flow diagram, and conducting simulation by available data and measurements. Therefore, this chapter will be divided into three parts from what have been discussed.

5.1. Causal Loop Diagram

The first step is to realize the variables and their relationships in the context of this topic and especially in the context of Indonesia. Since there are not many previous researches in this area, the writer decided to collected literature reviews from research from other geographical context, with the adjust of knowledge about Indonesia. The reason that system dynamics exists is because it should simplify what happen in the complex real world. Therefore, it is not necessarily useless to work on simply model if it can accurately picture the real world condition – at least nearly accurate.

Causal loop diagram is called so because the relationships would eventually loop to the beginning of the diagram. The diagram fundamentally explains the movement of higher education students abroad and the number of scientists and engineers abroad and factors influencing them. The number of human capital does not significantly define the level of their quality; this happens in countries that are already

developed. However, right now Indonesia lacks of it, quantitatively. Therefore, it is better to have as many human resources as it can. Aside from the number of students and professionals, the diagram also explains on the productivity and leads to technology development that eventually leads to economic development and then goes back to the number of the number of students abroad.

First of all is the number of students abroad. The number of students is influenced by the individual financial capability, gap in economic condition, gap in scholarships, and gap in education quality. The reason why there are many gap variables is because the condition of destination and source countries must be influencing; the more the gap, the more people will move to the higher level. Hence, it is logical to use push-pull theory (Lee, 1966). Economic condition in source country (SC) influences the individual financial capacity, because the financial sources for Indonesian students to study abroad are not only coming from scholarships given (from Indonesian government or abroad). In the Netherlands, the majority of Indonesian bachelor students (95% of questionnaire's bachelor students' sample) were financially supported by their parents. However, it is different case compared to postgraduate students who were mostly supported by sponsors or scholarships.

Second is the number of scientists and engineers (S&E) abroad. Students who pursue education abroad will graduate and they will have the choice of whether they will return or stay abroad. Why in this diagram the number of students and scientists and engineers in Indonesia are not included is because the focus is the movement of people abroad. The factors that directly explain the number of S&E abroad are gap in R&D expenditure, gap in technology development, and distance. Here, distance is not only defined as geographical distance, but also emotional distance between a person and their home country. For scientists and engineers, it is important to have enough funds to generate technology improvement in the country, also not to mention the advanced facilities provided to do research activity, either by the government or by the institutions. Technology development in destination country (DC) is influenced by the government role by inventing jobs specific in the research fields. To create it, supporting immigration policy highly influences the specialised jobs. Take example, The United States: this country implements H1B visa specially made for people with talented and specific skills and knowledge. This is created to attract more international scientists and engineers to work there. And combined with cutting edge research

facilities, The United States has become one of the most technology-developed countries that produce significant amount of patents.

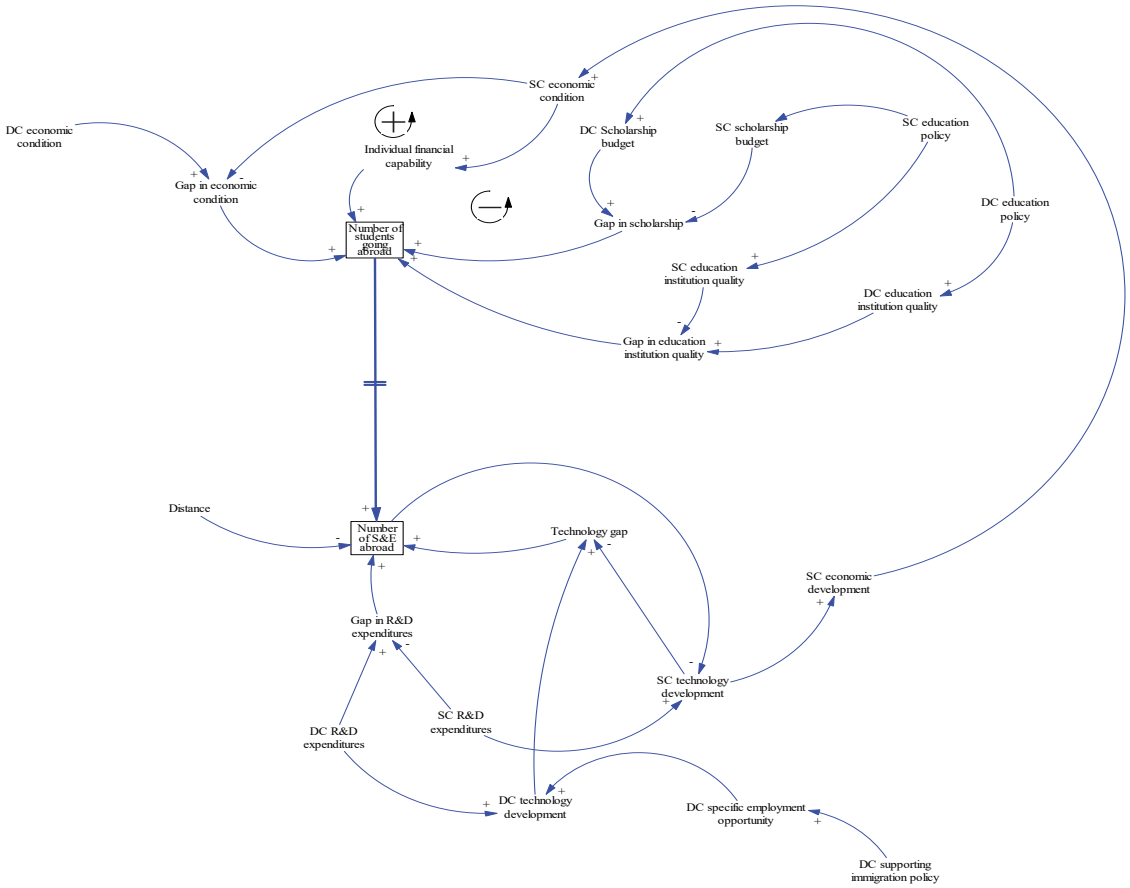

Figure 5-1. Causal loop diagram (Inayati et. al, 2016)

The number of scientists and engineers abroad will decrease the number of graduates from abroad in Indonesia; hence will influence the technology development in source country. When the technology development drops, the economic development theoretically decreases as well. The decrease in economic development leads back to the economic condition in source country and then influences the number of Indonesian students abroad. This diagram has three loops: one reinforcing and two balancing.

5.2. Stock and Flow Diagram

Stock and flow diagram's function is to construct more detailed diagram. In stock and flow diagram, variables are differentiated as stock, flow, and converter. In this part, numerical inputs to represent data and level of measurements are being cleared.

However, before discussing about parameters, the explanation of the diagram itself will be presented in this sub chapter.

The stock and flow here are Indonesian undergraduate students enrolled in Indonesia (represented as Ina Undergraduate Students), Indonesian postgraduate students enrolled in Indonesia (represented as Ina Graduate Students), Indonesian undergraduate students enrolled abroad (represented as Ina Undergraduate Students), Indonesian postgraduate students enrolled abroad (represented as Abroad Postgraduate Students), High-skilled Indonesians in Indonesia (represented as ABR HS) high-skilled Indonesians abroad (represented as INA HS), patents (represented as Patents Ina), and economic condition (represented as Ina economic condition.).

As discussed previously, the number of high-skilled workers consists of professionals who are having educational background in S&T fields and working within the fields that they are major in. These professions include teachers, researchers, scientists, engineers, and others. To understand the number input or parameter and the data source that we used in order to run the simulation, we can refer to Appendix B.

What we would like to comprehend are the number of Indonesian undergraduate students in Indonesia, Indonesian undergraduate students abroad, Indonesian postgraduate students in Indonesia, Indonesian postgraduate students abroad, high-skilled worker in Indonesia, high-skilled workers abroad, patents in Indonesia, and GDP growth. Meanwhile, to understand the process of stock and flow diagram, below is the breakdown of stock and flow for every process:

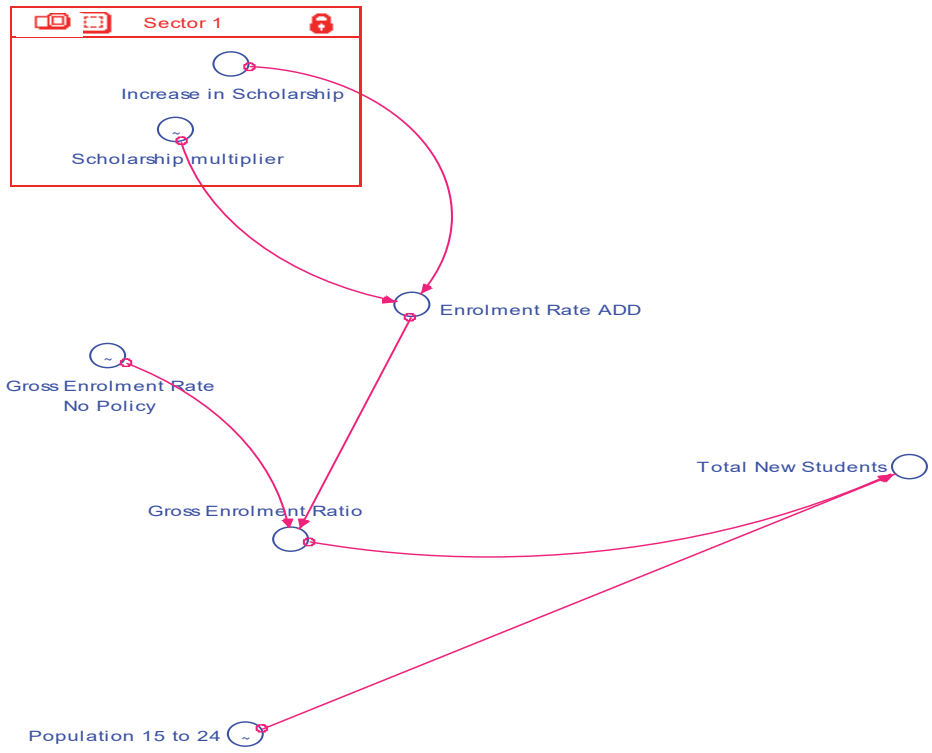

Figure 5-2. Process of enrolment

Sector one is the policy scenario about increase in scholarships. Increase in scholarships hypothetically will increase the number of applicants, hence, the rate of enrolment. Then with the increase of gross enrolment rate, total new students will also increase.

$$If\ E_{add} \leq 0.15, GER = GER_0.\quad Else\ GER_0 + E_{add} \qquad 2$$

GER = Gross enrolment ratio

GER = Gross enrolment ratio (no policy)

E_{add} = Enrolment added for policy policies

$$T = GER * P \qquad 3$$

T = Total new students

GER = Gross enrolment ratio

P = Population between 15 to 59 years old

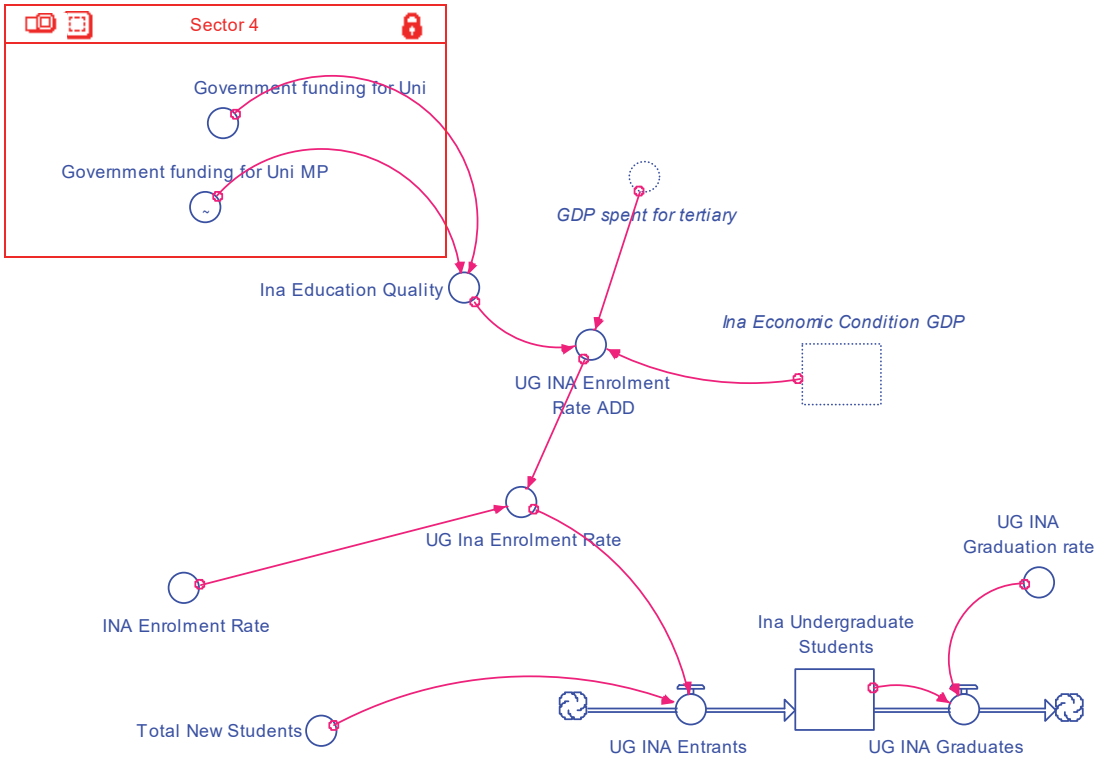

Figure 5-3. Stock and Flow of Indonesian undergraduate students in Indonesia

Sector 4 means the policy scenario that will be optimised in policy scenario that later on will be explain further. This policy is used to make a concern on the education quality, especially in higher education. GDP spent for tertiary means the GDP spent for tertiary education based on GDP of Indonesia. Education quality, GDP spent for tertiary education and GDP influence Undergraduate enrolment in Indonesia. The addition of policy will add the number of enrolment, hence increase the number of Undergraduate students each year. The formulas in the figure 5-1 will be explained below:

$$\boldsymbol{A = E_q * (\frac{B}{D})} \qquad \textbf{4}$$

A = the addition for enrolment in Indonesia undergraduate

E_q = Education quality

B = GDP spent for tertiary education

D = GDP

$$\boldsymbol{E_a = (T_i * I_u * I_s) + A} \qquad \textbf{5}$$

E_a = The undergraduate students in Indonesia's enrolment.

T_i = Total enrolment of students in Indonesia

I_u = The proportion of undergraduate students in Indonesia

I_{us} = The proportion of enrolment students in S&T fields

A = the addition for enrolment in Indonesia undergraduate

$$C_a = T * E_a \quad (6)$$

C_a = New enrolled undergraduate students

T = Total new students

E_a = The undergraduate students in Indonesia's enrolment

$$G_a = U_i * R_a \quad (7)$$

G_a = Undergraduate graduate students in Indonesia

U_i = Undergraduate students in Indonesia

R_a = Undergraduate students graduation rate

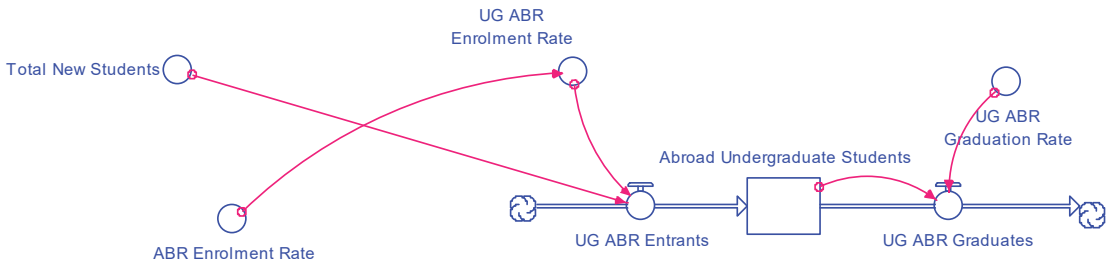

Figure 5-4. Stock and flow of Undergraduate students abroad

$$E_b = T_a * A_u * A_{us} \quad (8)$$

E_b = The undergraduate students abroad enrolment.

T_a = Total enrolment of students abroad

A_u = The proportion of undergraduate students abroad

A_{us} = The proportion of enrolment students in S&T fields

$$C_b = T * \square_b \quad (9)$$

C_b = New enrolled undergraduate students abroad

T = Total new students

E_b = The undergraduate students abroad enrolment

$$G_b = U_a * R_b \quad (10)$$

G_b = Undergraduate graduate students in Indonesia

U_a = Undergraduate students abroad

R_b = Undergraduate students graduation rate (abroad)

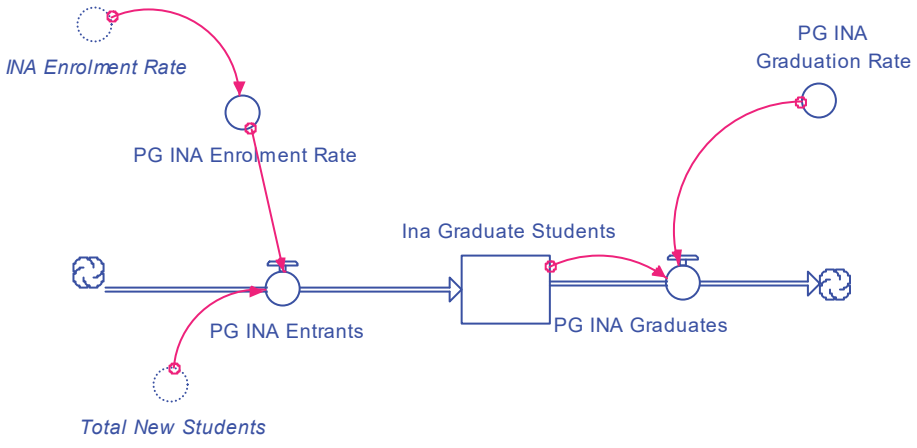

Figure 5-5. Stock and flow diagram for Postgraduate students in Indonesia

$$E_c = T_{ip} * I_{\square} * I_{ps} \quad (11)$$

E_c = The undergraduate students in Indonesia's enrolment.

T_i = Total enrolment of students in Indonesia

I_p = The proportion of postgraduate students in Indonesia

I_{ps} = The proportion of enrolment students in S&T fields

$$C_c = E_c * T \quad (12)$$

C_c = New enrolled postgraduate students in Indonesia

T = Total new students

E_c = The postgraduate students in Indonesia's enrolment

$$G_c = I_p * R_c \quad (13)$$

G_b = Postgraduate students in Indonesia

I_p = Postgraduate students in Indonesia

R_c = Postgraduate students graduation rate (Indonesia)

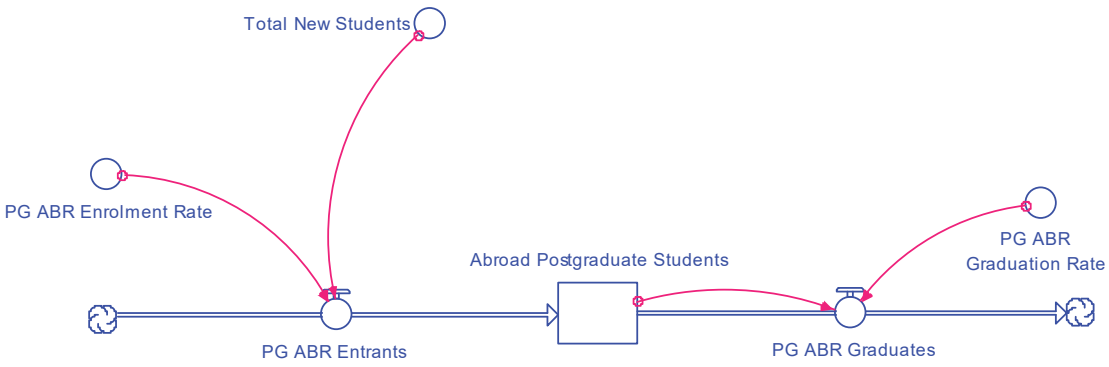

Figure 5-6. Stock and flow diagram of postgraduate abroad

$$E_{\square} = A_p * \left(T_a + \left(t * G_{ap}\right)\right) * A_{ps} \quad (14)$$

E_d = The postgraduate students abroad enrolment.

T_a = Proportion of total enrolment of students abroad

t = Time

G_{ap} = Growth in postgraduates students abroad

A_p = The proportion of postgraduate students abroad

A_{ps} = The proportion of enrolment students in S&T fields

$$C_d = T * E_d \quad (15)$$

C_d = New enrolled postgraduate students abroad

T = Total new students

E_d = The postgraduate students abroad enrolment

$$G_d = P_a * R_d \quad (16)$$

G_d = Postgraduate graduate students in Indonesia

P_a = Postgraduate students abroad

R_d = Postgraduate students graduation rate (abroad)

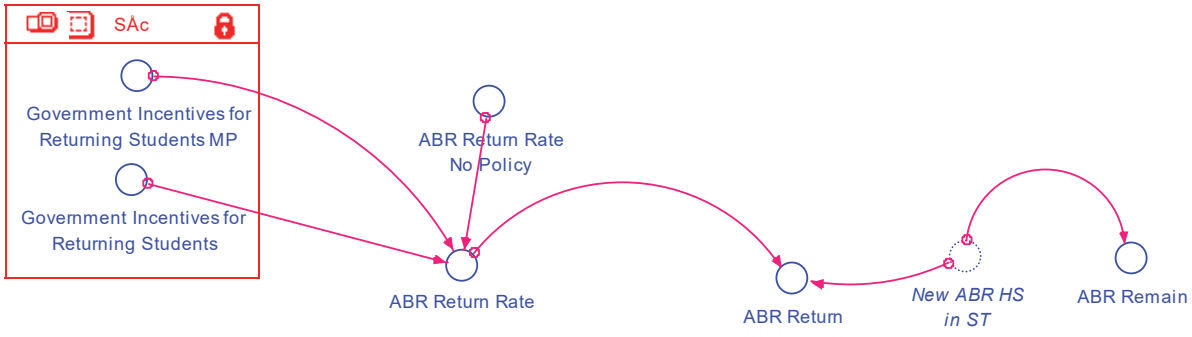

Figure 5-7. Returning or remaining flow of students abroad

After undergraduate students and postgraduate students finish their studies, they face the decision whether they would like to return or not. Here, the opinions of students are important. That is why, based on the questionnaire conducted and explained in the previous chapter, author put the proportion of students who planned to return and how many to remain. The result shows that 55% of students would like to return, while we assumed the rest would remain. Therefore, author set this rules on return rate for abroad graduates:

$$If\ S \leq 0.075, K_a = F.\ \ Else\ K_a = S + F \quad (17)$$

S = Government Incentives for Returning Students * Government Incentives for Returning Students MP

K_a = Return rate of abroad students

F = Return rate of abroad students (no policy)

With the policy, it is expected that Indonesian government can increase the rate with the number of total of returning students' formula as follows:

$$W = K_a * M \quad (18)$$

W = Number of returning students

M = Total abroad graduates

K_a = Return rate of students abroad

$$L = M * Z_a \quad (19)$$

L = Number of remaining students

M = Total abroad graduates

Z_a = Remain rate of students abroad

The same formula works for graduates in Indonesian universities who go abroad and stay. However, it is presumed that the number of graduates who work abroad only comprises of one percent of the total graduates.

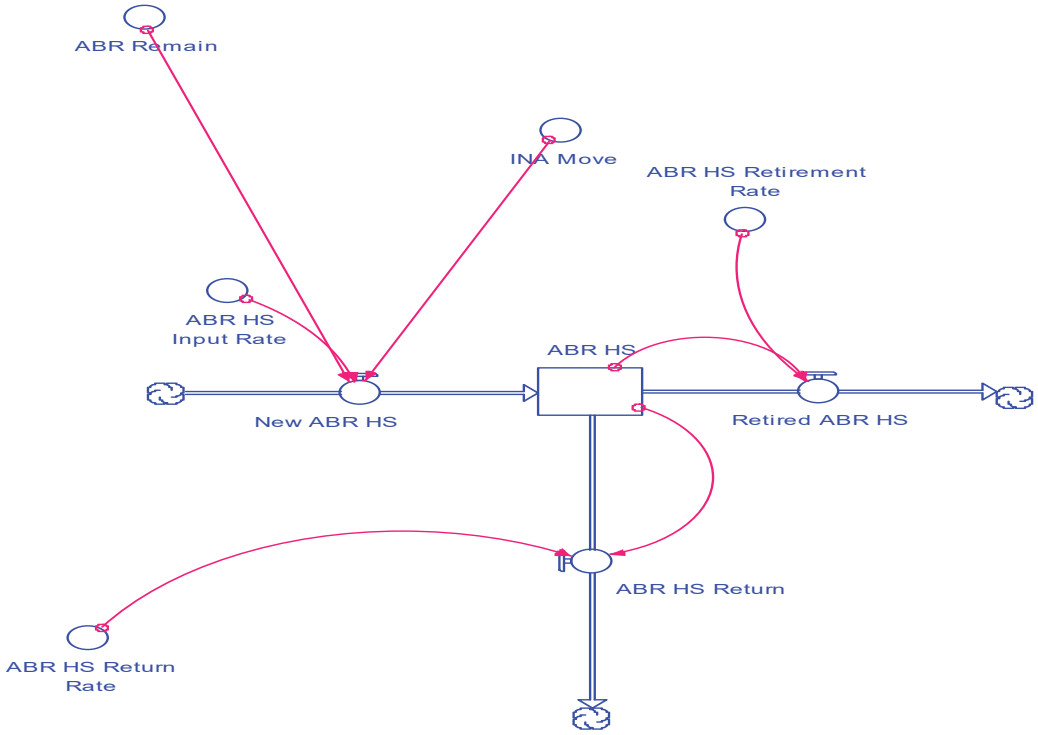

Figure 5-8. Stock and flow diagram of high-skilled workers abroad

The diagram of stock and flow has similar system as students. Therefore, the basic formula is also similar.

$$\boldsymbol{H_a = O_a * (W + J)} \qquad \textbf{20}$$

H_a = New high-skilled workers abroad

O_a = Input rate of high-skilled workers abroad

W = Number of remaining students

J = Number of moving students

$$\boldsymbol{B_a = HS_a * Q_a} \qquad \textbf{21}$$

B_a = Retired high-skilled abroad

HS_a = High-skilled workers abroad

Q_a = Retirement rate (abroad)

$$\boldsymbol{HS_{ret} = HS_a * RR} \qquad \textbf{22}$$

HS_{ret} = Returning High-skilled workers abroad

HS_a = High-skilled workers abroad

RR = Return rate

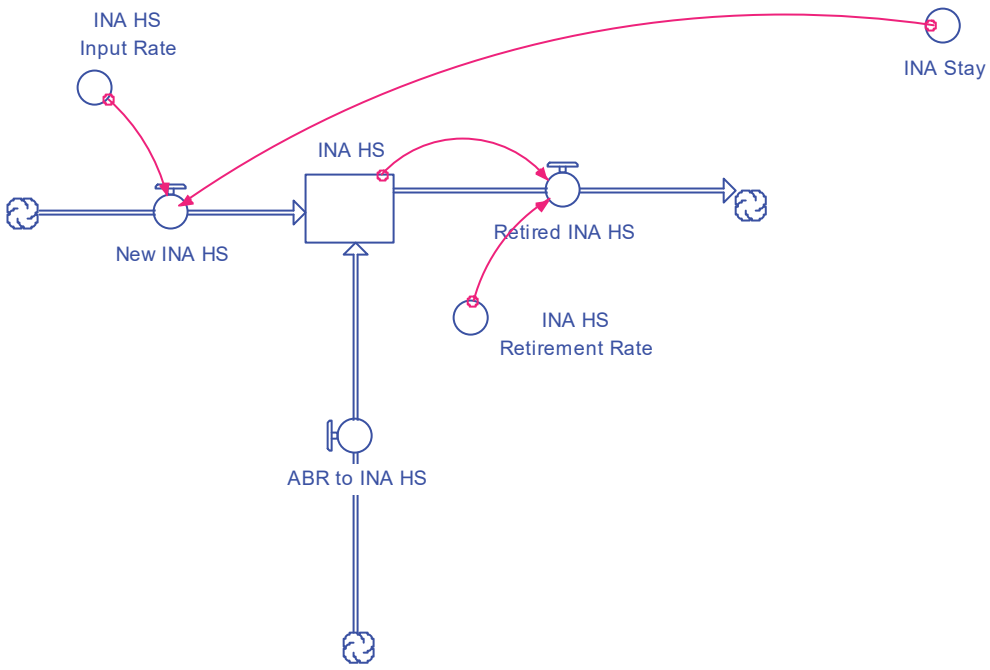

Figure 5-9. Stock and flow of high-skilled workers in Indonesia

High-skilled workers in Indonesia comprises of scientists, engineers, lecturers, and researchers. However, to conduct this simulation, it is difficult to collect the data, current and historically. Therefore, author combined the only data available from the government.

$$\boldsymbol{H_i = O_i * (X + N)} \quad 23$$

H_i = New high-skilled workers in Indonesia

O_i = Input rate of high-skilled workers abroad

X = Number of returning students

N = Number of staying students

$$\boldsymbol{B_i = HS_i * Q_a} \quad 24$$

B_i = Retired high-skilled Indonesia

HS_i = High-skilled workers in Indonesia

Q_i = Retirement rate (Indonesia)

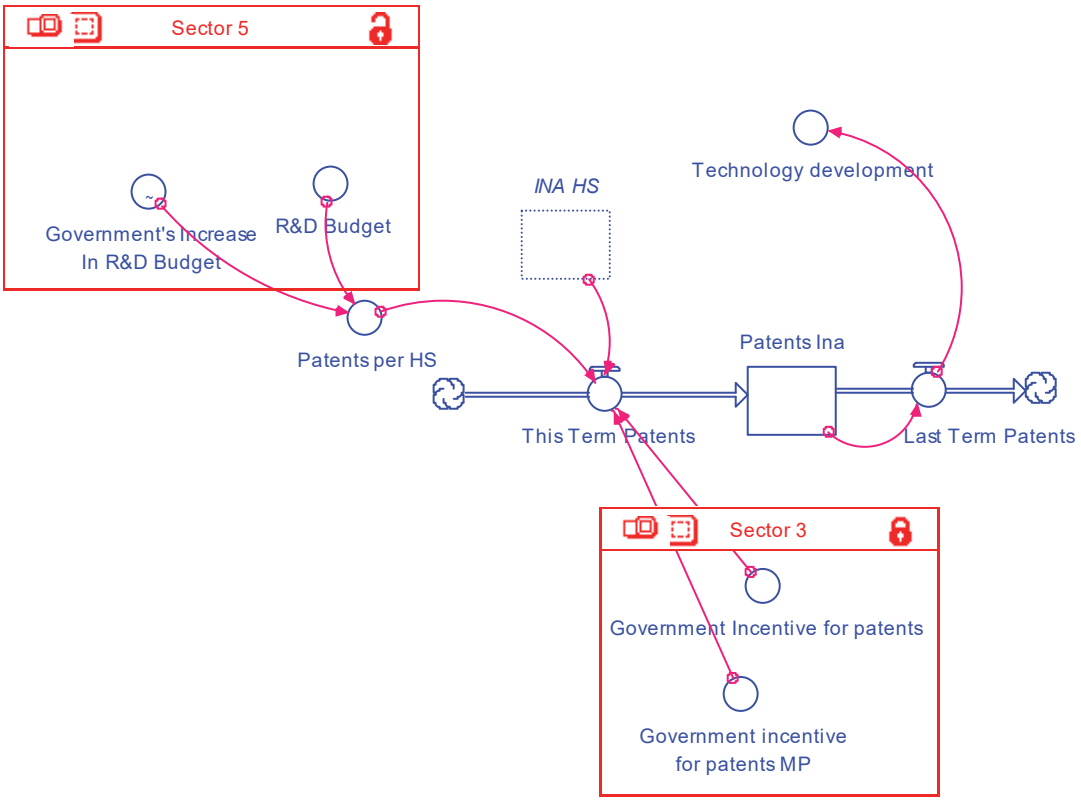

Figure 5-10. Stock and flow of patents in Indonesia

There are two policy scenarios relating to the production of patents in Indonesia: Incentives for patents produced, and increase in research and development expenditures. The latest data, R&D expenditure was on 0.09%, which is considered very low. Incentives for patents have not been implemented yet, but hypothetically will increase the number of patents. The number of patent is expected to increase technology development. In this diagram, technology development is represented by Technology Achievement Index (TAI). So far, the available data for TAI is in 2015.

$$PT_n = RD * RD_t * 2.2 \qquad 25$$

RD = R&D expenditure

RD_t = R&D expenditure increase

PT_n = Patents produced by every high-skilled workers

$$PT_i = (HS_i * PT_n) + (PAT * PAT_t) \quad (26)$$

PT_i = New patents

PAT = Incentive of patents

PAT_t = Increase of incentive for patents

PT_n = Patents produced by every high-skilled workers

HS_i = High-skilled workers in Indonesia

$$TD = LP * 0.017 \quad (27)$$

TD = Technology development

LP = Last term Patent

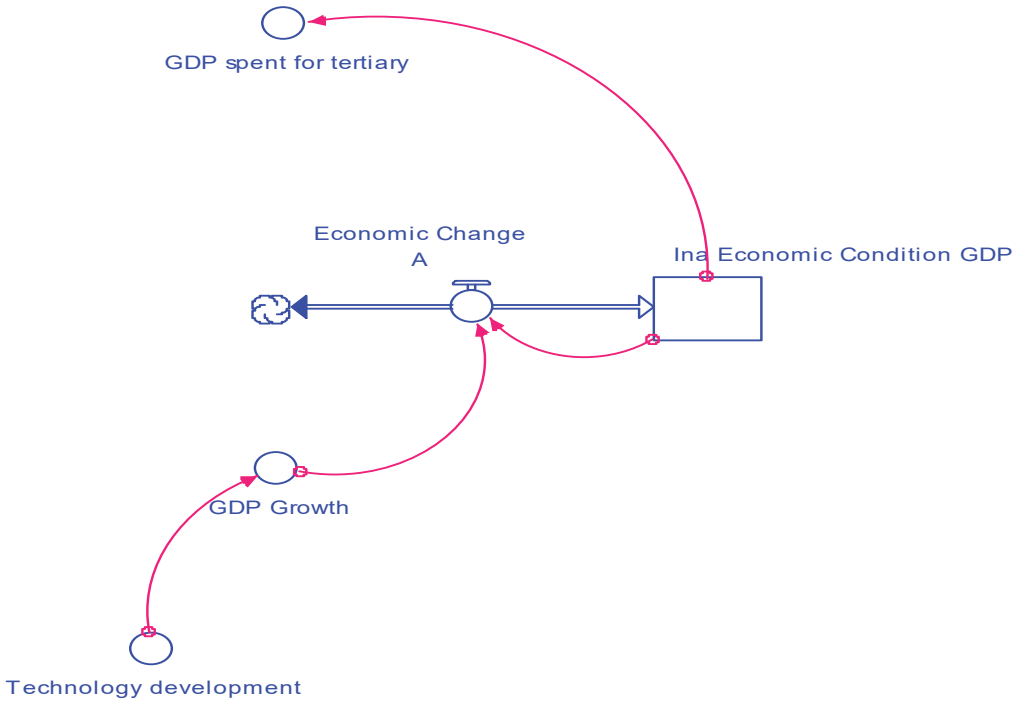

Figure 5-11. Stock and flow diagram of economic development

This diagram simply explains how technology development can influence GDP growth that is contributed by the technology production in Indonesia. Since there is also no complete history data of TAI, the formulation must be simplified. Therefore, TAI is

multiplied by 0.016. 0.016 is coming from the value of TAI (0.378) to reach six percent of GDP growth. Economic condition change is derived from GDP growth from previous year to the current year. Hence, the formula for economic change is:

$$\boldsymbol{GDP_c = D + (D * GDP_g)} \quad \textbf{28}$$

GDP_c = Change in GDP

D = GDP (Gross Domestic Product)

GDP_g = GDP growth

The last one is to calculate GDP spent for tertiary education. GDP spent for tertiary education is based on GDP. In this relationship, both GDP spent for tertiary education and GDP have historical data. Author used simple linear regression formula for this relationship:

$$\boldsymbol{B = 0.015699624 + (D * 2.32339_{E\text{-}14})} \quad \textbf{29}$$

5.3. Policy Scenarios

After building diagram and determining the parameters, simulations are conducted to check the sensitivity of the model. In this chapter, there will be one simulation with no policy and five policy scenarios in order to know which simulation has the most optimal result. The five scenarios are: government funding for university, increase on scholarship, incentives for returning students, increase in research and development expenditure, and incentives for patents created.

5.3.1. Policy 0 (no policy implemented)

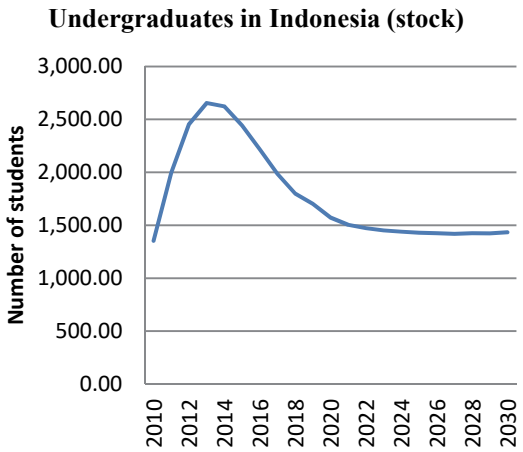

Figure 5-12. Trend in Undergraduate students in Indonesia (policy 0)

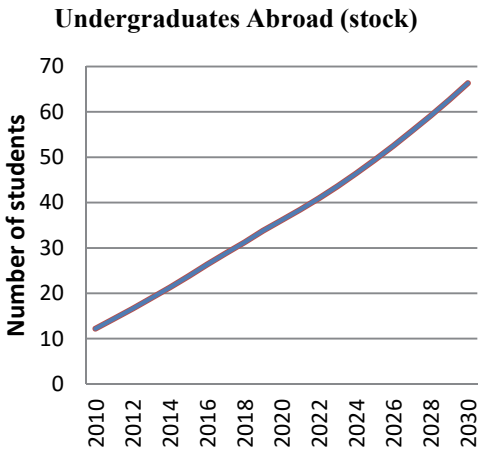

Figure 5-13. Trend in Undergraduate students abroad(policy 0)

In policy 0, the future trends for undergraduate students are sudden increase until 2014, then decrease until 2019 and stabilize until 2030. This sudden decrease was because the numbers of graduates is more than enrolled students, therefore the stock was decreasing. It is normal in Indonesia since university students have different condition on how long they will graduate, some students graduate after 4 years enrolment. For undergraduate students abroad, the trend is predicted as increasing; however, the number is considered not as big as the number of undergraduates in Indonesia.

As for postgraduate students in Indonesia, the trend is similar with undergraduates in Indonesia. With postgraduates have increasing trends; it is possible that Indonesia will have scarcity in university students, not only undergraduate students, but also postgraduates. In 14 years ahead it is possible that the number of postgraduates abroad is more that postgraduates in Indonesia.

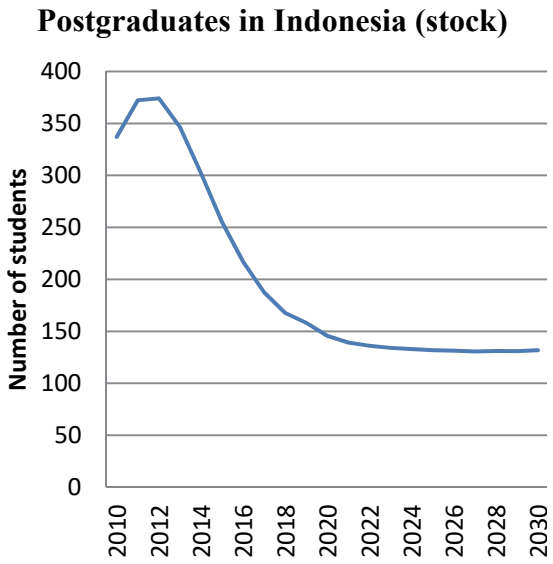

Figure 5-14. Trend in Postgraduate students in Indonesia (policy 0)

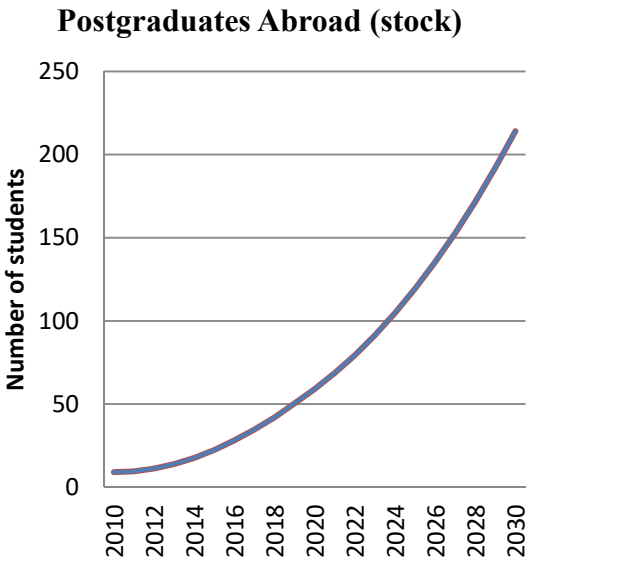

Figure 5-15. Trend in Postgraduate students abroad (policy 0)

In terms of high-skilled workers, the trends both Indonesia and abroad are increasing. The number of high-skills abroad is also not as significant as in Indonesia, but it is as expected that the increase will be slightly more that high-skilled in Indonesia. If so, the growth of high-skilled abroad will be higher than in Indonesia.

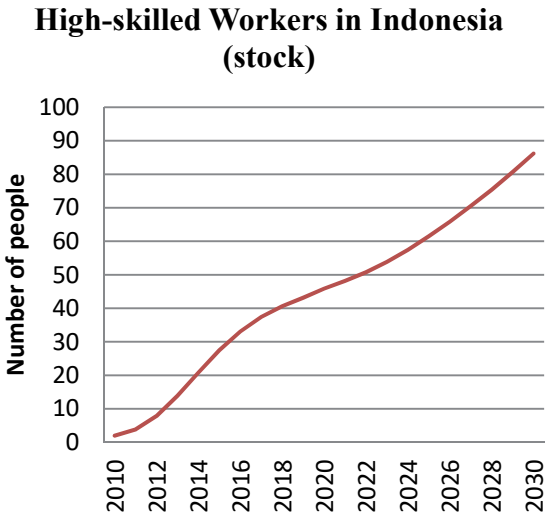

Figure 5-16. Trend in High-skilled workers in Indonesia (policy 0)

Figure 5-17. Trend in High-skilled workers abroad (policy 0)

Patents in Indonesia will have sudden decrease, then significant increase; this is due to the lack of patents production. In 2030, it is predicted that patents will have decrease in inputs but then slowly increase until the end of simulation. The same thing will occur to GDP growth, since GDP growth based on technology production is strongly influenced by patents production. Every patent produced also does not increase GDP growth instantly since logically there has to be process so that the technology production generated, hence the time lag between the patents produced and GDP growth is also considered. GDP growth will slightly decrease until it will increase almost steadily over the years.

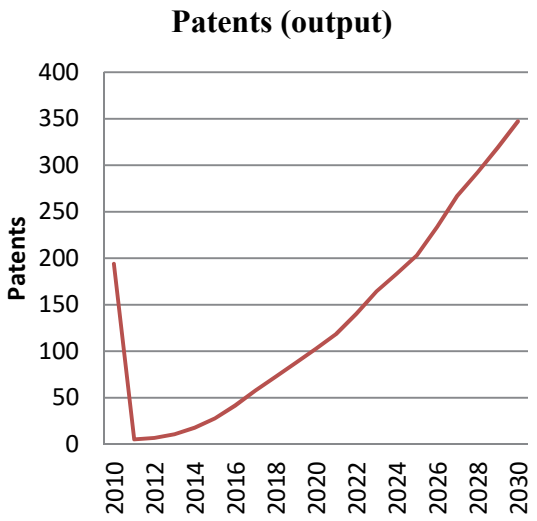

Figure 5-19. Patents (policy 0)

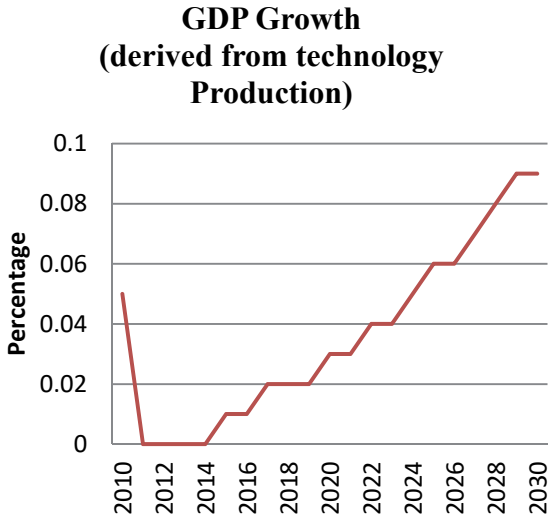

Figure 5-20. GDP growth (from technology production)

5.3.2. Policy scenarios

There are five policies scenarios. By simulating the scenarios, the sensitivity analysis can be measured. However, not all policies may have significant impact. This may due to the very low impact that cannot be detected by the software. Due to several missing data, author has to include several parameters that are not available in the base year (2010). For example, Technology Achievement Index (TAI) to measure technology development is using year 2015. Research and development expenditure is also using based on the year 2009. The questionnaire results that determine the parameter for return intention of students was conducted in 2014, also several other parameters. However, the simulation can detect changes in several scenarios. Therefore, it is important to analyze more on the simulation result and which policies can have direct impacts.

1. Policy 1

   Policy 1 is the government funding for university. The scenario was set where every policy option is not considered. Since this is a new type of policy, there is no measurement. However, author hypothesizes that the impact would have 1 percent increase every year until 20 years ahead. However, if the government would like to implement this scenario, the implication must be analyzed again.

   Increasing government funding for university affects several areas: Undergraduate students in Indonesia, high-skilled workers in Indonesia, high-skilled workers abroad, and the number of patents. Other areas are not affected since the target for university funding is only undergraduate students. The effect of this policy is not large, seen from the appendix …. that at the end of the simulation, the difference number of the affected areas is not significant. As seen in figures below also the trend does not change.

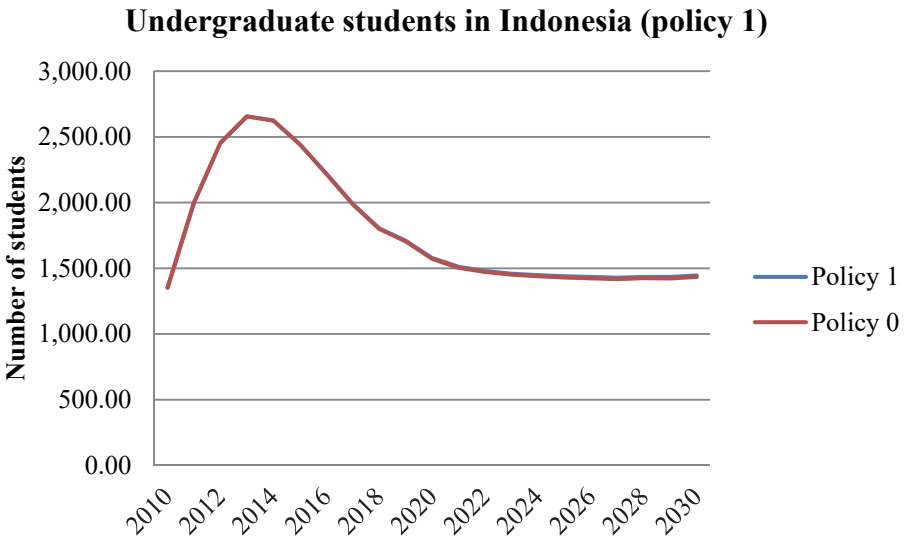

Figure 5-21. Undergraduate students in Indonesia (policy 1)

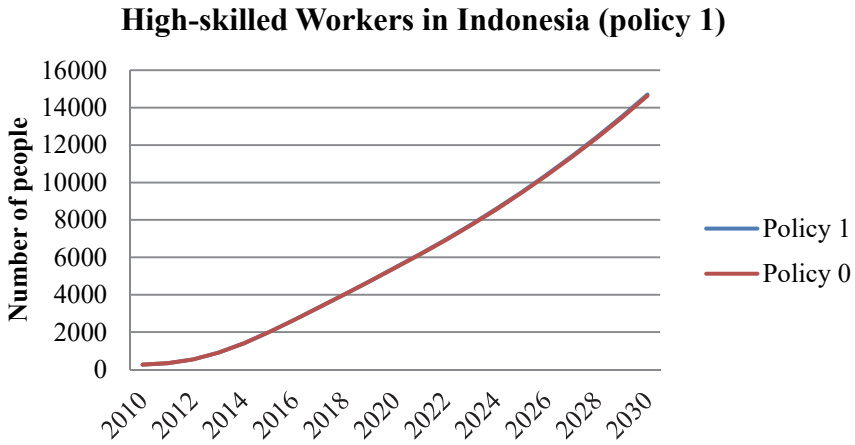

Figure 5-22. High-skilled workers in Indonesia (policy 1)

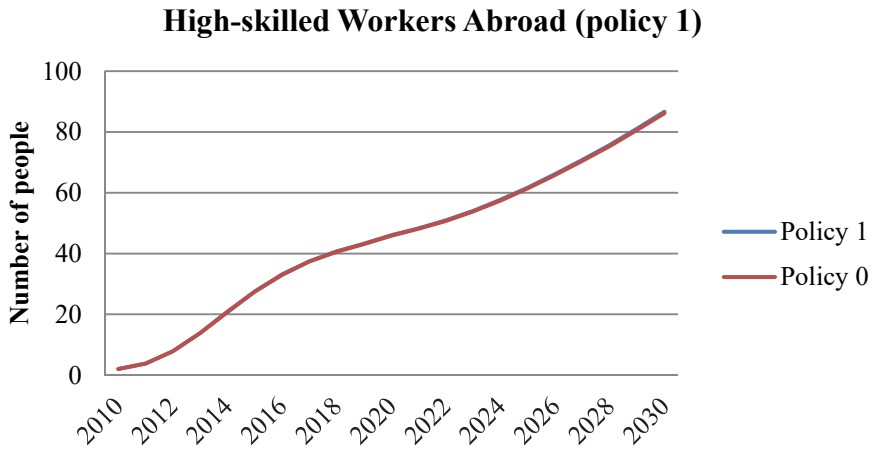

Figure 5-23. High-skilled workers abroad (policy 1)

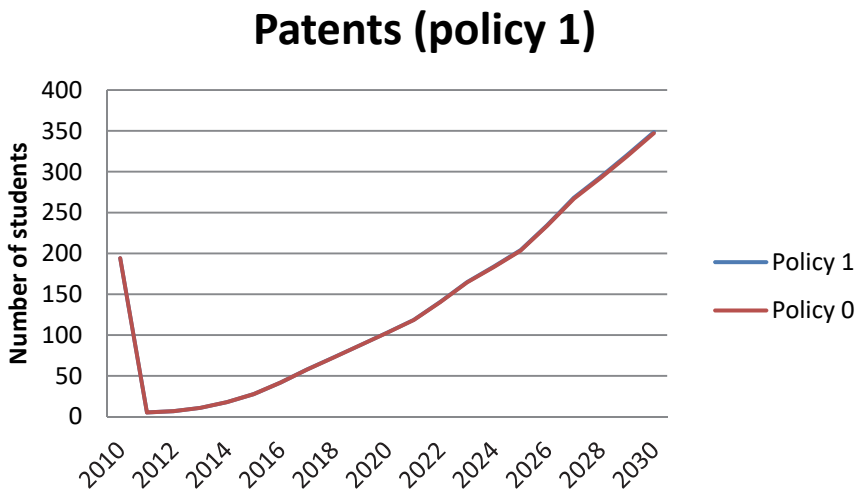

Figure 5-24. Patents (policy 1)

2. Policy 2

Policy 2 is the increase of scholarship. This policy increases the gross enrolment ratio, whether going abroad, or in Indonesia. This policy is as expected has significant impact not only on the number of students in Indonesia and abroad, but also the number of patents and growth in economy. This policy is considered to be the optimal policy because it affects mostly every aspect compared to other policy. Fortunately, Indonesian government already tries to implement this policy; hence there will be more positive impact in the long term. It is expected that the scholarship amount will be 50% from today's amount (10% increase every 4 years).

The result of increasing of scholarship can be shown in figures below where all aspects are affected. Increasing the number of students shows that higher education in S&T fields will rise significantly, generating effects to the number of scientists and engineers and patents production and GDP growth derived from technology production. Not only the changing the number may result from the effects of scholarships, but behavioral change also occurs in undergraduate and postgraduate students in Indonesia (as seen in figure 5-25 and 5-27). However, the scholarship policy effect is rather high due to the maximum change from base scenario (policy 0) with the set of 0.3 to 1; therefore it explains the behavior and extreme changes with condition of this policy.

Particularly for scholarships, we managed to calculate rough estimation on how much approximately scholarships are expensed per student to the GDP growth to estimate the cost efficiency in this policy. From an Indonesian article the number of students who received *bidik misi* scholarships (scholarships for non-affording students in Indonesia's universities) in 2016 were 60 thousands students, while the expense were 2.9 Trillion (or almost $216.5 million). Therefore each student gets a proportion of 2.07^{E-8} of the budget. GDP growth in 2016 was at the level of 5.08%, which if calculated based on this information, a student would contribute to 4.07^{E7} percent to GDP growth. However this calculation is based on only one source, the contribution would be larger if including other sources of scholarships.

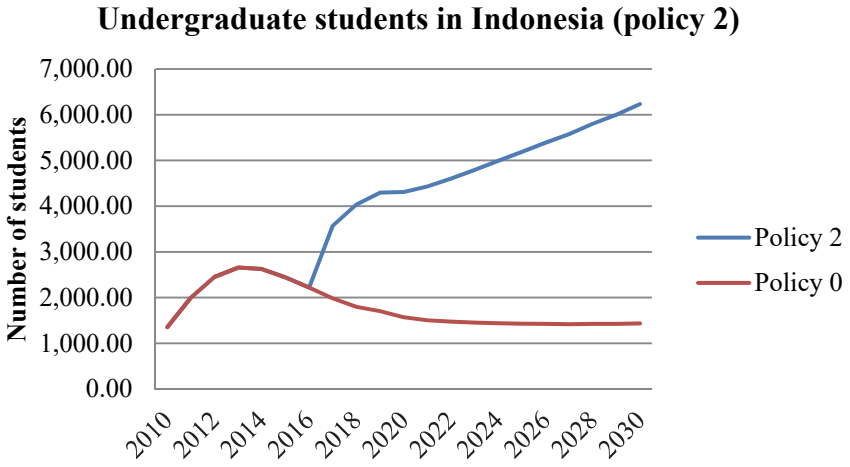

Figure 5-25. Undergraduate students in Indonesia (policy 2)

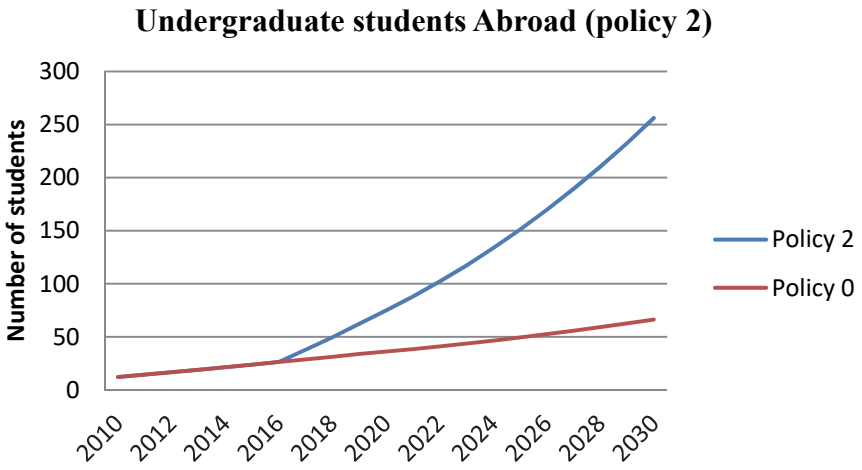

Figure 5-26. Undergraduate students abroad (policy 2)

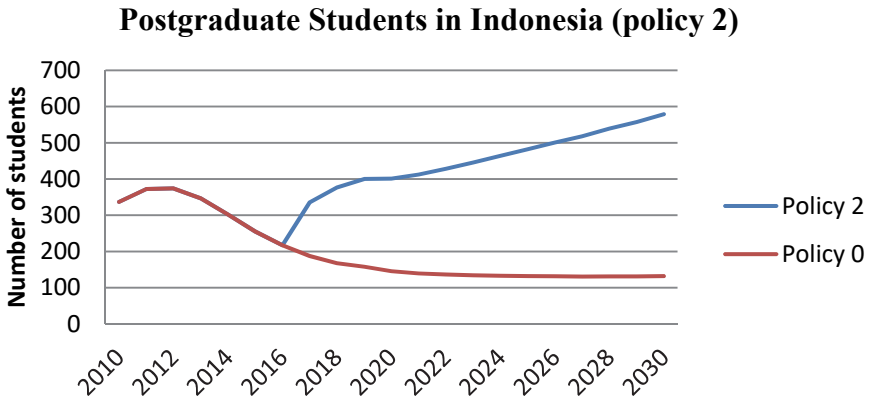

Figure 5-27. Postgraduate students in Indonesia (policy 2)

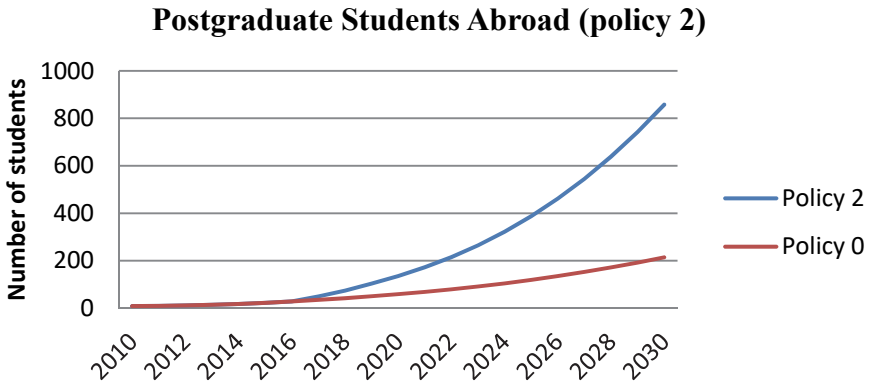

Figure 5-28. Postgraduate students abroad (policy 2)

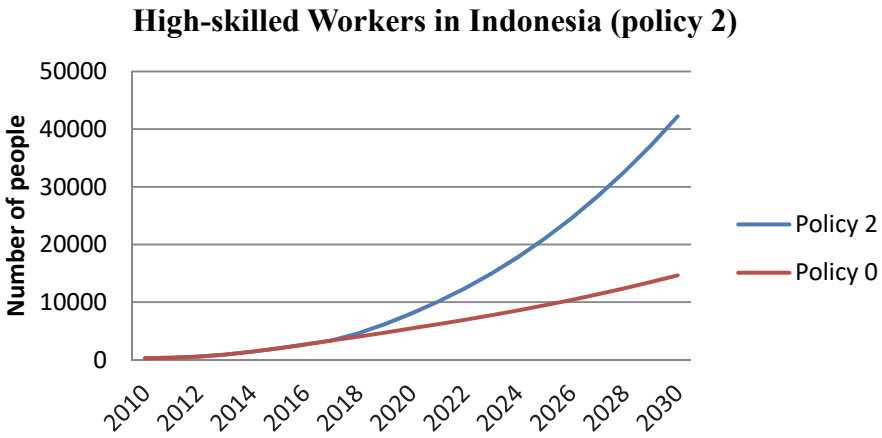

Figure 5-29. High-skilled workers in Indonesia (policy 2)

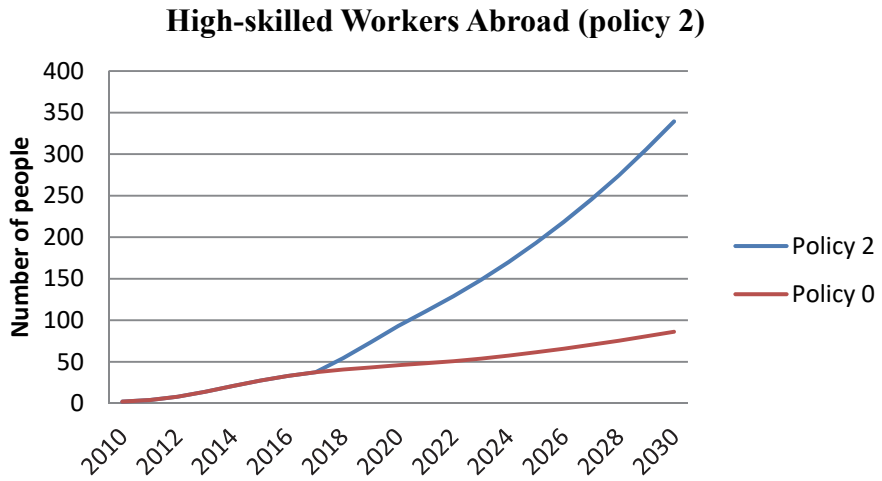

Figure 5-30. High-skilled workers abroad (policy 2)

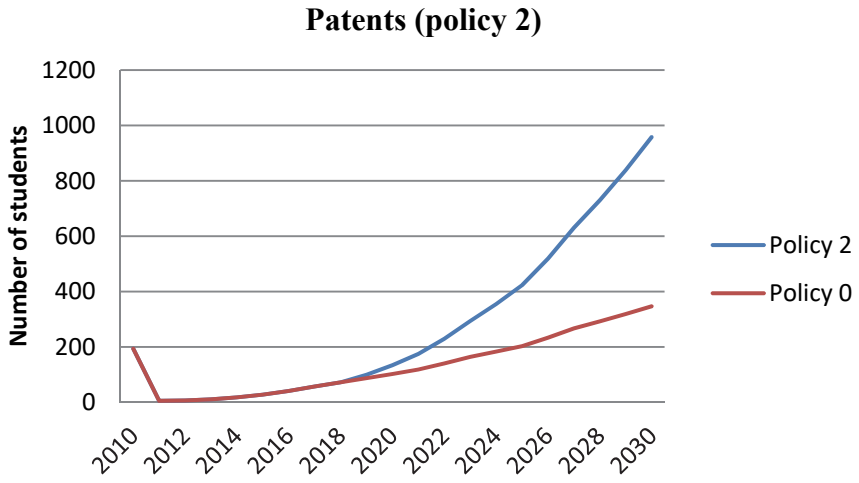

Figure 5-31. Patents (policy 2)

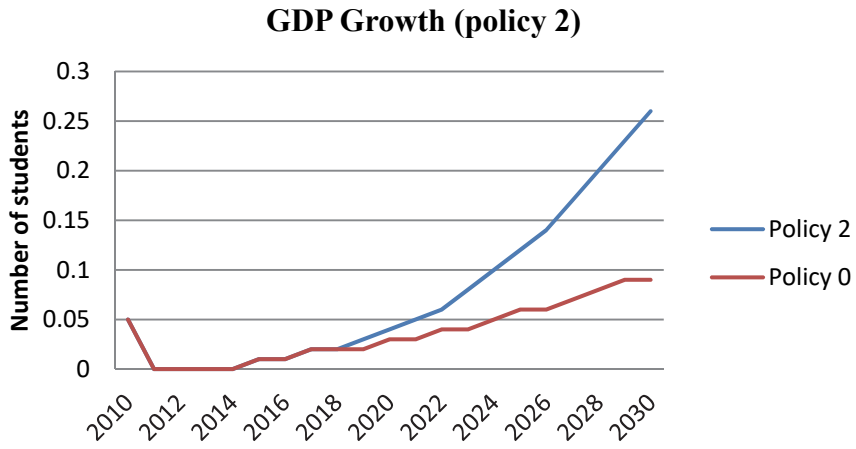

Figure 5-32. GDP growth (policy 2)

3. Policy 3

Policy 3 is a policy to attract students abroad to return home. This policy also has not been started, or according to interviews, if the government would like to regulate fines for non-returning students then it is considered not effective. Therefore, author tries to prove this consideration into the simulation. Consequently, author set the number to be flat multiplier every year (0.025). The result also shows no impact to the number of high-skilled in Indonesia. If not no impact, the result shows decrease in the number, even though not significantly. Other policies have zero or increasing effects to several aspects, but this policy does not have increasing effects when other conditions are considered same. Therefore, policy 3 is considered not effective.

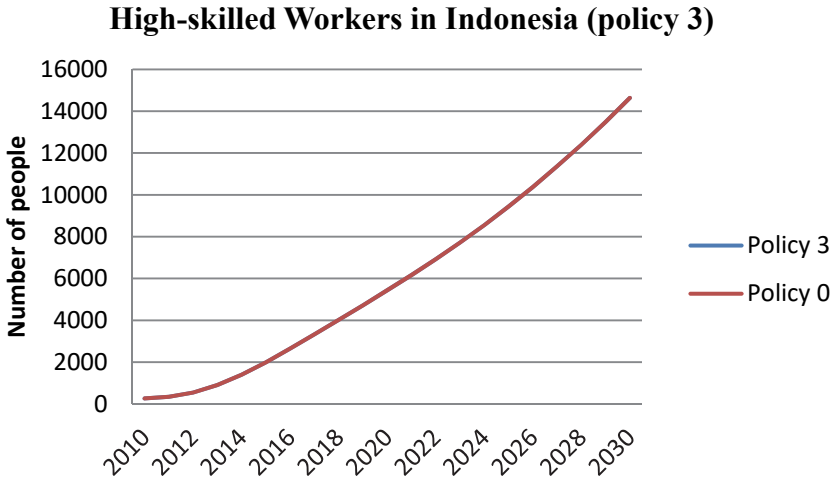

Figure 5-33. High-skilled workers in Indonesia (policy 3)

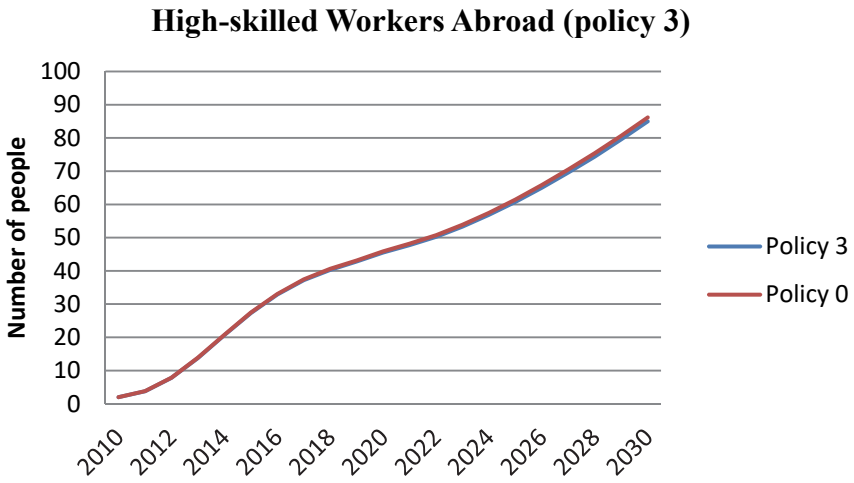

Figure 5-34. High-skilled workers abroad (policy 3)

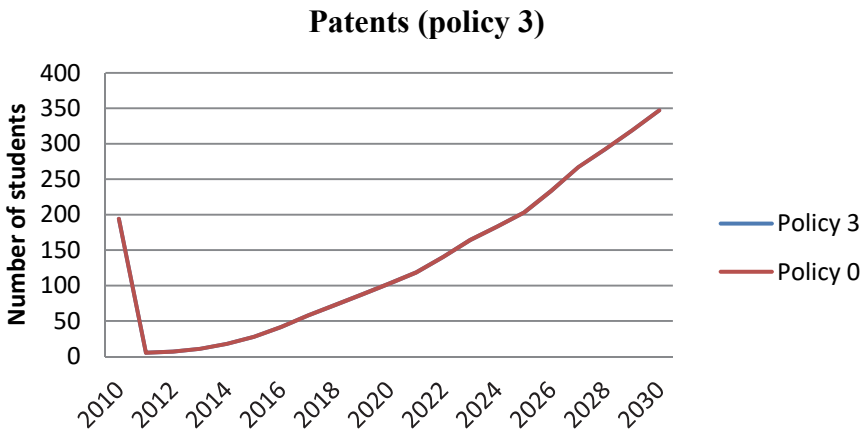

Figure 5-35. Patents (policy 3)

4. Policy 4

Policy 4 is to increase R&D expenditure from 0.09% to 1.5%, and is expected to rise by 1.3 times higher than base year. The result shows that it has direct and vast impact on the number of patent and GDP growth. The number is also higher than base year. However, the impact is not as large as policy 2. Therefore, it is better for the government to focus on the increase in scholarships to increase enrolment rate. To combine policy 4 and policy 2 (increasing scholarships), the behavior and numerical changes will be different. And, it is important for this dissertation to analyse which policy generates the most optimal results.

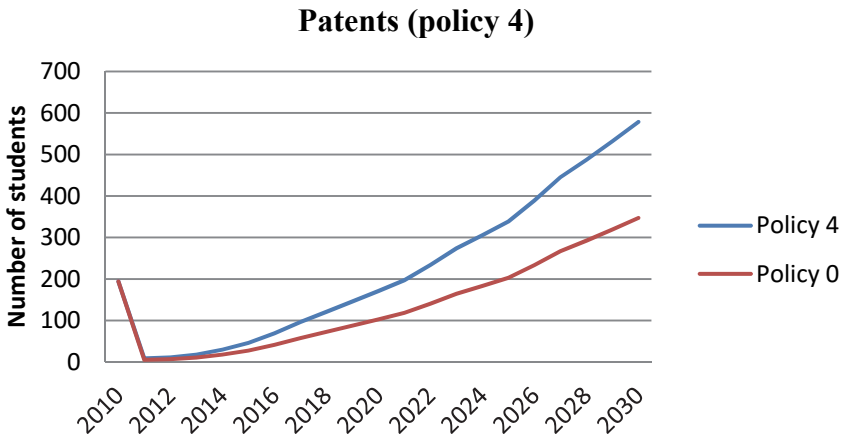

Figure 5-36. Patents (policy 4)

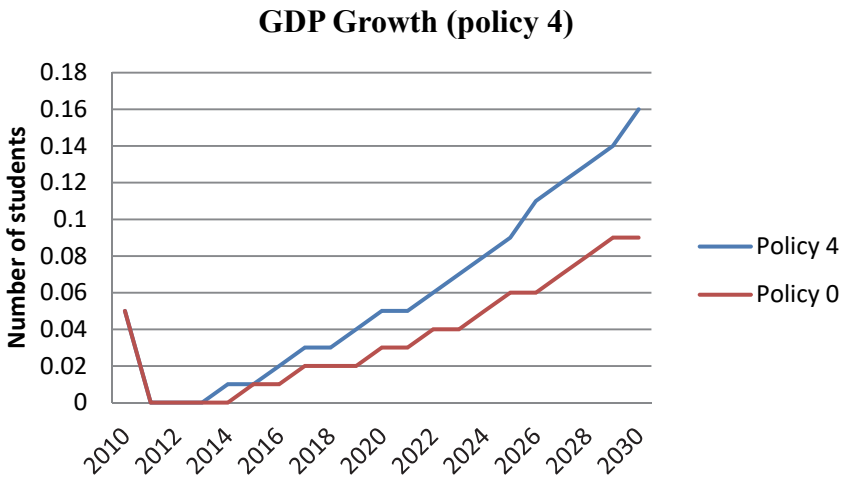

Figure 5-37. GDP growth (policy 4)

5. Policy 5

The last policy scenario is to give incentives for patents produced. In this particular policy the effects is incredibly small, and it only affects the number of patents which in the end cannot be identified as a progress. This is also due to the given small value of parameter. Because of that, author can only set the impact small with multiplier effects to be flat 0.015. As anticipated, the result of simulation has no significant impact to the production of patents. Therefore, this policy is considered as not effective unless there are other supporting policies implemented by the government simultaneously to achieve progress in patents production.

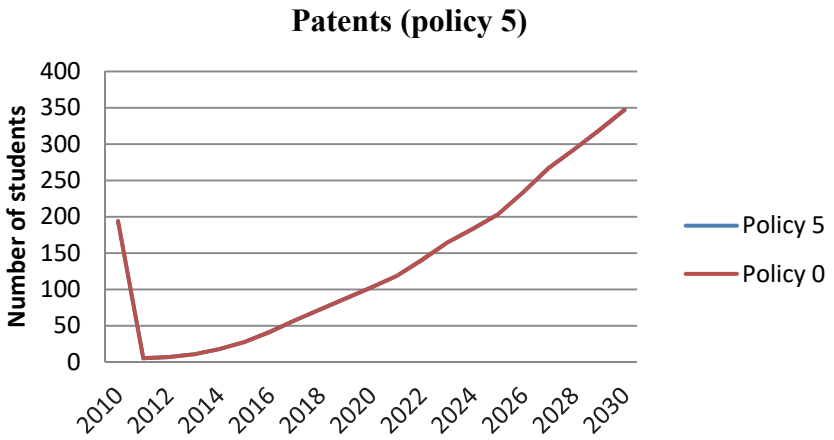

Figure 5-38. Patents (policy 5)

5.3.3. Validity and Verification

Forrester, as the inventor of System Dynamics itself, was avoiding to use the word validated, since the model has been described to be useful, illuminating, and inspiring rather than valid. To assess System Dynamics mode is not an easy task. However, according to Sterman (2000), there are several steps to indicate whether a System Dynamics model is objective and less biased. Those steps are: (1) Boundary adequacy; (2) Structure assessment; (3) Dimensional consistency; (4) Parameter assessment; (5) Extreme conditions; (6) Integration error; (7) Behaviour reproduction; (8) Behavior anomaly; (9) Family member; (10) Surprise behavior; (11) Sensitivity analysis; and (12) System improvement.

Table 5-1. Tests for assessments for dynamic models (Sterman, 2000)

Test	Purpose of test	Tools and Procedures
1. Boundary adequacy	Are the important concepts for addressing the problem endogenous to the mode?	Use model boundary charts, subsystem diagrams, causal diagrams, stock and flow maps, and direct inspection of model equations.
	Does the behavior of the model change significantly when boundary assumptions are relaxed?	Use interviews, workshops to solicit expert opinion, archival materials, review of literature, direct inspection/participation in system process, etc.
	Do the policy recommendations change when the model boundary is extended?	Modify model to include plausible additional structure; make constants and exogenous variables endogenous, then repeat sensitivity and policy analysis.
2.Structure Assessment	Is the model structure consistent with relevant descriptive knowledge of the system?	Use policy structure diagrams, causal diagrams, stock and flow maps and direct inspection of model equations.
	Is the level of aggregation appropriate?	Use interviews, workshops to solicit expert opinion, archival materials, direct inspection/participation in system process, etc.
	Does the model conform to basic physical laws such as conservation laws?	Conduct partial model tests of the intended rationality of decision rules.
	Do the decision rules capture the behavior of the actors in the system?	Conduct laboratory experiments to elicit mental models and decision rules o system participants.
		Develop disaggregate sub models and compare behavior to aggregate formulations.
		Disaggregate suspect structures, then repeat sensitivity and policy analysis.
3. Dimensional consistency	Is each equation dimensionally consistent without the use of parameters having no real world meaning?	Use dimensional analysis software.
		Inspect model equations for suspect parameters.
4. Parameter assessment	Are the parameter values consistent with relevant descriptive and numerical knowledge of the system?	Use statistical methods to estimate parameters (wide range of methods available)

	Do all parameters have real world counterparts?	Use partial model tests to calibrate subsystems. Use judgmental methods based on interviews, experts opinion, focus groups, archival materials, direct experience, etc. Develop disaggregate sub models to estimate relationships for use in more aggregate models.
5. Extreme conditions	Does each equation make sense even when its inputs take on extreme values?	Inspect each equation.
	Does the model respond plausibly when subjected to extreme policies, shock, and parameters?	Test response to extreme values of each input, alone and in combination. Subject model to large shocks and extreme conditions. Implement tests that examine conformance to basic physical laws (e.g., no inventory, no shipments; no labor, no production).
6. Integration error	Are the results sensitive to the choice of time step or numerical integration method?	Cut the time step in half and test for changes in behavior. Use different integration methods and test for changes in behavior.
7. Behavior reproduction	Does the model reproduce the behavior of interest in the system (qualitatively and quantitatively)?	Compute statistical measures of correspondence between model and data; descriptive statistics (e.g., R^2, MAE); time domain methods (e.g., autocorrelation functions); frequency domain methods (e.g., Spectral analysis); many others. Compare model output and data qualitatively, including modes of behavior, shape of variables, asymmetries, relative amplitudes and phasing, unusual events.
	Does it endogenously generate the symptoms of difficulty motivating the study?	
	Does the model generate the various modes of behavior observed in the real system?	Examine response of model to test inputs, shocks, and noise.
	Do the frequencies and phase relationships among the variables match the data?	
8. Behavior anomaly	Do anomalous behaviors result when assumptions of the model are changed or deleted?	Zero out key effects (loop knockout analysis).

9. Family member	Can the model generate the behavior observed in other instance of the same system?	Calibrate the model to the widest possible range of related systems. Keep accurate, complete, and dated records of model simulations. Use model
10. Surprise behavior	Does the model generate previously unobserved or unrecognized behavior?	to simulate likely future behavior of system.
	Does the model successfully anticipate the response of the system to novel conditions?	Resolve all discrepancies between model behavior and your understanding of the real system.
		Document participant and client mental models prior to the start of the modeling effort.
11. Sensitivity analysis	Numerical sensitivity: Do the numerical values change significantly…	Perform univariate and multivariate sensitivity analysis.
	Behavioral sensitivity: Do the modes of behavior generate by the model change significantly…	Use analytic methods (linearization, local and global stability analysis, etc.).
	Policy sensitivity: Do the policy implications change significantly…	Conduct model boundary and aggregation tests listed in (1) and (2) above.
	… when assumptions about parameters, boundary, and aggregation are varied over the plausible range of uncertainty?	Use optimization methods to find parameter combinations that generate implausible results or reverse policy outcomes.
12. System improvement	Did the modeling process help change the system for the better>	Design instruments in advance to assess the impact of the modeling process on mental models, behavior, and outcomes.
		Design controlled experiments with treatment and control groups, random assignment, pre-intervention and post-intervention assessment, etc.

5.4.Sensitivity Analysis

Because the prior policy scenarios do not give satisfactory results, the next step is to conduct sensitivity analysis. Sensitivity analysis is conducted in order to acknowledge the robustness of the model and parameters. Sensitivity analysis is one of the most crucial tests of a system dynamics model (as seen in table 5-1). This part will analyse the elasticity of the simulation. In the test, there are eight parameters that will be tested. Those parameters are the rate of return of high-skilled workers abroad, GDP spent for education, rate of high-skilled workers in Indonesia (i.e. percentage of how many graduates in S&T fields work in their area in Indonesia), patents produced for each

high-skilled workers, enrolment rate of postgraduate studies in Indonesia, research and development expenditures as a percentage of GDP, amount of scholarships, and enrolment rate for Undergraduate programs in Indonesia. Sensitivity analysis consists of three scenarios based on each parameter: best, base, and worst case. In the base case, the result of the simulation has been shown in the previous subchapter. In best scenario, the result of simulation will be drawn from doubling the parameters and to see the effects to the flow of undergraduate students, postgraduate students, high-skilled workers, patents, and GDP growth affected by technology development.

Another advantage of conducting sensitivity analysis is to understand which specific parameter influences the variables that we would like to develop or resist. By testing the effects of the parameters, this test can also give conclusion on which parameters should be considered and what kind of policy recommendations can be given to the government.

1. Rate of return of high-skilled workers abroad

   Rate of the return of high-skilled workers abroad is considered uncertain and there is a need for this parameter to be tested its sensitivity. The uncertain condition of Indonesia and also personal preference of Indonesians to return home has made this result be considered. In the base case, the rate of return for high-skilled workers from abroad was set on 0.40, based on author's calculation on the result of opinions in *quora.com.* In the best case, the rate is set to 0.80 and in the worst case the rate is set to 0.20. The simulation shows that among three scenarios the rate of returning high-skilled workers abroad is affecting the number of high-skilled workers abroad, the number of high-skilled workers in Indonesia, and patents. As seen in figure 5-43, at the end of simulation time, worst case scenario show that high-skilled workers abroad will increase two times than base case; on the contrary the number of high-skilled workers in Indonesia will increase not significantly in the worst case. The similar condition occurs in the best case: the number of high-skilled workers abroad will decrease significantly but does not increase the number of high-skilled workers in Indonesia in the same way. This can explain that the job opportunities specifically in S&T areas are limited causing spill-over for the number of talents. While in patents, among all cases there is no vast changes occur. The very small changes in patents lead to no changes in GDP growth between best, base, and worst cases.

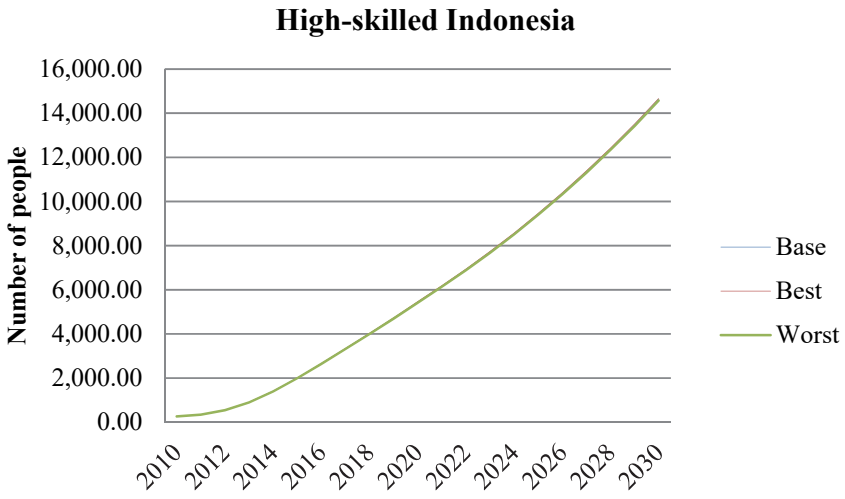

Figure 5-39. High-skilled workers in Indonesia (parameter 1)

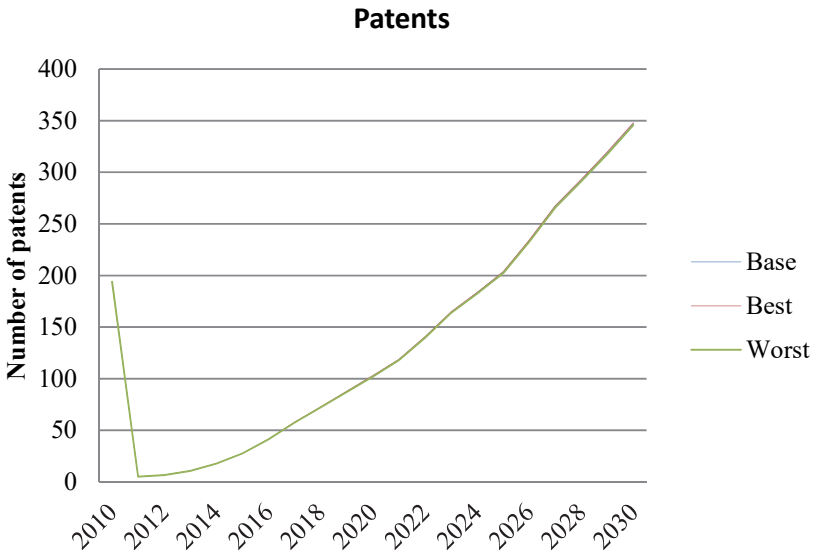

Figure 5-40. Patents (parameter 1)

Table 5-2. Elasticity of best scenario (parameter 1)

High-skilled abroad	High-skilled Indonesia	Patents
0.0000	0.0000	0.0000
-0.2343	0.0024	0.0000
-0.2414	0.0031	0.0030
-0.2879	0.0038	0.0037
-0.3546	0.0044	0.0034
-0.4242	0.0048	0.0043
-0.4895	0.0048	0.0048
-0.5421	0.0047	0.0048
-0.5832	0.0045	0.0047
-0.6079	0.0042	0.0044
-0.6116	0.0039	0.0042
-0.6234	0.0036	0.0038
-0.6226	0.0034	0.0036
-0.6158	0.0032	0.0034
-0.6104	0.0031	0.0032
-0.6069	0.0030	0.0030
-0.6057	0.0029	0.0029
-0.6054	0.0028	0.0029
-0.6064	0.0028	0.0028
-0.6059	0.0027	0.0028
-0.6077	0.0027	0.0027

Table 5-3. Elasticity of worst scenario (parameter 1)

High-skilled abroad	High-skilled Indonesia	Patents
0.0000	0.0000	0.0000
0.0993	-0.0012	0.0000
0.1284	-0.0020	-0.0015
0.1614	-0.0027	-0.0019
0.2033	-0.0034	-0.0028
0.2518	-0.0040	-0.0036
0.3031	-0.0044	-0.0039
0.3535	-0.0048	-0.0045
0.4007	-0.0050	-0.0048
0.4414	-0.0051	-0.0050
0.4702	-0.0051	-0.0051
0.4959	-0.0050	-0.0051
0.5136	-0.0049	-0.0050
0.5235	-0.0048	-0.0049
0.5290	-0.0047	-0.0048
0.5316	-0.0046	-0.0047
0.5331	-0.0045	-0.0046
0.5343	-0.0044	-0.0045
0.5359	-0.0043	-0.0044

0.5365	-0.0043	-0.0043
0.5379	-0.0042	-0.0042

2. Gross Domestic Product (GDP) spent for education

GDP spent for education changes is hoped to contribute significantly to the increase of number of students in Indonesia, starting in undergraduate programs. During the sensitivity analysis simulation, five parameters are influenced: the number of undergraduate students in Indonesia, the number of high-skilled workers abroad, the number of high-skilled workers in Indonesia, the number of patents, GDP growth. Although there are changes in those parameters, the number is still very small; hence, we can conclude that from the sensitivity analysis in this parameter, the number changes but not significantly change. There are also no behaviour changes in the sensitivity analysis, hence this is one of the evidences that the model is robust. The consideration that this parameter, although implemented in the worst case, would not get significant changes to GDP growth.

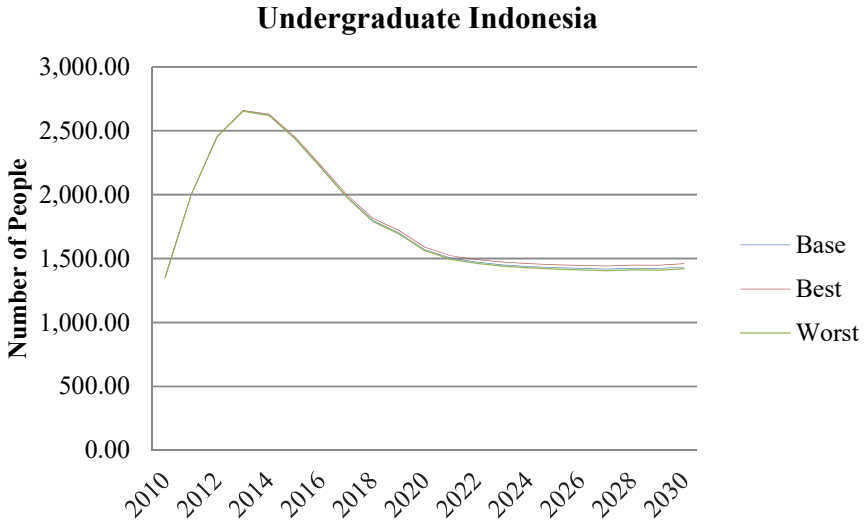

Figure 5-41. Undergraduate students in Indonesia (parameter 2)

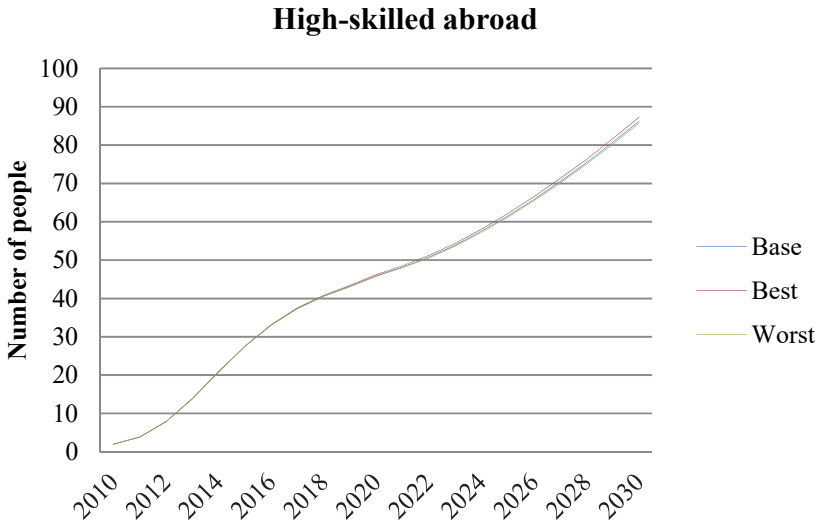

Figure 5-42. High-skilled workers abroad (parameter 2)

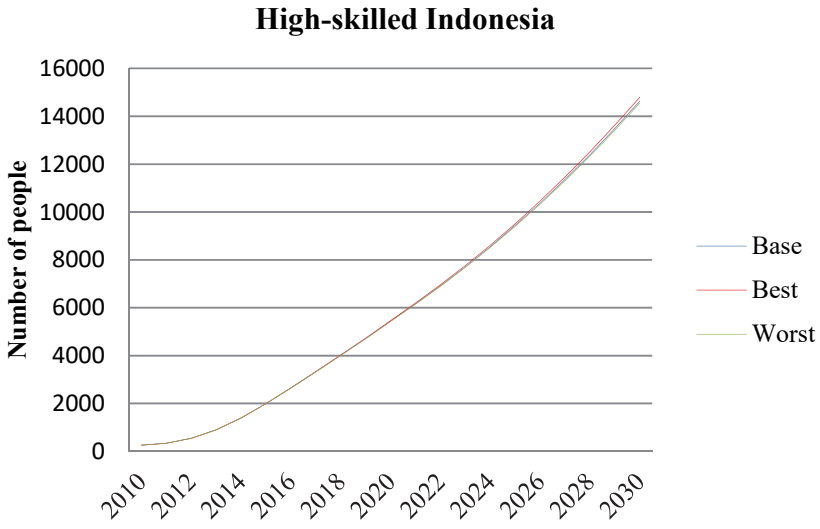

Figure 5-43. High-skilled workers in Indonesia (parameter 2)

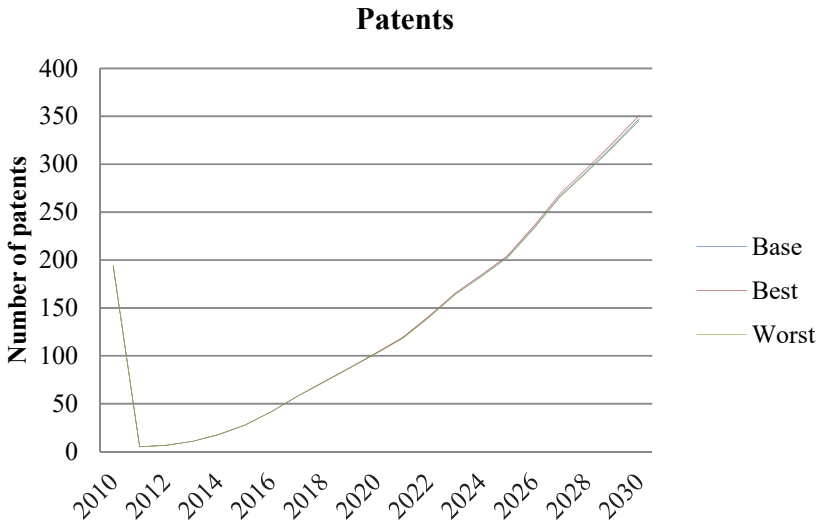

Figure 5-44. Patents (parameter 2)

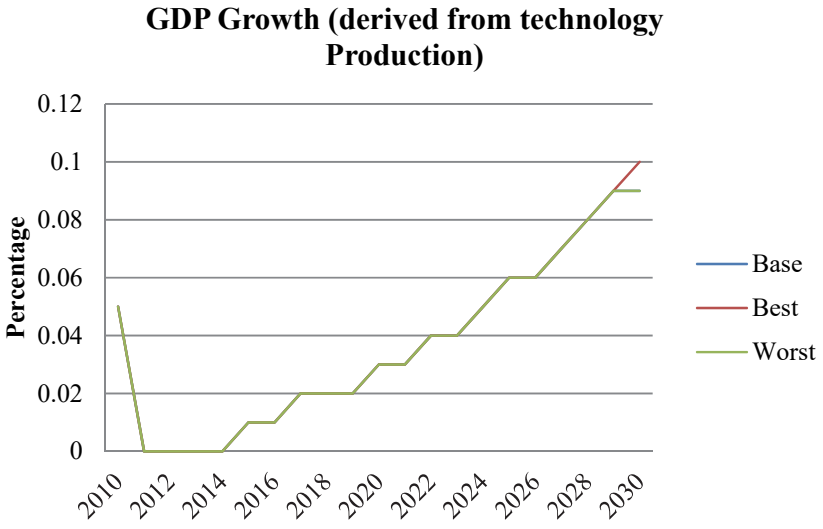

Figure 5-45. GDP growth (parameter 2)

Table 5-4. Elasticity of best scenario (parameter 2)

Undergraduate Indonesia	High-skilled abroad	High-skilled Indonesia	Patents	GDP GROWTH
0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	-
0.0006	0.0000	0.0000	0.0000	-
0.0015	0.0000	0.0002	0.0000	-
0.0028	0.0010	0.0006	0.0000	-
0.0042	0.0015	0.0012	0.0004	0.0000
0.0058	0.0024	0.0018	0.0012	0.0000
0.0075	0.0037	0.0026	0.0017	0.0000
0.0090	0.0047	0.0033	0.0026	0.0000
0.0103	0.0058	0.0041	0.0033	0.0000
0.0114	0.0067	0.0048	0.0041	0.0000
0.0125	0.0074	0.0055	0.0048	0.0000
0.0134	0.0082	0.0062	0.0055	0.0000
0.0142	0.0089	0.0069	0.0062	0.0000
0.0150	0.0095	0.0075	0.0069	0.0000
0.0157	0.0100	0.0081	0.0075	0.0000
0.0164	0.0104	0.0087	0.0081	0.0000
0.0170	0.0109	0.0093	0.0087	0.0000
0.0176	0.0113	0.0099	0.0093	0.0000
0.0182	0.0116	0.0104	0.0099	0.0000
0.0188	0.0119	0.0110	0.0105	0.1054

Table 5-5. Elasticity of worst scenario (parameter 2)

Undergraduate Indonesia	High-skilled abroad	High-skilled Indonesia	Patents	GDP GROWTH
0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	-
-0.0003	0.0000	0.0000	0.0000	-
-0.0008	-0.0007	-0.0001	0.0000	-
-0.0014	-0.0005	-0.0003	-0.0006	-
-0.0021	-0.0007	-0.0006	-0.0004	0.0000
-0.0029	-0.0012	-0.0009	-0.0005	0.0000
-0.0037	-0.0016	-0.0013	-0.0009	0.0000
-0.0045	-0.0025	-0.0017	-0.0012	0.0000
-0.0052	-0.0028	-0.0020	-0.0017	0.0000
-0.0058	-0.0033	-0.0024	-0.0020	0.0000
-0.0063	-0.0037	-0.0028	-0.0025	0.0000
-0.0067	-0.0043	-0.0031	-0.0028	0.0000
-0.0072	-0.0047	-0.0034	-0.0031	0.0000
-0.0076	-0.0047	-0.0038	-0.0034	0.0000
-0.0079	-0.0051	-0.0041	-0.0038	0.0000
-0.0083	-0.0053	-0.0044	-0.0041	0.0000
-0.0086	-0.0055	-0.0047	-0.0044	0.0000
-0.0089	-0.0057	-0.0050	-0.0047	0.0000

-0.0092	-0.0058	-0.0053	-0.0050	0.0000
-0.0095	-0.0061	-0.0055	-0.0053	0.0000

3. Input rate of high-skilled workers in Indonesia

This parameter indicates the rate of high-skilled workers in Indonesia who work in their fields (S&T fields). The input of base (0.4), best (0.8) and worst (0.2) scenarios show that there are changes in the number of the number of high-skilled workers in Indonesia, patents, and GDP growth based on patents or technology production. Different from rate of returning high-skilled workers abroad, input rate of high-skilled workers in Indonesia has significant influence in GDP growth; this is due to the significant increase of high-skilled workers in Indonesia and the patents production. To increase the number of high-skilled workers by twice as much (best case) generates more than 50 percent increase; the similar results when the input rate becomes half (worst case), then the decrease in the number of high-skilled workers in Indonesia would follow. The similar significant changes in number occur in the number of patents, which results in the changes of GDP growth. However, best case scenario results in much higher GDP growth based on technology production; although worst case scenario also reduces the GDP, but the changes are not as major as best case scenario.

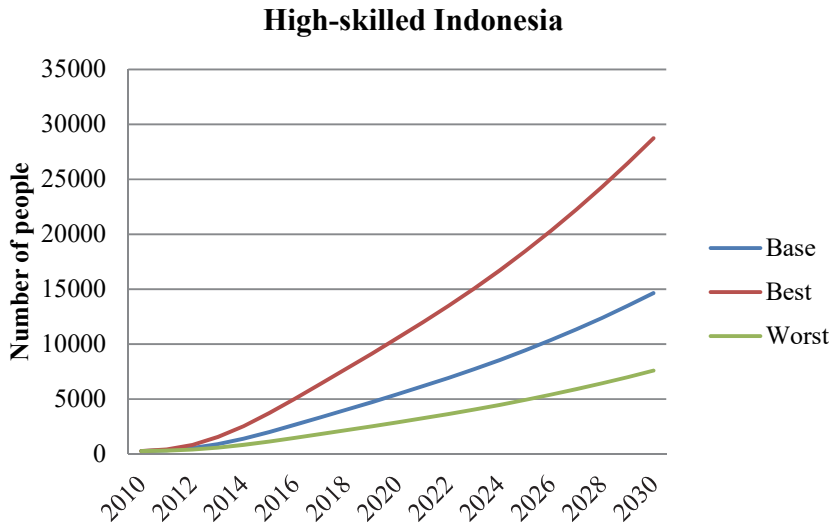

Figure 5-46. High-skilled workers in Indonesia (parameter 3)

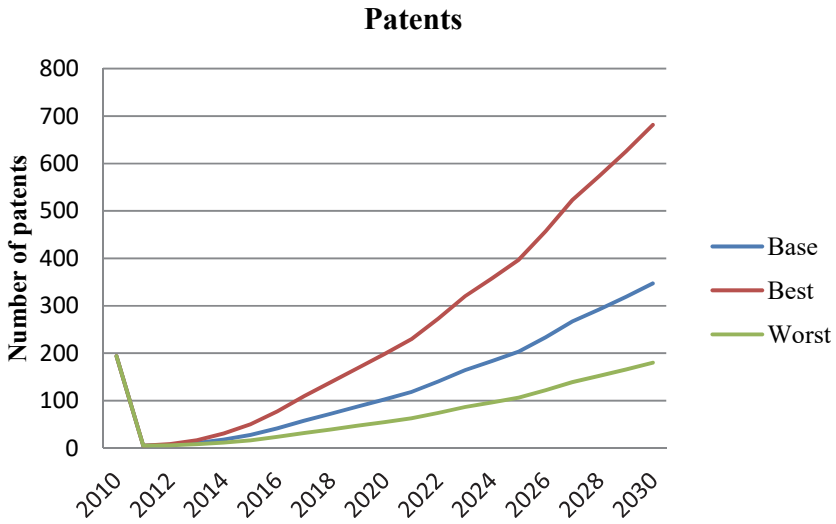

Figure 5-47. Patents (parameter 3)

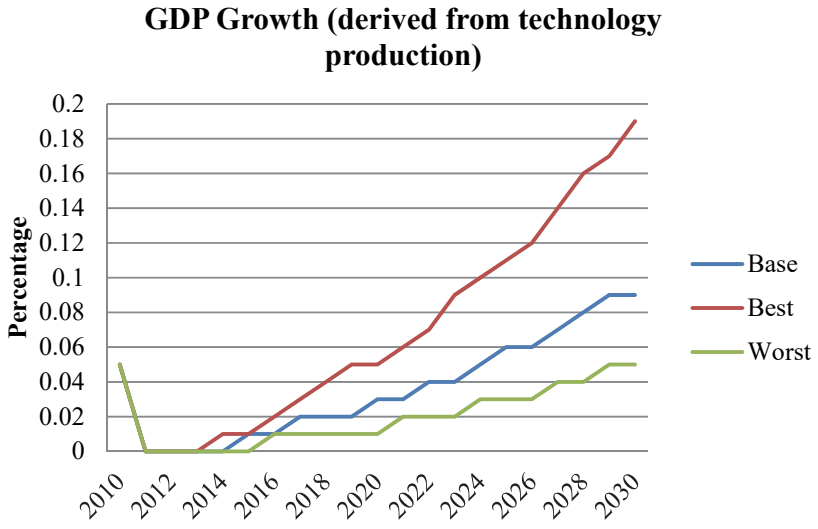

Figure 5-48. GDP growth (parameter 3)

In the elasticity table, the result was significant between best and worst case in terms of high-skilled workers in Indonesia, patents, and GDP growth. This indicates that this parameter is sensitive to influence these three sectors and should be considered on what policy is suitable.

Table 5-6. Elasticity of best scenario (parameter 3)

High-skilled Indonesia	Patents	GDP GROWTH
0.0000	0.0000	0.0000
0.2135	0.0000	-
0.4234	0.2136	-
0.5386	0.4238	-
0.5951	0.5383	-
0.6240	0.5949	0.0000
0.6398	0.6240	0.6931
0.6494	0.6398	0.4055
0.6554	0.6493	0.6931
0.6596	0.6554	0.9163
0.6628	0.6596	0.5108
0.6652	0.6628	0.6931
0.6671	0.6652	0.5596
0.6687	0.6671	0.8109
0.6700	0.6687	0.6931
0.6712	0.6700	0.6061
0.6722	0.6712	0.6931
0.6730	0.6722	0.6931
0.6738	0.6730	0.6931
0.6744	0.6738	0.6360
0.6749	0.6744	0.7472

Table 5-7. Elasticity of worst scenario (parameter 3)

High-skilled Indonesia	Patents	GDP GROWTH
0.0000	0.0000	0.0000
-0.1267	0.0000	-
-0.3059	-0.1268	-
-0.4413	-0.3058	-
-0.5219	-0.4414	-
-0.5677	-0.5222	-
-0.5944	-0.5674	0.0000
-0.6109	-0.5944	-0.6931
-0.6217	-0.6109	-0.6931
-0.6293	-0.6218	-0.6931
-0.6351	-0.6293	-1.0986
-0.6394	-0.6351	-0.4055
-0.6430	-0.6394	-0.6931
-0.6460	-0.6430	-0.6931
-0.6485	-0.6459	-0.5108
-0.6507	-0.6484	-0.6931
-0.6525	-0.6507	-0.6931
-0.6541	-0.6525	-0.5596
-0.6555	-0.6541	-0.6931
-0.6567	-0.6555	-0.5878

-0.6577	-0.6566	-0.5878

4. Patents per high-skilled workers (In Indonesia)

Patents per high-skilled workers indicate the productivity of patents production in Indonesia. The base case number indicates that 2.2 patents are produced by one high-skilled worker (data based on the number of patents and the number of high-skilled workers in that particular year in one Indonesia government's research institutions as a sample). Therefore, 4.4 is set as the best scenario, and 1.1 is set as the worst scenario. As indicated, the changes of patents per high-skilled workers occur in the number of patents and GDP growth. Changes in patents indicate that the number of patents is highly sensitive to the productivity of high-skilled workers in Indonesia. The similar conclusion can also be made in the sense of GDP growth.

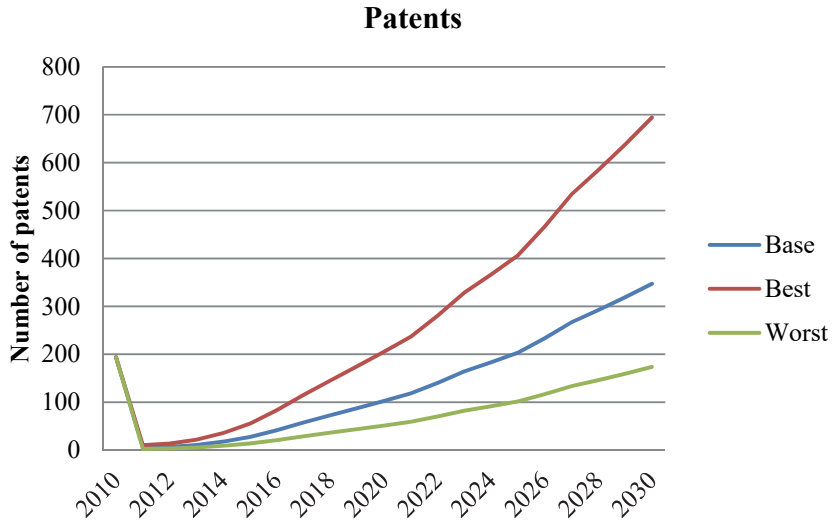

Figure 5-49. Patents (parameter 4)

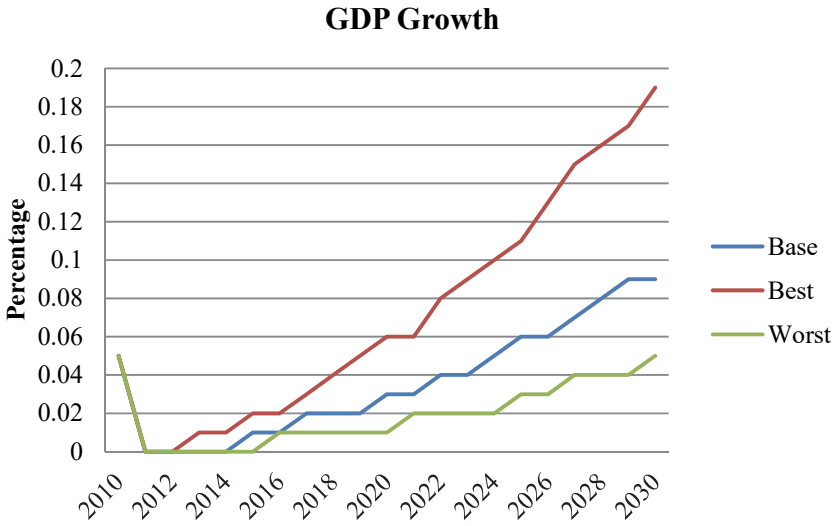

Figure 5-50. GDP growth (parameter 4)

Table 5-8. Elasticity of best scenario (parameter 4)

PATENTS	GDP GROWTH
0.0000	0.0000
0.6922	-
0.6931	-
0.6931	-
0.6929	-
0.6930	0.6931
0.6931	0.6931
0.6931	0.4055
0.6931	0.6931
0.6931	0.9163
0.6931	0.6931
0.6931	0.6931
0.6931	0.6931
0.6931	0.8109
0.6931	0.6931
0.6931	0.6061
0.6931	0.7732
0.6931	0.7621
0.6931	0.6931
0.6931	0.6360
0.6932	0.7472

Table 5-9. Elasticity of worst scenario (parameter 4)

PATENTS	GDP GROWTH
0.0000	0.0000
-0.6931	-
-0.6931	-
-0.6931	-
-0.6926	-
-0.6931	-
-0.6931	0.0000
-0.6930	-0.6931
-0.6931	-0.6931
-0.6931	-0.6931
-0.6930	-1.0986
-0.6931	-0.4055
-0.6931	-0.6931
-0.6931	-0.6931
-0.6931	-0.9163
-0.6931	-0.6931
-0.6931	-0.6931
-0.6931	-0.5596
-0.6931	-0.6931
-0.6931	-0.8109
-0.6931	-0.5878

5. Postgraduate program enrolment rate in Indonesia.

From the sensitivity analysis simulation, five sectors are influenced by postgraduate program enrolment rate in Indonesia: the number of postgraduate students in Indonesia; the number of high-skilled workers abroad, the number of high-skilled workers in Indonesia, the number of patents, and GDP growth based on technology production. The number of postgraduate students in Indonesia increases, based on best scenario, and decreases, based on worst scenario, significantly. The changes in postgraduate students in Indonesia changes not only high-skilled workers abroad, but also in Indonesia, even though the changes between best and worst scenarios are not as significant as the number, considering the rate of absorption in high-skilled workers in Indonesia is still consistent. Patents production and GDP growth also change but not as significant as previous parameters.

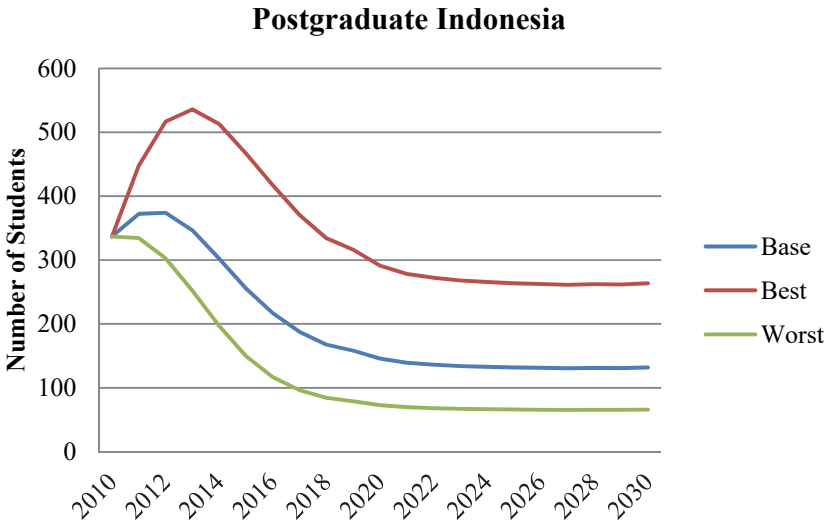

Figure 5-51. Postgraduate students in Indonesia (parameter 5)

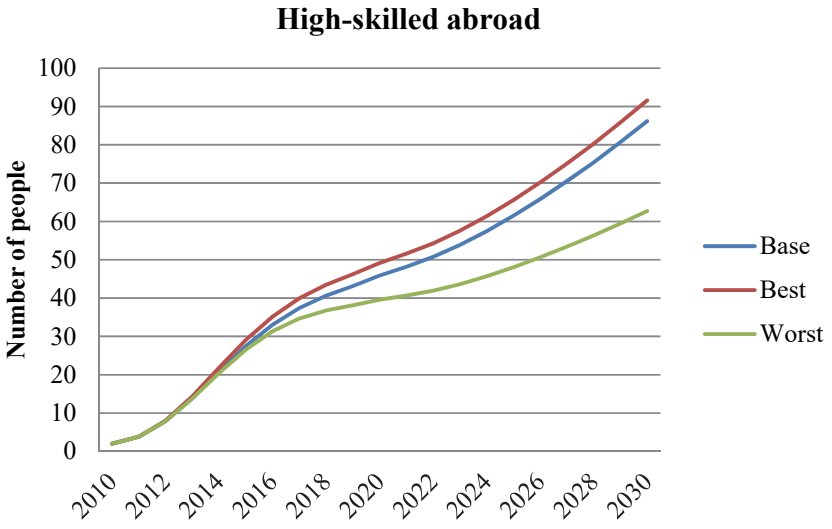

Figure 5-52. High-skilled workers abroad (parameter 5)

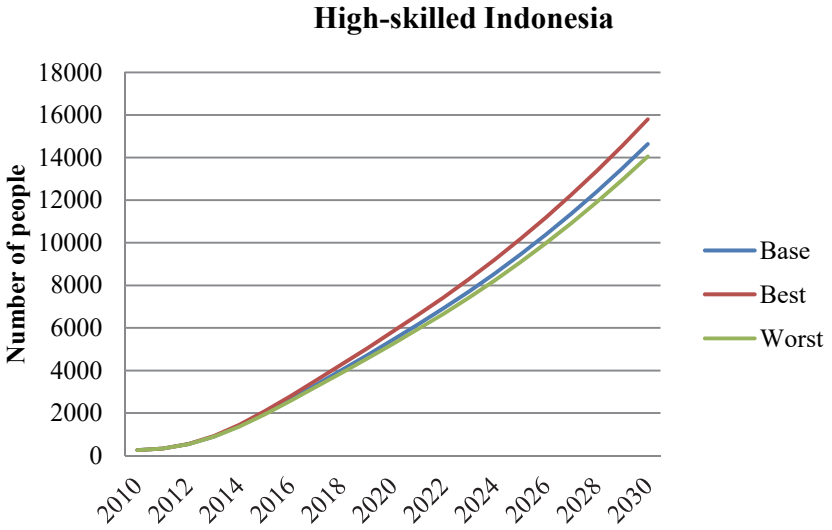

Figure 5-53. High-skilled workers in Indonesia (parameter 5)

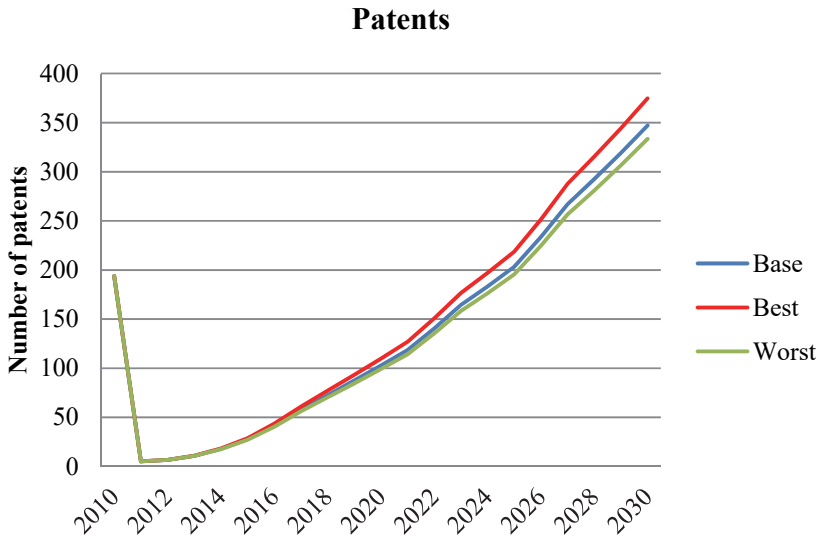

Figure 5-54. Patents (parameter 5)

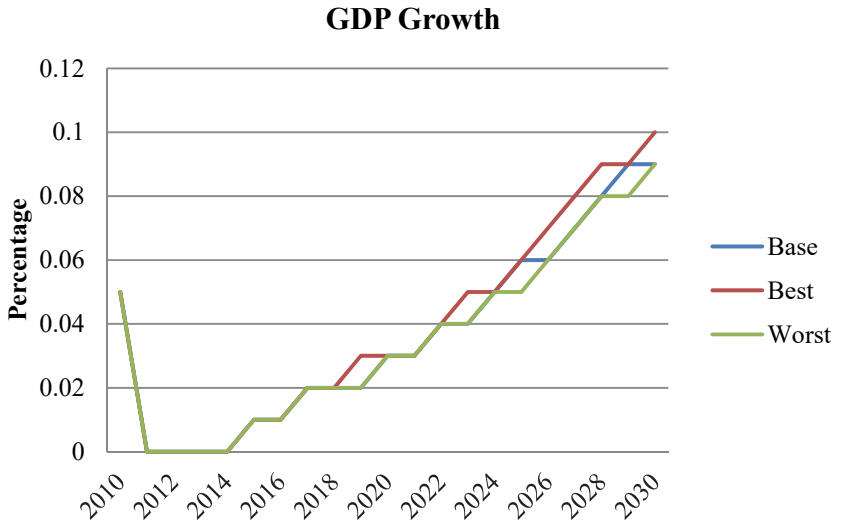

Figure 5-55. GDP growth (parameter 5)

Table 5-10. Elasticity of best scenario (parameter 5)

Postgraduate Indonesia	High-skilled abroad	High-skilled Indonesia	Patents	GDP GROWTH
0.0000	0.0000	0.0000	0.0000	0.0000
0.1852	0.0000	0.0000	0.0000	-
0.3233	0.0189	0.0120	0.0000	-
0.4358	0.0354	0.0270	0.0129	-
0.5294	0.0474	0.0394	0.0265	-
0.6034	0.0559	0.0486	0.0393	0.0000
0.6540	0.0619	0.0554	0.0487	0.0000
0.6806	0.0659	0.0604	0.0554	0.0000
0.6907	0.0678	0.0640	0.0604	0.0000
0.6929	0.0687	0.0667	0.0639	0.4055
0.6931	0.0686	0.0687	0.0667	0.0000
0.6931	0.0680	0.0703	0.0687	0.0000
0.6931	0.0671	0.0715	0.0703	0.0000
0.6931	0.0664	0.0725	0.0715	0.2231
0.6931	0.0657	0.0734	0.0725	0.0000
0.6931	0.0647	0.0741	0.0734	0.0000
0.6931	0.0640	0.0748	0.0741	0.1542
0.6932	0.0631	0.0753	0.0748	0.1335
0.6931	0.0623	0.0758	0.0753	0.1178
0.6931	0.0616	0.0762	0.0758	0.0000
0.6931	0.0608	0.0765	0.0762	0.1054

Table 5-11. Elasticity of worst scenario (parameter 5)

Postgraduate Indonesia	High-skilled abroad	High-skilled Indonesia	Patents	GDP GROWTH
0.0000	0.0000	0.0000	0.0000	0.0000
-0.1072	0.0000	0.0000	0.0000	-
-0.2118	-0.0102	-0.0061	0.0000	-
-0.3190	-0.0182	-0.0138	-0.0056	-
-0.4292	-0.0243	-0.0203	-0.0141	-
-0.5348	-0.0292	-0.0252	-0.0204	0.0000
-0.6192	-0.0326	-0.0289	-0.0251	0.0000
-0.6686	-0.0345	-0.0316	-0.0290	0.0000
-0.6881	-0.0358	-0.0336	-0.0316	0.0000
-0.6928	-0.0361	-0.0351	-0.0337	0.0000
-0.6932	-0.0359	-0.0362	-0.0351	0.0000
-0.6931	-0.0359	-0.0371	-0.0363	0.0000
-0.6932	-0.0355	-0.0378	-0.0371	0.0000
-0.6931	-0.0349	-0.0383	-0.0377	0.0000
-0.6931	-0.0345	-0.0388	-0.0384	0.0000
-0.6932	-0.0341	-0.0392	-0.0388	-0.1823
-0.6931	-0.0337	-0.0396	-0.0392	0.0000
-0.6931	-0.0332	-0.0399	-0.0396	0.0000
-0.6932	-0.0326	-0.0401	-0.0399	0.0000
-0.6931	-0.0322	-0.0404	-0.0401	-0.1178
-0.6932	-0.0318	-0.0406	-0.0403	0.0000

6. Research and development (R&D) expenditure

R&D expenditures are expected to generate changes in the number of patents and GDP growth based on technology production; and the results of sensitivity analysis is what is expected. R&D expenditures (from GDP expenditures) are counted as 0.9 per cent; thus best scenario sets the parameter into 1.8 per cent and worst scenario sets at 4.5 per cent. These scenarios change the number of patents and GDP growth significantly. In best scenario, increasing over 50 per cent than base case results in patents and GDP growth; the similar transformation also occurs that at the end of simulation the changes are more than 50 percent.

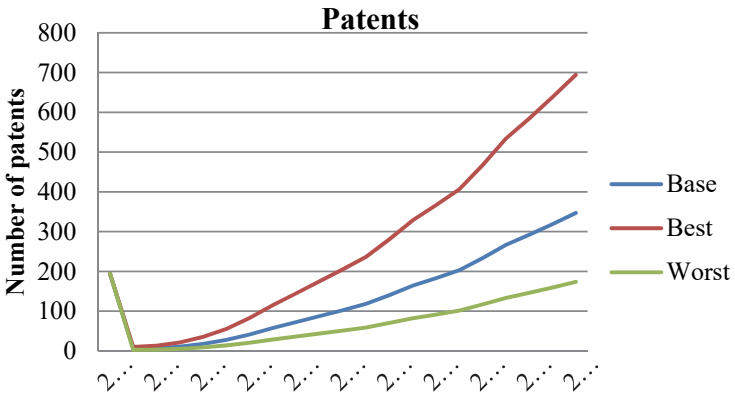

Figure 5-56. Patents (parameter 6)

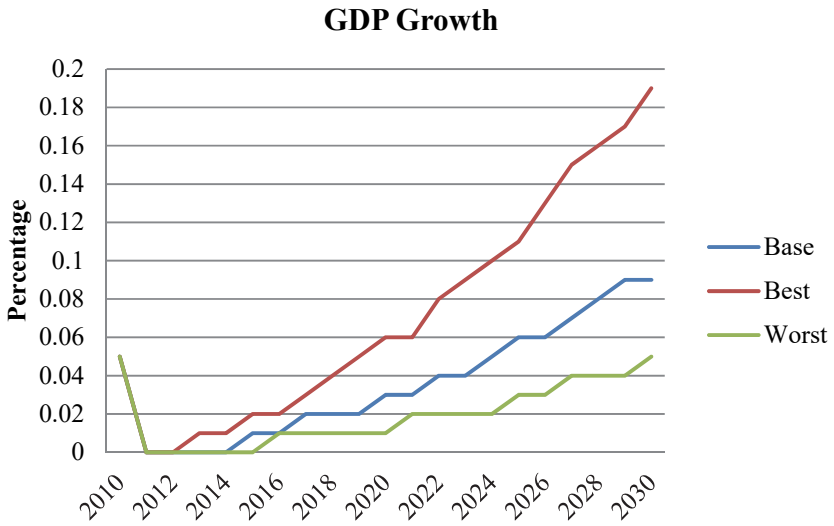

Figure 5-57. GDP growth (parameter 6)

Table 5-12. Elasticity of best scenario (parameter 6)

PATENTS	GDP GROWTH
0.0000	0.0000
0.6922	-
0.6931	-
0.6931	-
0.6929	-
0.6930	0.6931
0.6931	0.6931
0.6931	0.4055
0.6931	0.6931
0.6931	0.9163
0.6931	0.6931
0.6931	0.6931
0.6931	0.6931
0.6931	0.8109
0.6931	0.6931
0.6931	0.6061
0.6931	0.7732
0.6931	0.7621
0.6931	0.6931
0.6931	0.6360
0.6932	0.7472

Table 5-13. Elasticity of worst scenario (parameter 6)

PATENTS	GDP GROWTH
0.0000	0.0000
-0.6931	-
-0.6931	-
-0.6931	-
-0.6926	-
-0.6931	-
-0.6931	0.0000
-0.6930	-0.6931
-0.6931	-0.6931
-0.6931	-0.6931
-0.6930	-1.0986
-0.6931	-0.4055
-0.6931	-0.6931
-0.6931	-0.6931
-0.6931	-0.9163
-0.6931	-0.6931
-0.6931	-0.6931
-0.6931	-0.5596
-0.6931	-0.6931
-0.6931	-0.8109
-0.6931	-0.5878

7. Scholarships

Scholarships parameter is the most sensitive parameter since it affects all sectors: undergraduate program, postgraduate program, high-skilled workers, patents, and GDP growth based on technology production. However, since this parameter is the most sensitive, some behavioural patterns are not following the base scenario. For example, the number of undergraduate and postgraduate students in Indonesia arises rapidly after following the similar trend as base scenario in the beginning simulation time. These sudden changes lead to the exponential increase in other sectors, such as high-skilled workers, patents, and GDP growth. Increase in scholarships not only raises the number of high-skilled workers in Indonesia, but also abroad. Since the stock of high-skilled workers in Indonesia is large then the patents may as well increase. Worst scenario simulation implies that changes happen compared to base scenario but not as dramatic as best scenario. The sudden increase of the behaviour indicates that within the first half of the simulation, the trend of number of students will follow base scenario, however within the last half of the simulation the number increases due to the amplification of the inputs. A behaviour like this is explained due to the amplification as part of stock and flow unavoidable consequences. In the short term, the behaviour is considered strange; however, in the long run, as the effect of adjustment rate and time, the behaviour would be normal. (Sterman, 2000)

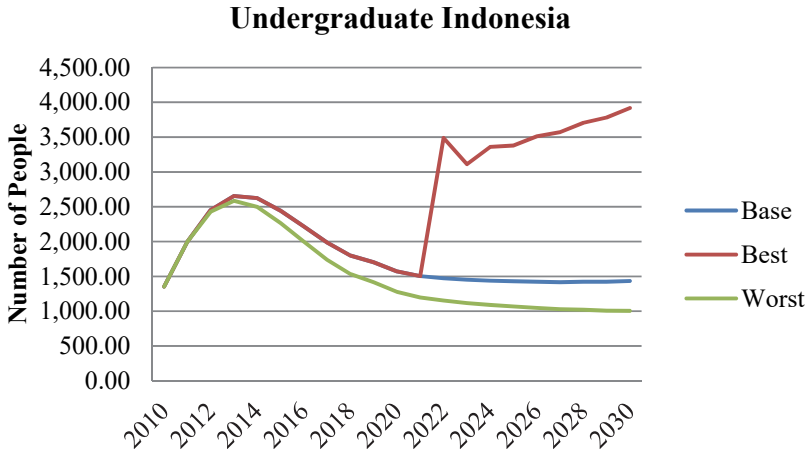

Figure 5-58. Undergraduate students in Indonesia (parameter 7)

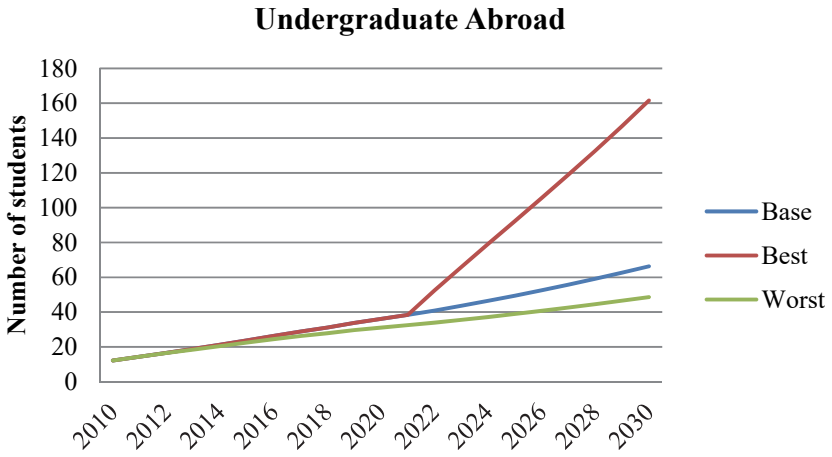

Figure 5-59. Undergraduate students abroad (parameter 7)

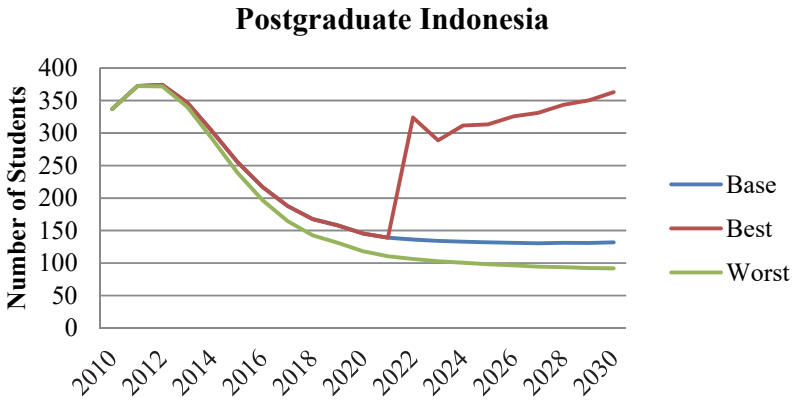

Figure 5-60. Postgraduate students in Indonesia (parameter 7)

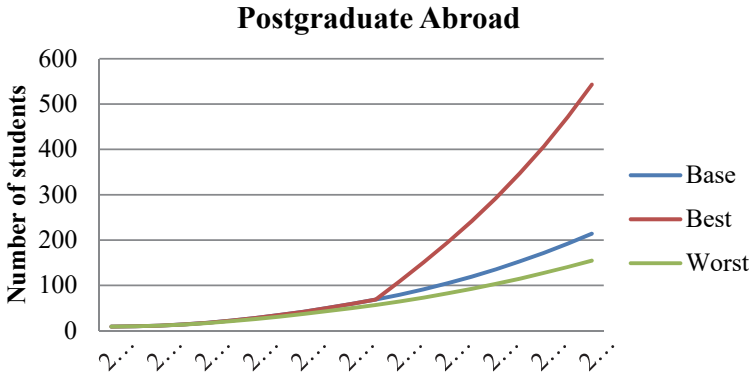

Figure 5-61. Postgraduate students abroad (parameter 7)

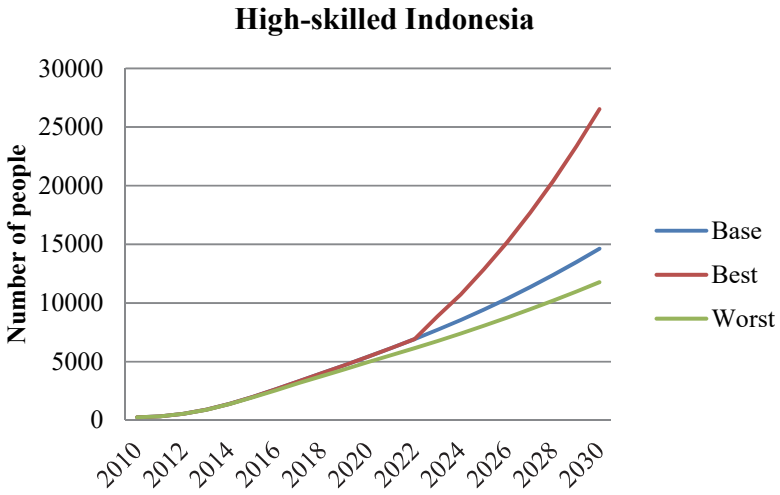

Figure 5-62. High-skilled workers in Indonesia (parameter 7)

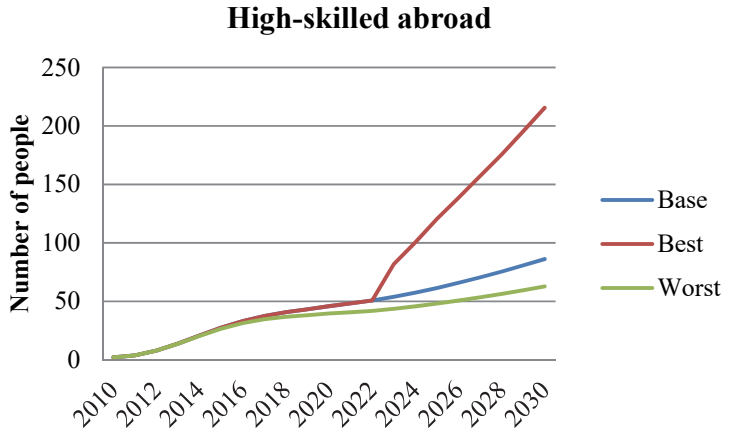

Figure 5-63. High-skilled workers abroad (parameter 7)

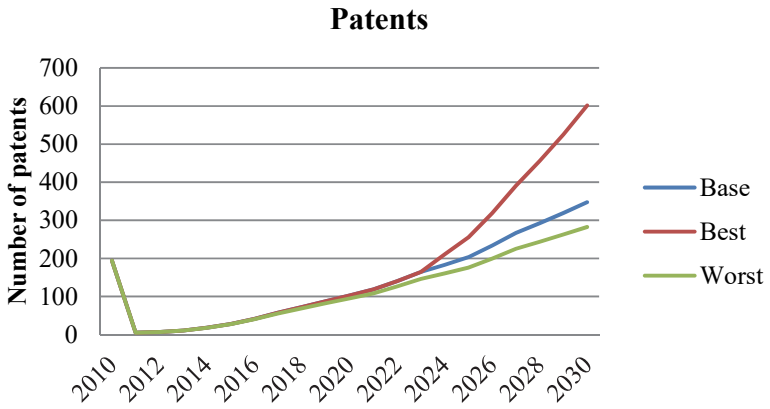

Figure 5-64. Patents (parameter 7)

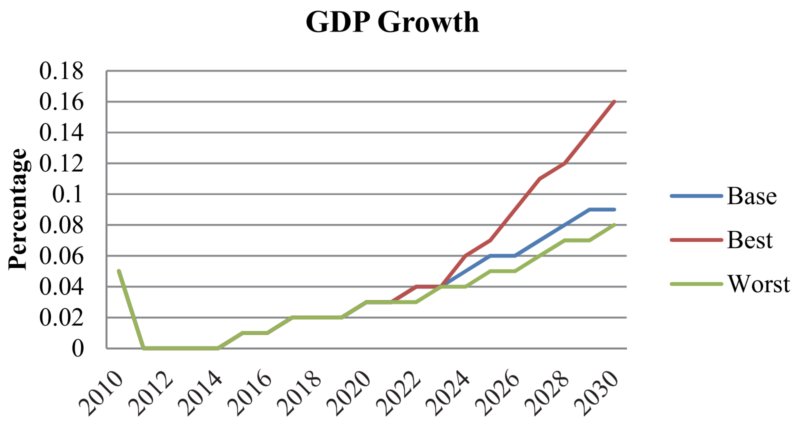

Figure 5-65. GDP growth (parameter 7)

Table 5-14. Elasticity of best scenario (parameter 7)

Postgraduate abroad	Postgraduate Indonesia	Undergraduate abroad	Undergraduate Indonesia	High-skilled abroad	High-skilled Indonesia	Patents	GDP GROWTH
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.3196	0.8672	0.2469	0.8625	0.0000	0.0000	0.0000	0.0000
0.5022	0.7674	0.4130	0.7628	0.4166	0.1393	0.0000	0.0000
0.6213	0.8532	0.5333	0.8479	0.5581	0.2266	0.1393	0.1823
0.7058	0.8659	0.6255	0.8604	0.6730	0.3105	0.2266	0.1542
0.7697	0.9088	0.6986	0.9028	0.7431	0.3800	0.3105	0.4055
0.8205	0.9308	0.7582	0.9244	0.8016	0.4433	0.3800	0.4520
0.8627	0.9635	0.8087	0.9566	0.8453	0.4986	0.4433	0.4055
0.8990	0.9847	0.8519	0.9776	0.8846	0.5493	0.4985	0.4418
0.9309	1.0128	0.8898	1.0053	0.9166	0.5948	0.5493	0.5754

Table 5-15. Elasticity of worst scenario (parameter 7)

Postgraduate abroad	Postgraduate Indonesia	Undergraduate abroad	Undergraduate Indonesia	High-skilled abroad	High-skilled Indonesia	Patents	GDP GROWTH
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-
-0.0099	-0.0064	-0.0091	-0.0104	0.0000	0.0000	0.0000	-
-0.0270	-0.0192	-0.0224	-0.0269	-0.0065	-0.0039	0.0000	-
-0.0477	-0.0392	-0.0388	-0.0485	-0.0179	-0.0118	-0.0039	-
-0.0694	-0.0664	-0.0567	-0.0745	-0.0341	-0.0225	-0.0120	0.0000
-0.0903	-0.0982	-0.0752	-0.1032	-0.0537	-0.0351	-0.0224	0.0000
-0.1109	-0.1308	-0.0938	-0.1325	-0.0758	-0.0489	-0.0351	0.0000
-0.1316	-0.1603	-0.1128	-0.1601	-0.0996	-0.0632	-0.0490	0.0000
-0.1515	-0.1858	-0.1316	-0.1849	-0.1234	-0.0775	-0.0633	0.0000
-0.1705	-0.2084	-0.1505	-0.2070	-0.1475	-0.0918	-0.0774	0.0000
-0.1890	-0.2290	-0.1686	-0.2275	-0.1699	-0.1056	-0.0919	0.0000
-0.2069	-0.2467	-0.1868	-0.2449	-0.1911	-0.1190	-0.1055	-0.2877
-0.2239	-0.2635	-0.2043	-0.2615	-0.2108	-0.1322	-0.1190	0.0000
-0.2402	-0.2794	-0.2216	-0.2771	-0.2292	-0.1452	-0.1322	-0.2231
-0.2559	-0.2944	-0.2376	-0.2918	-0.2463	-0.1579	-0.1452	-0.1823
-0.2708	-0.3085	-0.2534	-0.3058	-0.2625	-0.1703	-0.1579	-0.1823
-0.2851	-0.3222	-0.2687	-0.3192	-0.2776	-0.1825	-0.1703	-0.1542
-0.2988	-0.3351	-0.2832	-0.3318	-0.2918	-0.1943	-0.1825	-0.1335
-0.3119	-0.3476	-0.2971	-0.3440	-0.3054	-0.2059	-0.1943	-0.2513
-0.3245	-0.3592	-0.3108	-0.3555	-0.3184	-0.2172	-0.2059	-0.1178

8. Undergraduate program enrolment rate in Indonesia

The last parameter to change is the enrolment rate of undergraduate enrolment rate in Indonesia. It indicates the proportion of enrolled undergraduate students in Indonesia who choose S&E majors compared to all undergraduate students. In base scenario the proportion number of students enrolled in S&T fields is 33.4 of total undergraduate enrolment in that year; therefore, the best scenario is to set 66.8 and worst scenario is to set 16.7 percent out of the total enrolled undergraduate students in Indonesia in that year. Best scenario generates increase in the number of undergraduate students in Indonesia, high-skilled workers in Indonesia, patents, and GDP growth formed by technology production.

Different from previous parameter, the enrolment rate for undergraduate program in Indonesia has numerical sensitivity rather that behaviour sensitivity; as best and worst scenario will follow the behaviour of base scenario.

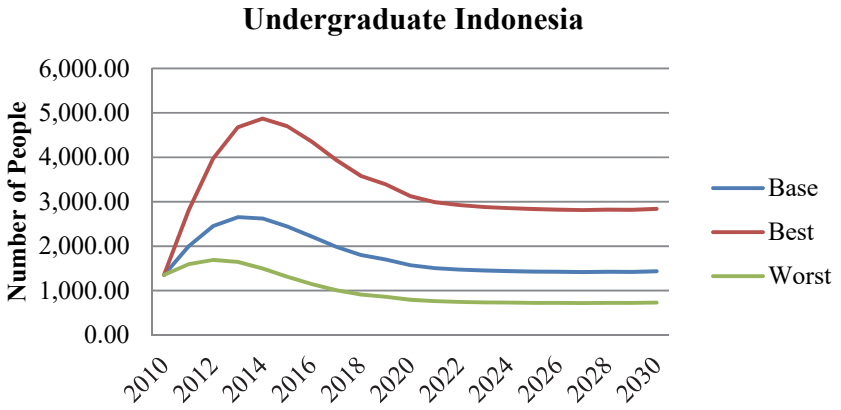

Figure 5-66. Undergraduate students in Indonesia (parameter 8)

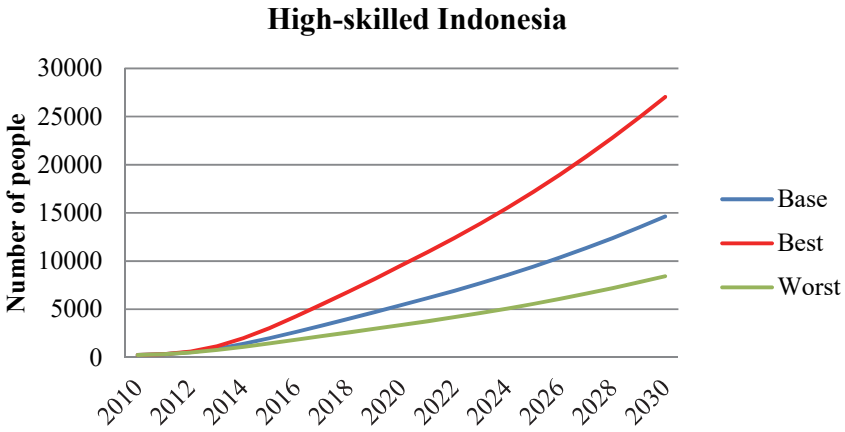

Figure 5-67. High-skilled workers in Indonesia (parameter 8)

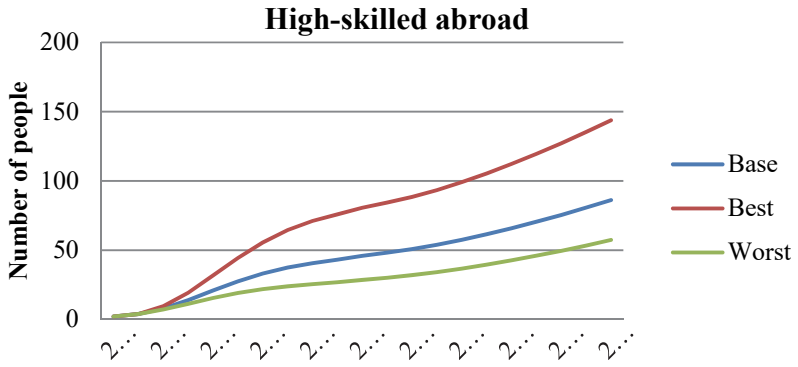

Figure 5-68. High-skilled abroad (parameter 8)

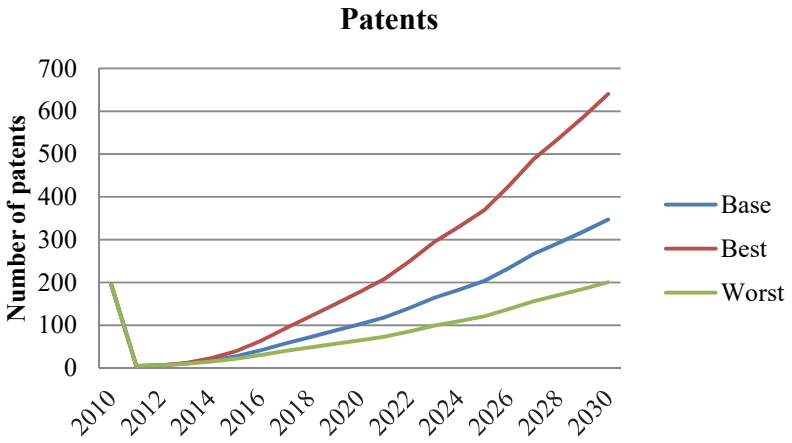

Figure 5-69. Patents (parameter 8)

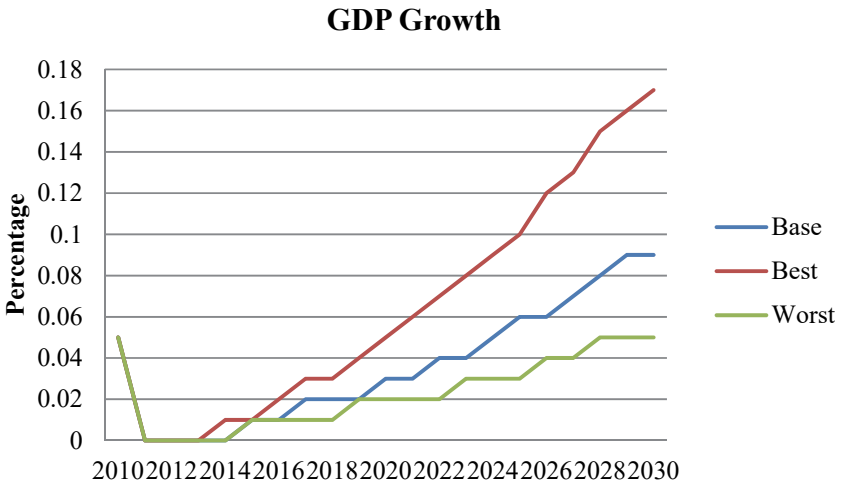

Figure 5-70. GDP growth (parameter 8)

Table 5-16. Elasticity of best scenario (parameter 8)

Undergraduate Indonesia	High-skilled abroad	High-skilled Indonesia	PATENTS	GDP GROWTH
0.0000	0.0000	0.0000	0.0000	0.0000
0.3395	0.0000	0.0000	0.0000	-
0.4830	0.1849	0.1216	0.0000	-
0.5657	0.3252	0.2564	0.1221	-
0.6193	0.4176	0.3566	0.2561	-
0.6543	0.4791	0.4262	0.3563	0.0000
0.6750	0.5199	0.4749	0.4263	0.6931
0.6847	0.5457	0.5094	0.4748	0.4055
0.6877	0.5590	0.5337	0.5093	0.4055
0.6879	0.5640	0.5513	0.5337	0.6931
0.6874	0.5640	0.5647	0.5513	0.5108
0.6869	0.5599	0.5747	0.5646	0.6931
0.6864	0.5548	0.5827	0.5747	0.5596
0.6860	0.5496	0.5893	0.5827	0.6931
0.6856	0.5443	0.5948	0.5893	0.5878
0.6852	0.5390	0.5994	0.5948	0.5108
0.6848	0.5335	0.6034	0.5994	0.6931
0.6845	0.5281	0.6067	0.6033	0.6190
0.6842	0.5227	0.6096	0.6067	0.6286
0.6839	0.5176	0.6121	0.6096	0.5754
0.6836	0.5122	0.6142	0.6121	0.6360

Table 5-17. Elasticity of worst scenario (parameter 8)

Undergraduate Indonesia	High-skilled abroad	High-skilled Indonesia	PATENTS	GDP GROWTH
0.0000	0.0000	0.0000	0.0000	0.0000
-0.2258	0.0000	0.0000	0.0000	-
-0.3717	-0.1071	-0.0668	0.0000	-
-0.4786	-0.2138	-0.1580	-0.0661	-
-0.5600	-0.2999	-0.2411	-0.1581	-
-0.6197	-0.3674	-0.3089	-0.2411	0.0000
-0.6578	-0.4172	-0.3623	-0.3088	0.0000
-0.6764	-0.4508	-0.4036	-0.3623	-0.6931
-0.6823	-0.4691	-0.4349	-0.4037	-0.6931
-0.6827	-0.4760	-0.4585	-0.4349	0.0000
-0.6817	-0.4758	-0.4771	-0.4584	-0.4055
-0.6807	-0.4708	-0.4915	-0.4771	-0.4055
-0.6798	-0.4637	-0.5033	-0.4915	-0.6931
-0.6790	-0.4564	-0.5131	-0.5033	-0.2877
-0.6782	-0.4489	-0.5214	-0.5131	-0.5108
-0.6774	-0.4417	-0.5285	-0.5214	-0.6931
-0.6768	-0.4347	-0.5346	-0.5285	-0.4055
-0.6761	-0.4275	-0.5399	-0.5347	-0.5596
-0.6755	-0.4205	-0.5444	-0.5399	-0.4700
-0.6749	-0.4139	-0.5484	-0.5445	-0.5878
-0.6744	-0.4072	-0.5518	-0.5484	-0.5878

6. CONCLUSIONS AND TENTATIVE RECOMMENDATIONS

The world market has become more open than ever, causing gaps of development between countries. These gaps affect countries to compete, especially in science and technology in order to push technology development and then receive benefits from it. The real demand of scientists and engineers in the world is high, hence countries put great effort to search for scientists and engineers to work in their countries to generate changes.

In most developed countries, the proportion for human capital and financial resources tend to be in optimal position. Developed countries seek scientists and engineers from other countries to develop their skills there, because not only there will be more jobs available, but also developed countries provide better facilities, incentives, and supporting policies in research and development. The governments also support innovation in their countries with policies such as R&D tax initiatives to support R&D activities by private companies to generate innovation (OECD, 2013).

Less developed countries (or developing countries) produce relatively small amount of scientists and engineers as professions. Even if there are professionals in science and technology areas, small opportunities of employment in science and engineering area or the lack of research area will be the next problem; students who are expected to be working in the same major in which they graduated look for job opportunities in managerial positions in corporations due to the level of salary and, again, the small opportunities in the area where they study.

As mobilization occurs, international mobility of students are also inevitable. The movement of students abroad in order to pursue higher education abroad is also critical because students will be exposed with more career options and better quality of life there. Good infrastructure and more stable economic and political condition in developed countries are some of the factors influencing people to move abroad, or for students to not return home after finishing their studies abroad.

Development in science and technology is essential for economic development in a country. While this is an important issue, it seems that not all countries are concern, especially in Indonesia. How Indonesia is not very much concerned about this matter can be apparent from very few research and analysis about the movement of scientists and engineers abroad.

The significance of this research is how to manage these relationships between stakeholders into one holistic view, in general, and to give caution to Indonesian government on what happens and help them make policy based on the result of this result, in particular.

There are several research objectives in this research:

1. The first objective of this research is to model the mechanism of Indonesian scientists and engineers mobilization that can collect perspective of shareholders. To understand the impacts of these movement to in terms of technology and economy development. The produced model is a model of prediction that will forecast the condition in the future.
2. The second objective is to understand and analyse the decision making process and factors affecting people's decision regarding their choices of studying abroad and their choices to return. This is essential to be acknowledged because this research is about human capital hence it involves human factor besides the macro view condition of a country. Additionally, this study will also
3. Finally, to analyse current policies in Indonesia related to the stakeholders, especially in education and technology policies; and next is to provide realistic policy recommendations for Indonesian government on the education and technology policies and adjusting to Indonesian government's objectives.

This research uses several methods to fulfil its objectives. First, it uses surveys to analyse the preferences of students and professionals, especially those who study and work abroad, and an additional binary logistic model to analyse the influence of career path and political stability for Indonesians. Second, it uses interviews and observation in Indonesian government's Ministry of Foreign Affairs and two Indonesian research institutions. This research also collect data from secondary sources. The last method is system dynamics, which conclude all results from methods above, and then conduct a policy scenario simulation to get the optimal impact for the development of Indonesia.

The result shows that the overall average of all respondents consider that opportunity to work in suitable fields; surrounding's or general country's safety; easy communication with colleagues; equal opportunity for every religion; and opportunity to work in desirable fields are the most important variables if they would like to live in a country. 55% of students would like to

return, and would like to work in a company according to their specialization. Additional binary logistic analysis indicated that career path increasing level can increase the chances to live in abroad three times larger, while political stability can increase the chances for people to live abroad 50% larger.

Data from interview is in the form of valuable comments and perspective from the government, thus it is easier to understand and create input in the simulation. There are five scenarios implemented: government funding for university, increase on scholarship, incentives for returning students, increase in research and development expenditure, and incentives for patents created. Significance increasing number in the beginning years before declining showed that there need to be improvement in the policy before the number decreases. It is clearly seen in almost all policy scenarios concerning undergraduate students. Government spending for university will increase the number of undergraduate students abroad, high skilled both in Indonesia and abroad, and patents number, compared to policy zero. Second policy, the increasing scholarship from the government showed overall increase, which increase the GDP growth by 4 times compared to the beginning year of simulation until year 20. This result for GDP growth is highly unlikely, logically, but it shows that how this policy can influence all aspect and leads to great leap of growth in GDP. Scenario 3, incentives for returning students, indicates that it will affect the number of high skilled abroad and in Indonesia, and also patents, however the number is not as large as the second policy scenario. Policy 4, the increase in R&D expenditure by Indonesian government, indicates that this policy will influence the number of patents and GDP growth, but not strongly influence the number of educated Indonesians, since this policy only has direct effects on the patents and GDP growth. It also indicates that the policy may only directed to managing existing researchers and research activities in order to strive. The last policy, incentives for patents, also shows no increase whatsoever in every aspects. Hence, since this policy has not been conducted before, more information should be included in order for this policy to make changes in several aspects.

The tentative recommendations for government, concluded from this research can vary. If Indonesian government would like to increase the number of students, Indonesian government should increase the number of scholarships to give chances for Indonesians to have higher education, especially in Science and engineering areas. Second, if the government would like to increase the technology advancement, then increase in R&D expenditures should be implemented,

and it will lead to the increase in GDP in twenty years. Third, if Indonesian government would like to increase Indonesian high skilled workers, then they should implement incentives for returning students. Overall, in order to increase the number in all aspects, Indonesian government should increase the number of scholarships because it will increase the number of Indonesian highly educated and highly skilled professionals which leads to the increase in technology development and economic development. Second best policy based on simulation is to increase subsidies to universities. Third best policy suggestion is increasing R&D expenditures. While incentive for returning students cause negative impact on high-skilled workers abroad, the difference is not fairly significant. While incentives for patents has no significant effects, or too small to be calculated, this policy scenario should be the least beneficial.

To test the model and to analyze further which specific parameters that can affect the aspects that the author would like to improve, eight parameters were chosen to explore their effects on eight aspects that explained previously. Those eight parameters are: (1) return rate of high-skilled workers abroad, (2) GDP spent on education, (3) high-skilled workers in Indonesia input rate, (4) patents produced per high-skilled workers in Indonesia, (5) Postgraduate program in Indonesia enrolment rate, (6) R&D expenditure, (7) scholarships, and (8) undergraduate program enrolment rate in Indonesia.

Table 6-1. Parameters sensitivity analysis

Parameter	Undergraduate (Indonesia)	Undergraduate (abroad)	Postgraduate (Indonesia)	Postgraduate (abroad)	High-skilled (Indonesia)	High-skilled (abroad)	Patents	GDP growth
1					V	V	V	
2					V	V	V	V
3					V		V	V
4							V	V
5			V		V	V	V	V
6							V	V
7	V	V	V	V	V	V	V	V
8	V				V	V	V	V

Based on the result of simulation on the parameters, the most sensitive parameter, of all parameters simulated, is the amount of scholarship given to Indonesian students since it affects the number of all aspects considered. The changes in behavior also indicates that this parameter will likely change the simulation in the future, therefore Indonesian government should consider this policy at best and would try to control education system and creating sufficient and informative job vacancy for people to work in their suitable fields. To increase scholarships and make it efficient is by avoiding cutting down operational costs and also information availability for future applicants, since one of the problems of this policy is the lack of information of scholarships availability to the society. The elasticity of the scenarios is not too elastic (which small reaction to extreme values), showing that the model is robust.

The limits in this research are the context and the fields of this topic. Also, since the data management is not very good in Indonesia (many missing data, or no data at all) may create bias. However, to test the validity of the model, sensitivity analysis must be conducted. And it succeeded. Therefore, as further research, more data completion the consistency of Indonesian government wants to implement this policy is important.

References

Alburo, F. A., & Abella, D. I. (2002). *Skilled Labour Migration from Developing Countries: Study on the Philippines.* Geneva: International Labour Office.

Ariss, A. A. (2010). Modes of Engagement: Migration, Self-Initiated Expatriation, and Career Development. *Career Development International, 15*(4), 338-358.

Badan Akreditasi Nasional Perguruan Tinggi. (2016, 08 19). *Badan Akreditasi Nasional Perguruan Tinggi*. Retrieved from Badan Akreditasi Nasional Perguruan Tinggi Website: http://ban-pt.kemdiknas.go.id/

Barré, R., Meyer, J.-B., & Valéria, H. (2003). *Scientific Diaspora: How Can Developing Countries benefit from Their Expatriate Scientists and Engineers?* Paris: Institut for Development Research.

Barro, R. (1991). Economic Growth in a Cross Section of Countries. *Q. J. Economics, 106*, 407-444.

Belot, M., & Hatton, T. (2008). *Immigrant Selection in the OECD.* London: Centre for Economic Policy Research.

Bhandari, R., & Blumenthal, P. (2011). Global Student Mobility and the Twenty-First Century Silk Road: National Trends and New Directions. In R. Bhandari, & P. Blumenthal (Eds.), *International Students and Global Mobility in Higher Education: National Trends and New Directions* (pp. 1-23). New York: Palgrave Macmillan.

Brettel, C., & Hollifield, J. (2007). *Migration Theory: Talking Across Disciplines* (2nd ed.). New York and London: Routledge.

Brucker, H., & Defoort, C. (2009). Inequality and the Self-Selection of International Migrants: Theory and New Evidence. *International Journal of Manpower, 30*(7), 742-764.

Burns, A., & Mohapatra, S. (2008). *International Migration and Technological Progress.* The World Bank.

Butler, K. (2001). Defining Diaspora, Refining a Discourse. *Diaspora, 10(2)*, 189-219.

Castles, S., de Haas, H., & Miller, M. J. (2014). *The Age of Migration: International Population Movements in the Modern World* (5th ed.). New York and London: The Guilford Press.

Cohen, R. (1997). *Global Diaspora.* London: UCLP.

Docquier, F., & Marfouk, A. (2004). *Measuring the International Mobility of Skilled Workers.* Washington DC: World Bank.

Docquier, F., & Rapoport, H. (2004). *Skilled Migration: The Perspective of Developing Countries.* World Bank.

Docquier, F., & Rapoport, H. (2006). The Brain Drain. Louvain-Bar Ilan: Unknown publisher.

Education New Zealand. (2015, August). *Education New Zealand.* Retrieved from Education New Zealand Website: nziec.co.nz

Fatah, F. A., Othman, A., & Abdullah, S. (2012). Economic Growth, Political Freedom and Human Development: China, Indonesia, and Malaysia. *International Journal of Business and Social Science, 3*(1), 291-299.

Findlay, A. M., & Li, F. L. (1998). A Migration Channels Approach to The Study of Professionals Moving to and From Hong Kong. *The International Migration Review, 32*(3), 682-703.

Forstenlechner, I. (2010). Exploring Expatriates' Behavioral Reaction to Institutional Injustice on Host Country Level. *Personnel Review, 39*(2), 178-194.

Frankema, E., & Lindblad, J. (2006). Technological Development and Economic Growth in Indonesia and Thailand since 1950. *ASEAN Economic Bulletin, 23*(2), 303-324.

Garrick, L. (1991). A Channels Framework for the Study of Skilled International Migration. Glasgow: Unpublished Ph.D. thesis.

Gibson, J., & McKenzie, D. (2011). *Eight Questions about Brain Drain.* The World Bank.

Gonzalez, E. T. (2010). Does International Migration Induce Human Capital Investment and Knowledge Transfer? Evidence from the Philippines. *Network of Asia Pacific Schools and Institutes of Public Administration and Governance*, (pp. 1-15). Trivandrum. Retrieved November 7, 2013, from http://www.napsipag.org/

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* (pp. 83-106). New York: Palgrave Macmillan.

Guellec, D., & Cervantes, M. (2002). *International Mobility of Highly Skilled Workers: From Statistical Analysis to Policy Formulation in OECD.* Paris: OECD.

Gungor, N. D., & Tansel, A. (2008). Brain Drain from Turkey: The Case of Professionals Abroad. *International Journal of Manpower, 29*(4), 323-347.

Gwynne, P. (1999). 'Brain Circulation' Replacing 'Brain Drain' to U.S. As Foreign-Born Scientists, Engineers Return Hime. *Research Technology Management, 42*(1), 2-3.

Holtzapple, M., & Reece, W. (1997). *Foundations of Engineering.* New York: McGraw Hill.

Inayati, T., Arai, T., & Putro, U. S. (2014). areer Path and Political Stability: Factors for Leaving Indonesia? *Open Journal of Social Sciences*, 179-185.

Kompas. (2010). *Kompas*. Retrieved January 15, 2014, from Kompas Website: http://edukasi.kompas.com/read/2010/12/13/11095326/Penelitian.Masih.Tumpang.Tindih

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

Lembaga Ilmu Pengetahuan Indonesia. (N.A). *LIPI*. Retrieved January 14, 2014, from Lembaga Ilmu Pengetahuan Indonesia website: http://www.pappiptek.lipi.go.id/

Mahroum, S., Eldridge, C., & Daar, A. (2006). Transnational Diaspora Options: How Developing Countries Could Benefit From Their Emigrant Populations. *International Journal on Multicultural Societies*, 25-41.

Meyer, J.-B., & Wattiaux, J.-P. (2006). Diaspora Knowledge Networks: Vanishing Doubts and Increasing Evidence. *International Journal on Multicultural Societies*, 4-24.

Mountford, A. (1997). Can a Brain Drain be Good for Growth in the Source Economy? *Journal of Development Economics, 53*, 287-303.

Organisation for Economic Co-operation and Development. (2013, October). *OECD.* Retrieved from Organisation for Economic Co-operation and Development official website: http://www.oecd.org/

Prausnitz, J. (1991). From Appolo to Prometheus and Hercules: Goals and Methods of Chemical Engineering. *Chem.-Ing.-Tech*(63), 447-457.

Richardson, J. (2007). Migration: New Urgencies Replace Traditional Welcome. *Foresight, 9*(5), 48-55.

Safran, W. (1991). Diaspora in Modern Society: Myths of Homeland and Return. *Diaspora, 1*, 83-99.

Schiff, M. (2005). *Brain Gain: Claims about its Size and Impact on Welfare and Growth Are Really Exaggerated.* The World Bank.

Smart, A., & Hsu, J. (2004). The Chinese Diaspora, Foreign Investment and Economic Development in China. *The Review of International Affairs, 3(4)*, 544-566.

Solimano, A. (2010). *International Migration in the Age of Crisis and Globalization.* New York: Cambridge.

Sterman, J. D. (2000). *Business Dynamics: Systems Thinking and Modeling for a Complex World.* Boston: Irwin McGraw-Hill.

Tansel, A., & Gungor, N. D. (2002). "Brain Drain" from Turkey: Survey Evidence of Student Non-Return. *Career Development International, 8*(2), 52-69.

Tempo. (2016, January 1). *Tempo*. Retrieved from Tempo online website: http://en.tempo.co/

Thorn, K. (2009). The Relative Importance of Motives for International Self-Initiated Mobility. *Career Development International, 14*(5), 441-464.

Tremblay, K. (2004, October 22). *Links Between Academic Mobility and Immigration.* Retrieved November 19, 2013, from http://www.wes.org/

Turner, W. (2003). *Project Proposal for UNESCO's International Migration Section on the Contribution of Information and Communication Technologies to the Development of Diaspora Knowledge Networks.* Orsay: The International Committee for Social Science Information and Documentation (ICSSD).

Universitas Gajah Mada. (2016, 08 01). *Universitas Gajah Mada.* Retrieved from Gajah Mada University Website: http://luk.staff.ugm.ac.id/atur/PP26-2015PTNBH.pdf

Wie, T. K. (2006). Policies Affecting Indonesia's Industrial Technology Development. *ASEAN Economic Bulletin, 23*(3), 341-358.

Williams, A. M. (2006). Lost in Translation? International Migration, Learning and Knowledge. *Progress in Human Geography, 30*(5), 588-607.

World Bank. (2014, January 22). *World Bank Data*. Retrieved 11 7, 2013, from World Bank Website: http://data.worldbank.org/

Xinyu, Y. (2011). Mobility Strategies and Trends: The Case of China. In R. Bhandari, & P. Blumenthal (Eds.), *International Students and Global Mobility in Higher Education: National Trends and New Directions* (pp. 25-41). New York: Palgrave Macmillan.

APPENDICES

APPENDIX A. SURVEY RESULTS

Table A-1. All respondents response

Factors	Average
Opportunity to work in suitable fields	4.584906
Easy communication with colleagues	4.471698
Surrounding's or general country's safety	4.471698
Opportunity to work in desirable fields	4.433962
Equal opportunity for every religion	4.433962
Distinct career path in workplace	4.415094
Financial and health support from employer	4.396226
Easy communication with family and friends	4.377358
Equal opportunity for every race	4.301887
Health support from the Government	4.283019
R&D budget	4.283019
Supportive community or neighborhood	4.245283
Research field's variety	4.245283
Scholarship availability	4.230769
Area of specialization's variety	4.226415
Equal opportunity for every gender	4.188679
Political stability	4.075472
Average salary	3.830189
Strong culture or tradition	3.45283
Foreign investment / the amount of multinational companies in a country	3.433962

Table A-2. Students responses

Variables	Average Score
Financial and health support from employer	4.542857
Opportunity to work in suitable fields	4.514286
Surrounding's or general country's safety	4.428571
Easy communication with colleagues	4.428571
Health support from the Government	4.4
Opportunity to work in desirable fields	4.342857
Equal opportunity for every religion	4.314286
Distinct career path in workplace	4.314286
R&D budget	4.285714
Easy communication with family and friends	4.285714
Supportive community or neighborhood	4.171429
Equal opportunity for every gender	4.142857
Scholarship availability	4.088235
Political stability	4.085714
Equal opportunity for every race	4.028571
Research field's variety	4.028571
Area of specialization's variety	4.028571
Average salary	3.8
Foreign investment / the amount of multinational companies in a country	3.485714
Strong culture or tradition	3.285714

Table A-3. Students' responses based on level of education

Variables	Bachelor	Master	Doctor	Variables	Bachelor	Master	Doctor
Average salary	3.75	4	3.6	Health support from the Government	4.25	4.4	5
Foreign investment / the amount of multinational companies in a country	3.95833333	2.8	2.6	Scholarship availability	3.875	4	4.2
Supportive community or neighborhood	4.125	4	4.8	Research field's variety	3.875	4.2	4.4
Surrounding's or general country's safety	4.375	4.4	4.6	Area of specialization's variety	3.875	4.4	4.4
Strong culture or tradition	3.125	3.4	3.6	Distinct career path in workplace	4.416667	4.4	3.4
Equal opportunity for every race	3.95833333	3.8	4.8	Easy communication with colleagues	4.541667	4	4.2
Equal opportunity for every religion	4.45833333	3.2	4.8	Opportunity to work in suitable fields	4.458333	4.6	4.8
Equal opportunity for every gender	4.08333333	4	4.8	Opportunity to work in desirable fields	4.375	3.8	4.6
Political stability	3.91666667	4	4.6	Financial and health support from employer	4.458333	4.4	5
R&D budget	4.08333333	4.4	4.8	Easy communication with family and friends	4.291667	4.4	4

Table A-4. Professional respondents

Variables	Mean
Equal opportunity for every race	4.8
Research field's variety	4.666667
Opportunity to work in suitable fields	4.666667
Equal opportunity for every religion	4.666667
Opportunity to work in desirable fields	4.6
Distinct career path in workplace	4.6
Scholarship availability	4.533333
Area of specialization's variety	4.533333
Surrounding's or general country's safety	4.466667
Easy communication with colleagues	4.466667
Easy communication with family and friends	4.466667
Supportive community or neighborhood	4.4
Equal opportunity for every gender	4.333333
R&D budget	4.266667
Political stability	4.133333
Financial and health support from employer	4.066667
Health support from the Government	4.066667
Average salary	3.866667
Strong culture or tradition	3.866667
Foreign investment / the amount of multinational companies in a country	3.266667

APPENDIX B. Data from Ministry of Foreign Affairs, BPPT, and LIPI

Table B-1. Data derived from annual report of BPPT

BPPT		**Year**												
Data type	**Unit**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Total Engineers (Indonesia)	*People*	*446*	*506*	*500*	*511*	*511*	*1806*	*2642*	*2176*	*2322*	*2328*	*2341*	*2332*	
Engineers (Min. of Agriculture)	People												40	
Engineers (Min. of Energy and mineral source)	People												178	
Engineers (Min. of public work and public housing)	People												72	
Engineers (Min. of maritime and fisheries)	People												301	
Engineers(Min. of Insudtry)	People												52	
Engineers (Min. of transportation)	People												39	
Engineers (Min. of culture, primary and secondary education)	People												110	
Engineers (Min. of labour)	People												19	
Engineers (National Institute of Aeronautics and Space)	People												97	
Engineers (National Atomic Energy Agency)	People												57	
Engineers (Indonesian Academy of Science)	People												41	
Engineers (Indonesian Agency for Meteorological, Climatological and Geophysics)	People												5	
Engineers (Agency for the Assessment and Application of Technology)	People												1318	
Engineers (Govt of West Borneo)	People												2	
Engineers (Govt of South East Celebes)	People												1	
Researchers / Scientists	People			361	373	327	301	270	257	232	216	180		
Engineers	People			86	126	157	770	945	1032	1153	1232	1084		
Patents registered	Piece							109		143		167		
Patents accepted	Piece							41		72		87		

Table B-2. Data derived from BPPT annual report

LIPI		**Year**										
Data type	Unit	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Scientists	People							1359	1522	1541	1536	
Engineers	People							38	36	41	42	
scientific publication	piece							1805	1929	2039	1302	
Patent registered	piece					38	43	35	29	43	53	
Patented product used by society	Percentage						3.15	4.78	3.05	4.34		
Products / prototype used by society	Percentage						30	40.46	35.2	39.7		
Research facilities	Building						0	5	5	83		
Laboratorium facilities	Report						1	1	1	4		
Increase of facilities and infrastructure	Report						3	6	22	6		
Certified laboratory	Laboratorium						12	10	11	10		
Scientists continuing studies (Master)	People							225	240	126		
Scientists continuing studies (Doctor)	People							52	89	106		
Scientists joining training program	People							969	1022	588		
Scientists joining training program	Percentage						26	20.51	30.17	18.2		

Table B-3. Data on Indonesians abroad (Ministry of Foreign Affairs)

Area	Category							
	University students	**Domestic Helper**	**Mining (oil, gas, gold, etc)**	**Health**	**Manufacturing Industry**	**Information technology**	**Education**	**International organization**
East and South East Asia	396	1883486	92	29	471	43	40	21
South and Central Asia	195	1682	6	7	9	2	3	36
Middle East	339	627776	128	178	306	18	29	14
Africa	1192	8080	119	3	28	0	15	4
North and Central America	458	67825	5	41	10	7	19	55
South America	16	1715	1	0	1	0	4	0
Western Europe	288	38696	18	9	18	5	21	5
South East and East Europe	300	21787	8	5	36	0	14	11
Oceania	150	63811	4	4	27	9	11	2
Carribean	7	647	0	0	0	0	2	0
Total	3341	2715505	381	276	906	84	158	148

Table B-4. Data on Indonesians abroad (Ministry of Foreign Affairs) continued

Area	Category						
	Hotel and tourism	**Finance**	**Legal / Law**	**Fashion industry**	**Entrepreneurship**	**Art and culture**	**Electronic media**
East and South East Asia	218	24	16	69	288	6	2
South and Central Asia	41	2	0	0	5	1	0
Middle East	618	14	1	56	14	6	3
Africa	195	2	0	0	1	0	0
North and Central America	261	15	1	1	151	0	3
South America	1	0	0	0	2	1	0
Western Europe	26	11	0	2	10	2	2
South East and East Europe	185	7	1	0	2	4	1
Oceania	26	11	2	0	15	0	3
Carribean	3	0	0	0	0	0	0
Total	1574	86	21	128	488	20	14

APPENDIX C. SYSTEM DYNAMICS (STOCK AND FLOW, FORMULAS)

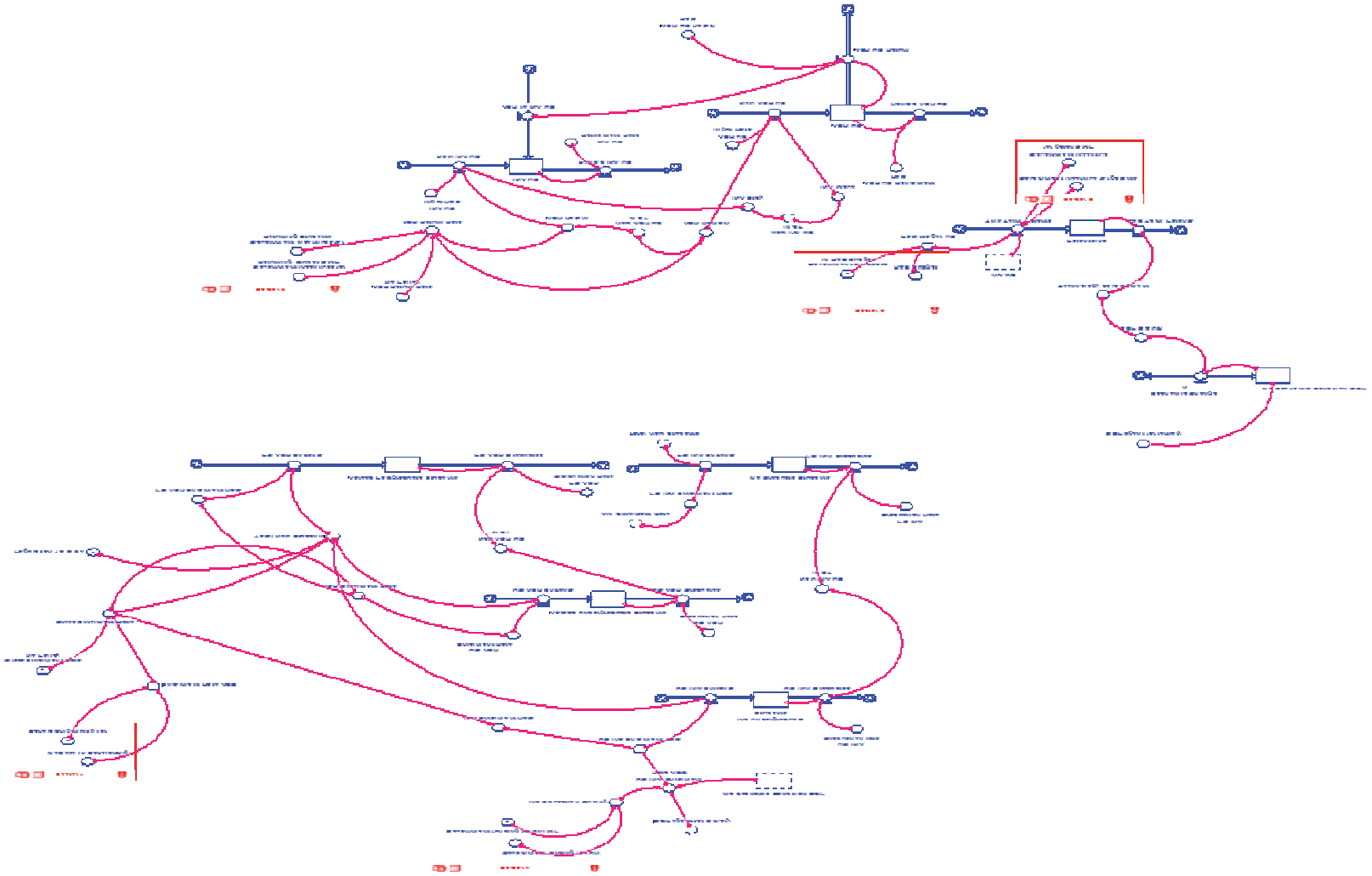

Figure C-1. System dynamics model of scientists and engineers international movements

Table C-1. Description of variables

No.	Variables	Formula	Value	Assumptions	Source	Data year
1	Abroad_Postgraduate_Students (t)	Abroad_Postgraduate_Students(t - dt) + (PG_ABR_Entrants - PG_ABR_Graduates) * dt	9		British Council	2012
2	INFLOWS:					
	PG_ABR_Entrants	PG_ABR_Enrolment_Rate*Total_New_Students				
3	OUTFLOWS:					
	PG_ABR_Graduates	Abroad_Postgraduate_Students*PG_ABR__Graduation_Rate				
4	Abroad_Undergraduate_Students(t)	Abroad_Undergraduate_Students(t - dt) + (UG_ABR_Entrants - UG_ABR_Graduates) * dt	37*0.33	0.33 = proportion of S&T students	UNESCO	2010, 2009
5	INFLOWS:					
	UG_ABR_Entrants	Total_New_Students*UG_ABR__Enrolment_Rate				
6	OUTFLOWS:					
	UG_ABR_Graduates	Abroad_Undergraduate_Students*UG_ABR__Graduation_Rate				
7	ABR_HS(t) = ABR_HS(t - dt) + (New_ABR_HS - Retired_ABR_HS - ABR_HS_Return) * dt		2	Number of high-skilled in Information Technology * the number of science and technology field	Ministry of Foreign Affairs	2016
8	INFLOWS:					
	New_ABR_HS	ABR_HS_Input_Rate*(ABR_Remain+INA_Move)				
9	OUTFLOWS:					
	Retired_ABR_HS	ABR_HS*ABR_HS_Retirement_Rate				

	ABR_HS_Return	ABR_HS*ABR_HS_Return_Rate				
10	Ina_Economic_Condition_GDP(t) =	Ina_Economic_Condition_GDP(t - dt) + (Economic_Change_A) * dt	7.55E+11	GDP	Worldbank	2010
11	INFLOWS:					
	Economic_Change_A	Ina_Economic_Condition_GDP+(Ina_Economic_Condition_GDP*GDP_Growth)				
12	Ina_Graduate_Students(t)	Ina_Graduate_Students(t - dt) + (PG_INA_Entrants - PG_INA_Graduates) * dt	337		Ministry of Education	2011
13	INFLOWS:					
	PG_INA_Entrants	PG_INA_Enrolment_Rate*Total_New_Students				
14	OUTFLOWS:					
	PG_INA_Graduates	Ina_Graduate_Students*PG_INA__Graduation_Rate				
15	INA_HS(t)	INA_HS(t - dt) + (New_INA_HS + ABR_to_INA_HS - Retired_INA_HS) * dt	260.301	The number of lecturers, researchers, and scientists and engineers	Worldbank, DIKTI, LIPI, BPPT	2010, 2016
16	INFLOWS:					
	New_INA_HS	(ABR_Return+INA_Stay)*INA_HS_Input_Rate				
	ABR_to_INA_HS	ABR_HS_Return				
17	OUTFLOWS:					
	Retired_INA_HS	INA_HS*INA_HS__Retirement_Rate				
18	Ina_Undergraduate__Students(t) =	Ina_Undergraduate__Students(t - dt) + (UG_INA_Entrants - UG_INA_Graduates) * dt	4100*0.16	The number of undergraduate students * the proportion of S&T graduates	Ministry of education	2009
19	INFLOWS:					

	UG_INA_Entrants	Total_New_Students*UG_Ina_Enrolment_Rate				
20	OUTFLOWS:					
	UG_INA_Graduates	Ina_Undergraduate__Students*UG_INA__Graduation_rate				
21	Patents_Ina(t) =	Patents_Ina(t - dt) + (This_Term_Patents - Last_Term_Patents) * dt	194	Patents accepted	*HakKekayaanIntelektual*	2010
22	INFLOWS:					
	This_Term_Patents =	(INA_HS*Patents_per_HS)+(Government_Incentive_for_patents*Government_incentive_for_patents_MP)				
23	OUTFLOWS:					
	Last_Term_Patents = Patents_Ina					
24	ABR_Enrolment_Rate	Gross_Enrolment_Ratio*0.008		0.008 = proportion in students abroad	UNESCO	2010
25	ABR_HS_Input_Rate		0.9	In developed countries, it is important to have specialized education background, especially working in S&T	Observation	2016
26	ABR_HS_Retirement_Rate		0.01	Similar with Indonesia's retirement rate assumption		
27	ABR_HS_Return_Rate = 0.4		0.4	From 43 Indonesian expats abroad, 40% would like to return	Quora forum	2016

28	ABR_Remain	New_ABR_HS_in_ST*(1-ABR_Return_Rate)				
30	ABR_Return	New_ABR_HS_in_ST*ABR_Return_Rate				
31	ABR_Return_Rate =	IF(Government_Incentives_for__Returning_Students* Government_Incentives_for__Returning_Students_MP)<=0.0075		0.0075 is the hypothetical assumption if returning students policy is not conducted		
		THEN ABR_Return_Rate_No_Policy				
		ELSE(ABR_Return_Rate_No_Policy+(Government_Incentives_for__Returning_Students*Government_Incentives_for__Returning_Students_MP))				
32	ABR_Return_Rate_No_Policy		0.55	55% of student respondents would like to return	Questionnaire	2014
33	Enrolment_Rate_ADD	Increase_in_Scholarship*Scholarship_multiplier				
34	GDP_Growth	0.016*Technology_development		If TAI is 3.78 and GDP is 6%, then the multiplier is 0.016	Shahaab	2015
35	GDP_spent_for_tertiary	0.015699624+(Ina_Economic_Condition_GDP*2.32339E-14)		Using regression analysis	Worldbank	2010
36	Government_funding_for_Uni = 0.7		0.7		Interview	2016
37	Government_Incentives_for__ Returning_Students = 0.3		0.3	0.3 is the hypothetical assumption if incentive for returning student is not conducted		
38	Government_Incentives_for__ Returning_Students_MP = 0.025		0.025	Multiplier effects		
39	Government_Incentive_for_patents		0.3	0.075 is the hypothetical assumption if	Interview	2016

				incentive for patents is not conducted		
40	Government_incentive_for_patents_MP =		0.015	Multiplier effects	Interview	2016
41	Gross_Enrolment_Ratio	IF Enrolment_Rate_ADD<=0.15				
		THEN Gross_Enrolment_Rate_No_Policy				
		ELSE (Enrolment_Rate_ADD+Gross_Enrolment_Rate_No_Policy)				
42	Ina_Education_Quality	Government_funding_for_Uni*Government_funding_for_Uni_MP				
43	INA_Enrolment_Rate	Gross_Enrolment_Ratio*0.99		0.99 is theproportion of students in Indonesia		
44	INA_HS_Input_Rate		0.4	40% of engineers work in their field	Tempo	2016
45	INA_HS__Retirement_Rate		0.01	Assuming every year, 1% will retire or die		
46	INA_Move	New_INA_HS_in_ST*0.01		0.01 shows small percentage, but still exists	Observation	
47	INA_Stay	New_INA_HS_in_ST*0.99		Almost certain graduates will work in Indonesia		
48	Increase_in_Scholarship		0.3	0.3 is the hypothetical assumption if incentive for increasing in scholarships is not conducted		
49	New_ABR_HS_in_ST	(PG_ABR_Graduates+UG_ABR_Graduates)*0.45		0.45 decided to stay	Questionnaire	2014
50	New_INA_HS_in_ST	PG_INA_Graduates+UG_INA_Graduates				

51	Patents_per_HS	(R&D_Budget*Government's_Increase__In_R&D_Budget)*2.2		2.2 calculated from number of S&E compared to the number of patents	BPPT	2010
52	PG_ABR_Enrolment_Rate	ABR_Enrolment_Rate*(0.22+(TIME*0.072))*0.56		7.2% increase each year to 2024, 0.22 is the proportion of postgraduate students, 56% is the proportion of S&T	PPI Belanda	
53	PG_ABR__Graduation_Rate		0.23	Assuming 1.7 times higher than in Indonesia (flat rate)		
54	PG_INA_Enrolment_Rate	INA_Enrolment_Rate*0.08*0.36		0.08 is the proportion of postgraduate, 0.36 is students in S&T		
55	PG_INA__Graduation_Rate	0.12+(TIME*0.1)		The possibility that graduation rate increase higher than previous year	Observation	
56	R&D_Budget		0.009	R&D expenditure	Worldbank	2013
57	Technology_development	Last_Term_Patents*0.017		TAI is 3.78, Assuming patent is 194, then the multiplier is 0.017		
58	Total_New_Students	Population_15_to_24*Gross_Enrolment_Ratio				
59	UG_ABR__Enrolment_Rate	ABR_Enrolment_Rate*0.64*0.34		0.64 is proportion of undergraduate students, 0.34 is the propotion in S&T	Ministry of education, UNESCO	
60	UG_ABR__Graduation_Rate		0.2	Assuming 1.7 times higher than		

				in Indonesia (flat rate)		
61	UG_Ina_Enrolment_Rate	(0.92*INA_Enrolment_Rate*0.334)+UG_INA_Enrolment__Rate_ADD		0.92 is the proportion of undergraduate, 0.33 is the proportion of S&T	Ministry of education, UNESCO	2011
62	UG_INA_Enrolment__Rate_ADD	Ina_Education_Quality*(GDP_spent_for_tertiary/Ina_Economic_Condition_GDP)				
63	UG_INA__Graduation_rate	0.12+(TIME*0.1)		The possibility that graduation rate increase higher than previous year	Observation	
64	Government's_Increase__In_R&D_Budget	GRAPH(TIME)				
		(0.00, 1.00), (2.00, 1.00), (4.00, 1.00), (6.00, 1.10), (8.00, 1.10), (10.0, 1.10), (12.0, 1.20), (14.0, 1.20), (16.0, 1.30), (18.0, 1.30), (20.0, 1.30)		Multiplier effects	Observation and interview	2016
65	Government_funding_for_Uni_MP	GRAPH(TIME)				
		(0.00, 0.00), (2.00, 0.01), (4.00, 0.02), (6.00, 0.03), (8.00, 0.04), (10.0, 0.05), (12.0, 0.06), (14.0, 0.07), (16.0, 0.08), (18.0, 0.09), (20.0, 0.1)		Multiplier effects	Observation and interview	2016
66	Gross_Enrolment_Rate_No_Policy	GRAPH(TIME)				
		(0.00, 0.25), (5.00, 0.31), (10.0, 0.35), (15.0, 0.4), (20.0, 0.45)		Multiplier effects	Observation and interview	2016
67	Population_15_to_24	GRAPH(TIME)				

		(0.00, 42498), (0.8, 42717), (1.60, 42961), (2.40, 43182), (3.20, 43377), (4.00, 43543), (4.80, 43730), (5.60, 43917), (6.40, 44066), (7.20, 44212), (8.00, 45465), (8.80, 44568), (9.60, 44757), (10.4, 44954), (11.2, 45184), (12.0, 45508), (12.8, 45854), (13.6, 46166), (14.4, 46477), (15.2, 46751), (16.0, 46955), (16.8, 47277), (17.6, 47556), (18.4, 47835), (19.2, 48135), (20.0, 48427)		Population projection	BAPPENAS	2015
68	Scholarship_multiplier	GRAPH(TIME)				
		(0.00, 0.00), (4.00, 0.1), (8.00, 0.2), (12.0, 0.3), (16.0, 0.4), (20.0, 0.5)		Multiplier effects	Observation and interview	2016

APPENDIX D. SIMULATION RESULTS

Table D-1. Policy 1: Increasing Government Funding for Universities

YEAR	UG INA	UG ABR	PG INA	PG ABR	HS INA	HS ABR	PATENTS	GDP GROWTH
2010	1,353.00	12.21	337	9	260.3	2	194	0.05
2011	1,998.64	14.39	372.29	9.55	339.25	3.83	5.16	0
2012	2,454.24	16.63	374.11	11.19	544.45	7.88	6.72	0
2013	2,656.95	18.93	346.59	13.89	901.15	13.87	10.78	0
2014	2,626.17	21.31	302.07	17.62	1,397.93	20.81	17.85	0
2015	2,446.74	23.78	255.25	22.37	1,996.08	27.5	27.68	0.01
2016	2,222.48	26.35	216.94	28.15	2,651.49	33.1	41.5	0.01
2017	1,991.63	28.82	187.58	34.67	3,334.90	37.48	57.75	0.02
2018	1,805.96	31.23	167.62	41.93	4,025.54	40.7	72.64	0.02
2019	1,710.63	33.81	158.02	50.37	4,722.15	43.25	87.68	0.02
2020	1,579.54	36.14	145.63	59.08	5,448.83	46.02	102.85	0.03
2021	1,512.07	38.47	139.19	68.63	6,179.96	48.33	118.68	0.03
2022	1,480.69	40.96	136.13	79.36	6,937.57	50.93	140.72	0.04
2023	1,460.10	43.61	134.07	91.36	7,736.33	54.07	164.84	0.04
2024	1,447.89	46.44	132.8	104.7	8,579.97	57.7	183.82	0.05
2025	1,438.82	49.41	131.83	119.38	9,472.00	61.75	203.86	0.06
2026	1,433.77	52.53	131.23	135.42	10,413.27	66.14	234.44	0.06
2027	1,427.84	55.77	130.56	152.79	11,405.67	70.84	268.04	0.07
2028	1,434.64	59.15	131.07	171.68	12,447.70	75.76	293.59	0.08
2029	1,433.58	62.67	130.86	192.09	13,549.05	81.11	320.41	0.09
2030	1,445.14	66.34	131.81	214.1	14,703.04	86.63	348.76	0.09

Table D-2. Policy 2: Increasing Scholarships

YEAR	UG INA	UG ABR	PG INA	PG ABR	HS INA	HS ABR	PATENTS	GDP GROWTH
2010	1,353.00	12.21	337	9	260.3	2	194	0.05
2011	1,998.64	14.39	372.29	9.55	339.25	3.83	5.16	0
2012	2,453.64	16.63	374.11	11.19	544.45	7.88	6.72	0
2013	2,655.23	18.93	346.59	13.89	901.07	13.87	10.78	0
2014	2,623.07	21.31	302.07	17.62	1,397.56	20.8	17.85	0
2015	2,442.29	23.78	255.25	22.37	1,995.08	27.48	27.68	0.01
2016	2,216.91	26.35	216.94	28.15	2,649.40	33.07	41.48	0.01
2017	3,568.34	37.85	335.46	49.82	3,331.23	37.42	57.71	0.02
2018	4,036.12	49.58	376.53	74.33	4,582.42	54.36	72.56	0.02
2019	4,292.82	62.24	399.77	103.46	6,168.62	73.53	99.81	0.03
2020	4,307.98	74.76	400.96	135.44	8,035.37	93.07	134.36	0.04
2021	4,431.43	87.92	412.29	172.29	10,085.31	110.78	175.01	0.05
2022	4,602.75	102.01	428.1	215.16	12,374.54	128.97	229.65	0.06
2023	4,790.69	117.17	445.47	264.88	14,939.03	148.6	294.02	0.08
2024	4,989.21	133.48	463.82	322.19	17,801.82	169.96	354.96	0.1
2025	5,186.35	150.94	482.04	387.63	20,984.05	193.25	422.98	0.12
2026	5,386.83	169.56	500.58	461.78	24,499.71	218.41	519.36	0.14
2027	5,574.90	189.28	517.97	544.93	28,365.98	245.54	630.63	0.17
2028	5,804.03	210.27	539.17	638.3	32,587.94	274.41	730.14	0.2
2029	5,997.53	232.52	557.06	742.34	37,213.38	305.93	838.82	0.23
2030	6,234.88	256.06	579.03	857.86	42,228.27	339.25	957.88	0.26

Table D-3. Policy 3: Incentives for Returning Graduates

YEAR	UG INA	UG ABR	PG INA	PG ABR	HS INA	HS ABR	PATENTS	GDP GROWTH
2010	1,353.00	12.21	337	9	260.3	2	194	0.05
2011	1,998.64	14.39	372.29	9.55	339.27	3.78	5.16	0
2012	2,453.64	16.63	374.11	11.19	544.47	7.8	6.72	0
2013	2,655.23	18.93	346.59	13.89	901.09	13.76	10.79	0
2014	2,623.07	21.31	302.07	17.62	1,397.57	20.67	17.85	0
2015	2,442.29	23.78	255.25	22.37	1,995.07	27.31	27.68	0.01
2016	2,216.91	26.35	216.94	28.15	2,649.37	32.87	41.48	0.01
2017	1,985.25	28.82	187.58	34.67	3,331.18	37.19	57.71	0.02
2018	1,799.03	31.23	167.62	41.93	4,019.73	40.34	72.56	0.02
2019	1,703.10	33.81	158.02	50.37	4,713.80	42.82	87.55	0.02
2020	1,571.80	36.14	145.63	59.08	5,437.43	45.51	102.67	0.03
2021	1,503.98	38.47	139.19	68.63	6,165.13	47.74	118.43	0.03
2022	1,472.21	40.96	136.13	79.36	6,918.85	50.25	140.38	0.04
2023	1,451.21	43.61	134.07	91.36	7,713.21	53.31	164.4	0.04
2024	1,438.59	46.44	132.8	104.7	8,551.91	56.83	183.27	0.05
2025	1,429.12	49.41	131.83	119.38	9,438.43	60.77	203.2	0.06
2026	1,423.69	52.53	131.23	135.42	10,373.60	65.04	233.61	0.06
2027	1,417.40	55.77	130.56	152.79	11,359.28	69.61	267.02	0.07
2028	1,423.77	59.15	131.07	171.68	12,393.97	74.4	292.39	0.08
2029	1,422.37	62.67	130.86	192.09	13,487.28	79.59	319.03	0.09
2030	1,433.50	66.34	131.81	214.1	14,632.57	84.96	347.17	0.09

Table D-4. Increase in R&D Expenditures

YEAR	UG INA	UG ABR	PG INA	PG ABR	HS INA	HS ABR	PATENTS	GDP GROWTH
2010	1,353.00	12.21	337	9	260.3	2	194	0.05
2011	1,998.64	14.39	372.29	9.55	339.25	3.83	8.59	0
2012	2,453.64	16.63	374.11	11.19	544.45	7.88	11.2	0
2013	2,655.23	18.93	346.59	13.89	901.07	13.87	17.97	0
2014	2,623.07	21.31	302.07	17.62	1,397.56	20.8	29.74	0.01
2015	2,442.29	23.78	255.25	22.37	1,995.08	27.48	46.12	0.01
2016	2,216.91	26.35	216.94	28.15	2,649.40	33.07	69.13	0.02
2017	1,985.25	28.82	187.58	34.67	3,331.23	37.42	96.18	0.03
2018	1,799.03	31.23	167.62	41.93	4,019.81	40.62	120.93	0.03
2019	1,703.10	33.81	158.02	50.37	4,713.93	43.14	145.92	0.04
2020	1,571.80	36.14	145.63	59.08	5,437.60	45.88	171.12	0.05
2021	1,503.98	38.47	139.19	68.63	6,165.36	48.18	197.39	0.05
2022	1,472.21	40.96	136.13	79.36	6,919.15	50.75	233.98	0.06
2023	1,451.21	43.61	134.07	91.36	7,713.58	53.87	274	0.07
2024	1,438.59	46.44	132.8	104.7	8,552.37	57.46	305.46	0.08
2025	1,429.12	49.41	131.83	119.38	9,438.98	61.48	338.68	0.09
2026	1,423.69	52.53	131.23	135.42	10,374.26	65.84	389.36	0.11
2027	1,417.40	55.77	130.56	152.79	11,360.06	70.51	445.06	0.12
2028	1,423.77	59.15	131.07	171.68	12,394.90	75.39	487.35	0.13
2029	1,422.37	62.67	130.86	192.09	13,488.36	80.7	531.75	0.14
2030	1,433.50	66.34	131.81	214.1	14,633.83	86.19	578.66	0.16

Table D-5. Policy 5: Incentives for Patents Produced

YEAR	UG INA	UG ABR	PG INA	PG ABR	HS INA	HS ABR	PATENTS	GDP GROWTH
2010	1,353.00	12.21	337	9	260.3	2	194	0.05
2011	1,998.64	14.39	372.29	9.55	339.25	3.83	5.17	0
2012	2,453.64	16.63	374.11	11.19	544.45	7.88	6.73	0
2013	2,655.23	18.93	346.59	13.89	901.07	13.87	10.8	0
2014	2,623.07	21.31	302.07	17.62	1,397.56	20.8	17.86	0
2015	2,442.29	23.78	255.25	22.37	1,995.08	27.48	27.69	0.01
2016	2,216.91	26.35	216.94	28.15	2,649.40	33.07	41.49	0.01
2017	1,985.25	28.82	187.58	34.67	3,331.23	37.42	57.72	0.02
2018	1,799.03	31.23	167.62	41.93	4,019.81	40.62	72.57	0.02
2019	1,703.10	33.81	158.02	50.37	4,713.93	43.14	87.57	0.02
2020	1,571.80	36.14	145.63	59.08	5,437.60	45.88	102.68	0.03
2021	1,503.98	38.47	139.19	68.63	6,165.36	48.18	118.45	0.03
2022	1,472.21	40.96	136.13	79.36	6,919.15	50.75	140.4	0.04
2023	1,451.21	43.61	134.07	91.36	7,713.58	53.87	164.41	0.04
2024	1,438.59	46.44	132.8	104.7	8,552.36	57.46	183.29	0.05
2025	1,429.12	49.41	131.83	119.38	9,438.98	61.48	203.22	0.06
2026	1,423.69	52.53	131.23	135.42	10,374.26	65.84	233.63	0.06
2027	1,417.40	55.77	130.56	152.79	11,360.06	70.51	267.05	0.07
2028	1,423.77	59.15	131.07	171.68	12,394.90	75.39	292.42	0.08
2029	1,422.37	62.67	130.86	192.09	13,488.36	80.7	319.06	0.09
2030	1,433.50	66.34	131.81	214.1	14,633.83	86.19	347.21	0.09

Table D-6. Parameter 1: Sensitivity analysis on high-skilled abroad return rate

BEST	Postgraduate		Undergraduate		High-skilled workers		PATENTS	GDP GROWTH
	Abroad	Indonesia	Abroad	Indonesia	Abroad	Indonesia		
2010	9.0000	337.0000	12.2100	1353.0000	2.0000	260.3000	194.0000	0.0500
2011	9.5500	372.2900	14.3900	1998.6400	3.0300	340.0500	5.1600	0.0000
2012	11.1900	374.1100	16.6300	2453.6400	6.1900	546.1300	6.7400	0.0000
2013	13.8900	346.5900	18.9300	2655.2300	10.4000	904.5400	10.8200	0.0000
2014	17.6200	302.0700	21.3100	2623.0700	14.5900	1403.7700	17.9100	0.0000
2015	22.3700	255.2500	23.7800	2442.2900	17.9800	2004.5800	27.8000	0.0100
2016	28.1500	216.9400	26.3500	2216.9100	20.2700	2662.1900	41.6800	0.0100
2017	34.6700	187.5800	28.8200	1985.2500	21.7600	3346.8900	57.9900	0.0200
2018	41.9300	167.6200	31.2300	1799.0300	22.6700	4037.7600	72.9000	0.0200
2019	50.3700	158.0200	33.8100	1703.1000	23.4900	4733.5800	87.9500	0.0200
2020	59.0800	145.6300	36.1400	1571.8000	24.8900	5458.6000	103.1000	0.0300
2021	68.6300	139.1900	38.4700	1503.9800	25.8300	6187.7000	118.8900	0.0300
2022	79.3600	136.1300	40.9600	1472.2100	27.2300	6942.6600	140.9000	0.0400
2023	91.3600	134.0700	43.6100	1451.2100	29.1000	7738.3400	164.9600	0.0400
2024	104.7000	132.8000	46.4400	1438.5900	31.2100	8578.6200	183.8700	0.0500
2025	119.3800	131.8300	49.4100	1429.1200	33.5100	9466.9500	203.8300	0.0600
2026	135.4200	131.2300	52.5300	1423.6900	35.9300	10404.1700	234.3100	0.0600
2027	152.7900	130.5600	55.7700	1417.4000	38.4900	11392.0800	267.8100	0.0700
2028	171.6800	131.0700	59.1500	1423.7700	41.1100	12429.1800	293.2400	0.0800
2029	192.0900	130.8600	62.6700	1422.3700	44.0300	13525.0300	319.9300	0.0900
2030	214.1000	131.8100	66.3400	1433.5000	46.9400	14673.0800	348.1400	0.0900

WORST	Postgraduate		Undergraduate		High-skilled workers		PATENTS	GDP GROWTH
	Abroad	Indonesia	Abroad	Indonesia	Abroad	Indonesia		
2010	9.0000	337.0000	12.2100	1353.0000	2.0000	260.3000	194.0000	0.0500
2011	9.5500	372.2900	14.3900	1998.6400	4.2300	338.8500	5.1600	0.0000
2012	11.1900	374.1100	16.6300	2453.6400	8.9600	543.3700	6.7100	0.0000
2013	13.8900	346.5900	18.9300	2655.2300	16.3000	898.6400	10.7600	0.0000
2014	17.6200	302.0700	21.3100	2623.0700	25.4900	1392.8700	17.8000	0.0000
2015	22.3700	255.2500	23.7800	2442.2900	35.3500	1987.2100	27.5800	0.0100
2016	28.1500	216.9400	26.3500	2216.9100	44.7800	2637.6900	41.3200	0.0100
2017	34.6700	187.5800	28.8200	1985.2500	53.2900	3315.3700	57.4500	0.0200
2018	41.9300	167.6200	31.2300	1799.0300	60.6400	3999.7900	72.2100	0.0200
2019	50.3700	158.0200	33.8100	1703.1000	67.0800	4689.9900	87.1200	0.0200
2020	59.0800	145.6300	36.1400	1571.8000	73.4200	5410.0600	102.1500	0.0300
2021	68.6300	139.1900	38.4700	1503.9800	79.1100	6134.4200	117.8400	0.0300
2022	79.3600	136.1300	40.9600	1472.2100	84.8200	6885.0700	139.6900	0.0400
2023	91.3600	134.0700	43.6100	1451.2100	90.9300	7676.5100	163.5900	0.0400
2024	104.7000	132.8000	46.4400	1438.5900	97.5200	8512.3100	182.4000	0.0500
2025	119.3800	131.8300	49.4100	1429.1200	104.6200	9395.8400	202.2600	0.0600
2026	135.4200	131.2300	52.5300	1423.6900	112.2100	10327.8900	232.5500	0.0600
2027	152.7900	130.5600	55.7700	1417.4000	120.3100	11310.2600	265.8400	0.0700
2028	171.6800	131.0700	59.1500	1423.7700	128.8400	12341.4500	291.1300	0.0800
2029	192.0900	130.8600	62.6700	1422.3700	138.0000	13431.0600	317.6700	0.0900
2030	214.1000	131.8100	66.3400	1433.5000	147.5900	14572.4300	345.7200	0.0900

Table D-7. Parameter 2: Sensitivity analysis on GDP for education

BEST	Postgraduate		Undergraduate		High-skilled workers		PATENTS	GDP GROWTH
	Abroad	Indonesia	Abroad	Indonesia	Abroad	Indonesia		
2010	9.0000	337.0000	12.2100	1,353.0000	2.0000	260.3000	194.0000	0.0500
2011	9.5500	372.2900	14.3900	1,998.6400	3.8300	339.2500	5.1600	0.0000
2012	11.1900	374.1100	16.6300	2,455.0500	7.8800	544.4500	6.7200	0.0000
2013	13.8900	346.5900	18.9300	2,659.2500	13.8700	901.2500	10.7800	0.0000
2014	17.6200	302.0700	21.3100	2,630.3100	20.8200	1,398.4100	17.8500	0.0000
2015	22.3700	255.2500	23.7800	2,452.6600	27.5200	1,997.4100	27.6900	0.0100
2016	28.1500	216.9400	26.3500	2,229.9100	33.1500	2,654.2700	41.5300	0.0100
2017	34.6700	187.5800	28.8200	2,000.1200	37.5600	3,339.8000	57.8100	0.0200
2018	41.9300	167.6200	31.2300	1,815.2100	40.8100	4,033.1800	72.7500	0.0200
2019	50.3700	158.0200	33.8100	1,720.6700	43.3900	4,733.1200	87.8500	0.0200
2020	59.0800	145.6300	36.1400	1,589.8500	46.1900	5,463.8000	103.0900	0.0300
2021	68.6300	139.1900	38.4700	1,522.8500	48.5400	6,199.4200	119.0100	0.0300
2022	79.3600	136.1300	40.9600	1,492.0000	51.1700	6,962.1400	141.1700	0.0400
2023	91.3600	134.0700	43.6100	1,471.9500	54.3500	7,766.6600	165.4200	0.0400
2024	104.7000	132.8000	46.4400	1,460.2900	58.0100	8,616.7700	184.5400	0.0500
2025	119.3800	131.8300	49.4100	1,451.7400	62.1000	9,516.0300	204.7400	0.0600
2026	135.4200	131.2300	52.5300	1,447.2100	66.5300	10,465.2900	235.5300	0.0600
2027	152.7900	130.5600	55.7700	1,441.7500	71.2800	11,466.4800	269.3800	0.0700
2028	171.6800	131.0700	59.1500	1,449.1200	76.2500	12,518.1100	295.1500	0.0800
2029	192.0900	130.8600	62.6700	1,448.5300	81.6400	13,629.9600	322.2200	0.0900
2030	214.1000	131.8100	66.3400	1,460.6700	87.2200	14,795.3200	350.8400	0.1000

WORST	Postgraduate		Undergraduate		High-skilled workers		PATENTS	GDP GROWTH
	Abroad	Indonesia	Abroad	Indonesia	Abroad	Indonesia		
2010	9.0000	337.0000	12.2100	1,353.0000	2.0000	260.3000	194.0000	0.0500
2011	9.5500	372.2900	14.3900	1,998.6400	3.8300	339.2500	5.1600	0.0000
2012	11.1900	374.1100	16.6300	2,452.9400	7.8800	544.4500	6.7200	0.0000
2013	13.8900	346.5900	18.9300	2,653.2200	13.8600	900.9800	10.7800	0.0000
2014	17.6200	302.0700	21.3100	2,619.4600	20.7900	1,397.1400	17.8400	0.0000
2015	22.3700	255.2500	23.7800	2,437.1000	27.4600	1,993.9100	27.6700	0.0100
2016	28.1500	216.9400	26.3500	2,210.4100	33.0300	2,646.9600	41.4600	0.0100
2017	34.6700	187.5800	28.8200	1,977.8200	37.3600	3,326.9500	57.6600	0.0200
2018	41.9300	167.6200	31.2300	1,790.9400	40.5200	4,013.1300	72.4700	0.0200
2019	50.3700	158.0200	33.8100	1,694.3100	43.0200	4,704.3300	87.4100	0.0200
2020	59.0800	145.6300	36.1400	1,562.7800	45.7300	5,424.5000	102.4600	0.0300
2021	68.6300	139.1900	38.4700	1,494.5400	48.0000	6,148.3200	118.1500	0.0300
2022	79.3600	136.1300	40.9600	1,462.3100	50.5300	6,897.6500	140.0000	0.0400
2023	91.3600	134.0700	43.6100	1,440.8300	53.6200	7,687.0400	163.8900	0.0400
2024	104.7000	132.8000	46.4400	1,427.7400	57.1900	8,520.1600	182.6500	0.0500
2025	119.3800	131.8300	49.4100	1,417.8200	61.1700	9,400.4600	202.4400	0.0600
2026	135.4200	131.2300	52.5300	1,411.9200	65.4900	10,328.7400	232.6700	0.0600
2027	152.7900	130.5600	55.7700	1,405.2300	70.1200	11,306.8500	265.8700	0.0700
2028	171.6800	131.0700	59.1500	1,411.1000	74.9600	12,333.2900	291.0400	0.0800
2029	192.0900	130.8600	62.6700	1,409.2900	80.2300	13,417.5600	317.4600	0.0900
2030	214.1000	131.8100	66.3400	1,419.9200	85.6700	14,553.0900	345.3700	0.0900

Table D-8. Parameter 3: Sensitivity analysis of high-skilled workers input rate in Indonesia

	Postgraduate		Undergraduate		High-skilled workers			
BEST	**Abroad**	**Indonesia**	**Abroad**	**Indonesia**	**Abroad**	**Indonesia**	**PATENTS**	**GDP GROWTH**
2010	9.0000	337.0000	12.2100	1,353.0000	2.0000	260.3000	194.0000	0.0500
2011	9.5500	372.2900	14.3900	1,998.6400	3.8300	420.0100	5.1600	0.0000
2012	11.1900	374.1100	16.6300	2,453.6400	7.8800	831.4600	8.3200	0.0000
2013	13.8900	346.5900	18.9300	2,655.2300	13.8700	1,544.1300	16.4700	0.0000
2014	17.6200	302.0700	21.3100	2,623.0700	20.8000	2,534.1400	30.5800	0.0100
2015	22.3700	255.2500	23.7800	2,442.2900	27.4800	3,723.4600	50.1800	0.0100
2016	28.1500	216.9400	26.3500	2,216.9100	33.0700	5,023.7700	77.4200	0.0200
2017	34.6700	187.5800	28.8200	1,985.2500	37.4200	6,376.9700	109.4200	0.0300
2018	41.9300	167.6200	31.2300	1,799.0300	40.6200	7,742.0100	138.8900	0.0400
2019	50.3700	158.0200	33.8100	1,703.1000	43.1400	9,116.9700	168.6300	0.0500
2020	59.0800	145.6300	36.1400	1,571.8000	45.8800	10,550.1700	198.5700	0.0500
2021	68.6300	139.1900	38.4700	1,503.9800	48.1800	11,990.5800	229.7900	0.0600
2022	79.3600	136.1300	40.9600	1,472.2100	50.7500	13,482.2900	273.0300	0.0700
2023	91.3600	134.0700	43.6100	1,451.2100	53.8700	15,054.4100	320.3400	0.0900
2024	104.7000	132.8000	46.4400	1,438.5900	57.4600	16,714.1700	357.7000	0.1000
2025	119.3800	131.8300	49.4100	1,429.1200	61.4800	18,468.3200	397.1300	0.1100
2026	135.4200	131.2300	52.5300	1,423.6900	65.8400	20,318.3800	457.1000	0.1200
2027	152.7900	130.5600	55.7700	1,417.4000	70.5100	22,267.9500	523.0000	0.1400
2028	171.6800	131.0700	59.1500	1,423.7700	75.3900	24,313.9400	573.1800	0.1600
2029	192.0900	130.8600	62.6700	1,422.3700	80.7000	26,475.4800	625.8500	0.1700
2030	214.1000	131.8100	66.3400	1,433.5000	86.1900	28,739.1500	681.4800	0.1900

WORST	Postgraduate		Undergraduate		High-skilled workers		PATENTS	GDP GROWTH
	Abroad	Indonesia	Abroad	Indonesia	Abroad	Indonesia		
2010	9.0000	337.0000	12.2100	1,353.0000	2.0000	260.3000	194.0000	0.0500
2011	9.5500	372.2900	14.3900	1,998.6400	3.8300	298.8800	5.1600	0.0000
2012	11.1900	374.1100	16.6300	2,453.6400	7.8800	400.9500	5.9200	0.0000
2013	13.8900	346.5900	18.9300	2,655.2300	13.8700	579.5500	7.9400	0.0000
2014	17.6200	302.0700	21.3100	2,623.0700	20.8000	829.2800	11.4800	0.0000
2015	22.3700	255.2500	23.7800	2,442.2900	27.4800	1,130.8900	16.4200	0.0000
2016	28.1500	216.9400	26.3500	2,216.9100	33.0700	1,462.2100	23.5200	0.0100
2017	34.6700	187.5800	28.8200	1,985.2500	37.4200	1,808.3700	31.8500	0.0100
2018	41.9300	167.6200	31.2300	1,799.0300	40.6200	2,158.7100	39.3900	0.0100
2019	50.3700	158.0200	33.8100	1,703.1000	43.1400	2,512.4000	47.0200	0.0100
2020	59.0800	145.6300	36.1400	1,571.8000	45.8800	2,881.3200	54.7200	0.0100
2021	68.6300	139.1900	38.4700	1,503.9800	48.1800	3,252.7500	62.7600	0.0200
2022	79.3600	136.1300	40.9600	1,472.2100	50.7500	3,637.5800	74.0700	0.0200
2023	91.3600	134.0700	43.6100	1,451.2100	53.8700	4,043.1600	86.4300	0.0200
2024	104.7000	132.8000	46.4400	1,438.5900	57.4600	4,471.4600	96.0700	0.0300
2025	119.3800	131.8300	49.4100	1,429.1200	61.4800	4,924.3100	106.2500	0.0300
2026	135.4200	131.2300	52.5300	1,423.6900	65.8400	5,402.2000	121.8800	0.0300
2027	152.7900	130.5600	55.7700	1,417.4000	70.5100	5,906.1200	139.0600	0.0400
2028	171.6800	131.0700	59.1500	1,423.7700	75.3900	6,435.3700	152.0300	0.0400
2029	192.0900	130.8600	62.6700	1,422.3700	80.7000	6,994.8100	165.6500	0.0500
2030	214.1000	131.8100	66.3400	1,433.5000	86.1900	7,581.1700	180.0500	0.0500

Table D-9. Parameter 4: Sensitivity analysis on patents produced per high-skilled workers in Indonesia

BEST	Postgraduate		Undergraduate		High-skilled workers		PATENTS	GDP GROWTH
	Abroad	Indonesia	Abroad	Indonesia	Abroad	Indonesia		
2010	9.0000	337.0000	12.2100	1,353.0000	2.0000	260.3000	194.0000	0.0500
2011	9.5500	372.2900	14.3900	1,998.6400	3.8300	339.2500	10.3100	0.0000
2012	11.1900	374.1100	16.6300	2,453.6400	7.8800	544.4500	13.4400	0.0000
2013	13.8900	346.5900	18.9300	2,655.2300	13.8700	901.0700	21.5600	0.0100
2014	17.6200	302.0700	21.3100	2,623.0700	20.8000	1,397.5600	35.6900	0.0100
2015	22.3700	255.2500	23.7800	2,442.2900	27.4800	1,995.0800	55.3500	0.0200
2016	28.1500	216.9400	26.3500	2,216.9100	33.0700	2,649.4000	82.9600	0.0200
2017	34.6700	187.5800	28.8200	1,985.2500	37.4200	3,331.2300	115.4100	0.0300
2018	41.9300	167.6200	31.2300	1,799.0300	40.6200	4,019.8100	145.1100	0.0400
2019	50.3700	158.0200	33.8100	1,703.1000	43.1400	4,713.9300	175.1100	0.0500
2020	59.0800	145.6300	36.1400	1,571.8000	45.8800	5,437.6000	205.3400	0.0600
2021	68.6300	139.1900	38.4700	1,503.9800	48.1800	6,165.3600	236.8700	0.0600
2022	79.3600	136.1300	40.9600	1,472.2100	50.7500	6,919.1500	280.7700	0.0800
2023	91.3600	134.0700	43.6100	1,451.2100	53.8700	7,713.5800	328.8000	0.0900
2024	104.7000	132.8000	46.4400	1,438.5900	57.4600	8,552.3700	366.5500	0.1000
2025	119.3800	131.8300	49.4100	1,429.1200	61.4800	9,438.9800	406.4100	0.1100
2026	135.4200	131.2300	52.5300	1,423.6900	65.8400	10,374.2600	467.2300	0.1300
2027	152.7900	130.5600	55.7700	1,417.4000	70.5100	11,360.0600	534.0700	0.1500
2028	171.6800	131.0700	59.1500	1,423.7700	75.3900	12,394.9000	584.8200	0.1600
2029	192.0900	130.8600	62.6700	1,422.3700	80.7000	13,488.3600	638.0900	0.1700
2030	214.1000	131.8100	66.3400	1,433.5000	86.1900	14,633.8300	694.3900	0.1900

WORST	Postgraduate		Undergraduate		High-skilled workers		PATENTS	GDP GROWTH
	Abroad	Indonesia	Abroad	Indonesia	Abroad	Indonesia		
2010	9.0000	337.0000	12.2100	1,353.0000	2.0000	260.3000	194.0000	0.0500
2011	9.5500	372.2900	14.3900	1,998.6400	3.8300	339.2500	2.5800	0.0000
2012	11.1900	374.1100	16.6300	2,453.6400	7.8800	544.4500	3.3600	0.0000
2013	13.8900	346.5900	18.9300	2,655.2300	13.8700	901.0700	5.3900	0.0000
2014	17.6200	302.0700	21.3100	2,623.0700	20.8000	1,397.5600	8.9300	0.0000
2015	22.3700	255.2500	23.7800	2,442.2900	27.4800	1,995.0800	13.8400	0.0000
2016	28.1500	216.9400	26.3500	2,216.9100	33.0700	2,649.4000	20.7400	0.0100
2017	34.6700	187.5800	28.8200	1,985.2500	37.4200	3,331.2300	28.8600	0.0100
2018	41.9300	167.6200	31.2300	1,799.0300	40.6200	4,019.8100	36.2800	0.0100
2019	50.3700	158.0200	33.8100	1,703.1000	43.1400	4,713.9300	43.7800	0.0100
2020	59.0800	145.6300	36.1400	1,571.8000	45.8800	5,437.6000	51.3400	0.0100
2021	68.6300	139.1900	38.4700	1,503.9800	48.1800	6,165.3600	59.2200	0.0200
2022	79.3600	136.1300	40.9600	1,472.2100	50.7500	6,919.1400	70.2000	0.0200
2023	91.3600	134.0700	43.6100	1,451.2100	53.8700	7,713.5800	82.2000	0.0200
2024	104.7000	132.8000	46.4400	1,438.5900	57.4600	8,552.3600	91.6400	0.0200
2025	119.3800	131.8300	49.4100	1,429.1200	61.4800	9,438.9800	101.6100	0.0300
2026	135.4200	131.2300	52.5300	1,423.6900	65.8400	10,374.2600	116.8100	0.0300
2027	152.7900	130.5600	55.7700	1,417.4000	70.5100	11,360.0600	133.5200	0.0400
2028	171.6800	131.0700	59.1500	1,423.7700	75.3900	12,394.9000	146.2100	0.0400
2029	192.0900	130.8600	62.6700	1,422.3700	80.7000	13,488.3600	159.5300	0.0400
2030	214.1000	131.8100	66.3400	1,433.5000	86.1900	14,633.8300	173.6000	0.0500

Table D-10. Parameter 5: Sensitivity analysis on postgraduate program enrolment rate in Indonesia

BEST	Postgraduate		Undergraduate		High-skilled workers		PATENTS	GDP GROWTH
	Abroad	Indonesia	Abroad	Indonesia	Abroad	Indonesia		
2010	9.0000	337.0000	12.2100	1,353.0000	2.0000	260.3000	194.0000	0.0500
2011	9.5500	448.0200	14.3900	1,998.6400	3.8300	339.2500	5.1600	0.0000
2012	11.1900	516.9100	16.6300	2,453.6400	8.0300	551.0500	6.7200	0.0000
2013	13.8900	535.8900	18.9300	2,655.2300	14.3700	925.7600	10.9200	0.0000
2014	17.6200	512.9100	21.3100	2,623.0700	21.8100	1,453.6900	18.3300	0.0000
2015	22.3700	466.7000	23.7800	2,442.2900	29.0600	2,094.4600	28.7900	0.0100
2016	28.1500	417.2400	26.3500	2,216.9100	35.1800	2,800.3400	43.5500	0.0100
2017	34.6700	370.5000	28.8200	1,985.2500	39.9700	3,538.6200	61.0000	0.0200
2018	41.9300	334.4100	31.2300	1,799.0300	43.4700	4,285.5400	77.0800	0.0200
2019	50.3700	315.9700	33.8100	1,703.1000	46.2100	5,038.9000	93.3400	0.0300
2020	59.0800	291.2500	36.1400	1,571.8000	49.1400	5,824.3500	109.7500	0.0300
2021	68.6300	278.3800	38.4700	1,503.9800	51.5700	6,614.1300	126.8600	0.0300
2022	79.3600	272.2600	40.9600	1,472.2100	54.2700	7,432.0300	150.6100	0.0400
2023	91.3600	268.1400	43.6100	1,451.2100	57.5700	8,293.9000	176.5900	0.0500
2024	104.7000	265.6000	46.4400	1,438.5900	61.3600	9,203.7600	197.0700	0.0500
2025	119.3800	263.6500	49.4100	1,429.1200	65.5900	10,165.3500	218.6900	0.0600
2026	135.4200	262.4600	52.5300	1,423.6900	70.1900	11,179.5800	251.6000	0.0700
2027	152.7900	261.1300	55.7700	1,417.4000	75.1000	12,248.4500	287.7700	0.0800
2028	171.6800	262.1400	59.1500	1,423.7700	80.2400	13,370.3500	315.2800	0.0900
2029	192.0900	261.7200	62.6700	1,422.3700	85.8300	14,555.6500	344.1600	0.0900
2030	214.1000	263.6200	66.3400	1,433.5000	91.5900	15,797.1800	374.6700	0.1000

WORST	Postgraduate		Undergraduate		High-skilled workers		PATENTS	GDP GROWTH
	Abroad	Indonesia	Abroad	Indonesia	Abroad	Indonesia		
2010	9.0000	337.0000	12.2100	1,353.0000	2.0000	260.3000	194.0000	0.0500
2011	9.5500	334.4300	14.3900	1,998.6400	3.8300	339.2500	5.1600	0.0000
2012	11.1900	302.7100	16.6300	2,453.6400	7.8000	541.1500	6.7200	0.0000
2013	13.8900	251.9400	18.9300	2,655.2300	13.6200	888.7300	10.7200	0.0000
2014	17.6200	196.6500	21.3100	2,623.0700	20.3000	1,369.5000	17.6000	0.0000
2015	22.3700	149.5200	23.7800	2,442.2900	26.6900	1,945.3900	27.1200	0.0100
2016	28.1500	116.7900	26.3500	2,216.9100	32.0100	2,573.9300	40.4500	0.0100
2017	34.6700	96.1200	28.8200	1,985.2500	36.1500	3,227.5400	56.0600	0.0200
2018	41.9300	84.2300	31.2300	1,799.0300	39.1900	3,886.9500	70.3000	0.0200
2019	50.3700	79.0400	33.8100	1,703.1000	41.6100	4,551.4400	84.6600	0.0200
2020	59.0800	72.8100	36.1400	1,571.8000	44.2600	5,244.2300	99.1300	0.0300
2021	68.6300	69.6000	38.4700	1,503.9800	46.4800	5,940.9700	114.2200	0.0300
2022	79.3600	68.0600	40.9600	1,472.2100	48.9800	6,662.7000	135.2800	0.0400
2023	91.3600	67.0400	43.6100	1,451.2100	52.0200	7,423.4100	158.3100	0.0400
2024	104.7000	66.4000	46.4400	1,438.5900	55.5100	8,226.6700	176.3800	0.0500
2025	119.3800	65.9100	49.4100	1,429.1200	59.4200	9,075.7900	195.4700	0.0500
2026	135.4200	65.6200	52.5300	1,423.6900	63.6600	9,971.6000	224.6300	0.0600
2027	152.7900	65.2800	55.7700	1,417.4000	68.2100	10,915.8600	256.6700	0.0700
2028	171.6800	65.5300	59.1500	1,423.7700	72.9700	11,907.1700	280.9800	0.0800
2029	192.0900	65.4300	62.6700	1,422.3700	78.1400	12,954.7200	306.5000	0.0800
2030	214.1000	65.9000	66.3400	1,433.5000	83.4900	14,052.1600	333.4600	0.0900

Table D-11. Parameter 6: Sensitivity analysis on R&D expenditures

BEST	Postgraduate		Undergraduate		High-skilled workers		PATENTS	GDP GROWTH
	Abroad	Indonesia	Abroad	Indonesia	Abroad	Indonesia		
2010	9.0000	337.0000	12.2100	1,353.0000	2.0000	260.3000	194.0000	0.0500
2011	9.5500	372.2900	14.3900	1,998.6400	3.8300	339.2500	10.3100	0.0000
2012	11.1900	374.1100	16.6300	2,453.6400	7.8800	544.4500	13.4400	0.0000
2013	13.8900	346.5900	18.9300	2,655.2300	13.8700	901.0700	21.5600	0.0100
2014	17.6200	302.0700	21.3100	2,623.0700	20.8000	1,397.5600	35.6900	0.0100
2015	22.3700	255.2500	23.7800	2,442.2900	27.4800	1,995.0800	55.3500	0.0200
2016	28.1500	216.9400	26.3500	2,216.9100	33.0700	2,649.4000	82.9600	0.0200
2017	34.6700	187.5800	28.8200	1,985.2500	37.4200	3,331.2300	115.4100	0.0300
2018	41.9300	167.6200	31.2300	1,799.0300	40.6200	4,019.8100	145.1100	0.0400
2019	50.3700	158.0200	33.8100	1,703.1000	43.1400	4,713.9300	175.1100	0.0500
2020	59.0800	145.6300	36.1400	1,571.8000	45.8800	5,437.6000	205.3400	0.0600
2021	68.6300	139.1900	38.4700	1,503.9800	48.1800	6,165.3600	236.8700	0.0600
2022	79.3600	136.1300	40.9600	1,472.2100	50.7500	6,919.1500	280.7700	0.0800
2023	91.3600	134.0700	43.6100	1,451.2100	53.8700	7,713.5800	328.8000	0.0900
2024	104.7000	132.8000	46.4400	1,438.5900	57.4600	8,552.3700	366.5500	0.1000
2025	119.3800	131.8300	49.4100	1,429.1200	61.4800	9,438.9800	406.4100	0.1100
2026	135.4200	131.2300	52.5300	1,423.6900	65.8400	10,374.2600	467.2300	0.1300
2027	152.7900	130.5600	55.7700	1,417.4000	70.5100	11,360.0600	534.0700	0.1500
2028	171.6800	131.0700	59.1500	1,423.7700	75.3900	12,394.9000	584.8200	0.1600
2029	192.0900	130.8600	62.6700	1,422.3700	80.7000	13,488.3600	638.0900	0.1700
2030	214.1000	131.8100	66.3400	1,433.5000	86.1900	14,633.8300	694.3900	0.1900

WORST	Postgraduate		Undergraduate		High-skilled workers		PATENTS	GDP GROWTH
	Abroad	Indonesia	Abroad	Indonesia	Abroad	Indonesia		
2010	9.0000	337.0000	12.2100	1,353.0000	2.0000	260.3000	194.0000	0.0500
2011	9.5500	372.2900	14.3900	1,998.6400	3.8300	339.2500	2.5800	0.0000
2012	11.1900	374.1100	16.6300	2,453.6400	7.8800	544.4500	3.3600	0.0000
2013	13.8900	346.5900	18.9300	2,655.2300	13.8700	901.0700	5.3900	0.0000
2014	17.6200	302.0700	21.3100	2,623.0700	20.8000	1,397.5600	8.9300	0.0000
2015	22.3700	255.2500	23.7800	2,442.2900	27.4800	1,995.0800	13.8400	0.0000
2016	28.1500	216.9400	26.3500	2,216.9100	33.0700	2,649.4000	20.7400	0.0100
2017	34.6700	187.5800	28.8200	1,985.2500	37.4200	3,331.2300	28.8600	0.0100
2018	41.9300	167.6200	31.2300	1,799.0300	40.6200	4,019.8100	36.2800	0.0100
2019	50.3700	158.0200	33.8100	1,703.1000	43.1400	4,713.9300	43.7800	0.0100
2020	59.0800	145.6300	36.1400	1,571.8000	45.8800	5,437.6000	51.3400	0.0100
2021	68.6300	139.1900	38.4700	1,503.9800	48.1800	6,165.3600	59.2200	0.0200
2022	79.3600	136.1300	40.9600	1,472.2100	50.7500	6,919.1400	70.2000	0.0200
2023	91.3600	134.0700	43.6100	1,451.2100	53.8700	7,713.5800	82.2000	0.0200
2024	104.7000	132.8000	46.4400	1,438.5900	57.4600	8,552.3600	91.6400	0.0200
2025	119.3800	131.8300	49.4100	1,429.1200	61.4800	9,438.9800	101.6100	0.0300
2026	135.4200	131.2300	52.5300	1,423.6900	65.8400	10,374.2600	116.8100	0.0300
2027	152.7900	130.5600	55.7700	1,417.4000	70.5100	11,360.0600	133.5200	0.0400
2028	171.6800	131.0700	59.1500	1,423.7700	75.3900	12,394.9000	146.2100	0.0400
2029	192.0900	130.8600	62.6700	1,422.3700	80.7000	13,488.3600	159.5300	0.0400
2030	214.1000	131.8100	66.3400	1,433.5000	86.1900	14,633.8300	173.6000	0.0500

Table D-12. Parameter 7: Sensitivity analysis on Scholarships

BEST	Postgraduate		Undergraduate		High-skilled workers		PATENTS	GDP GROWTH
	Abroad	Indonesia	Abroad	Indonesia	Abroad	Indonesia		
2010	9.0000	337.0000	12.2100	1,353.0000	2.0000	260.3000	194.0000	0.0500
2011	9.5500	372.2900	14.3900	1,998.6400	3.8300	339.2500	5.1600	0.0000
2012	11.1900	374.1100	16.6300	2,453.6400	7.8800	544.4500	6.7200	0.0000
2013	13.8900	346.5900	18.9300	2,655.2300	13.8700	901.0700	10.7800	0.0000
2014	17.6200	302.0700	21.3100	2,623.0700	20.8000	1,397.5600	17.8500	0.0000
2015	22.3700	255.2500	23.7800	2,442.2900	27.4800	1,995.0800	27.6800	0.0100
2016	28.1500	216.9400	26.3500	2,216.9100	33.0700	2,649.4000	41.4800	0.0100
2017	34.6700	187.5800	28.8200	1,985.2500	37.4200	3,331.2300	57.7100	0.0200
2018	41.9300	167.6200	31.2300	1,799.0300	40.6200	4,019.8100	72.5600	0.0200
2019	50.3700	158.0200	33.8100	1,703.1000	43.1400	4,713.9300	87.5600	0.0200
2020	59.0800	145.6300	36.1400	1,571.8000	45.8800	5,437.6000	102.6700	0.0300
2021	68.6300	139.1900	38.4700	1,503.9800	48.1800	6,165.3600	118.4400	0.0300
2022	109.2400	324.0100	52.4300	3,487.7900	50.7500	6,919.1500	140.3900	0.0400
2023	150.9600	288.8200	65.9100	3,111.9400	81.7100	8,866.2800	164.4000	0.0400
2024	194.8900	311.6900	79.1600	3,358.7900	100.4000	10,727.3600	210.6700	0.0600
2025	241.8100	313.3800	92.3600	3,378.4600	120.5100	12,875.5900	254.8900	0.0700
2026	292.3900	325.6300	105.6300	3,511.3800	138.4300	15,170.7600	318.6800	0.0900
2027	347.0800	331.1800	119.0400	3,572.3300	157.1800	17,696.6400	390.5000	0.1100
2028	406.8100	343.5000	132.7900	3,705.9900	175.5600	20,406.1400	455.5200	0.1200
2029	471.9700	350.3200	146.9100	3,780.5700	195.4500	23,363.1100	525.2600	0.1400
2030	543.1300	362.9300	161.5100	3,917.2800	215.5500	26,525.7000	601.3700	0.1600

WORST	Postgraduate		Undergraduate		High-skilled workers		PATENTS	GDP GROWTH
	Abroad	Indonesia	Abroad	Indonesia	Abroad	Indonesia		
2010	9.0000	337.0000	12.2100	1,353.0000	2.0000	260.3000	194.0000	0.0500
2011	9.5500	372.2900	14.3900	1,998.6400	3.8300	339.2500	5.1600	0.0000
2012	11.0800	371.7300	16.4800	2,428.2300	7.8800	544.4500	6.7200	0.0000
2013	13.5200	340.0000	18.5100	2,584.7500	13.7800	897.5500	10.7800	0.0000
2014	16.8000	290.4500	20.5000	2,498.8500	20.4300	1,381.2000	17.7800	0.0000
2015	20.8700	238.8500	22.4700	2,266.8800	26.5600	1,950.7200	27.3500	0.0100
2016	25.7200	196.6400	24.4400	1,999.5700	31.3400	2,557.9600	40.5600	0.0100
2017	31.0300	164.5800	26.2400	1,738.8800	34.6900	3,172.1700	55.7200	0.0200
2018	36.7600	142.7900	27.9000	1,532.8600	36.7700	3,773.6500	69.0900	0.0200
2019	43.2900	131.2200	29.6400	1,415.6200	38.1300	4,362.4800	82.1900	0.0200
2020	49.8200	118.2400	31.0900	1,277.8800	39.5900	4,960.4800	95.0200	0.0300
2021	56.8100	110.7000	32.5000	1,197.9900	40.6500	5,547.6800	108.0400	0.0300
2022	64.5300	106.3700	33.9800	1,152.4200	41.9200	6,142.6600	126.3300	0.0300
2023	73.0300	103.0100	35.5500	1,117.2800	43.6300	6,758.1300	145.9500	0.0400
2024	82.3400	100.4300	37.2100	1,090.4500	45.6900	7,396.5600	160.5800	0.0400
2025	92.4300	98.2100	38.9600	1,067.3900	48.0600	8,060.3100	175.7500	0.0500
2026	103.2900	96.3900	40.7700	1,048.5600	50.6400	8,749.5600	199.5000	0.0500
2027	114.8900	94.6000	42.6300	1,030.0900	53.4200	9,465.3300	225.2200	0.0600
2028	127.3400	93.7500	44.5600	1,021.7300	56.3100	10,206.0900	243.6400	0.0700
2029	140.6200	92.4400	46.5600	1,008.3300	59.4600	10,978.4600	262.7100	0.0700
2030	154.7700	92.0300	48.6200	1,004.6400	62.6900	11,777.1200	282.5900	0.0800

Table D-13. Parameter 8: Sensitivity analysis on undergraduate program enrolment rate in Indonesia

BEST	Postgraduate		Undergraduate		High-skilled workers		PATENTS	GDP GROWTH
	Abroad	Indonesia	Abroad	Indonesia	Abroad	Indonesia		
2010	9.0000	337.0000	12.2100	1,353.0000	2.0000	260.3000	194.0000	0.0500
2011	9.5500	372.2900	14.3900	2,806.6500	3.8300	339.2500	5.1600	0.0000
2012	11.1900	374.1100	16.6300	3,977.1800	9.4800	614.8400	6.7200	0.0000
2013	13.8900	346.5900	18.9300	4,674.9300	19.2000	1,164.4700	12.1800	0.0000
2014	17.6200	302.0700	21.3100	4,872.6300	31.5800	1,996.3700	23.0600	0.0100
2015	22.3700	255.2500	23.7800	4,698.3900	44.3700	3,055.4400	39.5300	0.0100
2016	28.1500	216.9400	26.3500	4,354.0100	55.6200	4,259.8300	63.5300	0.0200
2017	34.6700	187.5800	28.8200	3,936.9300	64.5800	5,543.9100	92.7800	0.0300
2018	41.9300	167.6200	31.2300	3,578.5200	71.0400	6,854.9700	120.7500	0.0300
2019	50.3700	158.0200	33.8100	3,388.3600	75.8300	8,181.2100	149.3100	0.0400
2020	59.0800	145.6300	36.1400	3,125.5600	80.6400	9,564.0000	178.1900	0.0500
2021	68.6300	139.1900	38.4700	2,989.0800	84.3400	10,953.5100	208.3100	0.0600
2022	79.3600	136.1300	40.9600	2,924.6100	88.3900	12,391.3700	249.4200	0.0700
2023	91.3600	134.0700	43.6100	2,881.6600	93.3300	13,905.3400	294.4200	0.0800
2024	104.7000	132.8000	46.4400	2,855.4900	99.0300	15,502.3700	330.4000	0.0900
2025	119.3800	131.8300	49.4100	2,835.6300	105.3900	17,188.9700	368.3400	0.1000
2026	135.4200	131.2300	52.5300	2,823.8500	112.2500	18,966.6100	425.4300	0.1200
2027	152.7900	130.5600	55.7700	2,810.4500	119.5600	20,838.7300	488.2100	0.1300
2028	171.6800	131.0700	59.1500	2,822.2100	127.1500	22,802.4000	536.3900	0.1500
2029	192.0900	130.8600	62.6700	2,818.5700	135.4100	24,875.7600	586.9400	0.1600
2030	214.1000	131.8100	66.3400	2,839.8400	143.8500	27,046.0900	640.3100	0.1700

WORST	Postgraduate		Undergraduate		High-skilled workers		PATENTS	GDP GROWTH
	Abroad	Indonesia	Abroad	Indonesia	Abroad	Indonesia		
2010	9.0000	337.0000	12.2100	1,353.0000	2.0000	260.3000	194.0000	0.0500
2011	9.5500	372.2900	14.3900	1,594.6400	3.8300	339.2500	5.1600	0.0000
2012	11.1900	374.1100	16.6300	1,691.8700	7.0800	509.2500	6.7200	0.0000
2013	13.8900	346.5900	18.9300	1,645.3800	11.2000	769.3800	10.0900	0.0000
2014	17.6200	302.0700	21.3100	1,498.2900	15.4100	1,098.1600	15.2400	0.0000
2015	22.3700	255.2500	23.7800	1,314.2400	19.0300	1,464.9000	21.7500	0.0100
2016	28.1500	216.9400	26.3500	1,148.3600	21.7900	1,844.1800	30.4600	0.0100
2017	34.6700	187.5800	28.8200	1,009.4100	23.8400	2,224.8900	40.1700	0.0100
2018	41.9300	167.6200	31.2300	909.2900	25.4100	2,602.2300	48.4600	0.0100
2019	50.3700	158.0200	33.8100	860.4700	26.8000	2,980.2800	56.6800	0.0200
2020	59.0800	145.6300	36.1400	794.9200	28.5100	3,374.4100	64.9200	0.0200
2021	68.6300	139.1900	38.4700	761.4300	30.0900	3,771.2800	73.5000	0.0200
2022	79.3600	136.1300	40.9600	746.0000	31.9200	4,183.0300	85.8800	0.0200
2023	91.3600	134.0700	43.6100	735.9800	34.1300	4,617.7000	99.3900	0.0300
2024	104.7000	132.8000	46.4400	730.1500	36.6800	5,077.3600	109.7200	0.0300
2025	119.3800	131.8300	49.4100	725.8700	39.5300	5,563.9900	120.6400	0.0300
2026	135.4200	131.2300	52.5300	723.6000	42.6300	6,078.0800	137.7100	0.0400
2027	152.7900	130.5600	55.7700	720.8800	45.9800	6,620.7200	156.4500	0.0400
2028	171.6800	131.0700	59.1500	724.5600	49.5100	7,191.1400	170.4200	0.0500
2029	192.0900	130.8600	62.6700	724.2700	53.3500	7,794.6700	185.1000	0.0500
2030	214.1000	131.8100	66.3400	730.3300	57.3600	8,427.7100	200.6400	0.0500