Paper presented in the 28th International Conference of the System Dynamics Society at Seoul, Korea during July 25 – 29, 2010

Dynamics of Technology Spillover through Foreign Direct Investment in Thailand under R&D Consortia Policy

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This paper studies the effect of R&D consortia policy and the consequences of the policy implementation process on technology spillover through Foreign Direct Investment (FDI) in Thailand using a system dynamics method. The results show that the R&D consortia policy increases the level of technology spillover and improves the economy of Thailand by boosting the productivity and GDP per capita of Thailand. The R&D consortia policy also amplifies the level of FDI which adds up to the productivity growth. When considering the policy implementation process, shortening the implementation time significantly increases the benefits in the short run but in the long run the additional benefits from shortening the implementation duration diminished. The FDI signaling effect reduces the benefits of the policy. However, when accounting for the signaling effect, Thailand is still better off if the R&D consortia policy is implemented.

Keywords: Technology Spillover, Productivity Spillover, Foreign Direct Investment, R&D Consortia Policy, System Dynamics, Thailand, Policy Analysis

Introduction

Foreign Direct Investment (FDI) is one of the key factors that drive the economy of FDI recipient countries. Foreign enterprises provide more jobs with higher compensation to local workers (Williams 1999; Conyon et al. 2002; McDonald, Tüselmann, and Heise 2002; Bandick 2004; Lipsey and Sjöholm 2004; Martins 2004; Fu and Balasubramanyam 2005; Girma and Görg 2007; Heyman, Sjöholm, and Tingvall 2007) and also transfer technology and operational practices from the multinational firms' headquarters to their local subsidiaries which increase the country's production output (Baranson 1970; Contractor and Sagafi-Nejad 1981). Moreover, the presence of foreign firms in the industry makes the productivity of domestic firms in the related industries increase even though they have no direct interaction with the foreign firms, which also improves the welfare of the host countries (Sawada 2005). This phenomenon is called "technology spillover".

Technology spillover is perceived as a method that reduces the productivity capability gap between developing countries and developed countries. Therefore, a lot of research has been thoroughly conducted on technology spillovers through FDI including the existence of technology spillover (for example, see Blomström and Sjöholm (1999), Chuang and Lin (1999), Liu (2002), and Cheung and Lin (2004)), the determinants of technology spillover through FDI (Wang 1997; Blomström and Sjöholm 1999; Chuang and Lin 1999; Sawada 2005; Kohpaiboon 2006; Sermcheep 2006), and the effect of public policy on technology spillover (Stoneman and

Diederen 1994; Bozeman 2000; Sawada 2005; Derwisch, Kopainsky, and Henson-Apollonio 2009). However, most of the research approaches the problem based on a static perspective which treats the problems as a snapshot picture instead of a change during a period of time. Moreover, they assume that the level of technology spillover has no effect on the level of FDI which is not realistic. Besides, the delay of the effects between each factor and the technology spillover are neglected. These are the major flaws that this paper aims to shed some light on. For parsimony, Thailand is used as the case study.

Although technology transfer and technology spillover provide benefits to the FDI recipient countries, this rarely happens without the assistance from public sectors through public policy. Public policy has been considered an important factor to facilitate the technology transfer and technology spillover because the technology market is not a perfect competition market (Stoneman and Diederen 1994; Bozeman 2000). As a result, many policies have been studied in terms of their ability to assist the technology transfer. One of such policies is the intellectual property rights which many scholars present as a type of policy that prevents, instead of encouraging, the technology spillover (Sawada 2005; Derwisch, Kopainsky, and Henson-Apollonio 2009). The R&D consortia policy is, on the other hand, a policy that has been examined and proved that it stimulates the technology transfer and spillover (Ouchi and Bolton 1988; Evan and Olk 1990; Lin et al. 2009).

The R&D consortium is an inter-organization cooperation to conduct R&D together. This policy can stimulate technology and knowledge transfer between firms in the consortium and with the research institutes that participate with the consortium. The success story of the R&D consortia policy starts in the semiconductor industry of Japan in 1961 which made Japan one of the global leaders (Ouchi and Bolton 1988; Sakakibara 1997; Watanabe, Kishioka, and Nagamatsu 2004). In the U.S., the R&D consortia policy was implemented after the U.S. semiconductor industry lost its competitiveness to Japan (Evan and Olk 1990; Aldrich and Sasaki 1995). Besides Japan and the U.S., the R&D consortia policy has also been implemented in Europe, South Korea, and Taiwan (Mothe and Quélin 2000; Mathews 2002; Sakakibara and Cho 2002; Lin et al. 2009).

Even though the implementation of the R&D consortia policy has been done in many countries, there is no research showing the use of this policy in Thailand which have the problem of limited technology capacity (NSTDA 2007). This study shows the effect of R&D consortia policy on the technology spillover in Thailand.

The system dynamics model on technology spillover through FDI is developed and verified with the empirical data of Thailand. The simulation from the model can significantly trace the change of the historical data of Thailand. Then, the R&D consortia policy is implemented into the model. The effect of the R&D consortia policy on the economic system is obtained from analyzing Japan's economic situation because Japan had similar economic situation at the time the policy was implemented. The result indicates that an R&D consortia policy can stimulate the technology spillover indicated by higher productivity from the presence of FDI. The economy of Thailand is also improved as measured by the higher GDP per capita. In addition, the R&D consortia policy also stimulates more FDI which in turn increases the level of technology spillover.

The implementation process of the R&D consortia policy affects the result of the policy on Thailand's economy. By shortening the implementation time, Thailand can gain additional benefits from the R&D consortia policy. On the other hand, the benefits from the R&D consortia policy are reduced if the implementation involves a strong FDI signaling effect. Nevertheless, Thailand is better off from implementing the R&D consortia policy.

This paper is structured as follow: first, the technology spillover from FDI and R&D consortia policy is discussed. Then, the economic situation of Thailand is examined. After, the model is explained and validated and followed by the policy analysis.

Technology spillover through Foreign Direct Investment

The first topic to be discussed is whether the technology spillover through FDI exists. A lot of research has been conducted and found that, in various environments, the technology spillover exists as indicated by a statistically significant relationship between an improvement in the productivity of the local firms and the presence of foreign firms (Blomström and Sjöholm 1999; Chuang and Lin 1999; Liu 2002; Cheung and Lin 2004). However, the degree of technology spillover is depended on the characteristics of the recipient country, industry, domestic firms, and foreign firms.

The characteristics of the country affect not only the decision making of foreign investment (Dunning 1998) but also the degree of technology spillover. A country with trade openness, high quality human capital, high per capita income and well institutional development has higher technology spillover (Wang 1997; Meyer and Sinani 2009). The characteristics of the industry also affect the level of technology spillover. The low- and medium-technology industries can gain more technology spillover from foreign firms than the firms in high-technology industry because of the limitation in the technology absorptive capability (Sermcheep 2006). In addition, the industry with higher labor productivity, large market size, and high rate of protection is likely to have a higher technology spillover level (Kohpaiboon 2006). Regarding domestic firms' characteristics, the domestic firms with a small technology gap can gain more technology spillover due to the technology absorptive capability (Sawada 2005). The small and medium size domestic firms also gain more technology spillover than the large firms because the small and medium firms do not compete directly with the foreign firms (Sermcheep 2006). The foreign firms from a country with cultural and economical similarities also reduces the level of technology spillover in the host country due to the direct competition effect (Buckley, Clegg, and Wang 2007).

Public policy and technology spillover

Technology spillover is desired by domestic firms in order to improve their productivity. However, this rarely happens without the support from the public policies (Bozeman 2000) because the technology does not act as a public good (Contractor and Sagafi-Nejad 1981). The technology spillover provides benefits to local firms at a cost of losing competitive advantage for foreign firms (Sawada 2005).

Not only the technology is not a public good, the technology market is also an imperfect market due to the imperfect information, market power, and externalities (Stoneman and Diederen 1994). Technology sellers can provide only preferred information because the incentive of the technology is unknown to the technology buyers until it is used. The mismatch in the number of suppliers and customers also creates a market failure. If the number of customers is small, the technology sellers need to push the technology faster than the optimal speed. Last, the network externality also causes a market failure. If the benefits of the technology depend on the number of technology users, the technology that gains a start-up advantage can become a winner even it is an inferior technology (Arthur 1994; Sterman 2000).

Even though a public policy is required for the technology spillover, not all policies reach this goal. The policy in terms of the law and regulation is ineffective because there is always a way around the regulations. If the technology is essential for the country, the government can provide an exemption (Contractor and Sagafi-Nejad 1981). Many policies face a policy resistance problem (Sterman 2000). For example, the local content policy aims to encourage the establishment of foreign firms in the country to increase the productivity but results in the problem of poor quality, scheduling delays, and higher costs due to the limitation in number and quality of potential suppliers (Contractor and Sagafi-Nejad 1981). Another policy that is studied extensively and is presented as obstructing the technology spillover instead of stimulating it is the intellectual property rights (Sawada 2005; Derwisch, Kopainsky, and Henson-Apollonio 2009). On the other hand, R&D consortia policy has been proved practically in improving the technology transfer and spillover in many countries such as the US, Japan, South Korea, and Taiwan.

R&D consortia policy

The R&D consortia policy is a public policy that stimulates the cooperation of the research and development activities of the firms in the same and related industries to innovate new and advanced technology which can change the competitiveness of the firms in the industries. The firms who join the R&D consortia can gain economies of scale, share the risks of an innovation, set the standards for a new technology, and share complementary knowledge (Evan and Olk 1990). The R&D consortia policy has been used in many countries and regions including the U.S., Europe, Japan, South Korea, and Taiwan. The knowledge transfer and spillover within R&D consortia is not limited to only between domestic firms, but also between foreign firms and domestic firms as shown by a number of consortia that include foreign members (Ouchi and Bolton 1988).

The R&D consortia, as defined above, contradicts the law of competition. How can two direct competitors conduct research together and come up with the same product offer to the same customers at the same time? If it happens, we would call it a cartel instead of competition. Therefore, only some types of technology and knowledge are appropriate for the R&D consortia. Ouchi and Bolton (1988) divide intellectual property into three types: private property, public property, and leaky property. Private property is the intellectual property that a private party legally has a full right to appropriate and transfer to others. Public property is the knowledge that inventors cannot appropriate even for a short period of time. Leaky property is the knowledge that inventors can appropriate for a short period of time.

Even though only the private property is worth conducting R&D, all types of knowledge are essential. Ouchi and Bolton (1988) recommended that the government sector, public-funded universities, and not-for-profit research organizations should produce public property. For leaky property, the incentive for inventors is less than the benefit they can get from the knowledge. However, with the collaboration of the parties which will gain benefits from that knowledge such as the R&D consortia, the return for each party on researching on leaky property is positive.

Another challenge is how to manage and hold the collaboration when every member has an incentive to defect, as in the prisoner's dilemma situation. Arend (2005) suggests that all parties must signal the truthful expectation of the value of their joint work and provide the penalties for defecting in order to have the R&D collaboration. However, most R&D consortia do not have the same characteristics as the suggestion.

The iconic and early examples of R&D consortia are the Very Large Scale Integrated circuits (VLSI) project of Japan and the Microelectronics and Computer Technology Corporation (MCC) project of the U.S. (Evan and Olk 1990).

The VLSI project was triggered by the Mining and Industrial Technological Research Association Law issued by the Ministry of International Trade and Industry (MITI) of Japan. The concept of this consortium was developed from the "Technology Research Association" of the UK. The goal of the VLSI project was to set up the standard and create foundation knowledge for the fourth generation technology of the integrated circuit industry. At the end of the project, many foundation technologies such as DRAM and gate logic had been developed and more than 1000 patents were filed. This factor is considered as one of the important forces that drove the transformation of Japan from labor intensive into technology intensive (Ouchi and Bolton 1988; Aldrich and Sasaki 1995).

The success story of VLSI project became a threat for the electronics industry in the U.S. Therefore, the firms in microelectronics and computer technology had pushed the congress to come up with the law that allows the R&D collaboration between firms. In 1984, the National Cooperative Research Act was passed and became active. The first major R&D consortium is the MCC project. The MCC project aimed to reduce the technical risk on Artificial Intelligence/Knowledge Based Systems, Database Management Systems, Human Interface Systems, Parallel Processing Architecture, VLSI Computer Aided Design, Semiconductor Packaging/Interconnect, and Expert Systems Software Technologies. With this project, the U.S. electronics industry became competitive again (Ouchi and Bolton 1988).

Thailand

Thailand is an interesting country to study the effect of an R&D consortia policy because Thailand is a hub of the trade within the Southeast Asia region in terms of its connections and also the key player in terms of the trade volume (Thanakijsombat and Renard 2009). Besides, Thailand has a continuous growth of inward FDI, productivity, GDP, and GDP per capital since 1987, except during the Asian Financial Crisis period, as shown in Figure 1 and Figure 2.

However, the technology capability of the firms in Thailand is limited compared to developed countries (NSTDA 2007).

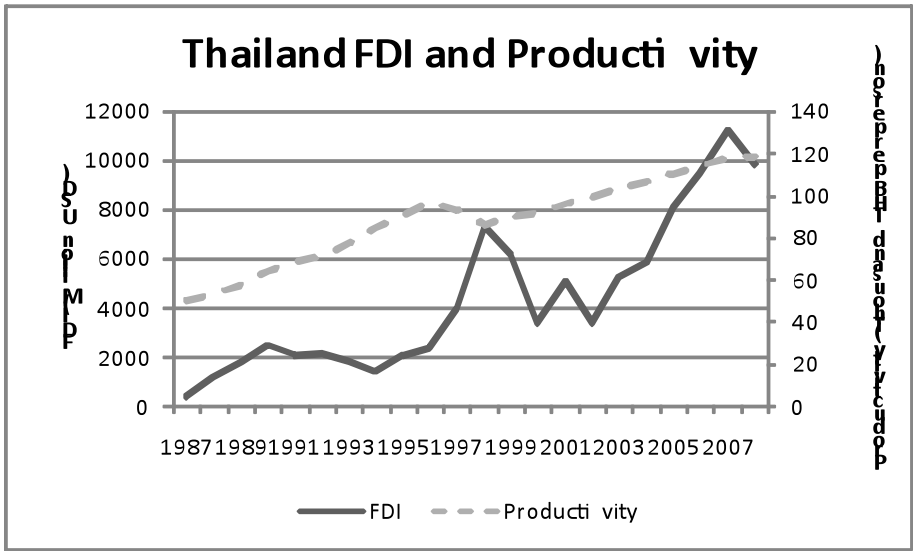

Figure 1 FDI and productivity of Thailand during 1987 – 2008
Source: IMF International Financial Statistics and Economist Intelligence Unit

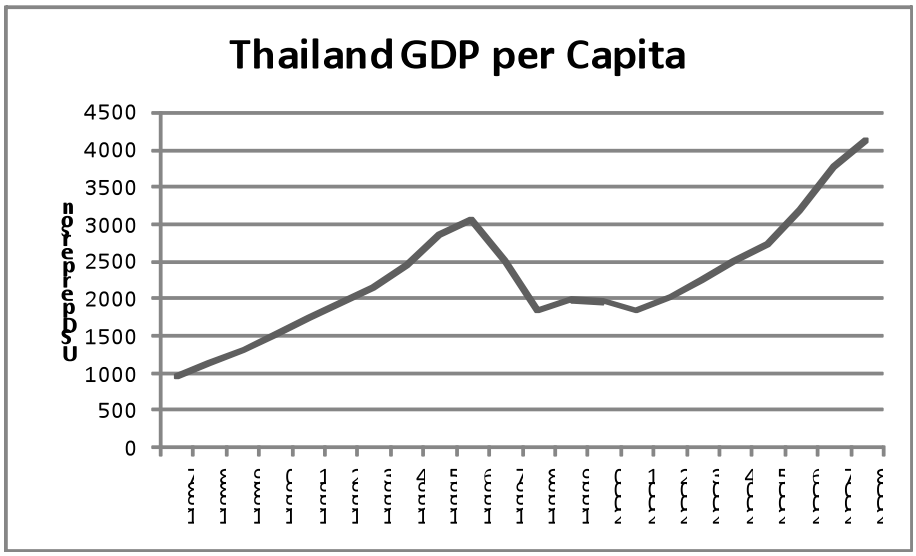

Figure 2 GDP per capita of Thailand during 1987 - 2008
Source: Economist Intelligence Unit

With the emergence of China, India, and Vietnam as countries with low labor costs, Thailand is stuck in the middle of the low labor cost provider and the technological advanced countries. To solve this problem, the government of Thailand aims to shift the position of Thailand into becoming a high quality, technological advance country with cheaper labor cost compared to the developed countries (NSTDA 2007). The R&D consortia policy is one choice of the policies that the government can implement to improve the technological capability.

Technology spillover through Foreign Direct Investment model

The model of technology spillover through FDI measures the technology spillover level from an increase in the productivity of the country when foreign firms are in the country which is also used in most existing research on technology spillover (for example see Chuang and Lin (1999), Blomström and Sjöholm (1999) and Liu (2002)). The productivity of the country is measured by the GDP per employment (OECD 2008). The OECD measures productivity using GDP per hour work. However, due to the data limitation in obtaining the number of working hours, we assume that the average working hour per worker is constant.

The productivity of the country is affected by the fixed capital per employment and the technical change which accounts for the technology change, innovation, and new management techniques (Cobb and Douglas 1928; Solow 1957). In this research, the technology gap is also considered in the calculation of the country's productivity because the technology gap affects the level of technology spillover from foreign firms to local firms (Sawada 2005; Sermcheep 2006; Meyer and Sinani 2009). The productivity gap acts as a bridge to reduce the difference between the productivity capability between domestic firms and foreign firms because the technology spillover increases when the productivity of the country increases as shown by R1: Increase Learning Capability in Figure 3.

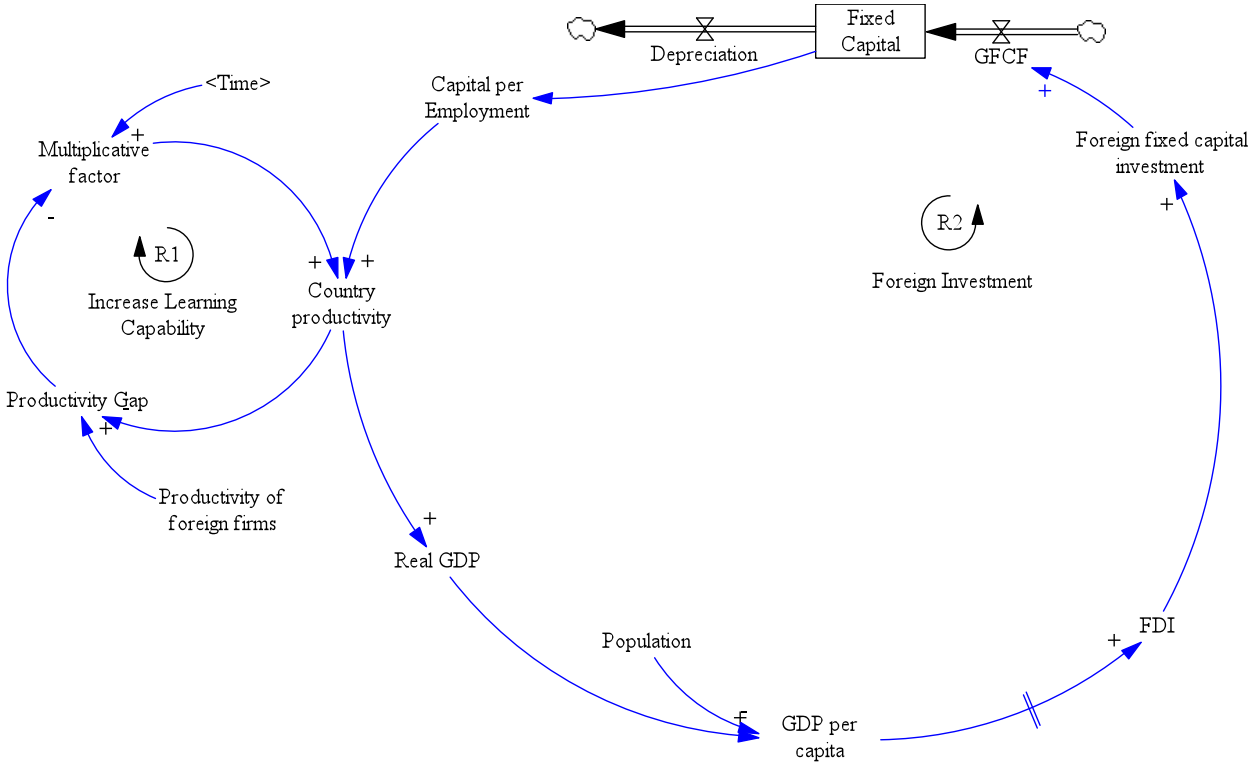

Figure 3 The model with learning capability and foreign investment

An increase in the productivity drives up the real GDP and the real GDP per capita of the country assuming the number of employment and population is constant. When the GDP per capita increases, Thailand is more attractive for foreign investment as the market opportunities increase. When foreign firms invest in the country, they also invest in fixed capital which adds

up the fixed capital per employment (Krkoska 2001). Higher capital per employment increases the productivity of the country. This loop is shown by R2: Foreign Investment in Figure 3.

The growth in real GDP reflects the economic growth of the country. We assume that the local firms also expand on average at the same rate as the economic growth, but with a delay. Therefore, the GDP growth drives up the local investment. The expansion of the local investment also requires an expansion in the fixed capital. An enlargement in the fixed capital increases the capital per employment and the productivity of the country. With an improvement of the productivity, the real GDP of the country grows faster. This relationship also works as another reinforcing loop in the development of the country's productivity as shown by R3: Local Investment in Figure 4.

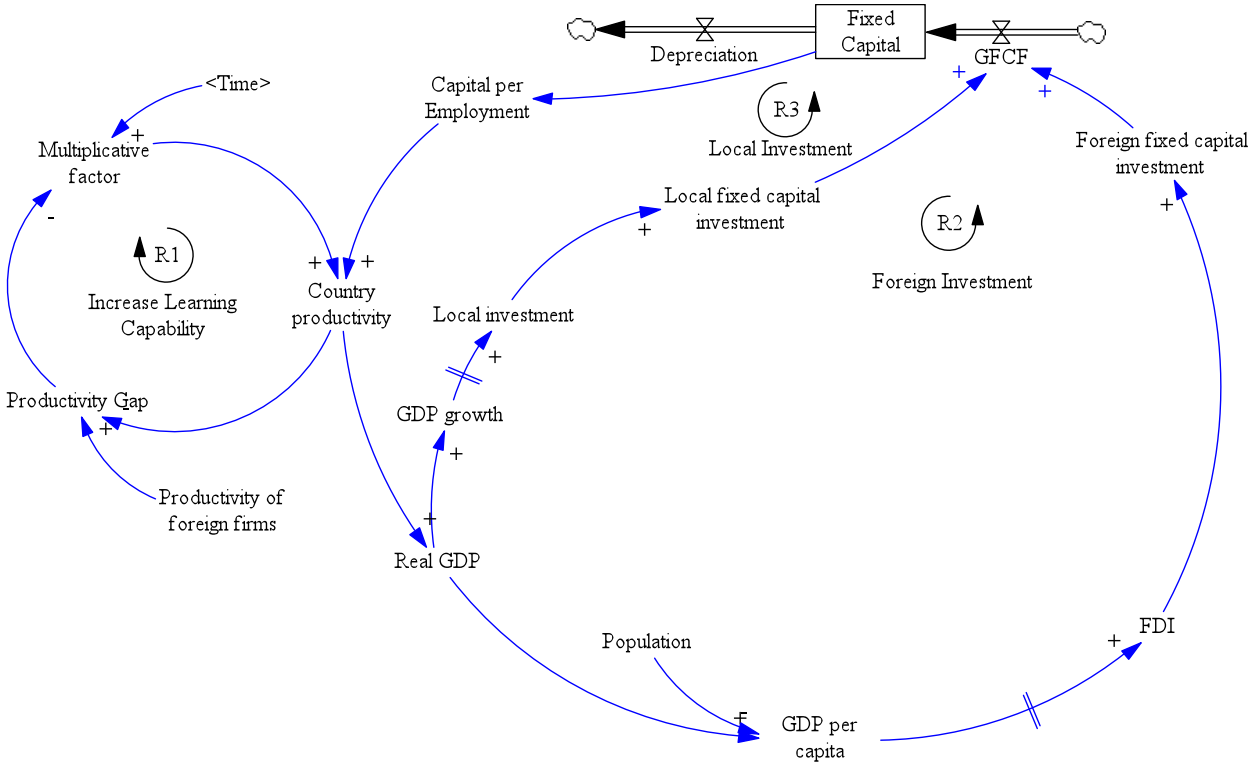

Figure 4 The model with local investment

The growth of foreign investment and local investment increases not only the fixed capital formation in the country but also the employment rate. When foreign and domestic firms expand their operation, they need to hire additional workers. However, the number of workers to hire is limited by the number of unemployed. When the number of employment increases, it also increases the real GDP of the country assuming the productivity of the country is constant. An increase in real GDP adds up to the GDP per capita and also stimulates more foreign investment which feeds back to an increase in the employment as shown by R4: Foreign Hiring in Figure 5. Growing real GDP of the country also encourages an expansion of the local firms which in turn adds up the number of employment hiring as shown by R5: Local Hiring in Figure 5.

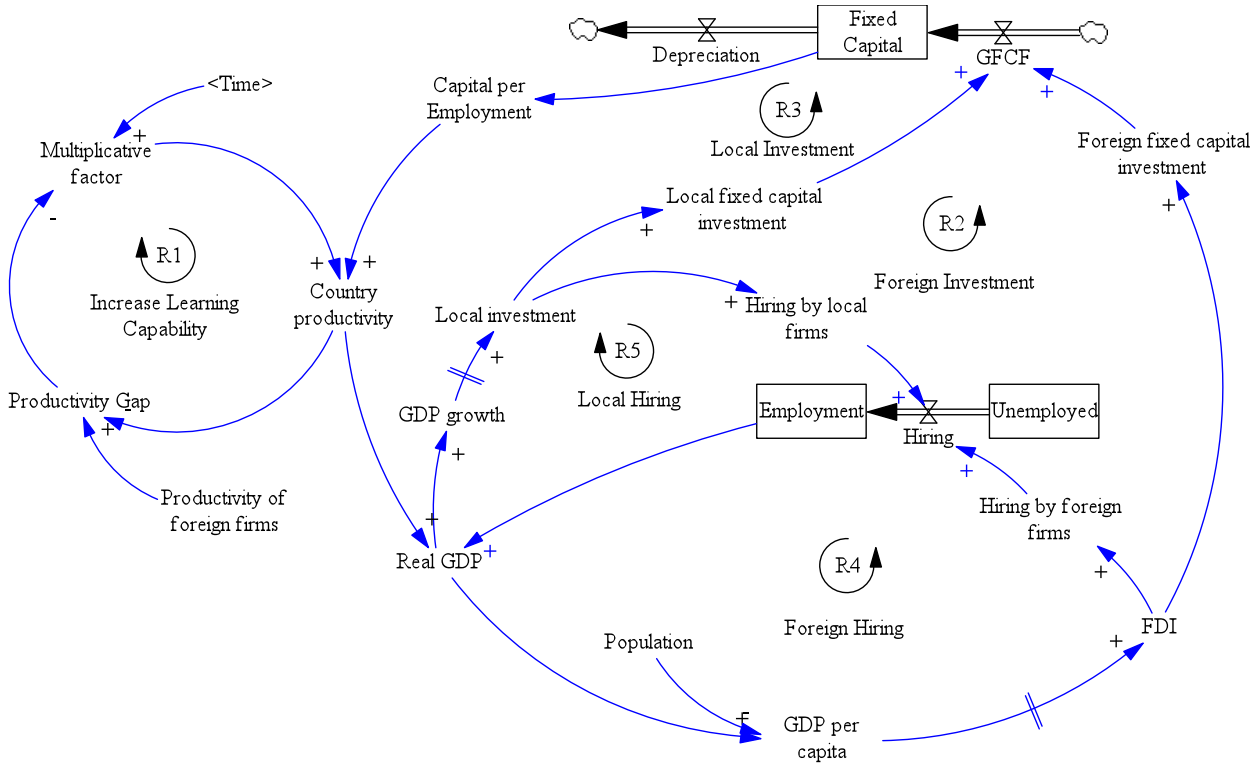

Figure 5 The model with employment hiring by foreign and local firms

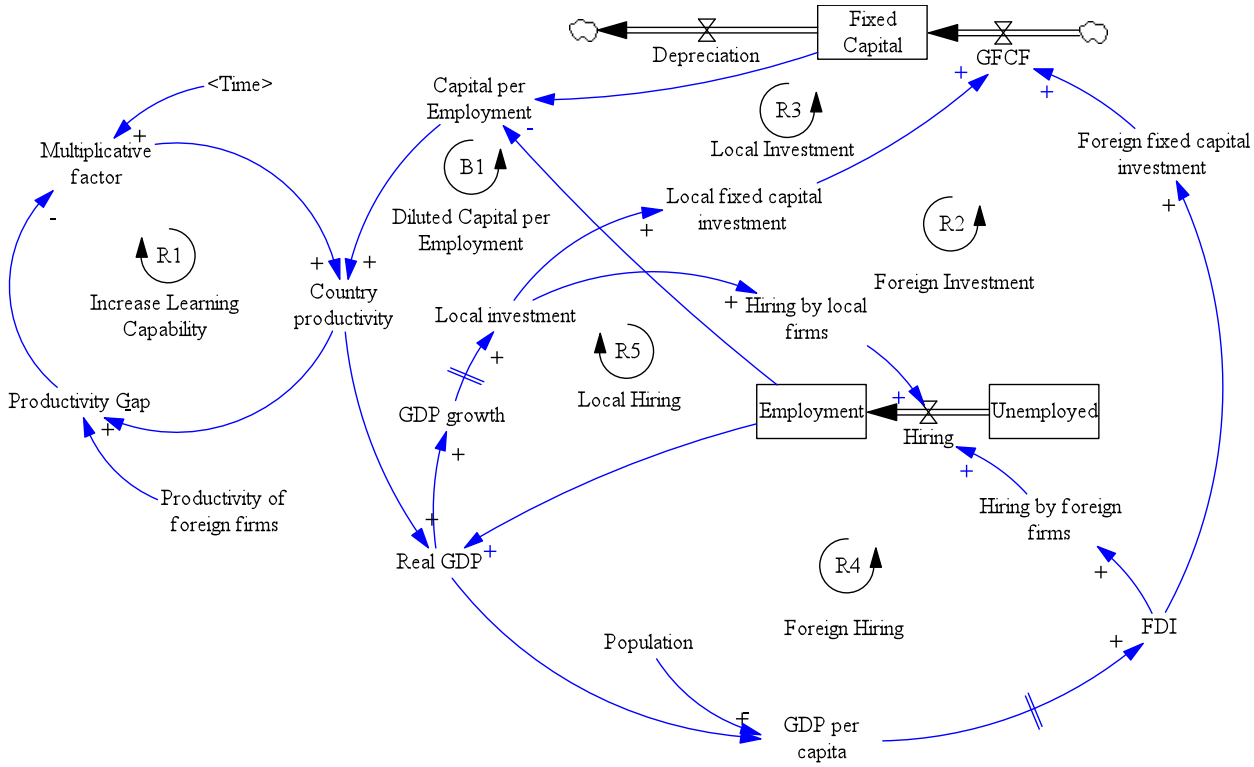

Figure 6 The model with diluted capital

Although an increase in the number of employment can drive up the real GDP of the country, it also reduces the capital per employment. A reduction in the capital per employment makes the productivity of the country decrease which also reduces the real GDP of the country. The decrease in the real GDP reduces the GDP per capita and the FDI of the country as well as tightens the domestics operations which in turn reduce the employment rate. This interconnection acts as a balancing loop of the system and it is shown by B1: Diluted Capital per Employment in Figure 6.

Model validation

The model is validated using the dimension consistency test, behavior reproduction test, and family member test. The dimension consistency test is conducted by using the Vensim's unit check function. The result shows that the units of the variables in the model are consistent.

For the behavior reproduction test, we parameterize the model to reproduce the behavior of the Thailand's economy from 1988 to 2008. The statistical results of the fit between the simulation and the historical data shown in Table 1 indicate that the model of the technology spillover through FDI can statistically significantly reproduce the behavior of the economic situation in Thailand.

Table 1 The comparison between the simulation and the historical data of Thailand, 1988 - 2008

	R^2	MAPE	SMAPE
Foreign productivity	0.7572	10.15%	10.34%
Country productivity	0.9416	3.88%	3.87%
Real GDP	0.9319	5.36%	5.29%
FDI	0.7576	52.05%	47.08%
Fixed capital	0.9237	11.18%	10.35%
Employment	0.8510	1.72%	1.71%
Population	0.9693	0.93%	0.94%

Remark: MAPE = Mean Absolute Percentage Error, SMAPE = Symmetric MAPE

The model is also applied to the case of Malaysia which has similar business environment as Thailand to test for the family member test. With a minor parameter adjustment, the model can significantly trace the change of the variables in the Malaysia's economy as shown in Table 2.

Table 2 The comparison between the Simulation and the historical data of Malaysia, 1988 - 2008

	R^2	MAPE	SMAPE
Foreign productivity	0.8119	8.08%	8.33%
Country productivity	0.9361	3.70%	3.66%
Real GDP	0.9813	3.14%	3.18%
FDI	0.3928	58.44%	37.75%
Fixed capital	0.9695	9.74%	8.87%
Employment	0.9648	2.26%	2.31%
Population	0.9717	2.07%	2.09%

Remark: MAPE = Mean Absolute Percentage Error, SMAPE = Symmetric MAPE

Effect of R&D consortia on Thailand's economy

The effect of an R&D consortia policy on the improvement of the technology spillover is studied from the case of Japan. Japan is selected because Japan has implemented the R&D consortia policy for a period of time. Besides, the economic situation of Japan before implementing the R&D consortia policy was similar to the current economic situation in Thailand which is mainly comprised of labor intensive industries. Due to the goal of this paper as a policy analysis instead of forecasting, the simulation iteration is used instead of the time to avoid misunderstanding.

Productivity growth from technology spillover can be studied through the calculation of the country's productivity in the model. The productivity of the country is determined by the capital per employment and a multiplicative factor. Capital per employment is not related to the technology spillover therefore we focus on the multiplicative factor. The multiplicative factor consists of the effect of the technology gap and a time dummy variable representing the change in technology, innovation, and management technique. The R&D consortia policy affects both factors in a multiplicative factor because the R&D consortia policy is expected to reduce the technology gap between local and foreign firms and also stimulate technology and innovation research. Therefore, to implement the R&D consortia policy in Thailand, the coefficient of the multiplicative factor is modified. The coefficient of the multiplicative factor of Japan is used in the model of Thailand to represent the implementation of the R&D consortia policy.

We assume that the R&D consortia policy is implemented in 2008 which is the last year of the empirical data we have. The R&D consortia policy is modeled to be gradually implemented and to be fully implemented by 8 simulation iteration durations in order to observe the dynamics of the change of country productivity and technology spillover in Thailand. The model is also simulated for 12 simulation iteration durations after 2008 to observe the effect of the R&D consortia policy during and after the implementation.

When implementing the R&D consortia policy to Thailand, the productivity of Thailand increases significantly compared to the case without the R&D consortia policy as shown in Figure 7. This result indicates that the R&D consortia policy can improve the productivity growth from technology spillover in Thailand.

The GDP per capita also increases extensively from the R&D consortia policy compared to the graph of the GDP per capita without the R&D consortia policy as shown in Figure 8. This result suggests that people in Thailand will gain benefits by having a higher average income if the government uses the R&D consortia policy.

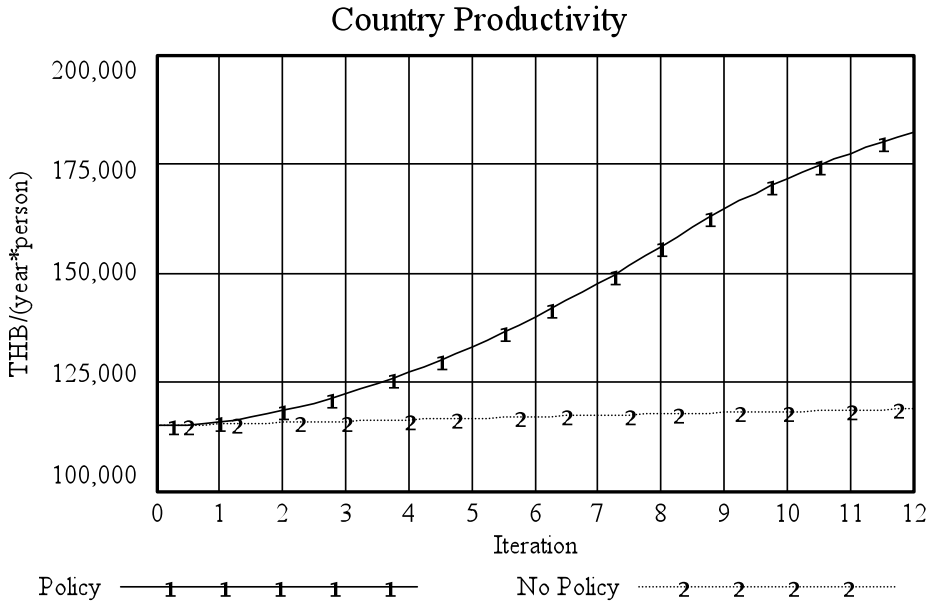

Figure 7 The productivity of Thailand with and without the R&D consortia policy

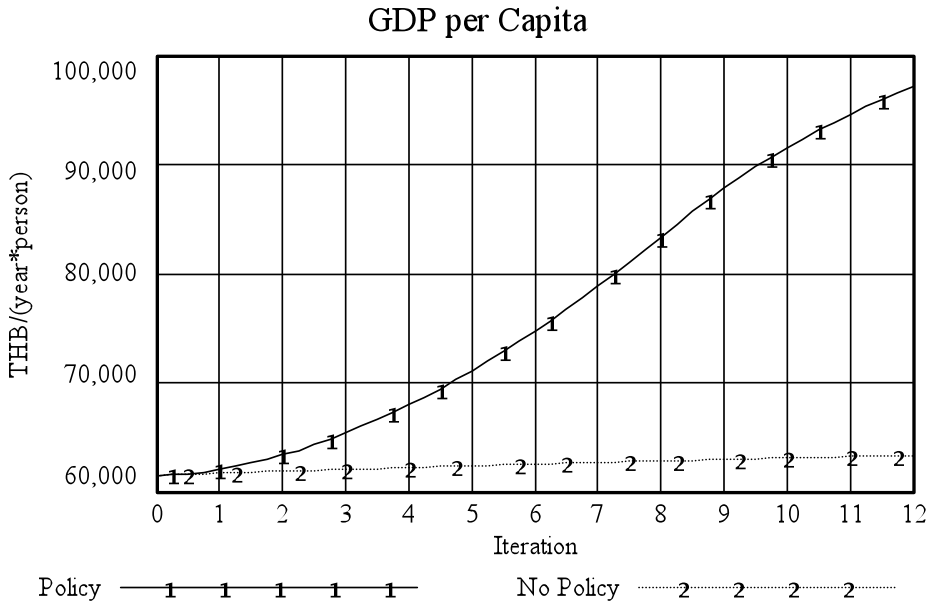

Figure 8 The GDP per capita of Thailand with and without the R&D consortia policy

FDI also grows exponentially when Thailand implements the R&D consortia policy as presented in Figure 9. This result indicates that even though productivity and technology spillover in Thailand are high, foreign firms are still willing to invest in Thailand to gain market opportunity which is identified by the higher GDP per capita.

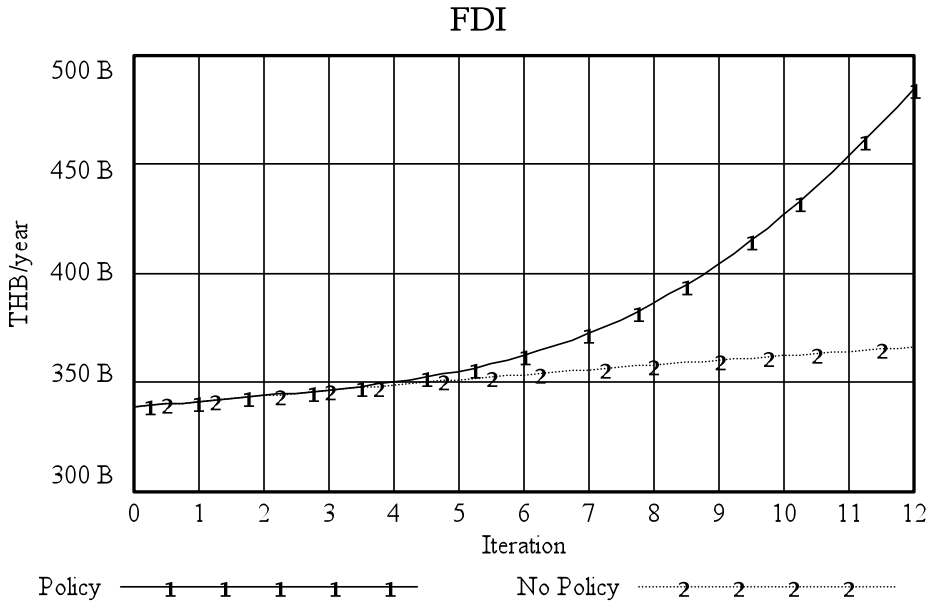

Figure 9 The FDI of Thailand with and without the R&D consortia policy

In summary, the R&D consortia policy can encourage the productivity growth from the technology spillover through FDI as shown by a continuous increase in the productivity of Thailand. Increase in productivity also drives up the wealth of people in Thailand as indicated by a higher GDP per capita. With higher GDP per capita, Thailand becomes a market opportunity for foreign firms. Even though foreign firms are likely to lose their technology through technology spillover and have more direct competition with local firms due to the increase in productivity of the local firms, the country attractiveness from higher GDP per capita still outweighs the risk and results in an increase in FDI.

The effect of the R&D consortia policy on the FDI is lagged by a couple iteration durations whereas the effect on the productivity of the country and the GDP per capita is significant immediately after the policy is implemented. This result shows that even though Thailand is more attractive from an increase in the GDP per capita, foreign firms still require a significant period of time to make an investment decision. The ineffective bureaucratic process related to the establishment and expansion of foreign firms also causes the delay in the foreign investment.

When considering the growth pattern of the productivity of the country and the GDP per capita, the graphs follow an S-shaped pattern with a shift of the dominant loop at the time when the policy is fully implemented. It shows that the benefits of the R&D consortia policy on the productivity of the country and the GDP per capita are limited by the growth of technological capability of the foreign firms. During the policy implementation period, the productivity of the country grows faster than the productivity of the foreign firms. This fast growth in the country's productivity reduces the productivity gap and increases the technology spillover from foreign firms to local firms. When the policy is fully implemented, the growth of the productivity of local firms grows at a slower rate than the foreign firms even though the level of productivity is increased from the policy. The difference in the growth ratio between foreign firms and local

firms acts as a negative feedback that reduces the level of technology spillover which slows down the growth of the productivity and the GDP per capita in the long run. However, the effect on FDI is not clear because the effect on the FDI is lagged by 4 iteration durations.

Policy implementation process and the consequence on the policy result

It has been demonstrated that the R&D consortia policy provides benefits to Thailand. However, the implementation process can affect the result of the policy as well as the policy itself. We focus the analysis on the implementation process of the R&D consortia policy by using the sensitivity analysis method.

The focus is on two dimensions of the policy implementation; implementation duration and the FDI reaction to the implementation. It is not clear how the duration to implement the policy affects the result of the policy. Rapid changes can provoke strong resistance and can be costly but they may also instantly push the country into a better competitive position. In this analysis, we focus only on the effect on the policy with different implementation periods without considering the cost of implementation. If the different implementation periods create a significant change in the effect of the policy, it would be worth to study further on the cost of implementation and compare the costs and the benefits. If the result is not significantly different, the government should implement the policy in a way that minimizes the implementation cost and resistance.

Another dimension to be studied is the reaction of foreign investors on the implementation of the R&D consortia policy. Sawada (2005) argued that by having higher technology spillover, foreign investors are discouraged because they have to invest more to prevent the technology spillover. Thus, implementing the R&D consortia policy can create a signaling effect on the decision making of foreign investors because it is a sign of increasing technology spillover.

Policy implementation duration

We study the effect of the implementation duration by altering the period to implement the policy in the model. We compare 3 cases of different implementation duration with the case "No Policy" as a base case with no R&D consortia policy implementation. "Policy" case is the scenario that the policy requires 8 iteration durations to be fully implemented which is the case that we considered in the previous section. "Short" and "Long" cases are the situation that the implementation duration lasts for 4 iteration durations and 12 iteration durations respectively.

The effects of different R&D consortia policy implementation periods on the result of the policy in Thailand are presented in Figure 10, Figure 11, and Figure 12. The implementation duration affects the country productivity and GDP per capita in the short term. However, the difference becomes narrower in the long term because of the mismatch in the productivity growth as explained previously. To be specific, short implementation duration makes the country productivity and GDP per capita significantly higher than the long implementation duration.

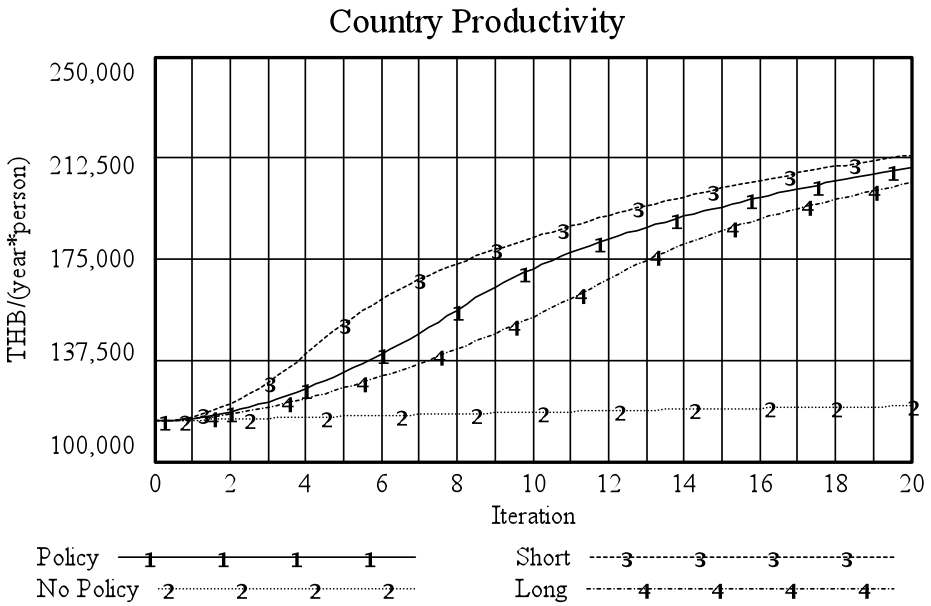

Figure 10 The productivity of Thailand when implemented the R&D consortia policy with different implementation durations

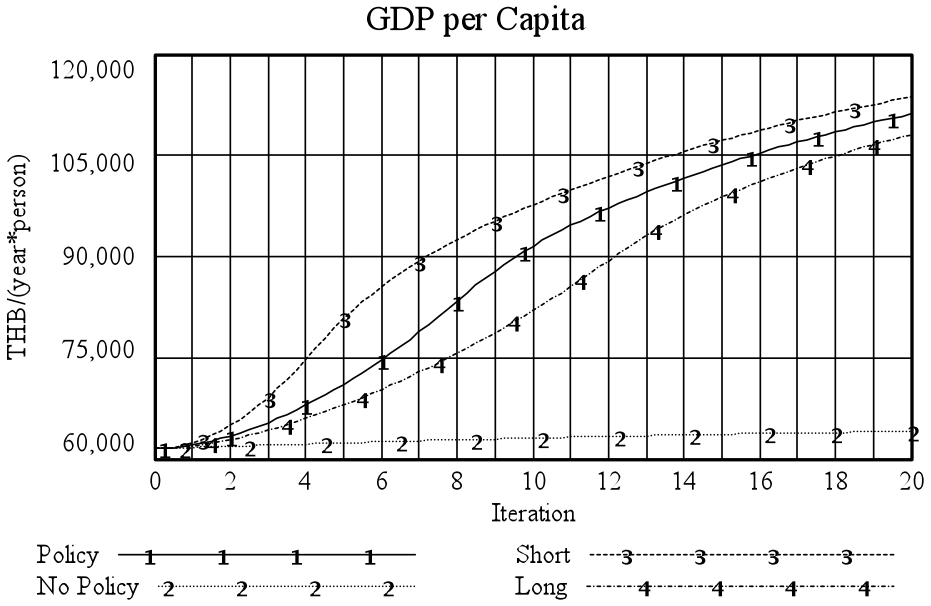

Figure 11 The GDP per capita of Thailand when implemented the R&D consortia policy with different implementation durations

The effect of the implementation periods on the FDI is not significant in the short term but it is enlarged and becomes parallel in the long term as shown in Figure 12. The effect of the implementation duration is unclear in the short term because of the delay time between the policy implementation and the effect of the policy on FDI as discussed before.

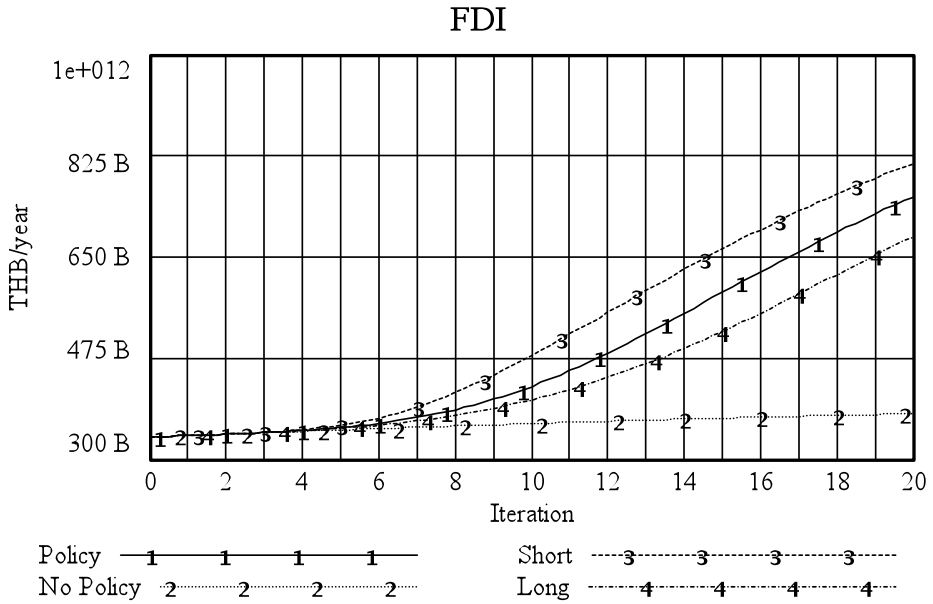

Figure 12 The FDI of Thailand when implemented the R&D consortia policy with different implementation durations

The FDI signaling effect

There is an argument that with high technology spillover, FDI is reduced because foreign firms incur additional costs from preventing the technology leakage (Sawada 2005). The implementation of the R&D consortia policy signals to the foreign firms that the level of technology spillover is going to increase. Thus, based on Sawada's argument, FDI will drop if the R&D consortia policy is implemented. In order to study this issue, we compare the simulation incorporating the signaling effect from implementing the R&D consortia policy with the case of implementing the policy without the signaling effect and the case in which the R&D consortia policy is not implemented. For the simulation with signaling effect, we examine 2 scenarios – "Weak" and "Strong". The "Weak" case is the case in which the signaling effect reduces the FDI by 5%, and for the "Strong" case FDI is reduced by 10%.

The signaling effect from implementing the R&D consortia policy does not create a difference in the consequences of implementing the R&D consortia policy in Thailand on country productivity and GDP per capita as shown in Figure 13 and Figure 14 even though the FDI volume is different as presented in Figure 15.

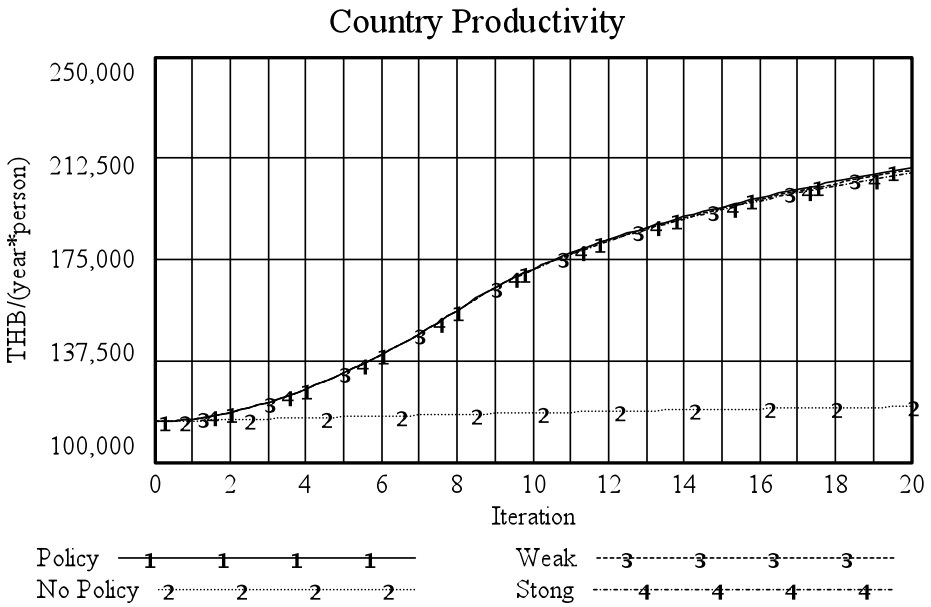

Figure 13 The productivity of Thailand when implemented the R&D consortia policy with different signaling effect on FDI

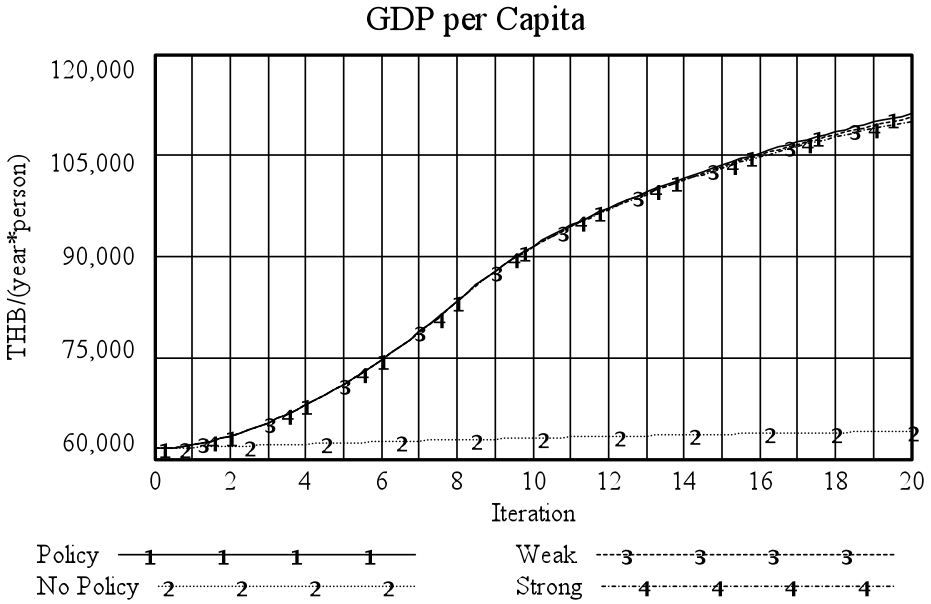

Figure 14 The GDP per capita of Thailand when implemented the R&D consortia policy with different signaling effect on FDI

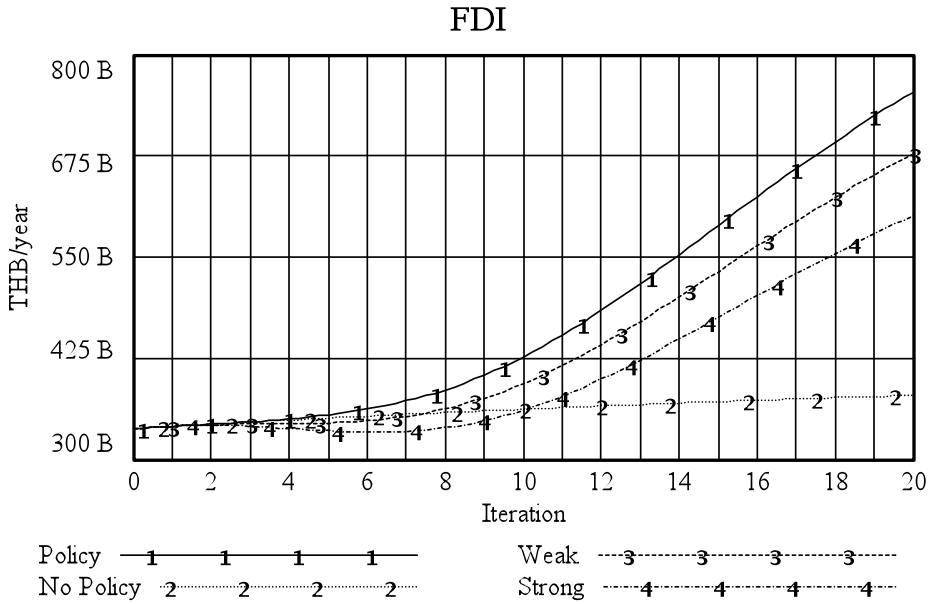

Figure 15 The FDI of Thailand when implemented the R&D consortia policy with different signaling effect on FDI

The result of the signaling effect on FDI is not unexpected. The strong signaling effect pulls down the FDI volume and FDI is highest if the signaling effect is not considered as shown in Figure 15. However, even though the FDI is reduced by 10% ("Strong" case) from implementing the R&D consortia policy, Thailand still gains significant benefits from having more FDI inflows in the long term.

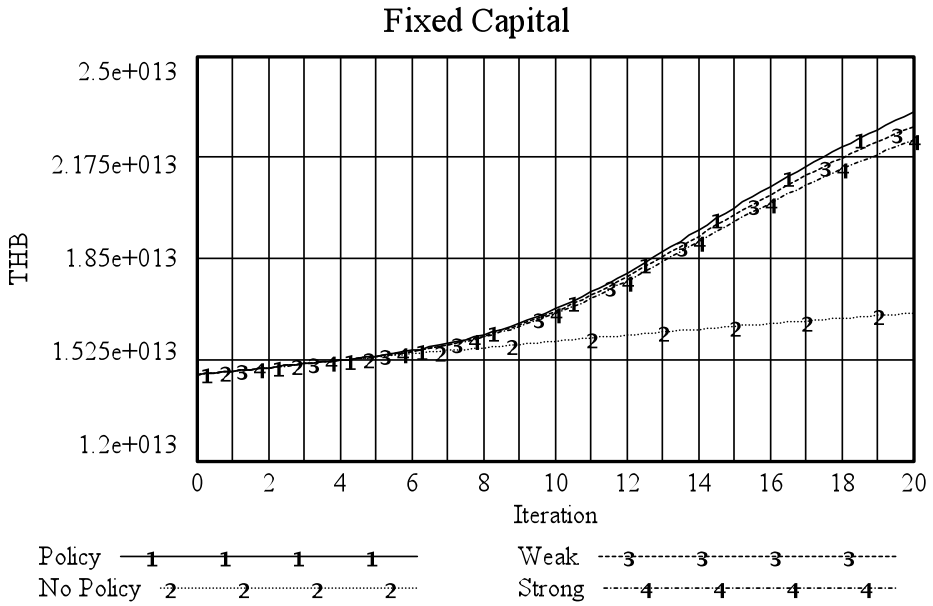

Figure 16 Comparison of the fixed capital of Thailand when implemented the R&D consortia policy with different signaling effect on FDI

Even though the signaling effect reduces the inflow of FDI, the productivity and GDP per capita receive no effect from it because of the fixed capital as presented in Figure 16. The amount of fixed capital in Thailand does not change significantly even though the difference in FDI is significant because the new fixed capital investment is small compared to the existing stock of fixed capital.

Conclusion

This paper studies the effect of R&D consortia policy on the dynamics of technology spillover from FDI in Thailand using a system dynamics approach. The simulation results indicate that Thailand gains significant benefits in terms of higher productivity, GDP per capita, and FDI. However, the advantage Thailand obtains from implementing the policy is mainly a short-term benefit instead of a long term one. The policy can significantly increase the productivity of the country which also pushes up the GDP per capita and the FDI of the country. However, as long as the productivity growth after the policy implementation is slower than the productivity growth of the foreign firms, an increase in the productivity gap will reduce the technology spillover which in turn reduces the growth of the productivity of Thailand in the long run.

The implementation process also affects the result of the policy. By shortening the implementation duration, Thailand can gain extra benefits in terms of having higher productivity, GDP per capita, and FDI. However, the benefits are more significant in the short term than in the long term. Reducing the FDI signaling effect also enhances the growth of FDI. However, weakening the signaling effect does not provide significant benefits on the productivity of the country and the GDP per capita.

The policy implication from this research clearly indicates that the government of Thailand should implement the R&D consortia policy because it will improve the productivity growth of the country as well as the wealth of people in that country as well as FDI. However, the results do not suggest that the government should implement the policy at all cost. The key factor that drives up all the improvement from the R&D consortia policy is the productivity growth. The R&D consortia policy will increase productivity, average population income, and FDI in both the short term and the long term only if the R&D consortia policy pushes the productivity up from the start. Therefore, if the policy implementation process involves a significant reduction in the productivity of the firms, the R&D consortia policy should be re-analyzed. However, if the implementation process of the R&D consortia policy consists of having lower FDI, the R&D consortia should still be implemented because the higher productivity growth from the R&D consortia policy will drive up the country GDP per capita which then attracts more FDI.

Every research has limitations, including this paper. One of the limitations is that there are some country factors that may affect the decision making of foreign investment. These factors include the economic and political situation of the country, exchange rate, interest rate, the degree of government intervention, and corruption and transparency level. The results may also differ according to the industrial characteristics. Besides, this study is conveyed on the macro level and thus the results are the average results of every firm in every industry. The

results on each firm in a different industry may vary and would need the firm-level and industry-level analysis if the detail results are required. Using Japan as the only country to represent a country with the R&D consortia policy is also another limitation of this paper. Some country-specific factors may have an influence on the effect of the R&D consortia policy on technology spillover. By comparing and contrasting several different countries which already implemented the R&D consortia policy would eliminate the effect of these country-specific factors. Another interesting issue to be studied is the effect of a delay period between policy implementation and the result. Since it takes a significant amount of time for FDI to grow from the R&D consortia policy, this may raise questions during the implementation period if the policy is effective especially if the signal effect is strong. A government that mainly concentrates on short-term results may pull out the R&D consortia implementation process which may create an unexpected result. Therefore, it would be interesting to consider the goals and behavior of the government.

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