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Does Immigration Promote Innovation in Developing Countries? Evidence from Thai Manufacturers

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ABSTRACT

Contrary to studies of other migrant-receiving countries, most of which are developed countries, this paper examines impacts of immigrant workers on innovative capacities in Thailand, which is not only a representative of a receiving country that is a developing country but also a country where the majority of its immigrant workers are unskilled. Analysis of firm-level survey data in Thailand finds that employing unskilled and cheap labor from neighboring countries, namely, Myanmar, the Lao PDR, and Cambodia, is like adopting a kind of "labor-saving technology" which actually impedes firms' R&D investment. Contrary to developed countries in which immigrants are found to boost innovation and promote sustainable growth, in Thailand, even though employing unskilled immigrant workers helps firms maintain their cost competitiveness in the short run, its negative impacts on R&D investment tend to hamper improvements in productivity and thus diminish global competitiveness in the long run. Employing skilled or educated migrants, on the other hand, complements technological progress and encourages firms to innovate more quickly. In addition, the paper finds that providing government incentives and promoting access to financing have become effective tools in facilitating Thai firms' investment in innovation.

Key words: Immigration, Innovation, Developing Country, Thailand

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INTRODUCTION

During the past decades, the movement of workers and their families has been increasing rapidly and has become an important social and economic development issue in many countries, including developing countries such as Thailand. The segmentation of the labor market explains why the country has experienced both large-scale immigration and emigration of low-skilled workers at the same time. As a result, Thailand has, for a long time, faced the dilemma of having a shortage of low-skilled and semi-skilled workers but a surplus of high-skilled workers. The lack of employment and educational opportunities in rural areas and the segmentation of the labor market in urban areas can be identified as the major push factors driving Thai workers to seek employment overseas.

On the other hand, even though the country itself is considered a developing country, Thailand is surrounded by the less-developed countries of Cambodia, the Lao PDR, and, especially, Myanmar. Much of the immigration to Thailand from those three countries is due mainly to widening income disparities between them and Thailand, where immigration issues are in the forefront of current economic and political concerns and are hotly debated (Pholphirul, 2012). Since major immigrant-receiving countries are generally more developed, Thailand, which is still developing, has become a special case study for investigating the economic and social roles of immigrant workers.

Similar to those in other countries, Thailand's immigrant workers are made up of both skilled and unskilled workers. As of December 2012, there were 109,467 foreign professionals and skilled immigrants residing in Thailand, according to the number of work permits issued. Japanese topped the list of foreign groups in Thailand with work permits (25,714), followed by skilled immigrants from the United Kingdom, China, India, the Philippines, and the United States, respectively. Nearly two-thirds of the work permits for foreign nationals were for senior officials and managers and nearly one-fourth were for professionals. A majority of the work permits held by Japanese were for employment in business and manufacturing while 59 percent Filipinos were either professionals of one kind or another or worked in education. Thirty percent of work permits held by skilled foreign workers were in manufacturing, 16 percent were in education, and 16 percent in trade.

Widening income gaps between Thailand and neighboring countries, the slowing growth of Thailand's workforce, and the improvements in roads and infrastructure linking the region are

the major drivers of cross-border movement of low-skilled laborers into Thailand. To manage unskilled immigrants, Thailand has signed Memoranda of Understanding (MOUs) with Cambodia, the Lao PDR, and Myanmar for the formal recruitment of migrant workers. Under the MOUs, there were around 1.3 million migrants who held work permits for low-skilled employment at the end of 2009, a total of 73 percent of them coming from Myanmar. These unskilled migrants have been working in a range of 3D jobs (Dirty, Dangerous, and Demeaning), around 50 percent of which are in fisheries and seafood processing, 17 percent in agriculture, 17 percent in construction, 8 percent in domestic employment, and 43 percent in a range of other jobs.

Table 1: Number of Skilled Immigrants and Foreign Professionals Holding Work Permits in Thailand (December 2012)

Occupation	Total	Japan	UK	China	India	Philippines	USA	Others
All Occupations	109,467	25,714	9,061	9,618	8,546	7,837	7,398	41,133
Senior Officials and Managers	70,136	20,286	4,897	4,988	6,794	1,521	3,267	28,383
Professionals and Education	26,133	2,612	3,442	2,897	830	5,523	3,754	7,075
Technicians	7,896	2,209	450	1,021	491	490	262	2,973
Clerks	1,779	252	185	108	69	151	57	957
Service and Sales Workers	1,325	185	38	107	205	44	18	728
Skilled Agricultural and Fisheries	33	2	1	3	0	3	2	22
Craft and Related Trade Workers	617	123	14	169	74	19	12	206
Plant and Related Operators	827	205	28	274	37	28	20	235
Elementary Occupations	271	7	2	6	3	2	3	248
Trainees	450	13	4	45	43	56	3	286

Source: Department of Employment, Ministry of Labor

Table 2: Registered Migrant Workers in Thailand from Cambodia, the Lao PDR, and Myanmar (December 2010)

Sector	Total	Cambodia	Lao PDR	Myanmar
Total	1,248,064	235,521	106,970	905,573
Fishing	41,128	15,073	1153	24902
Seafood processing	106,851	9,149	820	96,882
Agriculture	228,041	35,882	17,737	174,422
Construction	232,162	84,368	12,321	135,473
Agric. processing	81,882	10,335	3,493	68,054
Meat processing	42,037	3544	1767	36,726
Recycling	18,331	4,955	1395	11,981
Mining, quarrying	2724	289	190	2245
Metal sales	24,437	3,687	2,978	17772
Food sales	61,598	9,340	13,499	38,759
Soil business	9,842	956	718	8168
Const. materials	17,010	2,653	1435	12,922
Stone processing	3272	366	174	2732
Garment industry	74,681	4423	6,285	63,973
Plastics industry	24,135	3,214	2,670	18,251
Paper industry	5282	1253	457	3572
Electronics	6893	1352	461	5080
Transport	10,765	2588	513	7664
Trade	55,595	10,089	8,067	37,439
Car repair & service	8,769	1221	1646	5902
Fuel and gas	4910	692	1103	3115
Education	2103	248	141	1714
Household	85,062	7,427	16,452	61,183
Other	100,554	22,417	11,495	66,642

Source: Department of Employment, Ministry of Labor, Thailand

Challenges also exist for management related to unskilled immigrants since a large number of immigrants are undocumented–as many as 1.44 million migrants and their family members (Huguet and Chamratrithirong, 2011). This large number of undocumented migrants posed a problem for Thai policymakers as to how to manage them in such a way that could generate economic benefits while at the same time control potential costs that might occur from employing unskilled migrants.

A number of empirical studies attempt to explain the costs and benefits of immigration in Thailand. They have addressed questions such as whether mass unskilled immigration has depressed the wages of Thai workers, whether immigration of people with little education and

few job skills contribute to a widening income gap, and whether immigrants displace unskilled Thais from their jobs.

Rukumnuaykit (2008) states that the benefits of migrant workers to the Thai economy are most obvious from the contribution of immigrant labor to the increase of economic output. How the macro-economy benefits from employing immigrants was the first aspect explained by Thai economists in quantifying the benefits the overall economy has received. Sussangkarn (1996) used the SAM-CGE model to gauge the impact and concluded that about 750,000 immigrants (about 2.2 percent of the labor force) raised Thai GDP by 0.55 percent at 1995 prices. Martin (2007) applied the model to the data ten years later, adjusting for the increase of the migrant share of the labor force. He found that immigrants, who by then comprised about 5 percent of total number of workers, increased GDP by about 1.25 percent. Pholphirul and Rukumnuaykit (2010) used a similar methodology, with an adjustment on the informal labor share, and found that the net contribution from immigrant workers to the Thai economy was approximately 0.023 percent. On average, this is a net contribution of approximately 0.023 percent of the real national income (in constant 1988 Thai Baht) per year, or around 760 million Baht per year. The most recent study from Pholphirul and Kamlai (2011) uses other approaches but also confirms the economic contribution of immigrants to the Thai economy.[1] These techniques have confirmed that immigrants increase real GDP by around 0.75-1.07 percent, depending on the methodology used.[2]

Even though there are benefits from employing immigrants, there are also costs. In terms of GDP growth and investment, these benefits are unevenly distributed, mainly going to the owners of capital (i.e., firm owners and employers) and the immigrants themselves while native workers are considerably jeopardized (Pholphirul and Rukumnuaykit, 2010). A number of empirical studies suggest that immigration does indeed reduce native wages and threaten the employment of Thai workers. Bryant and Rukumnuaykit (2012) found that immigration appears to have caused a small reduction in wages rather than in employment. But a 10-percentage increase in the migrant share of the labor force is found to cause only a 0.23 percent reduction in domestic wages. A similar small impact of immigration on native wages was also discovered by

[1] Namely: (1) Macroeconomic Simulation Model, (2) Growth Accounting, and (3) Econometrics.

[2] The contribution of 0.75 percent (of GDP) was computed from the Macroeconomic Simulation Model and the contribution of 1 percent was computed from the Growth Accounting method (during 1990-2008). During the period 2006-2008, migrants were found to contribute around 1.07 percent of real GDP growth. Our results are similar to those of Martin (2007), who found that migrant workers contributed around 1.25 percent of the Thai GDP in 2005.

Kulkolkarn and Potipiti (2007), who found no significant effect of immigration on the reduction Thai workers' wages. Even though these effects are found to be rather slight overall, they can be significant for those unskilled or low-educated Thais who are highly susceptible to replacement by immigrants. Furthermore, if classification by skills and education is considered, the adverse impacts on Thai workers from immigration are found to be much larger for young and low-skilled workers (Lathapipat, 2010).

Quibria and Islam (2010), however, investigate long-run impacts of immigration on a growing economy. They find that while the short-run impact of immigration on economic outcomes such as capital per worker, output per worker, and real wages can be negative, the long-run impact of immigration on these key variables is not necessarily always adverse. In fact, striking a balance between the labor-augmentation effect and the innovation effect of immigration may influence these variables in positive directions.

Even though cost-benefits of employing migrant workers are explained to some extent in a number of previous studies, not many of them empirically test the roles of immigration on long-term economic activities such as innovative investment and productivity growth. Since the long-term productivity of a firm is determined by its innovation and upgrading of technology, innovation is a positive sum game that develops new fields of value creation and spills over positively to a national level.

Research in immigration and innovation is not new. Studies in developed countries that have a high rate of immigration and a highly skilled foreign-born population, such as certain European economies and the United States, have identified a positive link between the presence of immigrants and the level of innovation in firms. In the case of Europe, research Ozge et al. (2011) measured the impact of immigration and the skills and diversity of immigrants on innovation for the periods 1991-1995 and 2001-2005. Constructing a panel of data for 170 regions in Europe and using patent applications per million inhabitants as a marker of innovation, they found positive links between the diversity of the immigrant community and increases in patent applications. This relationship is found to be even stronger the higher skill level of immigrants.

The positive relationship between immigration and innovation has also been found in a number of research findings in the US, where high skilled immigrants have become a main source of innovation, especially in the STEM (Science, Technology, Engineering, and

Mathematics) fields. The US attracts a disproportionate number of highly qualified scientific and technical personnel from around the world largely because the resources that these world-class researchers need can be found at many American universities. Using state-level data between 1950-2000, Hunt and Gauthier-Loiselle (2008) find that a percentage-point rise in the share of immigrant college graduates increases patents per capita by 6 percent, and highly educated immigrants have been shown to generate positive spill-over effects on innovation. Stuen et.al. (2012) find that, along with native US citizens, foreign students and researchers contribute significantly to the production of knowledge at scientific laboratories and technology-based innovation launched by universities. Matloff (2013) finds a similar positive result of immigration and innovation in the US technology industry, which, first of all, hires foreign workers to reduce labor costs but also uses native employees to promote research and development.

Nevertheless, there is a concern that the USA, even though it is the world's top immigrant-host country, accepting over a million immigrants and several hundred thousand temporary foreign workers a year, is not getting enough highly skilled immigrants and temporary workers who could bolster innovation and competitiveness in an increasingly knowledge-based economy. The country therefore finds it difficult to measure the benefits and costs of immigrant workers (Martin, 2013). Similar studies can be drawn from state-level panel data (Zucker and Darby, 2009) and time-series patterns (Chellaraj et al, 2008) in USA.

In the case of Europe, Faggian and McCann (2006) analyze regional patent application rates as a function of local educational and occupational measures and including flows of foreign graduates. Findings show that inflows of highly educated foreign graduates promote innovation. Besides adding to the skilled labor force, immigration brings with it cultural diversity, which enhances innovative capacity and economic performance. Using German regional data, Niebuhr (2012) suggests that differences in knowledge and capabilities of workers from diverse cultural backgrounds enhance R&D. Thus, the benefits of diversity seem to outweigh the costs. Using firm-level data in Finland, Simonen and McCann (2008) examine the relationship between innovative outcomes of Finnish firms and the proportion of their foreign workforces and find a positive impact on innovation from hiring foreign workers who have worked in the same industry elsewhere.

For Canada, Downie (2010) examines different dimensions of innovation across areas such as research, the culture sector, business, and global commerce, as well as effects on the

individual immigrant, the firm, and the national and international economy. At every level of analysis, immigrants are shown to have a beneficial impact on innovation.

In their study of New Zealand, Maré et al. (2011) combine firm-level innovation data to examine the relationship between local workforce characteristics, especially the presence of immigrants and local workers, and the likelihood of innovation by firms. Classifying by ranges of innovation outcomes, they find a positive relationship between local workforce characteristics and average innovation outcomes, but this is accounted for by variation in firm characteristics such as firm size, industry, and research and development expenditure. There is no systematic evidence of an independent link between local workforce characteristics and innovation by controlling for these different characteristics.

A range of mechanisms has been posited to explain the influence of immigration and innovation. For instance, Maré et al. (2011) note that skilled immigration may increase the number of research workers, which key to innovation. In addition, skilled immigrants likely bring different types of knowledge than are familiar to native workers. Overall, immigrant workers can increase the diversity of knowledge in an area and through local interaction contribute to innovation within local firms. In addition to introducing knowledge and skills that are not readily accessible locally, immigrants often have access to a different set of personal and business networks from those of native workers. These differences have the potential to raise creativity and productivity of local interactions and therefore promote innovation.

A number of studies such as those mentioned above have identified a positive link between the presence of immigrants and the level of innovation in firms since immigration may increase competitiveness and growth through innovation. However, analyzing the impacts of immigration and innovation has become a challenge for migrant-receiving countries that are developing countries. In this regard, Thailand offers unique case studies worthy of investigation because, first of all, most migrants are less skilled and can substitute for similar low-skilled native workers. This could result in a decrease in overall labor productivity due to an accompanying decrease in wages. On the other hand, a positive relationship may result when low-skilled immigrants complement high-skilled natives. Therefore, an overall increase in labor productivity may occur. This scenario counters arguments focusing on the negative aspects of immigration in a developing country where most immigrants are unskilled.

Secondly, in contrast to developed immigrant-host countries such as the USA, Europe, New Zealand, Germany, or Singapore, Thailand is still a developing country, though surrounded by even less developed neighbors. Since the long-term productivity of a firm is determined by its innovation and upgrading of technology, innovation is a positive sum game that develops new fields of value creation that can spill over to a national level, especially for a developing country such as Thailand. Even though employing unskilled migrants may help a firm to save some labor costs, doing so may blunt incentives to invest in new technology. Employing cheap and low-skilled labor from abroad constrains adoption of "labor-saving technology" that in turn impedes improvements in long-term productivity and diminishes international competitiveness.

Thailand has been pursuing an export-led development strategy for decades. This strategy has resulted in the country focusing on producing labor-intensive manufactured goods produced using low-skilled workers. But export-led growth can promote development to only a certain stage. According to the World Bank (2008), economic growth in Thailand has been driven primarily by an expansion of employment and capital goods. Factor accumulation in the form of more people working and more capital invested in production has produced the observed growth in output. Foreign direct investment has also contributed to this. Yet gains from productivity have been relatively low, with total factor productivity accounting for only one-sixth of the annual growth rate between 1985 and 2005 (World Bank, 2008). Less than one-tenth of the growth can be attributed to improvements in human resources. But due to the diminishing marginal contribution of capital, returning to the high growth rates of previous decades will not be feasible if future growth is based solely on factor accumulation. With the ongoing decline in labor cost advantages and the appreciation of the Thai Baht, the nation's success in sustaining high growth in the future will depend on its ability to improve its innovative capacity.

The Thai government now aspires to reach the next stage of development, characterized by a more knowledge-intensive and innovation-driven economy. Compared to other successful economies in the region such as South Korea, Singapore, Hong Kong, Taiwan, or even Malaysia, Thailand will urgently need to shift from a strategy of competing on the basis of low wages to competing on the basis of high productivity. At this moment, Thailand is lagging in terms of innovative capacity, investing only approximately 0.2 percent of GDP in R&D in 2011, compared South Korea's 3.22 percent, Singapore's 2.25 percent, China's 1.44 percent, and the world average of 1 percent (Pholphirul and Bhatiasevi, 2012). Therefore the challenge to Thai

firms is not just to survive in the export market, but also to strengthen its capacity for innovation responsive to consumers in both domestic and international markets.

Among relevant studies carried out on immigration and innovation in Thailand, Kohpaiboon (2009) argues for a concern about adverse effects on technological progress from employing Myanmar migrants in clothing factories in Tak, a province bordering Myanmar. This conclusion is consistent with Bryant (2006), who uses the 2003 Thai Agriculture Census to reject the hypothesis that farms in districts with many migrants use less labor-saving technology. Investigation of the relationship between immigration and innovative investment in the research cited above (Kohpaiboon, 2009; Bryant, 2006)focuses on a particular geographic area (Tak Province) and a particular industry (clothing manufacturing and agriculture).Still, empirical evidence to back up these claims on a larger-scale impact is surely lacking and more empirical research ought to be undertaken.

Using firm-level survey which is the national representative would help clarify understanding of the immigration-innovation dynamic in the country as a whole. Impacts of employing immigrant workers and decision of innovative investment can definitely vary according to firm-level characteristics, location, industry, and production structure. For example, innovative investment would presumably be less of a concern among smaller Thai firms using more labor-intensive production. Skills of native workers as well as research capacity would be another important determinant of innovative investment.

This paper aims to determine how and to what extent Thai manufacturing firms seek to hire immigrant workers as well as how immigration affects the likelihood and magnitude of innovation and R&D investment. It then examines the likelihood of firms adopting skill-biased technological investment, which has a strong impact on long-term productivity growth. Findings from this empirical analysis should therefore help policymakers to better understand and complete the puzzle of how immigration should be managed in order to encourage or discourage innovative investment and promote competitiveness among Thai firms. Findings will also address the issue of labor-market policies and how migration management as well as industrial and science and technology policies can be practically implemented. Findings should thus help policymakers to understand how policies supporting innovation can be successfully implemented given the substantive increase in hiring unskilled immigrant workers. In the next section, the paper offers a theoretical model to study the linkage between unskilled immigration and

investment on innovation. Section III presents descriptive data on R&D, innovation activities and the linkages to employment of migrant workers in Thailand. Section IV presents results on multivariate analyses of the effects of skilled and unskilled migrants on technology adoption and innovation investment among Thai manufacturers. Section IV discusses the findings and gives policy recommendations.

UNSKILLED IMMIGRATION AND INNOVATIVE INVESTMENT: A THEORETICAL FOUNDATION

According to Ortega's (2004) simple model, there are two types of workers in the economy: low-skilled (i.e., unskilled, denoted as L_L) and high skilled (L_H). N_L and N_H denote a number of native workers and M_H and M_L denote a number of immigrant workers with high skill and low skill, respectively. Immigrants are assumed to be adult when they arrive in the receiving country and thereafter immediately participate in the labor market. The economy's labor supply is then given by $L^H = N^H + M^H$ and $L^H = N^H + M^H$. So skilled to unskilled premium $k = \frac{L^H}{L^L} = \frac{N^H + M^H}{N^L + M^L}$, in this case, is lower than for the case of skilled to unskilled premium of the natives, which is $n = \frac{N^H}{N^L}$ since a majority of these immigration workers are unskilled ($k < n$). And, for a developing country in which the majority of its labor force (both native workers and immigrant workers) is unskilled, k is therefore between 0 and 1, $k \in (0,1)$.

Using the Skill-Bias Technological Changes model from Behar (2013), total output of final goods is a CES aggregate of two types of laborers, as described by the linearly homogenous technology.

$$Y = \left[(y^H)^{\frac{\epsilon-1}{\epsilon}} + (y^L)^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon-1}{\epsilon}} \quad (1)$$

Where y^H uses skilled labor $L^H = N^H + M^H$ and T^H different machines while y^L uses low skilled (unskilled) labor $L^L = N^L + M^L$ and T^L different machines. Therefore, in a firm's production level

$$y_i^H = (L_i^H)^{1-\alpha} \sum_{j=1}^{T^H} X_{ij}^{\alpha} \text{ and } y_i^H = (L_i^L)^{1-\alpha} \sum_{j=1}^{T^L} Z_{ij}^{1-\alpha}$$

Where X_{ij} is machines of type *j* used by firm *i*, which is the quantity of each of T^H that complement skilled laborers. And Z_{ij} is machines of type *j* used by firm *i*, which is the quantity of each of T^L that complement unskilled laborers. While the price of final output is assumed unity, by having profit maximization, firm-level demand for each type of skilled machine on quantity of skilled labors is

$$X = \alpha^{\frac{2}{1-\alpha}}(p^H)^{\frac{1}{1-\alpha}}L^H = \alpha^{\frac{2}{1-\alpha}}(p^H)^{\frac{1}{1-\alpha}}(N^H + M^H) \quad (2)$$

Similarly, the economy-wide demand for each unskilled

$$Z = A\alpha^{\frac{2}{1-\alpha}}(p^L)^{\frac{1}{1-\alpha}}L^L = \alpha^{\frac{2}{1-\alpha}}(p^L)^{\frac{1}{1-\alpha}}(N^L + M^L) \quad (3)$$

Price of machine (p^H and p^L) is given, the economy-wide output of skilled and unskilled intermediates is

$$y^H = T^H(N^H + M^H)^{1-\alpha}X^\alpha \text{ and } y^L = T^L(N^L + M^L)^{1-\alpha}Z^\alpha \quad (4)$$

Assuming a constant return to scale in production function, an increase of *T* should cause *y* to increase. The variable *T* shown in this model, not only shows different types of machines a firm can use, but also be considered in terms of technical complexity of a firm's production processes.

In a closed economy, for the economy to be in equilibrium in which demand equals supply of each intermediate input, intermediates must have price ratio such that

$$\frac{p^H}{p^L} = \left(\frac{y^H}{y^L}\right)^{\frac{-1}{\epsilon}} \quad (5)$$

For a closed economy, a rise in supply of one input relative to the other should therefore reflect a relative price adjustment. Substituting equation (2) and (3), then combining Equation (4) and (5) altogether, there will be

$$p \equiv \left(\frac{p^H}{p^L}\right)^{\frac{1}{1-\alpha}} = \left(\frac{T^H(N^H+M^H)}{T^L(N^L+M^L)}\right)^{-\frac{1}{\sigma}} \equiv (tk)^{-\frac{1}{\sigma}} \quad (6)$$

Where $t \equiv \frac{T^H}{T^L}, k = \frac{L^H}{L^L} = \frac{N^H+M^H}{N^L+M^L}$ and $\sigma = \epsilon + \alpha - \varepsilon\alpha$ is the elasticity of substitution between skilled and unskilled labor.

An exogenous change in the relative unskilled supply due to unskilled immigrant workers (reduction of *k)* would lead to a fall in *p*, then to higher quantity of y^L produced (relative to y^H) without changing *t*, the ratio of T^H and T^L. The equation (6), therefore, shows a negative relationship between the relative price of high-skilled intensive goods and unskilled immigrant workers. In the meantime, assuming the price ratio is fixed, there is a negative relationship between usage of relative high-skilled machine and employment of unskilled immigrant workers.

For the case of a small-open economy, however, prices are set at the world price $p^* = p$, supply and demand of intermediate goods are however mismatched such that export or import activities of intermediate goods are promoted. Therefore, an increase in relative supply of unskilled intermediaries, for example, due to immigration of unskilled workers M^L, does not require a fall in relative prices. This is consistent with basic H-O Theorem in which a small open economy that has an unskilled supply will tend to export unskilled intermediaries.

In terms of adoption of technology, the supposed cost of investing in innovation for a high-skilled machine (X_j) is $C^H = \left(\frac{T^H}{B^H}\right)^{\delta}$ and for a low-skilled machine (Z_j) = $C^L = \left(\frac{T^L}{B^L}\right)^{\delta}$, defining $C \equiv \frac{C^H}{C^L}$, then

$$C = \left(\frac{t}{B}\right)^{\delta}$$

B is skill-biased technology abundance such that the relative cost of adopting technologies is inversely related to it. $\delta$is a measure of how fast the cost of technological adoption rises as a technological frontier comes closer.

Adopting innovation will be considered if the value of innovation exceeds the cost. The value is however measured as present value of future return from innovative investment, which can be classified into the return from skilled innovation at time *t* is,

$V^H = \sum_i^{\infty}(P_{t+i}^X - 1)\,X_{t+i}(1+r)^{-i}$, and value of an unskilled innovation at time *t* is $V^L = \sum_i^{\infty}(P_{t+i}^X - 1)\,Z_{t+i}(1+r)^{-i}$, where *r* is discount ratio. From $P^X = \frac{1}{\alpha}$ and use of equation (2), we can define that $\Phi = (1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}}$, value of skilled innovation and unskilled innovation are

$$V^H = \Phi\left[\sum_{i=1}^{\infty}\frac{L_{t+i}^H(P_{t+i}^H)^{\frac{1}{1-\alpha}}}{(1+r)^i}\right]$$

$$V^L = \Phi\left[\sum_{i=1}^{\infty}\frac{L_{t+i}^L(P_{t+i}^L)^{\frac{1}{1-\alpha}}}{(1+r)^i}\right]$$

For constant value of *k* and *B*an equilibrium can be found in which *p*, *V*, and *t* are constant and dropping of time subscript, relative value of a skilled technology $V = \frac{V^H}{V^L}$is shown by

$$V = kp \quad (7)$$

in which $k = \frac{L^H}{L^L} = \frac{N^H + M^H}{N^L + M^L}$ and $p \equiv \left(\frac{p^H}{p^L}\right)^{\frac{1}{1-\alpha}}$, skilled innovation can be expected to be of more value to adopt if there is relatively more skilled labor to be complementary with it and if price ratio of skill intermediate is higher.

For a constant price ratio, a lowering of *k* due to higher proportion of unskilled immigrant workers should deteriorate incentives to adopt high-skilled innovation. On the other hand, a higher proportion of high-skilled immigrants should be expected to increase the value of high-skilled technological adoption.

Assuming a condition of free entry in which value of adopting innovation equals to its cost of adoption (V=C), therefore

$$t = B(kp)^{1/\delta} \quad (8)$$

The ratio of skilled to unskilled innovation in this country is positively related to the relative abundance of skilled technology, relative higher price of skilled intermediates, and relative supply of skilled labor. However, in the case of a developing country in which the majority of laborers are unskilled and where there is an abundance of unskilled technology

(lower *B*), the price of unskilled intermediates is higher (lower *p*) and supply of unskilled workers due to unskilled immigration is relatively greater (lower *k*), the ratio of skilled to unskilled innovation adoption is expected to be lower.

As profit-maximizing producers of intermediate goods will hire labor such that wage equals marginal revenue production, relative wages of skilled-unskilled workers, $W = \frac{W^H}{W^L}$ are a function of the relative price (for skilled and skilled intermediaries) and relative labor productivity (shown by $t = \frac{T^H}{T^L}$), then $W = tp$. Substituting into equation (8), relative wage between skilled-unskilled workers will be

$$W = Bk^{\frac{1}{\delta}} \; p^{\frac{\delta-1}{\delta}} \quad (9)$$

Now, at the equation (6), substituting for *p* in equation (9), then

$$t = k^{\frac{\sigma-1}{\sigma\delta+1}} B^{\frac{\sigma\delta}{\sigma\delta+1}} \quad (10)$$

$$W = k^{\frac{\sigma-1-\delta}{\sigma\delta+1}} B^{\frac{\delta(\sigma-1)}{\sigma\delta+1}} \quad (11)$$

This equation (10) shows that the elasticity of substitution between skilled and unskilled labor, σ, is an important parameter governing the sign and extent of the response of skill-bias technological change and wage premium. For a given *B*, the response is positive to *t* and *W* if only if $\sigma > 1$. The wage premium is negatively related to the supply of low-skilled workers and relative higher price of low-skilled intermediates. Immigration of unskilled workers is found to be negatively related to technological change and wage premium. In this regard, we use Thailand as a case study of a developing country in which immigrant workers are relatively unskilled.

INVESTMENT ON INNOVATION IN THAILAND

The data used in our analysis on innovative investment and immigration are from the Enterprise Survey in Thailand, or the so called "Productivity and Investment Climate Survey (PICS)"(funded by the Royal Thai Government with technical assistance from the World Bank), which collected firm-level data in two rounds of surveys. The first round (PICS 2004) was conducted between March 2004 and February 2005 and surveyed 1,385 manufacturing establishments. The second round (PICS 2007) was conducted between April 2007 and November 2007 and surveyed 1,043 manufacturing establishments. A total of 426 manufacturing

firms participated in both surveys, which covered six regions of Thailand (North, Central, Bangkok and vicinity, East, Upper and Lower Northeast, and South) and nine industries based on ISIC classifications (food processing, textiles, garments, automobile components, electronic components, electrical appliances, rubber and plastics, furniture and wood, and machinery and equipment).

In the surveys, innovation activities were defined by types and stages of innovation. Overall, 86.4 percent of all surveyed firms engaged in innovative activities and either upgraded their machinery and equipment or upgraded their existing product line (80.3 percent). Half of surveyed firms reported being able to enter new markets due to process or product improvement in quality or cost, 49.3 percent developed a major new product line, and 46.7 percent introduced new technology that substantially changed the way the main product is produced.

Nevertheless, due to weak intellectual property right protection, less than 10 percent of the firms surveyed filed patents or copyrights. Since large, foreign, and exporting firms tend to have more financial resources to fund innovative activities, research activities are found to be more concentrated among those types of firms.

Innovations are also more common in the food processing, automotive parts, electrical appliance, and electronic components industries, than in the textiles and rubber/plastics industries. The East region, which is where a number of industrial estates are located, has the strongest record of innovation, which might be expected given that large Thai and foreign companies are located in that region. It should be noted that reported data should be viewed as merely suggestive, as they only show the proportion of firms that carried out innovative activities, but not the intensity or complexity of such activities (Table 3).

Table 3: **Percentage of Manufacturing Firms That Undertook Innovative Activities Classified by Region, Industry, and Firm Size**

Innovative Activities	Process Innovation		Product Innovation		Patent/Copyright/Joint-Venture	
	Upgraded machinery and equipment	Upgraded and existing product line	Developed a major new product line	Introduced new technology that changed the way the main product is produced	Filed any patent or copyrights	Entered a new joint venture agreement with a foreign partner
Thailand	86.4	80.3	49.3	46.7	9.1	2.5
Bangkok and vicinity	85.7	80.1	50.6	46.7	9.9	2.3
Central	89.4	83.1	50.3	46.3	7.9	2.8
East	91.1	85.9	51	56.1	10.7	3.4
North	62	56.6	41.8	28.4	3.9	2.3
Northeast	78.5	70.6	37.5	43.4	11.4	..
South	88.3	75.5	37.5	37.9	2.8	2.8
Auto components	93.7	81.3	56.6	61.4	9.6	0.8
Electrical appliances	79.2	91	57	38.2	14.6	..
Electronic components	90.1	79.6	53.3	58.7	10.9	2.7
Food processing	92.3	88.4	58.8	53.3	9.7	2.7
Furniture	78	87.3	58.4	34.7	9.2	4.7
Garments	82.5	75.8	52.1	48.6	11.6	3
Machinery	84.1	87.1	53.7	40.8	7.3	4.7
Rubber and plastics	90	78.1	41.5	48.8	7.6	2.7
Textiles	81.5	70.8	35.3	34	7.1	..
Small	76.8	78.4	38.6	32.6	5.3	1
Medium	90.9	78.1	52.2	46.9	8.7	3.1
Large	92.3	85.6	58.9	64.1	14.3	3.6

Source: Analyzed from PICS-2007

Data on research and development efforts by firms show that about one-fourth of firms hire staff exclusively for R&D or design purposes, especially in the electrical appliances and electronic components industries. Despite this, the share of overall R&D spending in operating revenue is only about 0.3 percent. About 7.4 percent of all firms subcontracted their R&D projects to other companies, especially in the South, where a large number of food processing factories are located. Outsourcing of R&D activities tends to benefit firms because they can gain more that way from global knowledge and more qualified human resources available elsewhere.

Thai manufacturers in capital-intensive industries such as electronic components and electrical appliances as well as machinery and equipment tend to spend more on R&D. More of these firms hire research and design staff. They also outsource more research projects, although

the evidence on R&D spending is less strong. Greater effort appears to have translated into more innovative activities carried out by these firms.

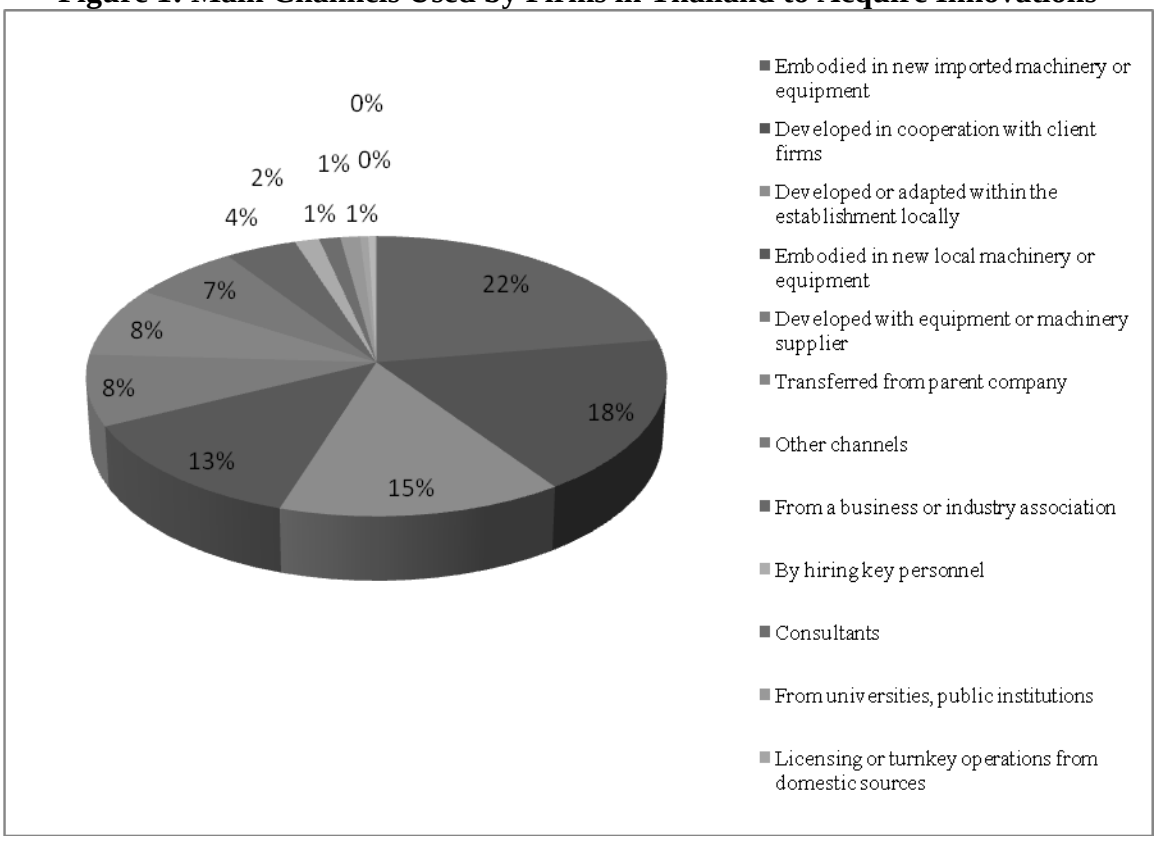
The survey data also reveal the main strategies adopted by manufacturing firms in Thailand to obtain new technology. The data show that 22 percent of firms acquired technology that was included in newly acquired local or imported machinery and equipment. About 40 percent of firms surveyed developed technology in-house or in collaboration with clients or machinery suppliers. Technological innovations originating from universities and public institutions were utilized by only 1 percent of surveyed firms. This clearly reflects weak linkages between manufacturing firms and research centres or universities, institutions that are essential for the generation of new technology. Moreover, another interesting point is that new technology acquisition channels that rely directly on the availability of human resources (such as key personnel and consultants) are uncommon in Thailand.

Table 4: R&D Indicators Classified by Region, Industry, and Firm Size

	Share of firms	Share of R&D	R&D spending	Share of firms
Thailand	22.4	3.8	0.3	7.4
Bangkok and vicinity	23	4.5	0.3	8
Central	22.6	3.1	0.4	6.1
East	21.4	3.7	0.1	5.5
North	19.3	1.7	0.1	4.9
Northeast	18.5	1.7	0.3	7.8
South	22.1	1.7	0.1	17.3
Auto components	22.3	2.5	0.3	12.4
Electrical appliances	38.9	3.4	0.3	5.6
Electronic components	34.7	7.2	0.7	10.8
Food processing	24.4	1	0.1	16.7
Furniture	29.4	3.4	0.5	2.4
Garments	19.6	2.7	0.3	4.4
Machinery	28.9	5.8	0.6	11.5
Rubber and plastics	18.2	4.1	0.2	5.6
Textiles	13	3.3	0.1	3.3
Small	13.1	9.5	0.4	4.4
Medium	22.3	3.3	0.3	7.2
Large	34	1.4	0.2	11.4

Source: Analysed from PICS-2007

Figure 1: Main Channels Used by Firms in Thailand to Acquire Innovations



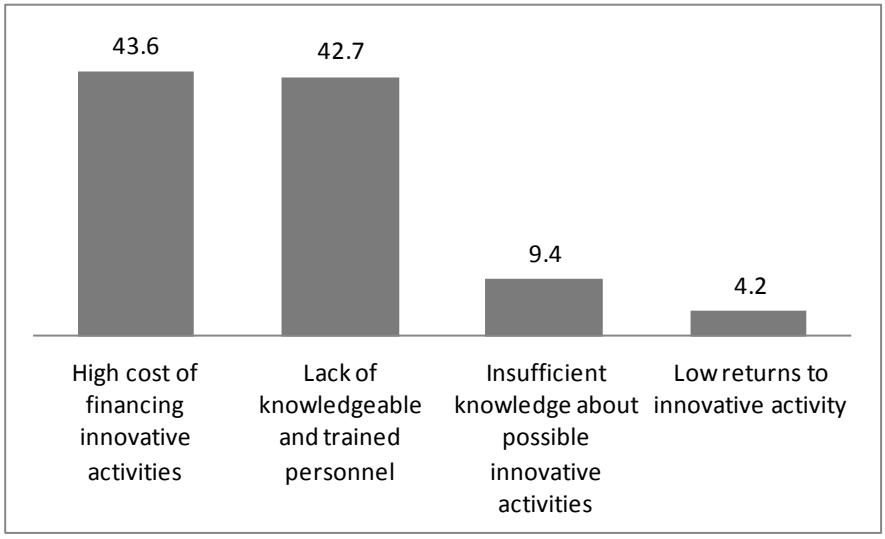
Source: Analysed from PICS-2007.

Shortages of well-trained staff limit firms' efforts to enhance productivity. Nearly all firms believe investment in innovation activities yields high returns. However, they do not increase their engagement in innovation for two reasons: they consider innovations to be financially costly (43.6 percent of all surveyed firms), and they lack knowledgeable and trained personnel (42.7 percent of all surveyed firms). Shortages and mismatches of skilled labor and inadequacies in the technological innovation system limit the ability of Thai firms to maintain their long-term competitiveness.

Results from the enterprise survey in Thailand show that managers perceive shortages of skilled labor as Thailand's major constraint to growth.[3] The survey indicated that Thailand is well placed in terms of infrastructure, regulation, and other objective investment climate measures, but its traditional labor cost advantage is being eroded by fast-growing countries, and skill shortages have become Thailand's biggest obstacle to doing business.

[3]The 2007 Productivity and Investment Climate Survey (PICS) ranked Thailand in 15th place out of 178 economies in terms of ease of doing business.

Figure 2: Percentage of Firms Reporting Their Reason for Not Engaging in Innovative Activity



Source: World Bank (2008), Figure 37

Skilled laborers are always in demand by Thai manufacturers, but unskilled laborers are in even greater demand (48.8 percent). While Thai industries, particularly firms in capital-intensive sectors, have reported shortages of skilled production workers, unskilled workers are in strong demand by all sectors, regardless of the type of production, ranging from a minimum of 38.6 percent in machinery and equipment to as high as 56 percent in garment production. However, this situation has brought a new concern.At the unskilled worker level, shortages create a serious problem, especially for labor-intensive industries, such as food processing and garments, where many vacancies result from too few applicants.Some sectors, such as auto parts, electronics and electrical appliances, and garments, also face serious shortages in both skilled and unskilled labor. The reasons for job vacancies are rather mixed. For example, the available workforce might have poor or nonexistent skills or possess only certain minimal or unrelated skills instead of, the basic or technical skills that firms require, resulting in still mismatches and thus vacancies.

As generally explained by economic theory, job vacancies always create invisible costs for firms, which then have to spend extra time and effort to find and recruit employees. Survey results show that, on average, Thai firms took around 5.2 weeks to find skilled production workers, but only 2.2 weeks to find unskilled production workers as these workers were more abundant (Table 6). The World Bank (2008) also reported that shortages of both skilled and

unskilled production workers among Thai manufacturers were much more prevalent in Thailand than in other countries in the region.

Table 5: Percent of Firms Reporting Vacancies in 2007

Industry	Skilled Labor	Unskilled Labor	Number of Observation
Food Processing	22.2	43.5	108
Textiles	22.6	55.6	133
Garments	32.7	56.0	159
Auto Parts	49.5	47.7	109
Electronics and Electrical Appliances	32.3	47.3	93
Rubber and Plastics	23.3	46.9	258
Furniture and Wood Products	28.0	50.0	100
Machinery and Equipment	33.7	38.6	83
Total	29.3	48.8	1,043

Source: Computed from PICS Data 2007

Table 6: Number of Weeks to Fill Job Vacancies by Region and Industry

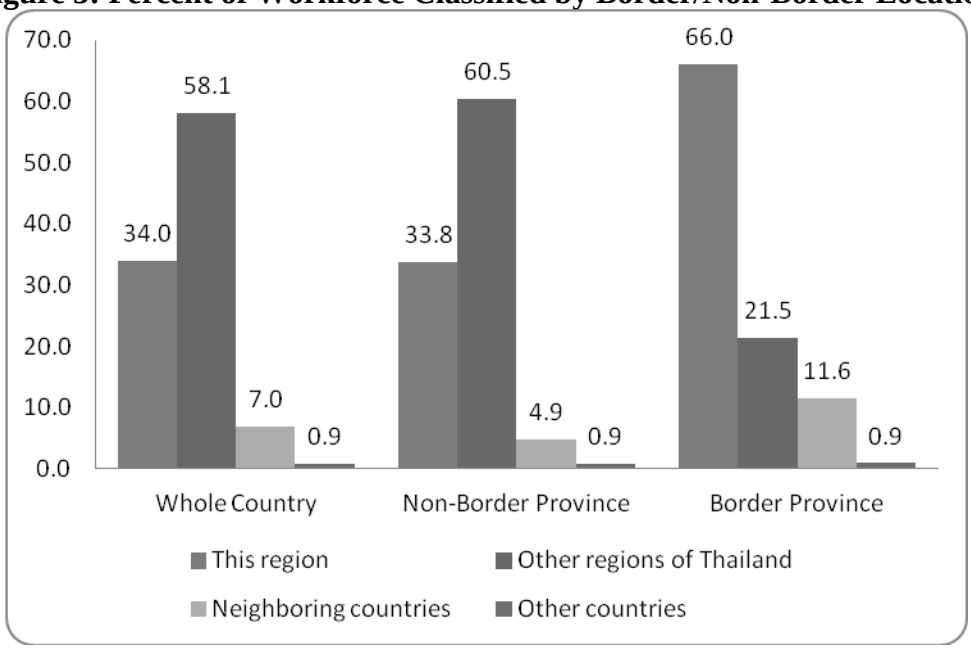
	Skilled Workers	Unskilled Workers
Thailand	5.2	2.2
Regions		
Bangkok and vicinity	5.2	2.0
Central	4.4	2.0
East	7.0	2.7
North	3.6	2.6
Northeast	5.5	1.7
South	5.5	3.2
Industry		
Food Processing	4.1	2.6
Textiles	5.1	2.3
Garments	5.1	2.2
Auto Components	5.9	1.9
Electronic Components	4.1	1.8
Rubber and Plastics	5.5	2.2
Furniture and Wood Products	4.9	2.1
Machinery and Equipment	5.2	2.2
Food Processing	4.1	2.6

Source: Computed from PICS Data 2007

However, in order to control costs in the face of a labor shortage, Thai firms actively search for workers outside the region and outside Thailand. Survey results suggest that 58.2 percent of workers were hired from other regions of Thailand while 39.7 percent of them were from the same region. Hiring workers from other regions clearly reflects a pattern of internal migration, especially for firms located in non-border provinces such as Bangkok and its vicinity, the Central Region, and the Eastern Region (Seaboard Area), where a large number of plants and factories are located.

Even though hiring foreign workers is still relatively less important than hiring Thais, classifying firms by their location gives some interesting results. Firms located in border provinces seem to rely more on immigrant workers to fill job vacancies than do firms in non-border provinces. Firms in border provinces reported that around 11.6 percent of their newly hired workers in 2006 were migrants, which is far higher than what firms in non-border provinces had reported. Even though newly hired workers cannot be distinguished by skill types, the result still shows the importance of migrant workers to Thai manufacturers, especially to those operating in border provinces

Figure 3: Percent of Workforce Classified by Border/Non-Border Location



Source: Computed from PICS Data 2007

Shortages of particular laborers can also exist because of various structural and behavioral factors associated with hiring difficulties. To address this issue, one question in the survey asks what firms believe about labor regulations concerning hiring procedures on a scale from 0 to 4, with "0" representing the belief that hiring procedures were "not the problem" and "4" that hiring procedures were a "major obstacle." As many as 61.1 percent of Thai firms reported no problems with procedures when hiring foreign workers, and slightly less than 68.9 percent reported no problems when hiring Thai workers. However, 15.2 percent of Thai manufacturers believed that procedures for hiring foreign workers were a major problem. On average, Thai firms reported having to spend two days to deal with immigration procedures for each migrant hired. Even more days (4-5 days) were spent by firms located in border provinces compared to those located in other provinces (Pholphirul, 2013).

In terms of firm size, larger firms tend to employ skilled immigrant workers. In 2007, large firms employed 1.84 percent of immigrants, followed by medium-sized firms (0.74 percent) and small firms (0.39 percent). However, employment of unskilled workers is almost unvaried among firms regardless of size (4 percent for small firms, 3.5 percent for medium-sized firms, and 5.32 percent for large firms).

Survey results on employment status show that firms reported a substantial increase in the employment of unskilled immigrants, from 0.31 percent in 2004 to 4.19 percent in 2007.There was clearly a sharp increase in employment of unskilled migrants during the period of 2004-2007 in labor-intensive sectors. Significant increases occurred mainly in the food processing industry (from 0.67 percent to 12.1 percent), the garment industry (from 0.07 percent to 7.65 percent), the textile industry (from 0.15 percent to 3.78 percent), the rubber and plastics industry (from 0.46 percent to 2.72 percent), and in furniture and wood production (from 0.84 percent to 4.73 percent). On the other hand, the share of skilled migrants increased only slightly, from 0.33 percent in 2004 to 0.92 percent in 2007. The most significant increases were seen in the food processing industry (from 0.05 percent to 1.46 percent), the garment industry (from 0.05 percent to 2.12 percent), and electronics and electrical appliance production (from 0.3 percent to 1.15 percent).[4]

[4] We understand that this figure, especially for the year 2004, is likely to be biased downward since firms may not report the true numbers of employed migrants and probably reported only documented ones.

Evidence shows that Thai firms decided to employ more immigrants, especially unskilled immigrants, in labor-intensive sectors during 2004-2007. The largest migrant registration campaign took place in 2004 from an effort to obtain more precise estimates of the number of irregular immigrants in Thailand.[5]The impetus for this came from the MOUs signed between Thailand and neighboring countries (the Lao PDR in October 2002, Cambodia in May 2003, and Myanmar in June 2003) that helped to facilitate the employment of immigrants via the recruitment process to fill vacancies requested by registered employers. Moreover, in 2005, the Thai government allowed registered migrants to stay in Thailand for another year.

While the percent of immigrants employed as reported by the PICS survey did not represent the actual number of immigrants working in Thailand and was biased downward, the number did show an increasing trend for Thai firms to employ more immigrants. Immigrants were concentrated in Bangkok and its vicinity, where the income level is relatively higher than in other regions. Otherwise, unskilled migrants were relatively more concentrated in the northern and the southern regions that are close to Myanmar.

[5] The Ministry of the Interior was assigned to be responsible for registering migrants from Myanmar, the Lao PDR, and Cambodia who had been working in Thailand for at least one year. Since there was no fee involved in the process, it was an incentive for the 1,284,920 migrants who eventually registered. The Ministry of Labor was responsible for registering employers who wished to employ migrants, to register migrants, and to obtain work permits. As a result, 248,746 employers registered (Rukumnuaykit, 2008).

Table 5: Percentage of Migrants Employed in Each Industry

Industry	Skilled Migrants	Unskilled Migrants	#Observations
2004			
Food Processing	0.05	0.67	175
Textiles	0.30	0.15	186
Garments	0.05	0.07	167
Auto Parts	1.14	0.10	144
Electronics and Electrical Appliances	0.30	0.16	235
Rubber and Plastics	0.56	0.46	234
Furniture and Wood Products	0.03	0.84	125
Machinery and Equipment	0.09	0.01	100
2007			
Food Processing	1.46	12.10	108
Textiles	1.13	3.78	133
Garments	2.12	7.65	159
Auto Parts	0.77	0.50	109
Electronics and Electrical Appliances	1.15	1.05	93
Rubber and Plastics	0.18	2.72	258
Furniture and Wood Products	0.28	4.73	100
Machinery and Equipment	0.64	0.26	83

Source: Computed from PICS Data (2004 and 2007)

Table 6: Percentage of Migrants Employed By Firm Size

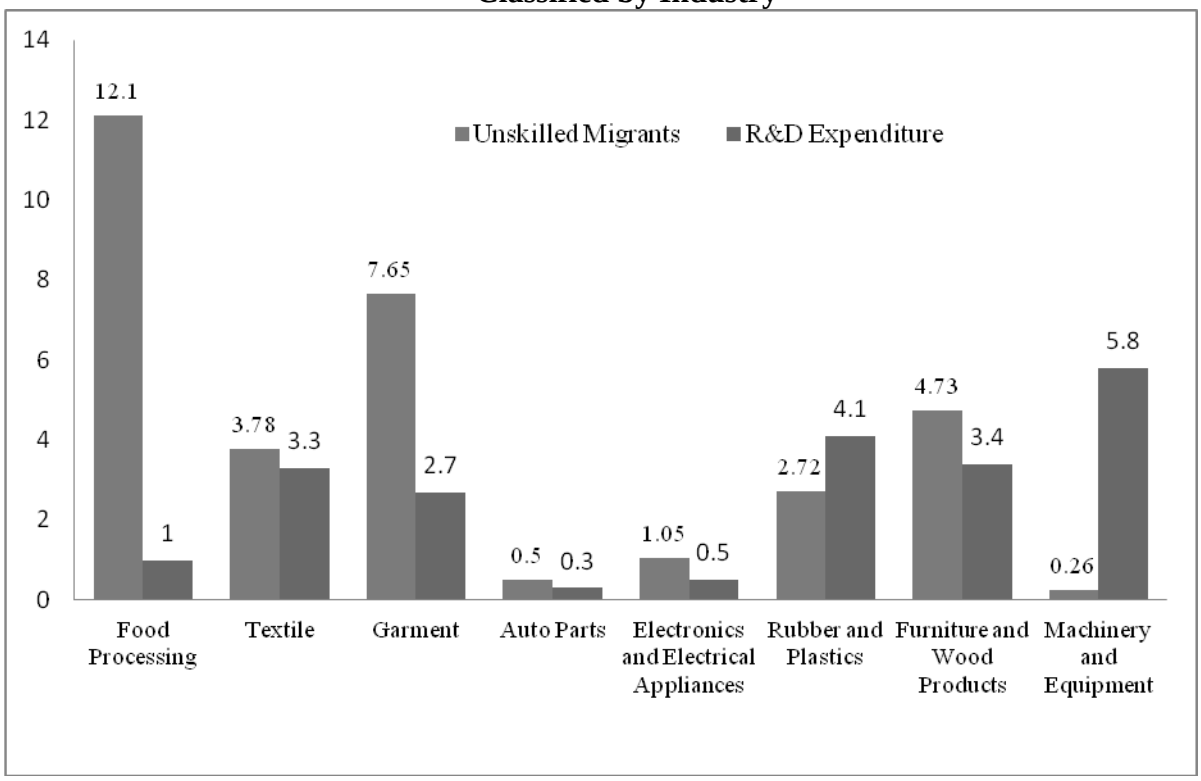
Firm Size classified by a number of employees	Skilled Migrants	Unskilled Migrants	# Observations
2004			
Small Firms*(Less than 50 employees)*	0.04	0.17	367
Medium Firms *(between 50-200 employees)*	0.53	0.38	493
Large Firms*(Greater than 200 employees)*	0.34	0.33	510
2007			
Small Firms*(Less than 50 employees)*	0.39*	4.00*	377
Medium Firms*(between 50-200 employees)*	0.74	3.50*	372
Large Firms *(Greater than 200 employees)*	1.84*	5.32*	294

Source: Computed from PICS Data 2007

There is also a correlation, varying by type of industry, between the share of unskilled immigrants employed relative to total employment and the share of R&D investment relative sales revenue. The reason seems to respond to our concern. Those industries highly reliant on hiring unskilled immigrant workers, such as food processing and garment production, seem to have a lower percentage share of R&D expenditure. On other hand, industries with a high

proportion of R&D expenditure, such as machinery and equipment, seem to have a lower percentage share of unskilled immigrants.

Figure 4: Percentage of Hiring Unskilled Migrants and Percentage of R&D Expenditure Classified by Industry



Source: Computed from PICS-2007

MEASURING IMPACTS OF IMMIGRATION ON INNOVATION

Even though the Thai economy as a whole has relied to a huge extent on both investment and exports, this reliance varies according to firm type. In addition to how firms in different industries hire certain types of migrants, their spending on innovation also varies according to firm-level characteristics such as industry characteristics, location, production technology, firm size, firm age, skills and education level of native workers, and government supports. To better understand the link between immigration and innovation, this section aims to analyze how the magnitude and likelihood of innovation is determined by firm-level factors. Using econometrics estimates, first we create a list of control variables in measuring firm-level characteristics and innovative measurements, for example, industry characteristics, location, firm age, firm size, capacity utilization, factor intensity, R&D Investment, computer control in production, STEM

laborers, education quality of workers, government support, and access to finance. In theory, these variables would have a strong influence on whether a firm invests in innovation.

Another set of control variables is immigration-related, namely: 1) share of skilled immigration workers to total skilled labor and 2) share of unskilled immigrant workers to total unskilled employment. Our key research questions involve both variables in determining whether employing skilled/unskilled workers should promote or dampen innovation in Thailand. We also construct a dummy variable for border provinces to assess firms located in a border province where cross-border immigrant workers from Lao PDR, Cambodia, and Myanmar, should be extensively relevant.

Two estimation models are adopted here. First, we use binary probit regression to quantify the probability of a Thai firm deciding to invest in innovation of various kinds. Innovative activities include both 1) "process innovation" activities such as upgrading machinery and equipment and introducing new ways the main product is produced and 2) "product innovation" activities–upgrading an existing product line and developing a major new product line. Filed patents or copyrights and entering into joint venture agreements with a foreign partner are not direct measures of R&D activities but are considered a potential enhancement of a firm's potential to enhance long-term innovative capacity. These innovative activities are considered to be equal to 1 if a firm reports that activity and equal to 0 otherwise. Definitions of all independent variables, including its mean, are reported in Table 7.

Secondly, to quantify the likelihood of a firm adopting innovations, the binary probit is estimated to determine whether a firm has any R&D expenditures. This dependent variable is constructed to be equal to 1 if a firm has positive expenditure on R&D, and 0 otherwise.

Another set of dependent variables is used to estimate the amount of R&D expenditure as a percentage of sales and administrative expenditure. However, there will likely be cases in which firms report no spending at all on innovation, which would cause the dependent variable (the amount of firm's spending in innovation) to be left-censored to zero. The Tobit model, also called a censored regression model, will be designed to estimate linear relationships between R&D expenditure where there is left-censoring (also known as censoring from below) and immigration among Thai firms. In addition, the PICS firm-level data helps measure the impacts of employing immigrant workers on innovative investment among Thai firms ranging across industries and geographic areas.

According to its marginal effect under binary probit regression in Table 8, a higher percentage of computer control used in production has a positive impact on innovative investment in all activities. A 10 percentage points increase of computer usage seems to increase the probability of process innovation investment (upgrading machinery and equipment and introducing new technology that changes the way the main product is produced) by around 1.1-1.7 percent and increases the probability of product innovation such as developing a major new product line by around 0.5-1.4 percent. Using a higher proportion of computer control should therefore be found to benefit a firm more by focusing more on its process innovation than on its product innovation

There is no doubt that a larger firm seems to involve itself in all types of innovative activities than does a smaller firm, especially with regard to entering a new joint venture agreement with a foreign partner. A medium-size firm seems to have about 6.5-7.4 percent higher probability of participating in process innovation than does a small firm while a large firm seems to have about 11.5-15.4 percent higher probability of participating in process innovation activities than does a small firm. A large firm also shows a higher probability (about 5.8 percent) of participating in the intellectual property rights system than does a small firm.

Even though a low proportion of surveyed firms participated in government schemes to conduct R&D (9 percent in 2007 and 12 percent in 2004), participation in such schemes seems to be an effective mechanism to promote R&D activities. Compared to firms that do not receive any government incentives,[6]a firm that receives any government incentive to conduct technological innovation has a 3.8 percent higher probability of upgrading machinery and equipment, an 8.3 percent higher probability of introducing new technology that changes the way the main product is produced, a 10.7 higher probability of upgrading an existing product line, and a 6.5 percent higher probability of developing a major new product line. Receiving a government incentive also generates a 7.3 percent higher probability of a Thai firm filing any patent or copyright and a 7.8 percent higher probability of entering into a new joint venture agreement with a foreign partner

Similarly, having access to financing by virtue of previous experience in taking out loans is also found to significantly promote technological innovation. Access to financing increases the

[6]Those government incentives include the Industrial Technology Assistance Program (NSTDA), the Open Lab (NSTDA), the Skill, Technology and Innovation Promotion (BOI), and the R&D Investment Promotion (BOI), etc.

probability of upgrading an existing product line by 4.7 percent, developing a major new product line by 3.5 percent, and introducing new technology that changes the way the main product is produced by 6.5 percent. Access to financing also generates 3.8 percent greater probability of filing any patent or copyright and 5.7 percent greater probability of entering a new joint venture agreement with a foreign partner.

Employing unskilled immigrant workers in Thai firms, however, does not have any statistically significant effect on innovative activities, either on process innovation or product innovation. Employing unskilled immigrants, even though it does not have a big impact, does increase the probability of a Thai firm entering into a new joint venture agreement with a foreign partner by around 0.36 percent. A one percentage point increase of the skilled immigrant workers, on the other hand, has a statistically positive impact on increasing the probability of upgrading an existing product line by about 0.8 percent.

As presented in Table 9, estimated coefficients from probit regression (marginal effect) show that employing unskilled immigrants has a negative impact on the probability of R&D spending. Employing 10 percentage points more unskilled immigrant workers (as compared to total number of unskilled laborers) decreases the probability of a firm investing in technology and innovation by around 2.2 percent. This adverse impact of employing unskilled immigrants is found to be statistically stronger for domestic firms, in which employing 10 percent more unskilled immigrant workers is found to decrease the probability of a firm investing in technology and innovation by around 3.3 percent. When the data are disaggregated into SME firms and large firms, the effects of the employment of unskilled migrants disappears. Furthermore, it seems that the adverse impact of unskilled migrant workers concentrates only on domestic firms as the share of unskilled migrant workers has no statistically significant effects on the probability of innovation for exporting firms[7] and foreign-owned firms.[8]

As for skilled workers, the analyses in our study find no effects of the share of skilled migrants on the probability of innovation. This result is robust even when we disaggregate the data into domestic, exporting, foreign-owned, SME, and large firms.

In Table 10 shows results from Tobit regressions to find the effects of migrant workers on R&D spending. The results suggest that there are negative impacts of hiring unskilled

[7] Using the same definition as the World Bank (2008), an "exporting firm" is a firm in which both direct and indirect exports (through distributors) account for at least 10 percent of its sales volume.
[8] Defined as a firm in which at least 10 percent of its shares belong to foreigners.

immigrant workers on spending on innovation. Specifically, a firm with a 10 percentage point increase in hiring immigrant workers exhibits a decrease in R&D spending (as a percentage of sales and administrative costs) by around 0.76 percentage points. The magnitude of this adverse effect is higher for domestic firms than for the overall firms, in which employing 10 percentage points more immigrant workers shows a decrease in R&D spending by around 0.9 percentage points for domestic firms. However, classifying according to firm size (small, medium, and large), foreign-owned firms, and exporting firms show no statistically significant impacts of unskilled immigration on R&D spending.

As for the impacts of skilled migrant workers on R&D spending, the finding is consistent to our results on the probability of innovation activities, where the share of skilled migrant workers has no statistically significant effects on R&D spending. Furthermore, the share of skilled migrant workers has no significant effects on R&D spending when the data are disaggregate into SME, large, foreign owned, exporting, and domestic firms.

Estimates of both the probability and magnitude of R&D expenditure were also conducted at the industry level. Results are shown in Table 11 and Table 12. We find that when the analysis is done by industry, neither the share of skilled or unskilled workers has effects on the probability of innovation. However, we find a hint of the effects employing skilled or educated migrants on technological progress and firms' innovation investment. For the garment industry, a 10 percentage point increase in the hiring of skilled migrants is associated with an increase in the share of R&D spending by around 12 percentage points.

One potential problem when estimating the effects of migrants on the innovation in firms is the endogeneity of the proportion of migrants hired by the firms. One can expect that the proportion of migrants is not an exogenous variable due to selectivity based on past performance or characteristics of the firms. A firm that spends on innovation and becomes relatively more productive tends to offer higher salaries relative to less productive firms as well as, possibly, higher fringe benefits to attract skilled immigrants. At the same time, low-productivity firms may choose to hire less productive, unskilled immigrants to save costs.

To investigate this endogeneity problem in the data, we took only panel firms (about 445 firms) that were surveyed in both 2004 and 2007 and looked for any pattern of relationship between outcome variables in 2004 and the percentage change of migrants employed during 2004-2007. We found no evidence of such selection for either the share of unskilled or the share of skilled

migrants. The amount of R&D investment has no significant effect on employing migrant workers.

Impacts of some control variables on the probability of innovation and R&D spending should be noted. Here, our analyses suggest that a larger and older firm with a higher degree of capital-intensive production seems to spend more on R&D than does a smaller and a younger firm. Financing for R&D investment seems an effective mechanism, not only to promote process innovation, production innovation, and to deepen R&D activities such as filing patents and copyrights, but also to encourage firms to invest their money on innovation. A firm with good access to financing and that has taken out a loan during the previous three years seems to have about a 3.2 percent higher probability of investing in innovation and increasing the proportion in spends on R&D by around 0.97 percentage points compared to a firm without such access. The positive impacts of access to financing are found to be statistically significant for both SME firms and large-size firms.

Measuring firms according to R&D activities shows that a higher percentage of computer control used in production has a positive impact on investment in innovation in both process innovation and product innovation. A 10 percent increase in computer usage seems to increase the probability of process investment (upgrading machinery and equipment and introducing new technology that changes the way the main product is produced) by around 1.1-1.7 percent and increases the probability of developing a major new product line by around 0.5-1.4 percent. Furthermore, larger firms seem to involve themselves in all types of innovative activities more than do smaller firms, especially with regard to seizing opportunities to enter into joint ventures with a foreign partner. Large firms also exhibit a higher probability of participating in the intellectual property rights system than do small firms.

Government incentives and access to financing seem to be effective tools in promoting innovation among Thai firms. Compared to firms that do not receive any government incentives to pursue technological innovation, firms that do receive such incentives have a 3.8 percent higher probability of upgrading machinery and equipment, an 8.3 percent higher probability of introducing new technology that changes the way the main product is produced, a 10.7 percent higher probability of upgrading an existing product line, and a 6.5 percent higher probability of developing a major new product line. Receiving a government incentive also results in a 7.3 percent higher probability of a Thai firm filing a patent or copyright and a 7.8 percent higher

probability of entering into a new joint venture with a foreign partner. The results also suggest that access to financing has positive effects on innovation investment, especially for the Thai SMEs, electronic appliances and machinery and equipment firms.

Similar to the case of receiving a government incentive, the ability to access financing by having taken out loans in the past also promotes technological innovation by increasing the probability of upgrading an existing product line by 4.7 percent, developing a major new product line by 3.5 percent, and introducing new technology that changes the way the main product is produced by 6.5 percent. Access to financing also increases the probability of filing a patent or copyright by 3.8 percent and of entering into a joint venture with a foreign partner by 5.7 percent.

Enhancing the quality of human capital and preparing capable staff is another important and necessary strategy for encouraging R&D spending among Thai manufacturers. In this regard, we find that an electrical appliance manufacturer that employs 10 percentage points more STEM workers will likely increase the R&D share of spending by 0.7 percentage points. On another note, a higher percentage of workers with college degrees should also boost R&D expenditure, especially for SMEs. A 10 percent point increase in workers with higher education degrees in Thai SMEs increases the probability of R&D investment by around 0.93 percent points and increases the share of R&D expenditure by 0.43 percentage points. This result is consistent with the case of hiring skilled immigrant workers: more highly skilled workers, whether native or foreign, promotes R&D investment by Thai manufacturers

Table 7: Definition and Mean of Independent Variables

Independent Variables	Definition	Mean (Year 2007)	Mean (Year 2004)
Share of Skilled Immigrants (Percent)	Percentage of skilled migrants employed by a firm relative to total production skilled workers	0.92	0.33
Share of Unskilled Immigrants (Percent)	Percentage of unskilled migrants employed by a firm relative to total production unskilled workers	4.19	0.31
Border Provinces (Dummy)	Constructed to be equal to 1 if a firm is located in a province sharing borders with Myanmar, the Lao PDR, or Cambodia, and 0 otherwise	0.07	0.41
Computer Control (Percent)	Percentage of production machine controlled by computer	10.84	19.51
Firm Age (Years)	Number of years since a firm commenced operations in Thailand	15.29	15.44
Medium-Size Firm (Dummy)	Constructed to be equal to 1 if a firm is a medium-size firm (employing between 50-200 employees)	0.36	0.36
Large Firm (Dummy)	Constructed to be equal to 1 if a firm is large firm (employing more than 200 employees)	0.28	0.38
Capacity Utilization (Percent)	Percentage of amount of output a firm actually produced relative to the maximum	77.73	77.02
Capital-Labor Ratio (Log-scale)	Amount of machinery and equipment rented or owned by a firm divided by total number of employees (log scale).	9.82	9.40
Government Incentive (Dummy)	Constructed to be equal to 1 if a firm received any government incentives to conduct technological; innovation and R&D, and 0 otherwise	0.09	0.12
STEM Personnel (Percent)	Percentage of personnel working in Science, Technology, Engineering, and IT to total employment	23.18	5.31
Secondary Education (Percent)	Percentage of labor educated at the secondary level	67.61	66.01
Higher Education (Percent)	Percentage of labor educated at university level	20.38	22.62
Access to Financing	Constructed to be equal to 1 if a firm has taken any loan during the previous 3 years, and 0 otherwise	0.77	0.50

Source: Computed from PICS 2004 and 2004

Table 8: Probit Regression (Marginal Effect) of Innovation Activities Undertaken by Firm

Variables	Process Innovation		Product Innovation		Patent/Copyright/Joint-Venture	
	Upgraded machinery and equipment	Introduced new technology that changed the way the main product is produced	Upgraded an existing product line	Developed a major new product line	Filed any patent or copyrights	Entered a new joint venture agreement with a foreign partner
Share of Skilled Immigrants	-0.00106	-0.000749	0.00827*	-0.00125	-0.00243	-0.0038
	[0.00165]	*[0.00294]*	*[0.00452]*	*[0.00210]*	*[0.00169]*	*[0.00306]*
Share of Unskilled Immigrants	0.00146	0.0015	0.000746	-0.001	0.000348	0.00359***
	[0.000940]	*[0.00120]*	*[0.00118]*	*[0.00101]*	*[0.000836]*	*[0.00121]*
Border Provinces (Dummy)	-0.00748	0.0518	-0.0134	0.00809	-0.0528*	-0.0337
	[0.0269]	*[0.0389]*	*[0.0382]*	*[0.0240]*	*[0.0312]*	*[0.0407]*
Computer Control (Percent)	0.00114***	0.00169***	0.00144***	0.000497**	0.000721**	0.00367***
	[0.000345]	*[0.000480]*	*[0.000469]*	*[0.000249]*	*[0.000351]*	*[0.000515]*
Firm Age (Years)	0.000443	-0.00292**	-0.00226*	9.11E-05	0.00112	0.000968
	[0.000899]	*[0.00131]*	*[0.00126]*	*[0.000751]*	*[0.000957]*	*[0.00134]*
Medium-Size Firm (Dummy)	0.0651***	0.0742***	0.0820***	0.0273	0.00526	0.0730**
	[0.0165]	*[0.0287]*	*[0.0271]*	*[0.0193]*	*[0.0195]*	*[0.0290]*
Large Firm (Dummy)	0.115***	0.154***	0.122***	0.0611***	0.0581***	0.200***
	[0.0186]	*[0.0326]*	*[0.0312]*	*[0.0229]*	*[0.0222]*	*[0.0324]*
Capacity Utilization (Percent)	0.000317	0.00226***	0.00152**	-3.16E-06	-0.000171	0.00183***
	[0.000407]	*[0.000648]*	*[0.000621]*	*[0.000378]*	*[0.000450]*	*[0.000661]*
Capital-Labor Ratio (Log-scale)	0.00960**	-0.0013	-0.011	-0.00225	-0.00555	0.0114
	[0.00465]	*[0.00733]*	*[0.00713]*	*[0.00421]*	*[0.00515]*	*[0.00750]*
Government Incentive (Dummy)	0.0385*	0.0826**	0.107***	0.0650**	0.0735***	0.0781**
	[0.0215]	*[0.0357]*	*[0.0328]*	*[0.0253]*	*[0.0226]*	*[0.0365]*
STEM Personnel (Percent)	9.27E-05	0.000347	-2.62E-06	1.78e-05*	0.000291	2.28E-06
	[0.000388]	*[0.000652]*	*[2.19e-05]*	*[1.04e-05]*	*[0.00102]*	*[2.27e-05]*
Secondary Education (Percent)	0.000633*	0.000947	-3.31E-05	-0.000205	-1.86E-05	0.00131**
	[0.000363]	*[0.000597]*	*[0.000572]*	*[0.000366]*	*[0.000411]*	*[0.000613]*
Higher Education (Percent)	0.000649	0.00198***	0.00197***	0.000684	0.000183	0.00272***
	[0.000472]	*[0.000759]*	*[0.000732]*	*[0.000428]*	*[0.000531]*	*[0.000776]*
Access to Financing	0.0217	0.0652***	0.0475**	0.0349**	0.0385**	0.0575**
	[0.0163]	*[0.0251]*	*[0.0242]*	*[0.0136]*	*[0.0184]*	*[0.0257]*
Observations	2,075	2,075	2,075	2,075	2,075	2,074
Pseudo R-Square	0.106	0.063	0.047	0.067	0.045	0.109

Standard errors are in brackets. Significant at 10%; ** significant at 5%; *** significant at 1%.
Estimated coefficients of Regional Dummy, Industry Dummy, and Time Dummy are not shown in this table.

Table 9: Probit Estimation (Marginal Effect) of Probability of Innovative Investment by Firm Size, Exporting Firm, Domestic Firm, and Foreign-Owned Firm

Variables	Total	SME Firms	Large Firms	Exporting Firms	Foreign-Owned Firms	Domestic Firms
Share of Skilled Immigrants (Percent)	-0.000619	0.000640	-0.00394	-0.000845	-0.00317	0.00477
	[0.00215]	*[0.00164]*	*[0.00544]*	*[0.00466]*	*[0.00368]*	*[0.00591]*
Share of Unskilled Immigrants (Percent)	-0.00221*	-0.00127	-0.00416	-0.000603	7.45E-05	-0.00326*
	[0.00114]	*[0.00104]*	*[0.00274]*	*[0.00213]*	*[0.00243]*	*[0.00193]*
Border Provinces (Dummy)	-0.00219	0.00578	-0.00260	-0.0568	0.0106	0.00157
	[0.0253]	*[0.0295]*	*[0.0538]*	*[0.0507]*	*[0.0589]*	*[0.0372]*
Computer Control (Percent)	-0.000487*	-0.000545	-0.000353	-0.00122**	-0.00107*	-0.000296
	[0.000291]	*[0.000344]*	*[0.000572]*	*[0.000580]*	*[0.000628]*	*[0.000389]*
Firm Age (Years)	0.00128	0.00168*	0.000706	-0.000183	0.00257	0.000309
	[0.000809]	*[0.000910]*	*[0.00165]*	*[0.00170]*	*[0.00210]*	*[0.00104]*
Medium-Size Firm (Dummy)	0.0539**	-	-	0.0918	0.0924	0.0552**
	[0.0228]	-	-	*[0.0648]*	*[0.0811]*	*[0.0275]*
Large Firm (Dummy)	0.124***	-	-	0.173***	0.175***	0.119***
	[0.0269]	-	-	*[0.0562]*	*[0.0614]*	*[0.0368]*
Capacity Utilization (Percent)	0.000721*	0.000779*	0.000512	0.000998	0.00155	0.000701
	[0.000430]	*[0.000411]*	*[0.00104]*	*[0.000922]*	*[0.00112]*	*[0.000547]*
Capital-Labor Ratio (Log-scale)	0.00750	0.00200	0.0196*	0.00535	-0.00611	0.0109*
	[0.00469]	*[0.00492]*	*[0.0101]*	*[0.00923]*	*[0.0106]*	*[0.00636]*
Government Incentive (Dummy)	0.0301	0.0399	0.0248	0.0812*	-0.0169	0.0535
	[0.0241]	*[0.0301]*	*[0.0454]*	*[0.0464]*	*[0.0485]*	*[0.0327]*
STEM Personnel (Percent)	-2.16e-05	-1.97e-05	0.000926	0.00121	0.00167	-6.55E-05
	[8.67e-05]	*[7.66e-05]*	*[0.00175]*	*[0.00176]*	*[0.00212]*	*[0.000218]*
Secondary Education (Percent)	0.000183	0.000285	0.000285	0.000182	0.00182	-0.000242
	[0.000402]	*[0.000388]*	*[0.000965]*	*[0.000804]*	*[0.00133]*	*[0.000479]*
Higher Education (Percent)	0.000961**	0.000933**	0.00139	0.00195*	0.0015	0.000777
	[0.000484]	*[0.000461]*	*[0.00117]*	*[0.00101]*	*[0.00144]*	*[0.000597]*
Access to Financing	0.0327**	0.0301**	0.0555*	0.0508*	0.0682**	0.0242
	[0.0149]	*[0.0148]*	*[0.0332]*	*[0.0301]*	*[0.0344]*	*[0.0199]*
Observations	2,075	1,343	732	835	547	1,194
Pseudo R-Square	0.0970	0.0798	0.0651	0.0843	0.115	0.0902

Standard errors are in brackets. Significant at 10%; ** significant at 5%; *** significant at 1%.
Estimated coefficients of Regional Dummy, Industry Dummy, and Time Dummy are not shown in this table.

Table 10: Tobit Estimation of Percentage of Innovative Investment to Total Sale and Administration Expenditure by Firm Size, Exporting Firm, Domestic Firm, and Foreign-Owned Firm

Variables	Total	SME Firms	Large Firms	Exporting Firms	Foreign-Owned Firms	Domestic Firms
Share of Skilled Immigrants (Percent)	-0.0378	0.0173	-0.111	-0.29	-0.102	0.103
	[0.0745]	*[0.0790]*	*[0.115]*	*[0.251]*	*[0.112]*	*[0.162]*
Share of Unskilled Immigrants (Percent)	-0.0762**	-0.0627	-0.0892	0.0549	-0.0125	-0.0897*
	[0.0375]	*[0.0473]*	*[0.0597]*	*[0.0563]*	*[0.0652]*	*[0.0497]*
Border Provinces (Dummy)	0.221	0.383	0.415	-1.761	1.287	0.021
	[0.789]	*[1.253]*	*[1.076]*	*[1.626]*	*[1.559]*	*[0.891]*
Computer Control (Percent)	-0.0107	-0.0164	-0.00454	-0.0137	-0.0245	-0.00464
	[0.00911]	*[0.0151]*	*[0.0117]*	*[0.00953]*	*[0.0171]*	*[0.00954]*
Firm Age (Years)	0.0489*	0.0847**	0.0240	-0.0104	0.0528	0.0288
	[0.0254]	*[0.0403]*	*[0.0336]*	*[0.0292]*	*[0.0563]*	*[0.0255]*
Medium-Size Firm (Dummy)	1.456**	-	-	1.519	2.318	1.211*
	[0.666]	-	-	*[1.051]*	*[2.019]*	*[0.637]*
Large Firm (Dummy)	3.114***	-	-	2.582**	5.480***	2.039***
	[0.722]	-	-	*[1.071]*	*[1.986]*	*[0.733]*
Capacity Utilization (Percent)	0.0190	0.0257	0.0114	0.00231	0.05	0.0083
	[0.0135]	*[0.0181]*	*[0.0212]*	*[0.0160]*	*[0.0307]*	*[0.0134]*
Capital-Labor Ratio (Log-scale)	0.259*	0.110	0.407**	0.071	-0.0376	0.268*
	[0.147]	*[0.219]*	*[0.204]*	*[0.164]*	*[0.288]*	*[0.157]*
Government Incentive (Dummy)	0.756	1.251	0.449	1.337*	-0.0851	0.967
	[0.660]	*[1.021]*	*[0.879]*	*[0.682]*	*[1.375]*	*[0.654]*
STEM Personnel (Percent)	-0.000665	-0.000837	0.0205	0.00477	0.045	-0.00159
	[0.00229]	*[0.00285]*	*[0.0403]*	*[0.0215]*	*[0.0598]*	*[0.00492]*
Secondary Education (Percent)	0.00809	0.0156	0.00643	-0.0182	0.04	-0.000766
	[0.0127]	*[0.0174]*	*[0.0196]*	*[0.0136]*	*[0.0359]*	*[0.0118]*
Higher Education (Percent)	0.0298*	0.0431**	0.0217	0.00408	0.0244	0.0212
	[0.0153]	*[0.0208]*	*[0.0237]*	*[0.0173]*	*[0.0392]*	*[0.0147]*
Access to Financing	0.975*	1.383*	1.007	0.683	1.750*	0.44
	[0.498]	*[0.710]*	*[0.721]*	*[0.519]*	*[0.997]*	*[0.509]*
Constant	-13.88***	-18.09***	-8.766***	-5.264*	-14.95***	-11.08***
	[2.354]	[3.846]	[3.371]	[2.734]	[5.371]	[2.458]
Observations	2,075	1,343	732	638	547	1,194
Pseudo R-Square	0.0437	0.0400	0.0241	0.0359	0.0478	0.0422

Standard errors are in brackets. Significant at 10%; ** significant at 5%; *** significant at 1%.
Estimated coefficients of Regional Dummy, Industry Dummy, and Time Dummy are not shown in this table.

Table 11: Probit Estimation (Marginal Effect) of Probability of Innovative Investment by Industry

Variables	Food Processing	Textile	Garment	Auto Parts	Electrical Appliances	Rubber& Plastic	Furniture	Machinery& Equipment
Share of Skilled Immigrants (Percent)	-0.00314	0.00164	4.41E-10	-0.00148	-0.00019	-0.0067	-0.00142	-0.000737
	[0.0139]	*[0.00187]*	*[2.42e-08]*	*[0.00569]*	*[0.0121]*	*[0.00604]*	*[0.0216]*	*[0.00848]*
Share of Unskilled Immigrants	0.00128	-	-	-0.0221	-	-0.00537	-	-
	[0.00174]	*[0.00577]*	-	*[0.0392]*	-	*[0.00373]*	-	-
Border Provinces (Dummy)	0.0184	0.000218	-3.09E-10	-0.0457	-0.0485	0.174	0.00013	-0.00415
	[0.0865]	*[0.0351]*	*[1.72e-08]*	*[0.0574]*	*[0.100]*	*[0.113]*	*[0.00239]*	*[0.0664]*
Computer Control (Percent)	-0.00116	-0.000515	0.001	-0.000105	-0.00079	-8.54E-05	-1.39E-06	-0.00105
	[0.00121]	*[0.000480]*	*[3.29e-10]*	*[0.000698]*	*[0.000933]*	*[0.000225]*	*[2.68e-05]*	*[0.000861]*
Firm Age (Years)	-0.00333	0.000297	0.001	0.00185	0.00117	0.000918	1.19E-05	0.00308
	[0.00255]	*[0.000918]*	*[2.08e-09]*	*[0.00223]*	*[0.00411]*	*[0.000695]*	*[0.000221]*	*[0.00233]*
Medium-Size Firm (Dummy)	0.410**	0.1	8.11E-09	0.106	-0.012	0.00633	8.76E-05	-0.0396
	[0.176]	*[0.0822]*	*[4.16e-07]*	*[0.0817]*	*[0.0811]*	*[0.0151]*	*[0.00159]*	*[0.0458]*
Large Firm (Dummy)	0.352***	0.124	6.03E-09	0.15	0.147	-0.00397	0.00464	-0.0536
	[0.0982]	*[0.0917]*	*[3.11e-07]*	*[0.101]*	*[0.0895]*	*[0.0178]*	*[0.0671]*	*[0.0408]*
Capacity Utilization (Percent)	0.00101	0.00116	0.001	0.000552	0.0014	-0.000182	5.14E-06	0.000588
	[0.00143]	*[0.000992]*	*[5.20e-10]*	*[0.00113]*	*[0.00159]*	*[0.000347]*	*[9.52e-05]*	*[0.00100]*
Capital-Labor Ratio (Log-scale)	0.00316	0.00949	0.001	0.00911	-0.00875	0.00493	0.00011	0.00138
	[0.0152]	*[0.00885]*	*[5.86e-10]*	*[0.0130]*	*[0.0164]*	*[0.00464]*	*[0.00203]*	*[0.0139]*
Government Incentive (Dummy)	0.206**	-0.000614	1.46E-09	-0.032	-0.0768	-0.00585	0.000735	-0.00189
	[0.0853]	*[0.0261]*	*[7.73e-08]*	*[0.0473]*	*[0.0783]*	*[0.0171]*	*[0.0122]*	*[0.0635]*
STEM Personnel (Percent)	-0.0156	0.000455	-9.93E-11	0.000225	0.00439	0.00178	1.76E-05	-0.00177
	[0.0111]	*[0.000538]*	*[5.29e-09]*	*[0.000509]*	*[0.00304]*	*[0.00367]*	*[0.000397]*	*[0.00421]*
Secondary Education (Percent)	-0.000866	-0.000392	0.001	0.000736	0.0029	0.00148*	4.70E-06	0.00154
	[0.00114]	*[0.000555]*	*[6.75e-10]*	*[0.00166]*	*[0.00284]*	*[0.000841]*	*[8.73e-05]*	*[0.00152]*
Higher Education (Percent)	0.00162	0.00151	0.001	0.00143	0.00276	0.00113	-1.38E-05	0.00205
	[0.00186]	*[0.00132]*	*[0.001]*	*[0.00159]*	*[0.00291]*	*[0.000844]*	*[0.000256]*	*[0.00158]*
Access to Financing	0.0469	-0.0173	1.85E-10	-0.00308	0.102*	0.0184	-7.12E-05	0.102**
	[0.0537]	*[0.0282]*	*[1.02e-08]*	*[0.0405]*	*[0.0529]*	*[0.0128]*	*[0.00132]*	*[0.0483]*
Observations	242	257	228	232	285	415	170	157
Pseudo R-Square	0.183	0.271	0.186	0.103	0.0591	0.205	0.0564	0.125

Standard errors are in brackets. Significant at 10%; ** significant at 5%; *** significant at 1%.
Estimated coefficients of Regional Dummy, Industry Dummy, and Time Dummy are not shown in this table.

Table 12: Tobit Estimation of Percentage of Innovative Investment to Total Sale and Administration Expenditure by Industry

Variables	Food Processing	Textile	Garment	Auto Parts	Electrical Appliances	Rubber& Plastic	Furniture	Machinery& Equipment
Share of Skilled Immigrants (Percent)	-0.12	0.0852	1.194***	-0.354	-0.0832	-0.196	-14.44	-0.0843
	[0.331]	*[0.001]*	*[0.458]*	*[0.777]*	*[0.169]*	*[0]*	*[87.61]*	*[0.001]*
Share of Unskilled Immigrants (Percent)	0.0174	-1.359	-49.85	-2.55	-70.27	-0.502	-91.42	-252.4
	[0.0340]	*[0.001]*	*[0.001]*	*[3.271]*	*[0.001]*	*[0.001]*	*[0.001]*	*[0.001]*
Border Provinces (Dummy)	0.882	-1.443	-2.891*	1.503	-0.585	6.12	2.033	-2.445
	[1.568]	*[0.001]*	*[1.558]*	*[4.816]*	*[1.359]*	*[0.001]*	*[2.216]*	*[0.001]*
Computer Control (Percent)	-0.019	-0.0296	-0.00979	-0.0107	-0.00486	-0.00486	-0.0173	-0.0702
	[0.0224]	*[0.001]*	*[0.0166]*	*[0.0491]*	*[0.0125]*	*[0.001]*	*[0.0442]*	*[0.001]*
Firm Age (Years)	-0.056	0.0498	0.0837*	0.0952	0.013	0.105	0.116	0.258
	[0.0474]	*[0.001]*	*[0.0436]*	*[0.170]*	*[0.0551]*	*[0.001]*	*[0.0750]*	*[0.001]*
Medium-Size Firm (Dummy)	5.833**	4.442	2.573**	6.18	0.131	0.258	1.422	-5.691
	[2.739]	*[0.001]*	*[1.029]*	*[5.287]*	*[1.089]*	*[0.001]*	*[1.970]*	*[0.001]*
Large Firm (Dummy)	7.138***	6.047	2.261**	9.053	1.759	0.0951	5.726***	-11.78
	[2.723]	*[0.001]*	*[1.148]*	*[5.814]*	*[1.205]*	*[0.001]*	*[2.157]*	*[0.001]*
Capacity Utilization (Percent)	0.0243	0.0669	0.00998	0.0337	0.00116	-0.0353	0.0504	0.0327
	[0.0269]	*[0.001]*	*[0.0227]*	*[0.0794]*	*[0.0208]*	*[0.001]*	*[0.0397]*	*[0.001]*
Capital-Labor Ratio (Log-scale)	-0.0725	0.638	-0.109	1.186	-0.0524	0.291	0.542	0.231
	[0.280]	*[0.001]*	*[0.244]*	*[0.964]*	*[0.218]*	*[0.001]*	*[0.492]*	*[0.001]*
Government Incentive (Dummy)	2.816**	-0.235	1.416*	-2.863	-1.148	-0.961	1.967	-1.085
	[1.108]	*[0.001]*	*[0.785]*	*[4.684]*	*[1.272]*	*[0.001][0.001]*	*[2.106]*	*[0.001]*
STEM Personnel (Percent)	-0.227	0.0309	-0.411	0.00974	0.0700*	0.312	-0.152	-0.226
	[0.209]	*[0.001]*	*[0.433]*	*[0.0364]*	*[0.0398]*	*[0.001]*	*[1.377]*	*[0.001]*
Secondary Education (Percent)	-0.0092	-0.0303	-0.0273**	0.0101	0.0464	0.129	0.0569	0.192
	[0.0207]	*[0.001]*	*[0.0123]*	*[0.115]*	*[0.0394]*	*[0.001]*	*[0.0388]*	*[0.001]*
Higher Education (Percent)	0.0135	0.0997	0.00214	0.0506	0.0442	0.11	-0.0857	0.203
	[0.0354]	*[0.001]*	*[0.0217]*	*[0.112]*	*[0.0402]*	*[0.001]*	*[0.0715]*	*[0.001]*
Access to Financing	0.719	-0.871	0.479	0.166	1.460*	1.464	-0.481	9.417
	[1.041]	*[0.001]*	*[0.719]*	*[2.865]*	*[0.749]*	*[0.001]*	*[1.302]*	*[0.001]*
Constant	-9.133*	-52.31	-3.919	-33.96*	-8.632*	-50.51	-23.09***	-94.78
	[4.638]	*[0.001]*	*[3.471]*	*[17.46]*	*[4.648]*	*[0.001]*	*[8.211]*	*[0.001]*
Observations	242	257	272	232	292	430	187	163
Pseudo R-Square	0.0944	0.129	0.161	0.0475	0.0351	0.128	0.191	0.215

Standard errors are in brackets. Significant at 10%; ** significant at 5%; *** significant at 1%.
Estimated coefficients of Regional Dummy, Industry Dummy, and Time Dummy are not shown in this table.

CONCLUSION AND POLICY RECOMMENDATIONS

This paper examines the economic impacts of foreign migrant workers on innovative capacities in a developing country in which majority of its immigrant workers are unskilled. Derived from firm-level survey data in Thailand as a case study, findings show that employing unskilled, but cheap, laborers from neighboring countries is like adopting a kind of "labor-saving technology," which actually impedes firms' R&D investment. Even though employing unskilled immigrant workers helps firms maintain their cost competitiveness, the negative impacts on firms' capacities to invest in innovation slows down productivity improvement and diminishes global competitiveness in the long run.

The impact of migrant workers on firm's innovation presented in this paper seems different from those found in other empirical studies reviewed earlier, most of which focus on developed countries such as the USA, EU countries, Canada, New Zealand, and Singapore. The paper suggests adverse effects of migration in migrant-receiving countries that are developing countries on firms' incentives to invest in innovation. According to the concept of "skill-biased technological changes," firms employing cheap labor from other countries will face relatively lower productivity, which results in less inclination to innovate and invest in new high skilled technology. A reduction of investment in innovation therefore jeopardizes those Thai manufacturers as it might in turn impede improvement in productivity and thus reduce their global competitiveness in the long run.

It is likely that developing countries such as Thailand will continue to rely heavily on unskilled immigrant workers, taking the benefits of saving on wage costs and maintaining cost competitiveness. Our results suggest that these short-term benefits are offset by a likelihood of foregoing R&D investment and missing the opportunity to adopt labor-saving technology that would enhance long-term competitiveness. These findings represent a challenge for a developing country such as Thailand as it tries to strike a balance between cost competitiveness based on cheap and unskilled migrant labor and enhanced long-term economic prospects based on strategic investment in innovation.

On the other hand, employing skilled or educated migrants promotes technological progress and encourages firms to innovate more quickly. In the garment industry, for example, a 10 percent increase in the hiring of skilled migrants is associated with an increased share of R&D spending of around 12 percent. This result is consistent with empirical studies found among the

OECD countries. Skilled migrants can bring broader economic benefits including a higher rate of innovation. This result implies a complementary effect from firms hiring more skilled workers (either natives or immigrants) and deciding to invest in high technology. Thus, skilled workers are complementary to technological progress by encouraging firms to innovate more quickly, which helps enhance productivity and competitiveness in the long run. These results of the effects of skilled migrants on innovation are consistent to those found in developed countries, where migrants are of relatively high skilled. In this regard, long-term policies for migrant receiving countries that are developing countries should focus also on encouraging higher shares of skilled migrant workers for skill-based technological improvement. Providing training and skill upgrade, not only for domestic workers, but also for unskilled immigrant workers should be an unavoidable policy.

Since there are a number of benefits from employing skilled immigrants, such as improving productivity, promoting R&D investment, attracting foreign investment, and increasing knowledge transfer, the importation of skilled (rather than unskilled) migrants should therefore be prioritized. Thailand should offer more flexible entry regimes and more promising long-term opportunities to attract skilled immigrants. Both tax and non-tax incentives, including the launching of a temporary program to employ foreign workers, can be attractive measures. Under this strategy, the government should make future projections for both labor demand and supply and for both the short and long terms by skill categories and geographical areas, as well as prepare a list of skill shortages. It could do so along the lines of the Canadian "Temporary Foreign Working Program" and the Australian "Migration Occupations in Demand List (MODL) Program." In East Asia and the Pacific, Singapore and Hong Kong (China) also have explicit policies to welcome foreign high-skilled professionals by facilitating permanent residence after defined working periods (two years for Singapore and seven years for Hong Kong).

Furthermore, migration policy should emphasize long-term objectives rather than short-term responses. Since Thailand is currently being challenged by countries with cheaper labor and more comparative advantage, such as China, Vietnam, the Lao PDR, and Myanmar, the overall long-term development policy toward a knowledge-based economy should be strongly considered. Promoting R&D investment within Thai firms, securing intellectual property rights, and increasing value in the production of goods and services should be an immediate response. These goals can be accomplished by promoting capital- and innovative-intensive production

technologies, adopting technology into labor-intensive production, providing financial access (especially to SMEs), offering government incentives, and enhancing labor skills from both formal and non-formal education. Without question, value-added goods and services will confer more competitive advantage and sustained global competitiveness than will continued reliance on cheap labor provided by immigrant workers.

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