Australian Academy of Business and Economics Review (AABER)
ISSN (Online) 2205-6726
ISSN (Print) 2205-6734

# Foreign Workers in Thai Manufacturing: Implications for Domestic Wages

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**Abstract**

This study aims to promote a better understanding of the impact of foreign workers on domestic manufacturing wages with reference to Thailand, a country where foreign labor has played a major role in the manufacturing sector since the early 2000's. In our core analysis, two approaches, simulation experiment and econometric analysis, are employed in a complementary manner. The key findings are consistent, and ensure that foreign workers are imported to fill jobs shunned by locals. The simulation experiment suggests that the entry of foreign workers causes depressing pressure on wages only affecting low-skilled Thai workers. Interestingly, the effect turns out to be positive in respect to other types of workers and higher-skilled labor in particular. In our econometric analysis, we find the significant negative impact of foreign worker dependency on real manufacturing wages, both in total and operational remuneration. However, the negative impacts become negligent overtime. Until 2011, we found the positive impact of foreign workers on both total and operational wages. The policy implication for the management of foreign workers to promote sustainable development is that facilitating the inflow of foreign workers at present could potentially promote the growth of domestic manufacturing wages instead of preventing such growth.

**Keywords:** International Migration; Foreign Workers; Wages; Asia; Thailand

## 1. Statement of the Problem

Within Asia and the Pacific region, Thailand, ranked fifth in receiving more than 3.72 million migrant workers, largely dominated by unskilled workers from neighboring countries (United Nations, 2013). The corresponding figure reported by the Foreign Workers Administration (OFWA), Department of Employment, Ministry of Labor, revealed the existence of 1.45 million legal migrant workers in 2015, principally comprising unskilled workers from CLM countries (i.e., 90% of the total). Such a large volume of immigrant workers is largely to be expected as Thailand is located at the center of the Indochinese Peninsula sharing long common borders with much lower per capita income neighboring countries. The common border allows workers to cross lines relatively easily to capitalize on vast income differences. In the foreseeable future, such income gaps will continue although a catching up process has kicked in over the past decade. In particular, the economic modernization of Laos and Cambodia started in the late 1990s and the early 2000s. Until 2011, Myanmar showed a clear sign of political transition from a military dictatorship to a more democratic society. Even though these three economies experienced high growth during the past decade, this was largely due to such a low base point. In 2016, income per capita[1] stood at 2353, 1270, and 1275 USD for Laos, Cambodia, and Myanmar, respectively. This is far below that of Thailand (5,908 USD) leading to a considerable push influencing these workers to seek better wages in Thailand.

1 Source: World Development Indicators (WDI) database.

Another important feature of the Thai economy lies in the fact that it is an aging society. The sector of the population aged over 65 has gained in relative importance to the total population, increasing from 5% in 1995 to 11% in 2016[2]. It is expected to reach 15% in 2020. This implies that a labor shortage in Thailand would present long-term structural challenges. In theory, when a country experiences severe labor shortage, two additional options are available for firms to cope with the problem in addition to importing workers from aboard. They include exporting capital through direct investment abroad and capital deepening (substituting labor with capital) (Athukorala and Manning, 1998; Athukorala and Devadason, 2012). Drawing from a survey of clothing factories in Thailand, Kohpaiboon and Jongwanich (2016) found that these three options are not mutually exclusive. Firms use them simultaneously to cope with any labor shortage. All in all, importing foreign workers will remain an ongoing challenge in Thailand as increasing wages continue regardless of preferences toward foreign workers from neighboring countries.

Importing foreign workers potentially results in various economic impacts on labor importing countries like Thailand. As argued in Thangavelu (2012) there are three possible effects, i.e., wage impacts, technology adoption, and productivity. Among them, the impact on wage is particularly important due to two reasons. First, the other two effects are triggered by changes in domestic wages. How much domestic wages respond to the entry of these foreign workers constitutes the critical starting point in assessing the impact. Second, wage represents the explicit less controversial measurable variable. In theory, importing foreign workers potentially puts pressure on wages in labor-importing countries (henceforth referred to as domestic wages for brevity). The negative effect on domestic wages is magnified with blue-collar workers when foreign labor is dominated by unskilled employees (Aydemir and Borjas, 2006; Borjas et al., 2010; Athukorala and Devadason, 2012; Bratsberg et al., 2014). Clearly, this benefits firm owners as a result of allowing a larger pool of workers. This could worsen any existing income inequality problems. The pressure on domestic wages may alter any upgrading effort firms might have and ultimately constitute a slowdown in productivity.

Nonetheless, the existence of pressure on domestic wage is predicated on the assumption that foreign and native workers are a perfect substitute. The opportunity cost of importing foreign workers lies in job losses of native laborers. This assumption is rather restrictive in circumstances where the labor market is tightening. In such a labor market (i.e., excess demand), native workers can choose jobs. Certain undesirable jobs may be shunned by them. Foreign workers may serve to fill such a void in these undesirable jobs. In this circumstance, the effect on wages would not necessarily be negative because foreign workers play a role as a complementary workforce, rather than being a competing workforce (Card, 2009; D'Amuri et al., 2010; Manacorda et al., 2012; Ottaviano and Peri, 2012). The counterfactual outcome without these foreign workers would be output loss in certain sectors. In the case of Thailand, there have at least two research projects estimating the effects of immigrant workers on domestic wages (Thailand Development Research Institute [TDRI], 2004; and Lathapipat, 2014). The first study was conducted in 2004 by TDRI. Employing a computational general equilibrium technique, the simulation of 700 thousand migrant workers in 1995 decreased the Thai wages of primary or lower level of education employees by about 3.5%. In 2014, Lathapipat (2014) used an updated Thai labor force survey (LFS) (2007) and found a negative effect of immigration on low-skilled native workers. However, the negative effect is much more severe in the case of existing migrant workers. Likewise, his paper confirmed the theoretical base that the degree of substitution between migrant and native workers is more than that degree among different experience workers.

This becomes increasingly policy-relevant when economic cooperation in Southeast Asian economies is strengthening. One consequence is to accommodate the movement of workers among member countries. In addition, exporting workers abroad on a temporary basis is widely regarded as representing a short-term economic cushion for low-income countries in the region where business opportunities remain underdeveloped. Hence, many international organizations including the Association of Southeast Asian Nations (ASEAN), Economic Research Institute of East Asia and ASEAN invest tremendous effort in laying down foundations to facilitate such labor movement.

2 Source: World Bank report named "Thailand economic monitor, June 2016: Aging society and economy."

Despite the inherent immense policy relevance, there has not been a systematic analysis assessing the economic impact of foreign workers on manufacturing wages in Thailand so far. Therefore, our objective is to examine the effects of foreign workers on domestic wages using Thailand as the case study. Due to the increasing importance of foreign workers in Thai manufacturing (Pitayanon, 2001), this sector is selected as the center of our focus. The sample of foreign workers in the study predominately comprises unskilled laborers as they represent the most controversial variable in the development process.

## 2. The Empirical Model

In general, there are two approaches used in the literature to estimate the effects of foreign workers on domestic wages, one concern the simulation experimental analysis derived from the theoretical model of labor demand and the other econometric analysis where all policy-relevant variables are captured in an eclectic fashion. There are both pros and cons inherent in each so that combining the two approaches are used in a complementary manner to constitute a robustness check.

The first approach involves the simulation experiments. The core model is based on the theoretical model wherein firms maximize their profits where heterogeneous labor is allowed (Appendix A). The key parameters and elasticity of substitution across worker groups used in the simulation are estimated coefficients from wage equations where relative wages, the dependent variable, are a function of worker characteristics such as education, work experience, and nationality. This approach is employed in many key studies in labor economics (Aydemir and Borjas, 2006; Card, 2009; Borjas et al., 2010; D'Amuri et al., 2010; Manacorda et al., 2012; Ottaviano and Peri, 2012; Bratsberg et al., 2014; and Lathapipat, 2014), when long period panel data sets regarding employment are available.

The main advantage of this approach is that the constructed model is fully informed by theories related to workers' decisions. In particular, demand for labor is derived from firms' profit maximization where labor is categorized according to nationality, education, and work experience. Hence, the estimated coefficient captures the effect of these factors on wages. The main shortcoming is that amassing such data is demanding. In particular, we need to have yearly individual data on wages, education, experiences, and nationalities. Hence, data availability becomes a necessary condition in obtaining reliable outcomes. In addition, the availability of long period data panel data is also crucial. This is done to obtain the reliable estimates of substitution elasticity among worker groups. Such data sets are not always available in many countries, including Thailand.

To the best of our knowledge so far, there has been one Thai study which adopted this approach. Lathapipat (2014) employed a LFS from 2007 (data for 2006). This data set is cross-sectional as sample identification in each year is not systematically collected and revealed. This could be problematic as the well-known shortcoming of such cross-sectional data sets is the relationships revealed are assumed to be at steady-state equilibrium. This assumption could be restrictive in reality especially when labor markets in developing countries are concerned. In fact, the decision of a firm to hire a worker could be influenced by existing market imperfections and/or constraints, such as location, financial considerations, information imperfection, and selecting siblings over and above the standard determinants (e.g., wage, experience, education, and nationality).

Alternatively, an econometric analysis is undertaken to obtain estimated wage equations where explanatory variables are nested in an eclectic manner. So far this method has been systematically employed in the recent study by Athukorala and Devadason, 2012[3]. The main advantage of this approach is that it requires much less information than the previous methodology. Any possible market imperfections and constraints, as well as other policy-relevant variables (e.g., export orientation, presence of foreign firms, and producer concentration), can be explicitly examined. This is highly relevant in the context of developing countries where many constraints are binding due to the presence

3 There was a Thai study by Kulkolkarn and Potipiti (2007). However, the analysis was subject to severe regression problem because they omitted the roles of experience, time, and capital variables. As we can see from the regression results, they are inconsistent subject to their alternative estimations.

of cumbersome regulation. The main shortcoming is that the model is not fully derived from the standard economic theory (e.g., optimization). Hence, both two approaches are employed in this study with appropriate comparisons.

## 2.1. The simulation-based model

As mentioned above, the only data available to perform correct simulation experiments is cross-sectional. Following Lathapipat (2014), province is used as a proxy of the time dimension to overcome problems caused by the absence of panel data. Hence, in the following discussion, t and p, denote time and provinces, respectively, and are used in an interchangeable manner.

To obtain elasticity measures of all of the substitution parameters used in the simulation, we begin with wage difference equation between migrants (M) and natives (N) with a given education background (k), skill intensity (SI) (b), and work experience (j) in province (p). This comprises a focus on the effect of nationality on wages which is a function of differences in productivity ($\theta_{Mkj}/\theta_{Nkj}$) and the relative importance of migrants to native workers ($M_{kjp}/N_{kjp}$) (Equation 2.1). The former is measured by an unobservable fixed-effect. The elasticity of substitution between locals and foreign workers is measured by the estimated coefficient corresponding to $M_{kjp}/N_{kjp}$). In particular, a 1% increase in migrants (M) narrows down wage differences by ($1/\sigma_M$) percent, all other things being equal.

$$\ln\left(\frac{w_{Mbkjp}}{w_{Nbkjp}}\right) = \ln\left(\frac{\theta_{Mkj}}{\theta_{Nkj}}\right) - \frac{1}{\sigma_M}\left(\frac{M_{kjp}}{N_{kjp}}\right) \tag{2.1}$$

Where ($w_{Mbkjp}/w_{Nbkjp}$) represents the wage difference between migrants and native workers at given b, k, j, and p ($\theta_{Mkj}/\theta_{Nkj}$) represents migrant-native productivity differences at a given k and j. Subscript b, k, j, and p indicate SI (low and high), education level (primary, secondary, vocational, and college), work experience, and province, respectively.

The productivity difference in Equation 2.1 is obtained by replacing by education by experience fixed effects (FE) ($I_{kj}$) as in Equation 2.2. Thus, Equation 2.1 can be estimated by the following equation:

$$\ln\left(\frac{w_{Mbkjp}}{w_{Nbkjp}}\right) = I_{kj} - \frac{1}{\sigma_M}\ln\left(\frac{M_{kjp}}{N_{kjp}}\right) + u_{bkjp} \tag{2.2}$$

Where ($I_{kj}$) reflect 16 education by experience FE and ($u_{bkjp}$) is a specific error term of nationality.

Next, we focus on the effect of experience on wages. Note that migrants and native workers are combined as a single category of a worker at given levels of k, j, and t ($L_{kjt}$) with the elasticity of substitution between them at $1/\sigma_J$. This is the aggregation of Equation A.7 and A.8 in Appendix A which implies the relationship between average wages paid to this single category of worker $\left(\bar{w}_{bkjt}\right)$ and its supply ($L_{kjt}$). Hence, the observations in this stage involve workers with different educational background, experience, and SI. At this stage, the composite of labor supply ($L_{kjt}$) allows us to perform panel estimation onwards, where province dimension (p) is switched into time dimension (t).

To capture the effect of experience on wages in practice, in Equation 2.3, the marginal pricing conditions for each education level and experience category, are estimated. In Equation 2.3, there are three unobservable FE, which are yearly FE ($I_t$), year by education FE ($I_{kt}$), and education by experience FE (Ikj). The roles of these three controlling variables are derived according to profit maximization procedure. In particular, a 1% increase in combined labor supply ($L_{kjt}$) narrows down the average wages paid by ($1/\sigma_J$) percent, all other things being equal. Thus, we can obtain the following equation:

$$\begin{aligned} \ln\left(\bar{w}_{bkjt}\right) &= \ln\left(\alpha A_t k_t^{1-\alpha}\right) + \frac{1}{\sigma_{HL}}\ln(L_t) + \ln(\theta_{bt}) - \left(\frac{1}{\sigma_{HL}} - \frac{1}{\sigma_{bb}}\right) \\ &\ln(L_{bt}) + \ln(\theta_{kt}) - \left(\frac{1}{\sigma_{bb}} - \frac{1}{\sigma_J}\right)\ln(L_{kt}) + \ln(\theta_{kt}) - \frac{1}{\sigma_J}\ln(L_{kjt}) \end{aligned} \tag{2.3}$$

Where ($k_t$) is the capital-labor ratio and $\left(\bar{w}_{bkjt}\right)$ is the weighted average wage between foreign and native workers in a combined labor supply. After we control for the effect of unobservable FE, Equation 2.3 is estimated as follow:

$$\ln\left(\bar{w}_{bkjt}\right) = I_t + I_{kt} + I_{kj} - \frac{1}{\sigma_J}\ln(L_{kjt}) + u_{kjt} \tag{2.4}$$

Where $I_t$ is 28 times FE (1986–2013), $I_{kt}$ is 112 education by time FE, and $I_{kj}$ is the same FE used in Equation 2.2. $u_{bkjp}$ is an education and experience specific error term.

Next, we focus on the effect of education background on wages. Note that migrants and native workers are combined as a single category of a worker at given levels of k, and t (Lkt) with the elasticity of substitution between them at $1/\sigma_{bb}$. This is a one level further aggregation of Equation A. 7 and A. 8 in Appendix A which implies a relationship between average wages paid to that single category of worker $(\bar{w}_{bkt})$ and its supply ($L_{kt}$). Hence, the observations in this stage concern workers with different SI, and education background.

To capture the effect of education background on wages in practice, Equation 2.6 is estimated. The combined labor supply measure ($L_{kt}$) is constructed using Equation A.4. In that equation, it is a function of experience-education specific relative efficiency ($\theta_{kj}$), elasticity of substitution between workers with different experience levels ($\sigma_J$), and a single category of worker at given levels of k, j, and t ($L_{kjt}$). The former is estimated by following Ottaviano and Peri (2012), while the rest are obtained from Equation 2.4. The estimations of $\left(\hat{\theta}_{kj}\right)$ are calculated from the education by experience FE using the following normalized formula:

$$\hat{\theta}_{kj} = \frac{\exp(\hat{I}_{kj})}{\sum_{j=1}^{4}\exp(\hat{I}_{kj})} \tag{2.5}$$

$$\ln\left(\bar{w}_{bkt}\right) = \ln\left(\alpha A_t k_t^{1-\alpha}\right) + \frac{1}{\sigma_{HL}}\ln(L_t) + \ln(\theta_{bt}) - \left(\frac{1}{\sigma_{HL}} - \frac{1}{\sigma_{bb}}\right)\ln(L_{bt}) + \ln(\theta_{kt}) - \frac{1}{\sigma_{bb}}\ln(L_{kt}) \tag{2.6}$$

Where $\left(\bar{w}_{bkt}\right)$ is the weighted average wage in the same SI group b and specific education group k at time t. Note that Equation 2.6, represents an abbreviated equation of two hidden equations where the subscript $b \in \{L,H\}$. To estimate the effect of education background (k) within the same SI group (b), we employ the method proposed by Katz and Murphy (1992). Thus, we can take a different expression (2.6) for any pair of schooling groups within the same SI to obtain Equation 2.7 and 2.8.

$$\ln\left(\frac{\bar{w}_{HSt}}{\left(\bar{w}_{PRt}\right)}\right) = \ln\left(\frac{\theta_{HSt}}{\theta_{PRt}}\right) - \frac{1}{\sigma_{LL}}\ln\left(\frac{L_{HSt}}{L_{PRt}}\right) \tag{2.7}$$

$$\ln\left(\frac{\bar{w}_{COt}}{\left(\bar{w}_{TVETt}\right)}\right) = \ln\left(\frac{\theta_{COt}}{\theta_{TVETt}}\right) - \frac{1}{\sigma_{HH}}\ln\left(\frac{L_{COt}}{L_{TVETt}}\right) \tag{2.8}$$

Equation 2.7 expresses the effect of education background on wages in a low SI group (primary and high school), while Equation 2.8 expresses the case of high SI (vocational and college). In both equations, the productivity differences are replaced by time FE in the same manner. Thus, the empirical transformations of those two equations are the following:

$$\ln\left(\frac{\bar{w}_{HSt}}{\left(\bar{w}_{PRt}\right)}\right) = I_{Lt} - \frac{1}{\sigma_{LL}}\ln\left(\frac{\hat{L}_{HSt}}{\hat{L}_{PRt}}\right) + u_{Lt} \tag{2.9}$$

$$\ln\left(\frac{\bar{w}_{COt}}{\left(\bar{w}_{TVETt}\right)}\right) = I_{Ht} - \frac{1}{\sigma_{HH}}\ln\left(\frac{\hat{L}_{COt}}{\hat{L}_{TVET_t}}\right) + u_{Ht} \tag{2.10}$$

Where $(\bar{w}_{HSt}/\bar{w}_{PRt})$ represents the wage differences between high school and primary workers, while $(\bar{w}_{HSt}/\bar{w}_{PRt})$ represents the wage differences between college and vocational workers. Note that the time FE ($I_{Lt}$) and ($I_{Ht}$) control the variations in productivity differences in low skill and high skill groups, respectively.

Finally, we focus on the effect of SI on wages. Note that migrants and native workers are combined again as a single category of a worker at given levels of b, and t ($L_{bt}$)with the elasticity of substitution between them at $1/\sigma_{HL}$. This is a top-level aggregation of Equation A.7 and A.8 in Appendix A which implies a relationship between average wages paid to the single category of worker $(\bar{w}_{bt})$ and its supply ($L_{bt}$). Hence, the observations in this stage concern workers with different SI.

To capture the effect of SI on wages in practice, Equation 2.13 is estimated. The combined labor supply ($L_{bt}$) is constructed using Equation A. 3. In that equation, it is a function of the education-specific relative productivities $(\theta_{kt})$, elasticity of substitution between workers with different education levels (σbb), and a single category of worker at given levels of k, and t ($L_{kt}$). The former is estimated as before, while the rest are obtained from Equations 2.9 and 2.10. The estimations of $(\hat{\theta}_{kt})$ are calculated from the education FE using the following normalized formula:

$$\hat{\theta}_{lt} = \frac{\exp(\hat{I}_{bt})}{1+\exp(\hat{I}_{bt})} \tag{2.11}$$

$$\hat{\theta}_{mt} = \frac{1}{1+\exp(\hat{I}_{bt})} \tag{2.12}$$

$$\ln\left(\bar{w}_{bt}\right) = \ln\left(\alpha A_t k_t^{1-\alpha}\right) + \frac{1}{\sigma_{HL}}\ln(L_t) + \ln(\theta_{bt}) - \frac{1}{\sigma_{HL}}\ln(L_{bt}) \tag{2.13}$$

The standardized relative productivity terms $\left(\hat{\theta}_{lt}\right)$ and $(\hat{\theta}_{mt})$ stand for the relevant (l,m)-pair of education groups within the same broad education b, where $(\bar{w}_{bt})$ is the weighted average wage in the same broad education group b at time t. Employing the method proposed by Katz and Murphy (1992) again, we can take a different expression (2.13) between pairs of broad education groups to obtain:

$$\ln\left(\frac{\bar{w}_{Ht}}{\bar{w}_{Lt}}\right) = \ln\left(\frac{\theta_{Ht}}{\theta_{Lt}}\right) - \frac{1}{\sigma_{HL}}\left(\frac{L_{Ht}}{L_{Lt}}\right) \tag{2.14}$$

Equation 2.14 represents the effect of differences in SI on wages. An empirical estimation of the above equation is as follows:

$$\ln\left(\frac{\bar{w}_{Ht}}{\bar{w}_{Lt}}\right) = I_{HLt} - \frac{1}{\sigma_{HL}}\ln\left(\frac{\hat{L}_{Ht}}{\hat{L}_{Lt}}\right) + u_{HLt} \tag{2.15}$$

Where the time FE ($I_{HLt}$) controls the variations in productivity differences between high and low SI. $u_{HLt}$ is a skill specific error term.

All of the estimated parameters, comprising ($\sigma_M$), ($\sigma_J$), ($\sigma_{LL}$), ($\sigma_{HH}$), and ($\sigma_{HL}$), represent filled in demand for worker equations (Equation A.7 and A.8) to capture the total effect on wages of the presence of foreign workers. Where the effect on wages among foreign workers is concerned, it is measured by:

$$\frac{\Delta w_{Mbkjt}}{w_{Mbkjt}} = \frac{\Delta w_{Nbkjt}}{w_{Nbkjt}} - \frac{1}{\sigma_M}\frac{\Delta M_{bkjt}}{M_{bkjt}} \tag{2.16}$$

To evaluate the effect on wages paid to the natives in Thailand, we undertake a partial derivation of Equation A.7, i.e., an increase of foreign workers in all subgroups of labor, as expressed in Equation 2.17. This is under the assumption that capital-labor ratios remain unchanged as a result of an increase in foreign workers.

$$\frac{\Delta w_{Nbkjt}}{w_{Nbkjt}} = \frac{1}{\hat{\sigma}_{HL}} \sum_{c\varepsilon B} \sum_{q\varepsilon E} \sum_{i=1}^{4} \frac{w_{Mcqit}}{\overline{w}_{t}} \frac{M_{cqit}}{L_{t}} \frac{\Delta M_{cqit}}{M_{cqit}} -$$

$$\left( \frac{1}{\hat{\sigma}_{HL}} - \frac{1}{\hat{\sigma}_{bb}} \right) \sum_{q\varepsilon b} \sum_{i=1}^{4} \frac{w_{Mbqit}}{\overline{w}_{tb}} \frac{M_{bqit}}{L_{bt}} \frac{\Delta M_{bqit}}{M_{bqit}} - \left( \frac{1}{\hat{\sigma}_{bb}} - \frac{1}{\hat{\sigma}_{J}} \right)$$

$$\sum_{i=1}^{4} \frac{w_{Mbkit}}{\overline{w}_{kt}} \frac{M_{bkit}}{L_{kt}} \frac{\Delta M_{bkit}}{M_{bkit}} - \left( \frac{1}{\hat{\sigma}_{J}} - \frac{1}{\hat{\sigma}_{M}} \right) \frac{w_{Mbkjt}}{\overline{w}_{kjt}} \frac{M_{bkjt}}{L_{kjt}} \frac{\Delta M_{bkjt}}{M_{bkjt}} \tag{2.17}$$

Where, B={L,H}, E={PR,HS,TVET,CO}, and the rest of the parameters are the same as in the previous declaration.

## 2.2. The econometric-based model

The empirical model used in this section is based on a wage determinant equation where wages are the dependent variable. A set of explanatory variables are nested in an eclectic fashion based on the relevant theories concerning labor markets in the context of developing countries. Given the study's core hypothesis, the extent to which firms rely on foreign workers is the first explanatory variable in our empirical model. The corresponding coefficient would indicate the effect of foreign workers on wages. Its expected sign, nonetheless, can be either positive or negative, depending on whether foreign workers are substitutes or complementary to the native workforce. Under a 3D job hypothesis, foreign workers take jobs shunned by native workers so that they complement each other. Hence, the coefficient is expected to be positive. Conversely, a negative coefficient is expected when foreign workers compete with native workers for a given job. In addition, there are six explanatory variables used as controlling variables in our analysis.

First, market orientation (MKT) is introduced according to the core postulation of the firm heterogeneity literature (Helpman, 2006; Bernard et al., 2011; Melitz and Redding, 2015) within which exporting firms exhibit higher productivity than domestic-oriented as higher productivity is needed for firms to compensate for any fixed costs incurred by exporting activities. However, it is possible that the exporting firms operate under higher demand pressure compared to non-exporting firms because they can exploit the benefits from policy-induced and natural protection. Hence, all other things being equal, exporting firms tend to pay higher wages so that the corresponding coefficient is expected to be either positive or negative.

Second, the foreign ownership is concerned. As echoed in the literature on foreign direct investment as well as that of firm heterogeneity (e.g., Lipsey, 2002; Melitz and Redding, 2015), multinational enterprises usually exhibit higher productivity to compensate for any disadvantages that they might have in operating aboard so that they pay their workers higher wages. Hence, foreign firms tend to pay a higher wage as opposed to their local counterparts.

Third, capital intensity (KI) is introduced in the empirical model to capture the extent to which fixed costs are important for an industry (Brown and Medoff, 1989; Murphy and Topel, 1990). The higher the fixed costs, the higher the wages firms in the industry tend to offer workers. Firms with a higher level of KI, size, or both, tend to offer higher wages to ensure that they can obtain workers at the level wherein they can exploit their capital investment efficiently. In other words, the opportunity cost of labor shortages tends to be higher for firms with higher fixed costs. In addition, wage expenses are rather a small proportion of overall production costs in the capital-intensive firm. Hence, we expect the estimated coefficient to be positive.

Fourth, the role of SI used as an explanatory variable is to a certain extent similar to that of KI (Harrigan and Reshef, 2015). Firms with a higher share of skilled workers in the total workforce offer higher wages as the marginal product of hired workers would be higher at a given level of total workers. This is because these skilled workers potentially lift up the firms' overall productivity. Hence, a positive sign is expected.

Fifth, labor productivity (LP) is controlled based on the fact that when a firm is expanding, firms must offer a higher wage to entice workers from elsewhere to change jobs (Hamermesh, 1993). Therefore, we expect the sign of the corresponding coefficient to be positive.

Sixth, producer concentration (CR) is employed to capture the effect of market power on wages. Nonetheless, the effect could be either positive or negative. On the one hand, firms operating together with fewer competitors (a highly concentrated industry) could avoid market pressure and experience excess profits. All other things being equal, they can offer higher wage rates compared to others in competitive markets. On the other hand, when firms gain market power due to existing within a highly concentrated industry, they could abuse their market power by freezing wages paid to employees. As a result, the expected sign of this coefficient can be positive, or negative.

## 3. Data Sources and Variable Construction

In this study, we employ three main sources of data - LFS, industrial census (IC), and household socioeconomic survey (SES). They are all provided by the National Statistical Office with different inherent features. In general, there are LFSs available in Thailand. LFS contain rich information on workers in Thailand, such as wages earned, education, experience, and working hours, all of which are required in the simulation experiment. LFS from 1986 to 2013 are used in the experiment.

However, LFS provide rather limited data on firm and industry-specific characteristics because the questionnaires are based on samples of individuals within the labor supply. Thus, it is too broad to examine the effect of relevant industry characteristics. Hence, when econometric analysis is concerned, IC is the main data source. So far there are three ICs available in Thailand, 1997, 2007, and 2012. Year expressed here represents when that data were released, but the information in the IC was actually measured in a year earlier. For example, the 1997 IC represented activities in 1996. IC provides data on the characteristics of firms in a given industry classified according to 4-digit ISIC. They include age, market orientation, ownership, capital, and workers. Interestingly, workers are further disaggregated into the operational and non-operational staff.

In theory, to assess the effect of foreign workers on wages, information about foreign workers hired by a given firm is needed. However, IC datasets do not contain such information. Hence, we need to find a proxy. To do so, SES is used in this study. A broad measure of the presence of foreign workers at the sectoral level is constructed. One might argue that LFS began reporting information about foreign workers. To the best of our knowledge so far, the found information is in 2013 which does not match with the IC dataset. Note that in SES there is no data on worker nationality. Hence, we use a proxy, language spoken in the family, to identify foreign workers.

### 3.1. Simulation experiments

We follow the practice used in Lathapipat (2014). Respondents covered in LFS whose age is under 16 or over 65 are dropped. Those are not legally classified as part of the labor force. Workers who reported positive working hours and zero wages, as well as unpaid family workers, are excluded. The hourly wage rate paid per worker represents total monthly wage earnings per total working hours (TOTAL_HR). Note that total earnings include monthly wage earnings (APPROX), “BONUS” per month and average overtime payments received per month, “OT.” All are adjusted to hourly wages.

Foreign workers are identified when respondents are registered as a foreigner. Otherwise, they are treated as native workers. Primary and secondary schooling comprise respondents having been in school for ≤6 years and between 7 and 12 years, respectively. Workers with vocational education and training refer to respondents attending school for more than 13 years without a bachelor degree, whereas the rest is composed of those with a college graduate background. To capture work experience, we assume that workers with less than a high school education entered the labor force at the age of 15, and those with a high school education entered at the age of 17, and the experience is calculated by deducing from the current age with that when entering the labor force and years in school. Worker experience is discretionarily categorized into four ranges, i.e., 0–10 years, 11–20 years, 21–30 years, and more than 30 years.

The resulting 2013 sample contains 50,648 individuals, of which the supply of foreign workers accounted for 4.29% of the total weekly hour supply in our sample. In addition, the total weekly wage bill of foreign workers accounted for 2.71% of the total weekly wage bill in our sample. Note that the LFS sampling weights are used in the calculations of all average and aggregate statistics and variables throughout this study.

In the dynamic level from 1986 to 2013, the variables again are constructed into 28 years - four schooling - four experience groups. Note that the four detailed schooling groups and four experience groups are classified employing the same criteria as defined earlier. After we obtained the proportions of foreign workers in each single category from 2013 LFS, we use these proportions to classify the proportions of foreign workers in other years (1986–2012) in the simulation experiment.

### 3.2. Econometric analysis

Ideally, detailed information on how many foreign workers are employed by a given firm is needed to measure the extent to which foreign workers are employed. Such data does not exist in Thailand and are not available in these three ICs. Hence, we opt to use information from the official report of foreign workers in the manufacturing sector by the OFWA, Ministry of Labor and Social Welfare. In practice, the data from OFWA and LFS are not compatible with IC. Finally, we employ data from SES using language spoken in the family as a proxy for nationality (Appendix B). The measurement of variables is presented in Table 1.

Our processed IC data have to be cleaned because the raw data incurs many problems that do not reflect reality, i.e., duplications, non-sense values from some variables and missing variables of interest. Thus, we create the following criteria to eliminate these problems. First, there exist the duplications in our dataset. For example, a firm has many factories, and respondents answer the questionnaire twice or more. In such cases, we mark the pair of observations as duplications when they have equal values with respect to the following data: (1) Registered capital, (2) male employees, (3) female employees, (4) total employees, (5) sales of good produced, (6) fixed assets at January, (7) fixed assets at December, and (8) costs of purchasing materials and components. Second, non-sense values are eliminated following these criteria: (1) The yearly output is <10,000 THB, (2) the total workers are zero, (3) the yearly nominal value added is <10,000 THB, (4) the yearly nominal total wage bill is <5000 THB, (5) the yearly nominal operational wage bill is <5000 THB, and (6) the fixed assets both in the beginning and at the end of year are 0. Ultimately, the missing variables of interest are eliminated from our dataset.

As the core dataset comprises IC collected at the plant level, there are two choices in performing econometric analysis, i.e., plant and industry levels. Each has advantages and disadvantages. Arguably, when workers can move freely within a given industry, wages across firms/plants would not be different. Any arbitrary wages could be eliminated by worker movement. It is less likely to observe arbitrary wages across firms within a given industry in circumstances where the labor market is tightening, such as we, currently, observe in Thailand. Hence, this would justify the analysis at the industry level. When the analysis is undertaken at the industry level, the main advantage is that we can perform panel econometric analysis. This is because even though there are three censuses, plant identification across censuses is not systematically collected. Hence, it is unlikely to panelize plant-level data of these three censuses. However, when plant level is aggregated to the industry-level, panelizing is possible in spite of certain shortcomings. This would allow us to understand the dynamics of wage determinants over the considered periods. This is especially true in the context of wage determinants where certain time differences are needed. The clear disadvantage of analysis at the industry level is certain theoretically sound firm-specific variables are unable to be fully captured. As echoed in the firm heterogeneity literature, operations tend to exhibit different productivity across firms. Hence, firm-specific characteristics, (e.g., non-exporting vs. exporting and foreign vs. domestic firms) matter in wage determinant analysis. This could result in wage differences across firms even though they are in the same industry. While these characteristics can be captured by the average figure at the industry

Table 1: Measurement of variables in econometric model

| Abbreviation | Variable | Measurement |
|---|---|---|
| lORW | Log operational real wage | Annual operational earning to total worker, deflated by consumer price index |
| lTRW | Log total real wage | Annual total earning per total worker, deflated by consumer price index |
| IMD_N2 | Actual immigrant dependency | Share of foreign workers in total employment |
| IMD_dum | Dummy of immigrant dependency | Dummy of industry that employed high proportion of foreign workers to total workers. 0 if the proportion is low, and 1 if the proportion is high (see Appendix B) |
| lRO | Log real output (value added) | Nominal value added deflated by producer price index |
| lLP | Log labor productivity | Labor productivity is calculated from real output divided by total workers |
| lKI | Log capital intensity | A ratio of nominal fixed assets deflated by gross fixed capital formation in total employees |
| SI | Skill intensity | Share of non-operational workers to total workers |
| CR | Concentration ratio | Share of four largest firms in total gross output in a given industry |
| FOS | Dummy of foreign ownership | Dummy of industry that has foreign shareholding. 0 if share is zero, and 1 if another |
| FOS_1 | Actual percentage of foreign ownership | Share of foreign shareholding, in percentage |
| MKT | Dummy of market orientation | Dummy of industry that export product. 0 if export is zero, and 1 if another |
| MKT_1 | Actual percentage of market orientation | Export share in gross output, in percentage |
| Time_2006 | Time dummy for year 2006 | Dummy of time fixed effect. 1 if year is 2006, and 0 if another |
| Time_2011 | Time dummy for year 2011 | Dummy of time fixed effect. 1 if year is 2011, and 0 if another |

Source: Author's tabulation

level, it would be far better to examine them at the plant level. Given this line of argument, we are in favor of plant-level analysis. As mentioned earlier, plant data in the censuses cannot be panelized so that the analysis at the plant level is pooled cross-sectional. Hence, this is the main trade-off.

To overcome this data shortcoming, we will perform both plant and industry level analysis instead of choosing one over the other. Both results are used to promote robust checking within our analysis. Some firm-specific variables will be proxied by the industry average in the industry-level analysis.

In the plant level analysis, wages are the dependent variable, measured by the ratio of total wage compensation to total workers. As foreign workers in our focus are unskilled, using overall wages might be misleading to a certain extent. Hence, wages paid for operational (blue-collar) workers are used as an alternative dependent variable.

As mentioned earlier, firm-specific information on how much a given firm hires foreign workers as a percentage of its total workforce is available only for 2011 onward. Hence, a dummy is needed. In this study, we use two alternative industry-level proxies. The first is the ratio of foreign workers used to total employment in a given industry. While this seems to be a proper measure of how important foreign workers are in a given industry, the employment data of the manufacturing sector in Thailand are rather poor in quality and not up-to-date. The only 1 year that can be estimated in this alternative is 2012 IC. This could make the proposed ratio problematic. As an alternative measure, the binary zero-one dummy is proposed. In industries, which heavily rely on foreign workers, the dummy variable is equal to one and zero otherwise. This could be a decent proxy because foreign workers in Thailand are highly concentrated in certain industries, such as processed foods, garments, and footwear. Hence, in such industries, the dummy variable is set to one. Both are used as a robustness check on the sensitivity of the estimates on choices of proxies.

## 4. Results from Simulation-based Models

The purpose of this section is to estimate the elasticity of substitution parameters. Table 2 summarizes all the interested parameters. In the first two columns (1), two elasticities of substitution between immigrants and native workers ($\sigma_M$) are reported. The left comprises results from all sectors estimated, while the right includes results from the manufacturing sector. Note that the estimated elasticities are 53.64 in absolute terms and statistically insignificant and 14.71 in absolute term and statistically significant, respectively. This suggests that these two types of workers are substitutable; interestingly, the degree is higher in case of all sectors. This seems to be in line with the 3D job hypothesis that migrant workers are imported to work in jobs shunned by locals in the manufacturing sector.

In the latter two columns (2), the elasticities of substitution between labor with different levels of experience groups ($\sigma_J$) are 6.43 in case of all sectors and 8.03 in the case of manufacturing. Both parameters are different from 0% at the 1% level. In addition, these two are higher than the elasticities of substitution according to education groups, regardless of SI.

Another found pattern is that the absolute value of elasticity of substitution across low educational background respondents ($\sigma_{LL}$) is higher than with those of a high educational background ($\sigma_{HH}$). However, the pattern reverses in the case of manufacturing. The former values are both different from 0% to 10%, while the latter values are different from 0 to 1% only with the group of low educational background. Finally, we found the lowest values of elasticity of substitution between low skill and high SI groupings ($\sigma_{HL}$) in both cases.

All estimated elasticities in Table 2 are used in the simulation exercises to assess the effects of foreign workers. The simulation results are presented in Tables 3 and 4. Table 3 summarizes the simulation results from all sectors. Meanwhile, Table 4 summarizes the case of the manufacturing sector. The total foreign and Thai wage bills are reported in columns (1) and (2), respectively. While the corresponding total foreign and Thai working hour supplies are reported in columns (3) and (4), respectively.

From the past two columns in Table 3, the effects of increases in foreign workers on foreign and Thai wages are exhibited. Its negative effect on foreign wages is in line with the theoretical framework. We find negative impacts in all skill groups. The percentage changes vary between −2.38 and −1.81. Note that the highest negative impact is found on foreign workers whose education is primary and experience duration is <11 years, while the most modest impact is found on foreign workers whose education is collegiate and experience more than 30 years. However, the effects tend to be ambiguous in the case of Thai wages. We find negative impacts for Thai workers whose education is primary and high school, while the effects turn to be positive when education is vocational and collegiate. The highest negative impact is found with the similar skill groups as in the case of foreign wages, and the highest positive impact is found in the same manner.

Table 4 summarizes the results with the focus on the manufacturing sector. We still find all negative impacts in case of foreign wages, highlighting that the effects are more severe in every skill group compared to the case of all sectors. The pattern of those impacts is not different from the former case. That is, the highest negative impact is found on foreign workers whose education is primary and experiences <11 years, while the most modest impact is found on foreign workers whose education is collegiate and experience more than 30 years. However, the effects tend to be lighter in the case of Thai wages. We find negative impacts for Thai workers whose education is only primary, while the effects

**Table 2: Regression estimates of the elasticity of substitution parameters**

| **Reported variables** | $\sigma_M$ **(1)** | | $\sigma_J$ **(2)** | | $\sigma_{LL}$ **(3)** | | $\sigma_{HH}$ **(4)** | | $\sigma_{HL}$ **(5)** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Total** | **MFT** | **Total** | **MFT** | **Total** | **MFT** | **Total** | **MFT** | **Total** | **MFT** |
| Inverse elasticity | −0.02 | −0.068*** | −0.16*** | −0.125*** | −0.19* | −0.267*** | −0.25* | −0.088 | −0.50*** | −0.364*** |
| Estimate | (0.03) | (0.022) | (0.021) | (0.029) | (0.1) | (0.0067) | (0.146) | (0.2694) | (0.016) | (0.0196) |
| p-value | 0.47 | 0.00 | 0.00 | 0.00 | 0.07 | 0.03 | 0.1 | 0.74 | 0.00 | 0.00 |
| Elasticity of substitution | 53.64 | 14.71 | 6.43 | 8.03 | 5.24 | 3.74 | 4 | 11.33 | 2.01 | 2.75 |
| Fixed effects: | | | | | | | | | | |
| Education×experience | Yes | Yes | Yes | Yes | No | No | No | No | No | No |
| Education×year | No | No | Yes | Yes | No | No | No | No | No | No |
| Year | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 615 | 268 | 448 | 448 | 28 | 28 | 28 | 28 | 28 | 28 |
| R-squared | 0.11 | 0.15 | 0.99 | 0.95 | 0.96 | 0.29 | 0.56 | 0.07 | 0.99 | 0.98 |

Source: Author's estimate from LFS database. Note: Robust standard errors in parentheses. MFT stands for manufacturing and ***p<0.01, **p<0.05,*p<0.1

**Table 3: Simulated long-run effects of foreign workers on domestic wages, all sectors**

| Education | Experience | Foreign wage bill (baht) (1) | Thai wage bill (baht) (2) | Foreign hours supply (3) | Thai hours supply (4) | Foreign wage change % (5) | Thai wage change % (6) |
|---|---|---|---|---|---|---|---|
| Primary | 0–10 | 273.75 | 1129.75 | 11.04 | 56.62 | −2.38 | −0.52 |
| | 11–20 | 185.23 | 1930.11 | 10.14 | 72.80 | −2.09 | −0.23 |
| | 21–30 | 111.04 | 1948.56 | 3.90 | 70.55 | −1.99 | −0.12 |
| | 31 plus | 40.14 | 1851.11 | 1.15 | 63.04 | −1.95 | −0.09 |
| High school | 0–10 | 54.06 | 2255.04 | 2.61 | 75.89 | −1.89 | −0.02 |
| | 11–20 | 49.94 | 2125.02 | 2.34 | 50.29 | −1.89 | −0.03 |
| | 21–30 | 13.51 | 1433.17 | 0.57 | 23.80 | −1.88 | −0.02 |
| | 31 plus | 0.12 | 10.83 | 5.83 | 10.27 | −1.88 | −0.01 |
| Technical and vocational education and training | 0–10 | 21.09 | 835.34 | 0.76 | 17.16 | −1.82 | 0.04 |
| | 11–20 | 14.16 | 819.63 | 0.36 | 10.90 | −1.82 | 0.05 |
| | 21–30 | 7.27 | 512.55 | 0.08 | 4.50 | −1.81 | 0.05 |
| | 31 plus | 1.36 | 237.76 | 0.01 | 1.41 | −1.81 | 0.05 |
| College | 0–10 | 114.66 | 2354.87 | 1.04 | 31.85 | −1.83 | 0.04 |
| | 11–20 | 68.07 | 3168.98 | 0.50 | 27.17 | −1.81 | 0.05 |
| | 21–30 | 7.96 | 2769.83 | 0.07 | 16.28 | −1.81 | 0.06 |
| | 31 plus | 1.10 | 1383.59 | 0.01 | 6.13 | −1.81 | 0.06 |

Source: Author's estimate from LFS database, 1986–2013. The units reported in column (1) and (2) are million baht, and those reported in column (3) and (4) are million hours. The past two column are percentage changes of foreign and Thai wages when we simulate positive shock (doubling of foreign workforce)

turn to be positive when education is high school, vocational, and collegiate. The highest negative impact is found with similar skill groups as in the case of foreign wages, and the highest positive impact is found in the same manner. Interestingly, the weighted average of Thai wage changes in all groups turns out to be positive (0.04%) in the case of the manufacturing sector.

## Results from Econometric-based Models

Table 5 summarizes the results of the plant-level econometric analysis. This is based on an ordinary least square estimation. In the table, the corresponding robust standard error is used to mitigate any possible heteroscedasticity problem. Correlation coefficient matrix, as well as variance inflation factor (VIF) analysis, suggests that any possible multicollinearity problem is not severe in our estimation results. In particular, correlation coefficients among variables are rather low (<0.4), and the VIF value is small (Table 6). Cook's Distance is used to indicate possible outliers. We found that there are 3524 samples identified as outliers by Cook's distance criteria[4]. 4-digit ISIC dummies are introduced in the regression to capture any industry-specific FE that might be present.

In Table 5, columns 1.1 and 1.2 represent the results with and without outlier samples where operational wage compensation is the dependent variable. The results are resilient to each other, suggesting outliers identified by Cook's Distance do not have any severe effect on our estimation. Nonetheless, the following analysis is based on the sample where outliers are excluded. Column 1.3 is a rerun of Column 1.2, but the dependent variable is total wage compensation. Results in Columns 1.2 and 1.3 are remarkably similar, except for the coefficient corresponding to SI. Since the main interest in our study is on the effects of foreign workers on operational workers' wage compensation,

4 The standard practice is samples are identified as outliers when the Cook's distance statistic is greater than 4/n, where n is the number of observations.

**Table 4: Simulated long-run effects of foreign workers on domestic wages, manufacturing sector**

| Education | Experience | Foreign wage bill (baht) (1) | Thai wage bill (baht) (2) | Foreign hours supply (3) | Thai hours supply (4) | Foreign wage change % (5) | Thai wage change % (6) |
|---|---|---|---|---|---|---|---|
| Primary | 0–10 | 185.773 | 342.727 | 7.131 | 7.320 | −8.13 | −1.33 |
| | 11–20 | 150.639 | 585.432 | 5.307 | 14.146 | −7.46 | −0.66 |
| | 21–30 | 25.057 | 554.085 | 1.502 | 14.976 | −7.17 | −0.37 |
| | 31 plus | 20.566 | 337.970 | 0.295 | 10.125 | −7.16 | −0.36 |
| High school | 0–10 | 23.052 | 970.127 | 1.130 | 29.425 | −6.78 | 00.02 |
| | 11–20 | 26.565 | 790.006 | 1.218 | 16.767 | −6.79 | 00.01 |
| | 21–30 | 6.211 | 356.321 | 0.251 | 5.583 | −6.78 | 00.02 |
| | 31 plus | 2.870 | 134.234 | 0.044 | 1.395 | −6.78 | 00.02 |
| Technical and vocational education and training | 0–10 | 5.801 | 263.827 | 0.338 | 4.881 | −6.68 | 00.11 |
| | 11–20 | 2.384 | 216.596 | 0.043 | 2.848 | −6.68 | 00.12 |
| | 21–30 | 5.925 | 77.109 | 0.041 | 0.667 | −6.70 | 00.10 |
| | 31 plus | 0.100 | 31.996 | 0.004 | 0.169 | −6.68 | 00.12 |
| College | 0–10 | 3.192 | 433.158 | 0.142 | 4.863 | −6.68 | 00.12 |
| | 11–20 | 3.374 | 456.683 | 0.074 | 3.211 | −6.68 | 00.12 |
| | 21–30 | 1.163 | 245.929 | 0.009 | 1.144 | −6.68 | 00.12 |
| | 31 plus | 0.000 | 86.942 | 0.000 | 0.263 | −6.68 | 00.12 |

Source: Author's estimate from LFS database, 1986–2013. All reported details are similar to Table 3. LFS: Labor force survey

the following discussion is based on Column 1.2. Findings found in Column 1.3 will be integrated when they are relevant.

In general, 2 times FE dummies (2006 and 2011) are statistically significant and negative. Together with the positive and significant intercept, the found negative and statistically significant estimates of these 2 times dummies indicate a slowdown in the growth rate of domestic wages.

The other controlling variables reach theoretical expected signs at the conventional statistical level, i.e., 5%, or better. The coefficient corresponding to lLP turns out to be positive and statistically significant at the 1% level of statistical significance, indicating firms exhibiting higher productivity pay higher wages, all other things being equal. This is even true when considering the fact of the increasing labor tightening in the market experienced within Thailand.

Similar to other previous studies, capital and labor in Thai manufacturing are used in a complementary manner so that firms with higher capital-labor ratios tend to have higher productivity - so that they pay higher wages. Nonetheless, the complementary effect is rather small at around 0.03.

When SI is concerned, a non-linear relationship is found. The corresponding coefficient of SI is negative, but its interaction term with SIZE is positive, both of which are statistically significant at the 1% level of significance. Our interpretation is that hiring white collar workers for firms with small sizes (lSIZE values of <5 or firms employing <150 total workers) might generate pressure on operational workers' wages. When the amount surpasses certain levels, hiring white-collar workers could enhance the overall productivity of firms and then raise wages paid to all employees, including operational workers. Interestingly, when the dependent variable is total wage compensation, the coefficient associated with SI turns out to be positive and statistically significant (Column 1.3). This indicates that in general non-operational workers receive higher wages. Firms hiring more non-operational workers tend to have higher average wage compensation.

We found that both export-oriented and foreign-owned firms paid higher wages to their operational workers as opposed to domestic-oriented and indigenous operations, all other things being equal. This

**Table 5: Explanations of inter-plant wage differences: Pooled OLS estimates**

| Regressors | (1.1) | (1.2) | (1.3) |
|---|---|---|---|
| Foreign worker dependence | −0.0938*** | −0.1670*** | −0.1684*** |
| (IMD_dum) | (0.0294) | (0.0261) | (0.0259) |
| Labor productivity | 0.2547*** | 0.2576*** | 0.2576*** |
| (lLP) | (0.0021) | (0.0019) | (0.0019) |
| Capital intensity | 0.039*** | 0.0345*** | 0.0342*** |
| (lKI) | (0.0015) | (0.0015) | (0.0014) |
| Skill intensity | −1.016*** | −1.312*** | 0.2435*** |
| (SI) | (0.0533) | (0.0489) | (0.0485) |
| Skill intensity×firm size | 0.1452*** | 0.2574*** | 0.2411*** |
| (SI_SIZE) | (0.0130) | (0.0122) | (0.0121) |
| Industry concentration | 0.1221*** | 0.0140 | 0.0161 |
| (CR) | (0.0289) | (0.0268) | (0.0266) |
| Foreign ownership | 0.0813*** | 0.0493*** | 0.0802*** |
| (FOS) | (0.0111) | (0.0101) | (0.0100) |
| Market orientation | 0.2151*** | 0.1698*** | 0.1953*** |
| (MKT) | (0.0085) | (0.0076) | (0.0075) |
| Time_2006 | −0.0414*** | −0.0414*** | −0.0409*** |
| | (0.0094) | (0.0094) | (0.0094) |
| Time_2011 | −0.1259*** | −0.1259*** | −0.1747*** |
| | (0.0084) | (0.0084) | (0.0084) |
| IMD_dum×time_2006 | 0.1881*** | 0.2082*** | 0.2205*** |
| | (0.0307) | (0.0283) | (0.0281) |
| IMD_dum×time_2011 | −0.2004*** | −0.0267 | −0.0247 |
| | (0.0272) | (0.0253) | (0.0251) |
| Constant | 7.165*** | 7.338*** | 6.910*** |
| | (0.0366) | (0.0334) | (0.0334) |
| Observations | 57,313 | 53,789 | 53,789 |
| R-squared | 0.442 | 0.483 | 0.581 |

Source: Author's estimate from IC and SES databases, 1997–2012. Dependent variables are logged real wages, lORW reported in column (1) and (2), while lTRW reported in column (3). Robust standard errors adjustment in parentheses, with ***p<0.01, **p<0.05, *p<0.1. IC: Industrial census, SES: Socioeconomic survey

is especially true for market orientation. The finding is consistent with the major finding in the firm heterogeneity literature wherein exporting firms tend to post higher productivity to cover the fixed costs incurred by them as well as to be able to survive in the more intense competition extant in the world market. Hence, wages paid to operational workers are higher than those paid by domestic-oriented firms. In addition, firms in Thai manufacturing are undergoing consolidation processes, as documented in Kohpaiboon and Jongwanich (2016) whereby exporting firms are expanding in size, whereas domestic-oriented become smaller, many of which are facing exiting the market. Such consolidation works on top of the tightening labor market. Kohpaiboon and Sri-udomkajorn (2017), drawing from Thai garment firms, also found that the latter is severely struggling to maintain both native and foreign workers in their employment. All in all, survival export-oriented firms pay higher wages to maintain their operations. One (e.g., Athukorala, P., Devadason, 2012) might argue that exporting companies might be facing tougher competition and this might put pressure on wages paid to operational workers. However, our findings suggest that such a negative effect is overshadowed by countermanding positive

**Table 6: Correlation matrix, plant level**

| | lTRW | lORW | IMD_dum | lRO | lKI | SI | CR | FOS | MKT | VIF |
|---|---|---|---|---|---|---|---|---|---|---|
| lORW | 1.00 | | | | | | | | | |
| lTRW | 0.94 | 1.00 | | | | | | | | |
| IMD_dum | −0.21 | −0.25 | 1.00 | | | | | | | 5.69 |
| lLP | 0.58 | 0.62 | −0.16 | 1.00 | | | | | | 1.57 |
| lKI | 0.33 | 0.30 | −0.17 | 0.41 | 1.00 | | | | | 1.48 |
| SI | 0.14 | 0.41 | −0.21 | 0.27 | 0.01 | 1.00 | | | | 8.77 |
| CR | 0.02 | 0.03 | −0.18 | 0.04 | 0.07 | 0.04 | 1.00 | | | 5.45 |
| FOS | 0.20 | 0.25 | −0.12 | 0.16 | 0.09 | 0.18 | 0.05 | 1.00 | | 1.34 |
| MKT | 0.25 | 0.31 | −0.12 | 0.19 | 0.05 | 0.20 | 0.02 | 0.44 | 1.00 | 1.51 |

Source: Author's tabulation from IC and SES database. IC: Industrial census, SES: Socioeconomic survey

effects, as previously discussed.

A rather similar argument is applicable for foreign-owned firms. Hence, the coefficient corresponding to FOS is positive and significant. Nonetheless, the magnitude of estimated coefficients is much smaller than that of MKT. This finding is not counter-intuitive when we consider the fact that Thailand has always welcomed foreign direct investors since the 1960s. The need for these direct investors to post higher productivity to compensate any disadvantage they might face compared to indigenous operations becomes less and less. Hence, the wage gap between these two types of firms was not expected to be huge by the mid-1990s onward. There is no statistical support for the possible effect of producer concentration on wages in Thai manufacturing. In particular, the coefficient turns out to be statistically insignificant.

With respect to the effect of foreign workers on operational wage, the main interest in this study, the figure is found to be negative and statistically significant at the 1% level of significance. Interestingly, coefficients of interaction terms with the 2006 time dummy turn out to be positive and different from zero statistically significant at the conventional level. The coefficient with the 2011 time dummy is not different from zero, significantly. Our interpretation is that while in theory, the presence of foreign workers could have a negative effect on domestic wages and operational workers' wage compensation; in particular, this was true in 1996 when a number of unskilled foreign workers from neighboring countries began entering Thailand. As the labor market in Thailand becomes more and more constricted and the need for foreign workers soar to fill in jobs shunned by the native workers, the negative effect tends to lessen. The effect on wages turned out to be positive in 2006 as the coefficient associated with the interaction term was larger than that associated with the foreign worker dummy. The net positive effect is not found in 2011. Such a finding is a bit surprising. This might be due to the flooding and its effect on data collection.

This is similar to the key finding in empirical studies such as Kohpaiboon et al. (2012), Kohpaiboon and Jongwanich (2016), and Kohpaiboon and Sri-udomkajorn (2017) based on firm survey analysis. In an example in the context of the garment industry, firm owners agreed to the fact that they had to hire foreign workers instead of Thai workers because this kind of work was not popular among Thai workers compared to other alternatives, and the problem of labor shortage was not as a consequence of wage differences. From the interview, they confirmed that they could pay workers slightly more than market rate (excluding overtime payments), but they were still unable to attract Thai workers.

There are two reasons supporting that the negative impact of foreign workers on wage is limited. First, the market for foreign workers in Thailand right now is very competitive. The movement of foreign workers among firms is determined by the difference among overtime payment rates. Second, firms hiring foreign workers are still improving their process upgrading and maintaining their productivity levels.

Two robustness checks are performed in this study. First, as the variable related to the presence of foreign workers is the main interest in this study, an alternative measure is used. As information about foreign workers in a given industry is available in SES 2011, hence, the actual ratio of foreign workers (IMD_N2) employed to total workers in a given industry is used and applied to IC 2012. The result is reported in Table 7. Interestingly, we found a positive effect of foreign workers on operational wages, and this was statistically significant at the 1% benchmark (Column 2.1). Note that the endogeneity problem is accounted for here using the lag term of the actual ratio of foreign workers (IMD_N2l) as an instrumental variable (Column 2.2). The positive effect is sharpened when we correct the endogeneity bias. Besides, the rest of the controlling variables are not different from each other. Column 2.3 and 2.4 represent the effect of foreign workers on total wages in the same manner. We found that the positive effect is echoed in the case of total wages.

Second, we rerun wage equation using panel data at the industry level. That is, plant-level data for a given year are added to the industry level. All variables in each year (i.e., 1996, 2006, and 2011) are converted into real terms and then panelized. The results are reported in Table 8. Note that the main difference in the model between plant- and industry-level analyses is the interaction term between SI and plant size. The interaction term in the plant-level analysis is introduced to capture the role of plant size, conditioning the effect of SI on wages. As an industry-level analysis is the average figure of plant-level data, such an interaction term becomes irrelevant. Hence, it is dropped from the industry-level analysis.

Columns 3.1 and 3.6 in Table 8 report the estimation results where dependent variables are operational and total wage rates, respectively. There are three estimation methods used in this industry-level analysis. First, the Generalized Least Squared estimates are reported in Columns 3.1 and 3.3. Second, the FE estimates are presented in Columns 3.2 and 3.4. Third, the random effect estimates are given in Columns 3.3 and 3.6. In addition, Table 9 summarizes the replication of Table 8, but the results are not subject to time trends and interaction terms.

**Table 7: Explanations of inter-plant wage differences: OLS and 2 SLS estimates**

| Regressors | (2.1) | (2.2) | (2.3) | (2.4) |
|---|---|---|---|---|
| Foreign worker dependence | 0.208*** | 1.690*** | 0.221*** | 1.793*** |
| (IMD_N2) | (0.0574) | (0.466) | (0.0567) | (0.461) |
| Labor productivity | 0.266*** | 0.262*** | 0.265*** | 0.261*** |
| (lLP) | (0.00263) | (0.00285) | (0.00258) | (0.00280) |
| Capital intensity | 0.0569*** | 0.0594*** | 0.0569*** | 0.0595*** |
| (lKI) | (0.00220) | (0.00234) | (0.00216) | (0.00230) |
| Skill intensity | −0.397*** | −0.391*** | 1.267*** | 1.274*** |
| (SI) | (0.0396) | (0.0395) | (0.0314) | (0.0315) |
| Skill intensity×firm size | 0.000274 | 0.000258 | 0.000313* | 0.000295* |
| (SI_SIZE) | (0.000195) | (0.000183) | (0.000186) | (0.000173) |
| Industry concentration | 0.0410* | 0.0368* | 0.0386* | 0.0342* |
| (CR) | (0.0210) | (0.0209) | (0.0207) | (0.0206) |
| Foreign ownership | 0.0559*** | 0.0579*** | 0.0772*** | 0.0793*** |
| (FOS_1) | (0.0171) | (0.0174) | (0.0166) | (0.0168) |
| Market orientation | 0.310*** | 0.313*** | 0.317*** | 0.320*** |
| (MKT_1) | (0.0120) | (0.0121) | (0.0116) | (0.0116) |
| Constant | 6.671*** | 6.640*** | 6.678*** | 6.645*** |
| | (0.0330) | (0.0360) | (0.0328) | (0.0357) |
| Observations | 36,483 | 36,483 | 36,483 | 36,483 |
| R-squared | 0.479 | 0.468 | 0.538 | 0.528 |

Source: Author's estimate from 2012 IC and SES databases. lORW is reported in column (2.1)-(2.2), while lTRW is reported in column (2.3)-(2.4). First, columns (2.1) and (2.3) represent the actual foreign worker dependency IMD_N2. Second, columns (2.2) and (2.4) represent the lagged foreign worker dependency $IMD\_N2_{i-1}$ in instrumental variable estimations

**Table 8: Explanations of inter-industry wage differences: Panel estimates**

| Regressors | Operational wages | | | Total wages | | |
|---|---|---|---|---|---|---|
| | GLS (3.1) | FE (3.2) | RE (3.3) | GLS (3.4) | FE (3.5) | RE (3.6) |
| Foreign worker dependence | −0.269*** | −0.362*** | −0.270*** | −0.178*** | −0.309*** | −0.185*** |
| (IMD_dum) | (0.0207) | (0.103) | (0.0355) | (0.0360) | (0.0997) | (0.0383) |
| Labor productivity | 0.0886*** | 0.0825** | 0.0870*** | 0.0569*** | 0.0555 | 0.0750*** |
| (lLP) | (0.0112) | (0.0378) | (0.0210) | (0.0116) | (0.0369) | (0.0208) |
| Capital intensity | 0.0224** | 0.0645** | 0.0372** | 0.0263** | 0.0577* | 0.0363** |
| (lKI) | (0.0114) | (0.0319) | (0.0184) | (0.0107) | (0.0304) | (0.0182) |
| Skill intensity | −0.408*** | −0.469* | −0.301 | 1.773*** | 1.651*** | 1.686*** |
| (SI) | (0.131) | (0.270) | (0.195) | (0.137) | (0.356) | (0.171) |
| Industry concentration | 0.0758** | 0.0964 | 0.103 | 0.174*** | 0.188 | 0.136** |
| (CR) | (0.0362) | (0.175) | (0.0687) | (0.0293) | (0.160) | (0.0648) |
| Foreign ownership | 0.00861*** | 0.00607** | 0.00775*** | 0.00705*** | 0.00595** | 0.00673*** |
| (FOS_1) | (0.000719) | (0.00271) | (0.00145) | (0.000649) | (0.00267) | (0.00121) |
| Market orientation | −0.00462*** | −0.00485*** | −0.00343*** | −0.00286*** | −0.00375** | −0.0026*** |
| (MKT_1) | (0.000509) | (0.00161) | (0.00121) | (0.000487) | (0.00146) | (0.000946) |
| Time_2006 | 0.00164 | −0.00248 | 0.00807 | −0.0803*** | −0.0803 | −0.0851** |
| | (0.0233) | (0.0654) | (0.0430) | (0.0220) | (0.0584) | (0.0397) |
| Time_2011 | 0.0662** | −0.0254 | 0.0666 | 0.0937*** | 0.0208 | 0.0510 |
| | (0.0285) | (0.0832) | (0.0533) | (0.0247) | (0.0727) | (0.0483) |
| Regressors | GLS (3.1) | FE (3.2) | RE (3.3) | GLS (3.4) | FE (3.5) | RE (3.6) |
| IMD_dum×time_2006 | 0.118*** | 0.139 | 0.158* | 0.281*** | 0.277*** | 0.293*** |
| | (0.0295) | (0.0978) | (0.0836) | (0.0511) | (0.0589) | (0.0592) |
| IMD_dum×time_2011 | 0.0537* | 0.147* | 0.0708 | 0.223*** | 0.267*** | 0.228*** |
| | (0.0299) | (0.0792) | (0.0578) | (0.0452) | (0.0688) | (0.0502) |
| Constant | 10.12*** | 9.683*** | 9.876*** | 10.37*** | 10.01*** | 10.03*** |
| | (0.149) | (0.477) | (0.226) | (0.152) | (0.474) | (0.238) |
| R−squared | - | 0.232 | 0.328 | - | 0.257 | 0.438 |
| Observations | 316 | 316 | 316 | 316 | 316 | 316 |
| Number of Industries | 112 | 112 | 112 | 112 | 112 | 112 |

In general, the key finding is consistent with the plant-level data analysis. All key variables such as LP, KI, SI, and concentration reach similar signs as in the plant-level except for differences in the level of statistical significance. The coefficient corresponding to IMD_dum turns out to be negative, but smaller than that associated with the interaction term between IMD_dum and Time_2006. Nonetheless, both coefficients are not statistically different from each other at the 5% level[5]. Similarly, the coefficient associated with Time_2011, despite being smaller in magnitude (0.223), is not different from that of IMD_dum significantly[6]. All in all, this indicates the limited effect of foreign workers on domestic wages.

The negative coefficient corresponding to MKT seems to be in contradiction with results found in the plant-level analysis. In fact, it is not. Such a negative coefficient must be interpreted with care. As echoed in the firm heterogeneity literature, the more the industry is integrated into the global economy, the larger the difference in firm productivity is observed. Hence, wage compensation paid by exporting firms tends to be larger than non-exporting operations, reflected in the results from the plant-level analysis. When an industry-level analysis is concerned, the wages paid between both groups of firms within a given industry must be averaged, using the number of plants as a weight. The larger value of MKT implies there are more firms exporting and the pressure to widen wage differences between these two groups is greater. Therefore, in an industry with higher MKT, the observed weighted average of wages tends to be lower, as opposed to that with lower MKT (see more elaboration in Appendix C).

## 6. Concluding Remarks

While the number of foreign and unskilled workers from this country's neighbors has continued to grow over the past decade, importing such workers remains controversial at the policymaking level with fears concerning possible adverse effects. One such prospective adverse effect lies in the perceived retarding effect on productivity and, subsequently, the pressure on wages paid to local workers. While policies governing these workers were changed toward managing them to serve domestic needs, a new policy known as the Decree on the Management of Foreign Workers Act 2017 was introduced on June 29, 2017 with hefty fines which could cause policy uncertainty. The lofty fees imposed on firms hiring illegal workers might signal a policy reversal. All in all, the effects of foreign workers remain controversial and at the center of policy circles in Thailand.

Against this backdrop, the current study undertakes a systematic analysis of their effect on Thai manufacturing wages. The effect on wages occupies the study focus simply because it represents the main economic consequence as well as being measurable. The other possible effects, such as sanitary, pandemic, social problems, and so on are on a par in importance, but measuring such effects is very difficult and cannot be performed given the time and resources available to conduct the research enabling this study. As the issue is controversial, various quantitative methods are used to mitigate any bias emerging from choices of methodology. Two approaches, simulation experiment and econometric analysis, are employed in a complementary manner. The former classification of the empirical equation is widely supported by conventional theory concerning the demand for workers from firms. Annual LFS from 1983 to 2013 are used. The latter classification concerns econometric analysis estimating (equilibrium) wage equations in which explanatory variables are nested in an eclectic fashion and policy-relevant variables, such as the relative importance of foreign workers, are included. The three available IC, i.e., 1997, 2007, and 2012 are all utilized.

From the beginning of the new millennium, Thai manufacturing has gained in relative importance as a destination of foreign worker inflows, dominated by unskilled labor from CLM countries. They are

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5 The Chi-square statistic under the hypothesis (Null Hypothesis is the coefficient associated with 2006 year interaction equals to that with IMD_dum; the alternative hypothesis is otherwise) is 0.09 and 0.03 for total and operation wage cases, respectively.

6 The Chi-square statistic under the hypothesis (Null Hypothesis is the coefficient associated with 2011 year interaction equals to that with IMD_dum; the alternative hypothesis is otherwise) is 0.13 and 0.25, for total and operation wage cases, respectively.

**Table 9: Explanations of inter-industry wage differences: Panel estimates without time trends and interaction terms**

| Regressors | Operational wages | | | Total wages | | |
|---|---|---|---|---|---|---|
| | GLS (4.1) | FE (4.2) | RE (4.3) | GLS (4.4) | FE (4.5) | RE (4.6) |
| Foreign worker dependence | −0.121*** | −0.172** | −0.0884** | −0.0527** | −0.0573 | −0.0283 |
| (IMD_dum) | (0.0228) | (0.0708) | (0.0365) | (0.0248) | (0.0825) | (0.0425) |
| Labor productivity | 0.0926*** | 0.0792*** | 0.0920*** | 0.0540*** | 0.0342 | 0.0625*** |
| (lLP) | (0.00945) | (0.0264) | (0.0179) | (0.0119) | (0.0290) | (0.0187) |
| Capital intensity | 0.0304*** | 0.0573** | 0.0445*** | 0.0682*** | 0.0895*** | 0.0646*** |
| (lKI) | (0.0100) | (0.0225) | (0.0154) | (0.00986) | (0.0218) | (0.0169) |
| Skill intensity | −0.608*** | −0.411 | −0.461*** | 1.375*** | 1.328*** | 1.390*** |
| (SI) | (0.0992) | (0.261) | (0.165) | (0.126) | (0.291) | (0.153) |
| Industry concentration | 0.0499 | 0.0980 | 0.0929 | 0.186*** | 0.272** | 0.160** |
| (CR) | (0.0388) | (0.137) | (0.0656) | (0.0280) | (0.127) | (0.0634) |
| Foreign ownership | 0.00842*** | 0.00609** | 0.00743*** | 0.00572*** | 0.00631** | 0.00638*** |
| (FOS_1) | (0.000804) | (0.00255) | (0.00142) | (0.000853) | (0.00263) | (0.00122) |
| Market orientation | −0.00505*** | −0.00471*** | −0.00390*** | −0.00273*** | −0.00395** | −0.00269*** |
| (MKT_1) | (0.000554) | (0.00140) | (0.00109) | (0.000614) | (0.00153) | (0.000910) |
| Constant | 10.04*** | 9.804*** | 9.778*** | 9.902*** | 9.828*** | 9.822*** |
| | (0.135) | (0.379) | (0.220) | (0.141) | (0.387) | (0.226) |
| R−squared | - | 0.228 | 0.214 | - | 0.228 | 0.211 |
| Observations | 299 | 299 | 299 | 296 | 296 | 296 |
| Number of Industries | 112 | 112 | 112 | 111 | 111 | 111 |

Source: Author’s estimate from IC and SES databases, 19972012. IC: Industrial census, SES: Socio-economic survey concentrated in labor-intensive industries, such as food, textiles, and garment industries, reflecting the hypothesis of 3D jobs found in Thailand's labor market. In particular, foreign workers are imported to fill jobs shunned by locals. Hence, the effect on wages of these workers is limited. This is supported by our quantitative analysis. The simulation experiment suggests that the entry of foreign workers causes depressing pressure on wages only affecting low-skilled Thai workers. Interestingly, the effect turns out to be positive with respect to other types of workers and higher-skilled labor in particular. This finding is consistent with Lathapipat (2014). In our econometric analysis, we find the significant negative impact of foreign worker dependency on real manufacturing wages, both in total and operational remuneration. However, the negative impacts have decreased overtime.

### 6.1. Policy implications

1. The complementary relationship revealed between foreign and local workers is in favor of facilitating foreign workers, instead of restricting/preventing their employment. In particular, these workers are employed in labor-intensive industries where associated jobs are shunned by locals. While this seems in line with overall policy changes since the new millennium, the recent changes are worrisome. When importing foreign workers are the result of a mutual benefit accrued between firms in labor-importing countries and workers in exporting countries, hefty fees could do more harm than good. They could, in turn, encourage such foreign workers to seek illegal employment resulting in various undesirable social consequences, including corruption and human rights violations. This also causes uncertainty that could jeopardize the overall investment climate unnecessarily.
2. A complementary policy to managing the flows of foreign workers is to facilitate local workers at the lowest end of education background levels to rise to higher levels. Facilitating these workers could improve their chance of gaining higher education, as well as lowering the cost of secondary and educational opportunities.
3. Another key policy implication is in favor of the global integration of firms. This is supported by the finding that the higher wages are paid by exporting and/or raw materials importing firms. The higher wages reflect the higher productivity levels in these firms. Thus, to mitigate any adverse effect of hiring foreign workers, policy measures encouraging firms to become globally integrated are recommended, including further trade liberalization, improving cumbersome customs procedures, as well as improving exporting-related activities.

### 6.2. Limitations of the study

The main shortcoming of this study lies in the data availability issue. In particular, data concerning how firms hire foreign workers do not exist for many years, although the number of foreign workers grew at a remarkable rate. In this study, a proxy of actual data is utilized so that the found estimation outcome could represent the best approximation. These points to the room for improvement for future projects.

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# Appendix

## Appendix A

Modified theoretical framework

Consider a Cobb-Douglas aggregate production function with constant returns to scale technology:

$$Y_t = A_t L_t^{\alpha} K_t^{1-\alpha} \tag{A.1}$$

Where $Y_t$ is aggregate output, $A_t$ is total factor productivity, $K_t$ is capital, $L_t$ is the Constant Elasticity of Substitution (CES) aggregate of different types of labor in year t, and α is the income share of labor.The labor aggregate $L_t$ is defined as:

$$Lt = \left[ \theta_{Lt} L_{Lt}^{\frac{\sigma HL-1}{\sigma HL}} + \theta_{Ht} L_{Ht}^{\frac{\sigma HL-1}{\sigma HL}} \right]^{\frac{\sigma HL-1}{\sigma HL}} \tag{A.2}$$

Where $L_{Lt}$ and $L_{Ht}$ are aggregate measures of labor with low (L) and high (H) education level observed in time t, respectively. The θ's used throughout are relative productivity levels specific to the particular skill groups - indexed by subscripts - within the same CES nest. The parameter $\sigma_{HL}$ is the elasticity of substitution between the two broad schooling groups. These two groups, low (L) and high (H), are in turn CES aggregates of detailed schooling groups of primary (PR), high school (HS), technical and vocational education and training (TVET), and college (CO) labor as follows:

$$L_{Lt} = \left[ \theta_{PRt} L_{PRt}^{\frac{\sigma_{LL}-1}{\sigma_{LL}}} + \theta_{HSt} L_{HSt}^{\frac{\sigma_{LL}-1}{\sigma_{LL}}} \right]^{\frac{\sigma_{LL}}{\sigma_{LL}-1}} \tag{A.3}$$

$$L_{Ht} = \left[ \theta_{TVETt} L_{TVETt}^{\frac{\sigma_{HH}-1}{\sigma_{HH}}} + \theta_{COt} L_{COt}^{\frac{\sigma_{HH}-1}{\sigma_{HH}}} \right]^{\frac{\sigma_{HH}}{\sigma_{HH}-1}}$$

Where the parameters $\sigma_{bb}$'s are the elasticity of substitution parameters between education subgroups within a broad schooling group b, where bÎ{L,H} .

A detailed education group kϵ {PR,HS,TVET,CO} further nests labor groups with different experience levels. In the spirit of Card and Lemieux (2001), this specification allows us to explore the possibility that similarly, educated workers in different experience groups are imperfect substitutes in production. Specifically:

$$L_{kt} = \left[ \sum_{j=1}^{4} \theta_{kj} L_{kjt}^{\frac{\sigma_J-1}{\sigma_J}} \right]^{\frac{\sigma_J}{\sigma_J-1}} \tag{A.4}$$

Where $\sigma_J$ is the elasticity of substitution between workers with different experience levels within the same detailed education subgroup, and the subscript j indexes the experience group. In this study, we separate workers into four experience levels. That is, workers with 0–10 years, 11–20 years, 21–30 years, and 31 or more years of experience are allocated to groups j=1,2,3, and 4, respectively. Note that we assume that the experience-education specific relative efficiency parameters, $\theta_{kj}$'s, are constant across time.

Finally, the $L_{kjt}$'s are CES aggregates of supplies of native ($N_{kjt}$) and migrant ($M_{kjt}$) workers within the same k and j, education-experience cell at time t:

$$L_{kjt} = \left[ \theta_{Nkj} N_{kjt}^{\frac{\sigma_M - 1}{\sigma_M}} + \theta_{Mkj} M_{kjt}^{\frac{\sigma_M - 1}{\sigma_M}} \right]^{\frac{\sigma_M}{\sigma_M - 1}} \quad \text{(A.5)}$$

Where $\sigma_M$ is the elasticity of substitution between native and immigrant workers.

In a competitive market, profit maximization must hold the first-order condition that the price of inputs in real terms equals its marginal product. The case for native workers is shown below:

$$w_{Nbkjt} = \alpha A_t \kappa_t^{1-\alpha} \left( \frac{\partial L_t}{\partial L_{bt}} \right) \left( \frac{\partial L_{bt}}{\partial L_{kt}} \right) \left( \frac{\partial L_{kt}}{\partial L_{kjt}} \right) \left( \frac{\partial L_{kjt}}{\partial N_{kjt}} \right) \quad \text{(A.6)}$$

Where (k) is a capital-labor ratio. Then, take the logarithm and rearrange to obtain:

$$\ln(w_{Nbkjt}) = \ln(\alpha A_t \kappa_t^{1-\alpha}) + \frac{1}{\sigma_{HL}} \ln(L_t) + \ln(\theta_{bt}) - \left( \frac{1}{\sigma_{HL}} - \frac{1}{\sigma_{bb}} \right) \ln(L_{bt}) +$$
$$\ln(\theta_{kt}) - \left( \frac{1}{\sigma_{bb}} - \frac{1}{\sigma_J} \right) \ln(L_{kt}) + \ln(\theta_{kj}) - \left( \frac{1}{\sigma_J} - \frac{1}{\sigma_M} \right) \ln(L_{kjt}) + \ln(\theta_{Nkj}) - \left( \frac{1}{\sigma_M} \right) \ln(N_{kjt}) \quad \text{(A.7)}$$

The case for immigrants is derived in the same manner:

$$\ln(w_{Mbkjt}) = \ln(\alpha A_t \kappa_t^{1-\alpha}) + \frac{1}{\sigma_{HL}} \ln(L_t) + \ln(\theta_{bt}) - \left( \frac{1}{\sigma_{HL}} - \frac{1}{\sigma_{bb}} \right) \ln(L_{bt}) +$$
$$\ln(\theta_{kt}) - \left( \frac{1}{\sigma_{bb}} - \frac{1}{\sigma_J} \right) \ln(L_{kt}) + \ln(\theta_{kj}) - \left( \frac{1}{\sigma_J} - \frac{1}{\sigma_M} \right) \ln(L_{kjt}) + \ln(\theta_{Mkj}) - \left( \frac{1}{\sigma_M} \right) \ln(M_{kjt}) \quad \text{(A.8)}$$

## Appendix B

Data constructed to generate foreign worker dependency in econometric-based model

So far, we have faced a severe problem concerning data scarcity. The data we lack to perform the analysis in Section 3.2 reflects foreign worker dependency in each plant/industry in 1996, 2006, and 2011. The 2011 SES data are employed to fill this gap.

The 2011 SES data basically does not provide the nationality of each worker, but we can use languages spoken in their families as a proxy of their nationalities. The languages that we use to specify foreign workers are Mon/Burmese and Cambodian/Soy. One advantage of using this SES data is that the total weighted number of foreign workers equals the total number from OFWA (about 1.6 million workers). Next, we aggregate the workers by industries using ISIC at the 4-digit level. This means that we eliminate all workers who are not working in the manufacturing sector. Again, the total weighted number of workers in the manufacturing sector equals the total number from IC (about 270 thousand workers). Up to this point, it is possible to merge two datasets together (IC and SES) to obtain a foreign worker dependency variable. This IMD_N2 is calculated from the number of foreign workers in a given industry divided by the total number of workers in that industry.

However, there is a problem from this merging process. The main issue when merging two data sources between IC and SES by 4-digit ISIC is that there exist some non-matching industries. There are two possible reasons for this event: (1) The SES data does not cover foreign workers in those absent industries, and (2) there are no foreign workers in those industries.

To overcome the first possibility, we find the average values of this variable using ISIC at the 3-digit level, and use them to fill in for the absent data. For the next possibility, we review the reserved jobs in detail and set the variable to be zero when those jobs are reserved only for Thai workers. The industries at the 4-digit level that match with reserved jobs are 1551–52, 1600, 2023, 2211–12, 2222, 2230, 2320, 2413, 2423-24, 2429, 2812–13, 2911–15, 2921–27, 2929–30, 3130, 3140, 3150, 3210, 3220, 3230, 3311–12, 3320, 3691-92, and 3710.

From the above construction, it is just available as an actual foreign worker dependency variable in 2011. Thus, we have to construct dummy variables IMD_dum, to deal with the other years of ICs. For the base case of this dummy, it is calculated using actual number IMD_N2. The dummy value is one when the actual number of IMD_N2 is greater than its mean. Step back to 2006; we modified the dummy in 2011 given the condition that IMD_N2 is greater than the summation of its mean and its one standard deviation, and two standard deviations for 1996.

## Appendix C

Elaboration on the market orientation variable

According to the inconsistent sign of the market orientation variable between plant and industry levels, it is indeed consistent if we interpret such findings with care. Let an average weighted wage in a given industry be a function of wages paid to exporting and non-exporting firms weighted by the total number of firms in that industry:

$$\overline{W} = \alpha W_1 + (1 - \alpha) W_2 \tag{C.1}$$

$\overline{W}$ =Weighted wage paid
$W_2$=Wage paid by non-exporting firms
$W_1$=Wage paid by exporting firms
$\alpha$=Share of exporting firms.

As echoed in the firm heterogeneity literature, the more the industry is integrated into the global economy, the larger the difference in firm productivity. Hence, wage compensation paid by exporting firms tends to be a function of wages paid by non-exporting firms with premiums, taking the formula as in Equation C.2:

$$W_1=(1+\epsilon(\alpha))W_2 \tag{C.2}$$

$\epsilon(\alpha)$=Wage premiums in exporting firms.

The assumptions here are that $\epsilon>0$ and $\partial\epsilon/\partial\alpha$ and, then we replace Equation C.2 in Equation C.1 above:

$$\begin{aligned}\overline{W} &= \alpha\left(1+\varepsilon(\alpha)\right)W_2 + (1-\alpha)W_2 \\ &= W_2 - \alpha\varepsilon(\alpha)W_2\end{aligned} \tag{C.3}$$

Next, we take a partial derivation with respect to the share of exporting firms ($\alpha$) to get the condition that explains the possibility of the negative sign:

$$\frac{\partial\overline{W}}{\partial\alpha} = -\left[\varepsilon(\alpha) + \alpha \, {}^{\partial\varepsilon}\!/\!_{\partial\alpha}\right] \tag{C.4}$$

The RHS of Equation C.4 is always negative, and this is consistent with our results.