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Labour Market Integration with the World: Case of Singapore

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Abstract

This study analyses the effects of labour market integration on the domestic economy. We explore the effects of skilled and unskilled foreign labour on the sustainability of a small open economy with innovation and growth. Welfare implications such as Gross Domestic Product growth and wage inequality are explicitly modelled in a general equilibrium framework. The model is applied to a small open economy such as Singapore to derive key policy implications to balance economic growth with skilled workers and innovation activities in the economy. The study critically examines the foreign workers' policy in the Singaporean economy in terms of allowing both skilled and unskilled workers into the domestic labour market. The results of the model indicate that balancing foreign skilled and unskilled labour, with the development of indigenous innovation capabilities, is crucial to maintain strong, sustainable growth in the domestic economy. The results of the model also indicate that a labour market policy that allows more skilled workers tends to increase the supply of labour and reduce the skilled wage gap in the economy.

JEL Classifications: E69, J61, O41
Keywords: Growth, Immigration, and Innovation

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I. Background

Labour market policy is increasingly becoming an important growth policy discussion in Asia in terms of developing key human capital and managing the flow of foreign workers, particularly for small open economies such as Singapore. For the past two decades, Singapore's economy is relying on foreign manpower to maintain competitiveness and economic growth in the economy. Foreign manpower is expected to fill the manpower shortage and maintain the cost competitiveness of the domestic firms in global trade. Foreign manpower, both skilled and unskilled, serves a dual purpose for the small open economy. Given that the Singaporean economy is transitioning to higher value-added activities, it faces a strong storage of skilled domestic workforce to maintain the viability of high-end value-added industries. Thus, skilled foreign workers are expected to augment domestic human capital and induce innovation activities in the domestic economy (Chander and Thangavelu 2005). This is expected to maintain competitiveness of local firms' exports of high-end products.

In contrast, the economy also attracts low-skilled foreign workers to manage the hollowing-out effects of multinationals as they restructure their production structure towards low-cost countries such as India and China. Since the 'hollowing-out' effects of multinationals could create structural unemployment of local workers in the economy due to the dislocation of the low-end production chain, the unskilled foreign workers are seen as one way to keep the cost of production down and manage the dislocation of multinationals in the domestic economy (Chia, Thangavelu, and Toh 2004).

Foreign workers have become an important component of the labour force in Singapore. While foreign workers are necessary to fill the manpower shortage and generate more economic activity, concerns have often been raised about whether the influx of foreign workers has depressing effects on the wages of local workers, particularly those of low-skilled workers.

However, the effects of migration on the equilibrium and dynamics of the labour market are quite complex given the characteristics of the migrants and current domestic economic structure of the economy. In the long-run, the impact on the long-term growth of foreign workers depends on their productivity and, hence, their skills and education. This will have a direct impact on innovation and technology adoption capability of domestic firms. Thus, the average human capital of foreign workers will have long-term implications for the Singaporean economy. In the short-run, inflow of foreign workers could resolve the cyclical fluctuations and short-term shortages of the labour market,

thereby maintaining the competitiveness of the labour market.

This paper studies the impact of foreign labour market policy and immigrants on the growth of the Singaporean economy by using a dynamic general equilibrium model. It is very interesting to examine as most countries only manage skilled workers, and unskilled workers are mostly restricted from entering the economy. In open economies such as Australia, Canada, and the United States, we only observe the targeted flow of skilled foreign workers into the domestic labour market. Second, foreign workers have become an increasingly important component of the labour force in Singapore as they are a large part of it. While foreign workers are necessary to fill the manpower shortage and generate more economic activity, concerns have often been raised about whether the influx of foreign workers has any impact on the sustainable and innovative development of economy. It will be interesting to examine the impact of foreign workers on the sustainable growth and innovation activities of the domestic economy. Lastly, Singapore's foreign manpower policy is applied in a targeted manner at certain innovation activities and industries such as pharmaceutical and chemical industries and non-innovation industries such as construction. Thus, Singapore's policy experience in calibrating the flow of foreign workers to sustain its economy will be an interesting policy case study on the impact of foreign manpower policy on sustainable economic growth.

The key question of this study examines is the labour market policy issue of balancing the appropriate level of skilled and unskilled foreign workers in the economy that will generate the maximum growth rate in the domestic economy. In this respect, this study accounts for the flow of skilled and unskilled foreign workers on (a) steady-state growth, (b) wage gap between the skilled and unskilled, and (c) innovation capabilities of the domestic economy. Further, the model also accounts for the contribution of immigrants to the welfare of the domestic economy through the immigration surplus that will accrue to the domestic economy. This study makes an important contribution to the impact of foreign manpower on innovation and inclusive growth which is mostly focused on developed Western countries. Further, this is the first study, to our knowledge, that carefully examines foreign manpower policy and the impact of foreign workers on growth and the wage gap of the Singaporean economy.

We adopt Drinkwater, Levine, Lotti, and Pearlman's three-sector general equilibrium model with endogenous growth (2007) and calibrate it to the Singaporean economy[1].

[1] The data on foreign workers are not publicly available in Singapore and, hence, adopting a dynamic general equilibrium model seems to be ideal to study the impact of foreign workers on the growth and innovation of the Singaporean economy.

The model constructs four major sectors in the Singaporean economy: (1) a labour-intensive service sector which is assumed to produce a homogenous good; (2) a capital-intensive manufacturing sector which produces differentiated goods with growing varieties; (3) an innovation sector, which is assumed to be the engine of growth of the economy that conducts the necessary research activities for new product development; and (4) a financial sector. All sectors employ three factor inputs, namely, the skilled workers, unskilled workers, and physical capital. Since there is no closed-form solution to our general model, we will adopt a numerical method and narrow down our analysis to the steady-state equilibrium. The results highlight that skilled foreign workers in the domestic economy is required to drive the innovation sector, which is the key driver of domestic economic growth. The study also highlights the need for a steady supply of foreign unskilled workers to manage the demand for the labour-intensive service sector. Our model also differs from Drinkwater, Levine, Lotti, and Pearlman's (DLLP) model as we explicitly study the impact of local and foreign skilled and unskilled labour on growth and innovation. Secondly, we modify the DLLP model by introducing a fourth sector as the innovation sector, compared to only the traditional and manufacturing sectors in the DLLP study. This clearly identifies multi-sectors in the growth process of the economy. Lastly, we carefully calibrate the model based on the foreign manpower policies of the Singaporean government to examine the impact of immigration policies on innovation and growth in the economy.

The paper is organised as follows. The next section provides an overview of the Singaporean economy. Section III provides the model for immigration. Section IV discusses immigration surplus and presents the results. The conclusions are discussed in Section V.

II. Macroeconomic Trends and Flow of Foreign Labour

Singapore has experienced one of the highest rates of economic growth in the world over the past three decades. The growth has in turn propelled Singapore's average real per capita income from 512 US dollars in 1965 to its current level of over 30,000 US dollars by 2015, surpassing many developed countries to become one of the highest in the world.

In recent years, the Singaporean economy is rebalancing to a lower growth rate due to

structural adjustments in the industrial sector as the economy shifts its activities towards the services sector. As seen in Table 1, the share of services sector has increased to nearly 70% of the GDP in 2015. The services sector is also becoming an important component of the overall GDP growth as the services sector grows at an average real rate of nearly 5.4% for the period from 2011 to 2015 as compared to the manufacturing sector's real growth rate of only 4.2%. The rebalancing of the industrial structure to more service activities also has affected productivity because the service sector tends to experience lower productivity growth than the manufacturing sector does(see Thangavelu, 2016). It is very clear that, within the Asian region, Singapore's labour productivity is very low and has declined significantly after the Asian financial crisis to less than 1% real growth rate from 1998 to 2010.

Table 1. Macroeconomic indicators

(1999~2014)

	1999	2000	2001	2002	2003	2005	2011	2013	2015
Real GDP (2000 market price & percent change)	7.2	10.0	-2.3	4.0	2.9	7.3	6.2	4.4	2.0
Manufacturing	13.6	15.3	-12.8	8.4	3.0	9.5	7.8	1.7	-5.2
Services	6.0	9.0	1.9	4.0	3.3	7.0	6.9	6.1	3.2
Construction	-8.8	-1.7	-1.2	-14.0	-9.0	-0.7	5.7	6.3	3.9
Share of Gross Value Added (percent)									
Manufacturing	23.1	26.8	23.7	25.8	26.3	25.7	19.4	26.6	20.0
Services	63.6	61.9	64.5	63.5	63.4	63.0	66.0	63.0	70.0
Construction	7.9	6.3	6.1	5.4	5.0	3.3	4.0	3.3	5.0
Others	5.1	5.0	5.7	5.3	5.3	7.1	11.0	12.0	5.0
Employment Share (percent)									
Manufacturing	20.3	20.5	19.8	19.8	19.7	20.5	14.6	14.1	11.1
Services	64.0	64.5	66.3	67.7	68.6	68.7	79.2	79.4	82.6
Construction	14.9	14.2	13.2	11.8	11.0	10.1	5.0	5.1	5.0
Others	0.8	0.8	0.7	0.7	0.7	0.7	1.0	1.3	1.0
Unemployment rate (average)	2.8	2.7	2.7	3.6	4.0	3.1	2.0	1.9	1.9

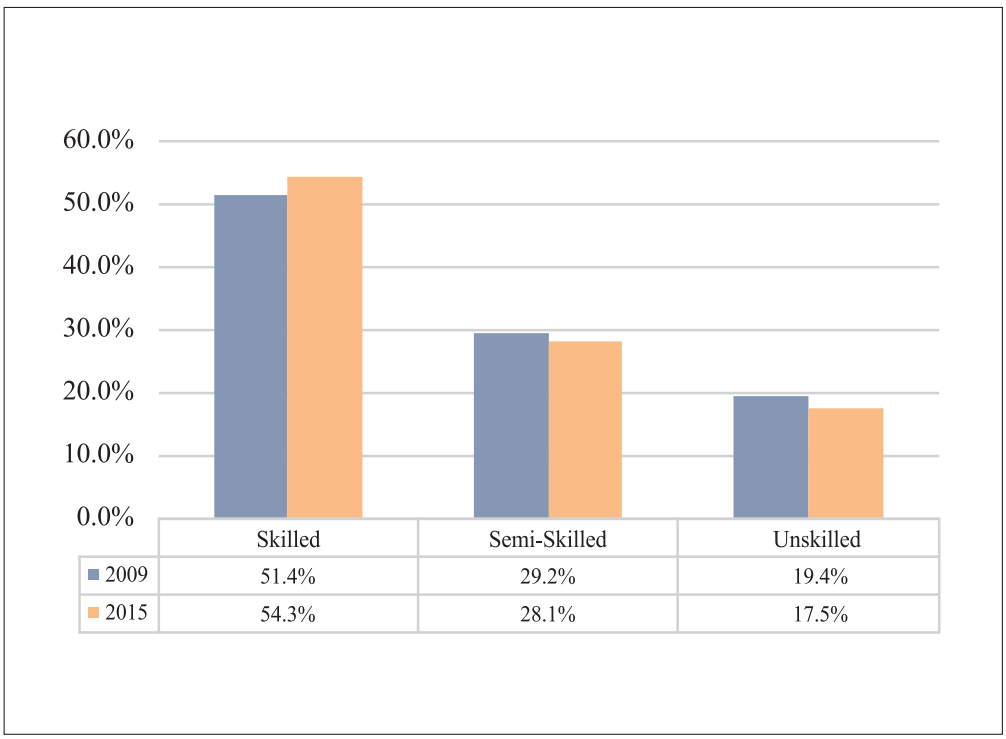
(Note) Real GDP is in 2000 base year and it given as percentage change over the years. The share of GDP to Gross Value Added is given as GDP to Gross Value Added (percent). The Employment Share is the sectoral employment to total employment. Services sector includes: Wholesale and Retail trade, Hotels and Restaurants, Transport and Communication, Financial Services, Business Services, other services.

(Source) Economic Survey of Singapore, MTI.

The share of skilled, semi-skilled, and unskilled workers in Singapore from 2009 to 2015 is given in Figure 1. Singapore has a very high share of skilled workers at nearly 54.3% of the total labour force. However, unskilled workers still account for nearly 18% of the total labour force and nearly 45% of the labour force is semi-skilled or less in the labour market.

Figure 1. Share of skilled, semi-skilled and unskilled workers in Singapore

(2009~ 2015)



	Skilled	Semi-Skilled	Unskilled
2009	51.4%	29.2%	19.4%
2015	54.3%	28.1%	17.5%

(Note) Occupational classifications are used to define the skills of workers. (a) Legislators, Senior Officials and Managers; Professionals; Associate Professionals and Technical workers are defined as Skilled workers; (b) Clerical and Service and Sales and Craftsman and related Trade workers are defined as semi-skilled workers; (c) Plant and Machine Operators and Assemblers; Cleaners and other related workers are defined as unskilled workers.

(Source) Ministry of Manpower, Singapore, various years

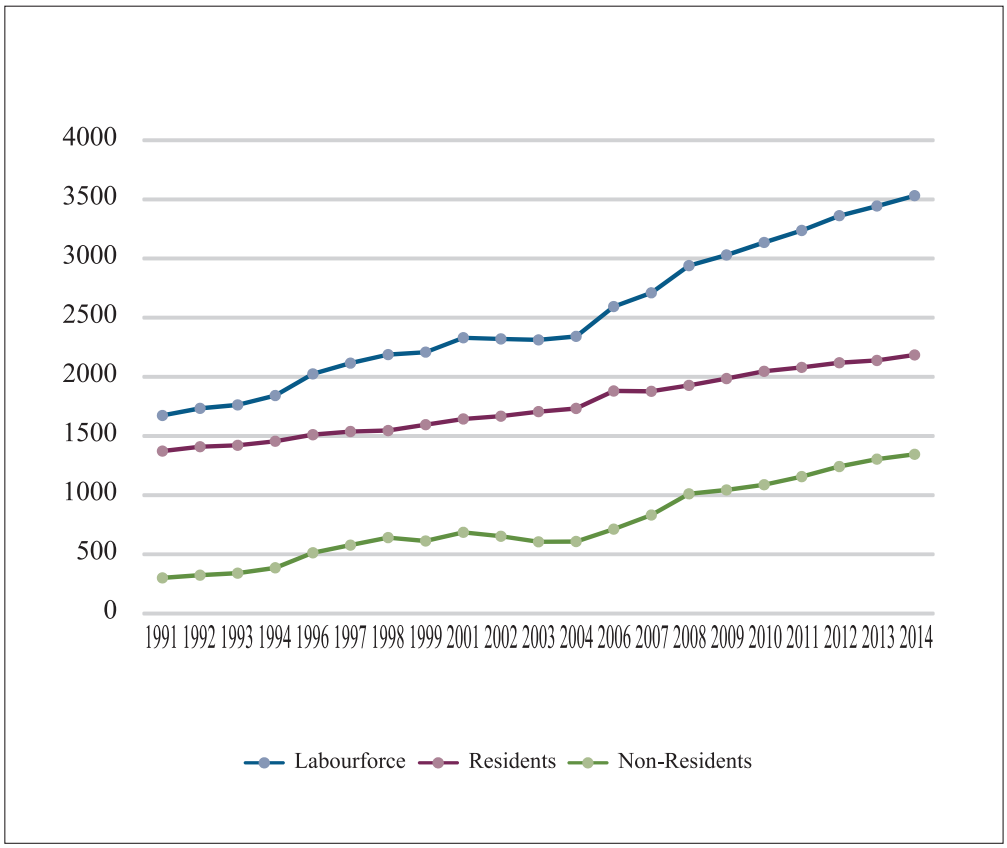
A. Employment trends of resident and non-resident labour force

For the past three decades, Singapore's economy has averaged about 8 to 9% GDP growth while experiencing a tight labour market and full employment. This necessitated the importation of foreign workers to ease the tightness in the labour market and help to smooth the transition in the structural changes in the economy. This is more evident in recent years as the external environment exerts strong pressures on the Singaporean economy to structurally adjust towards a knowledge-based economy. Given the lack of local human capital to support these strong pressures, the foreign labour force becomes an important component to augment domestic human capital and ease the transition towards a knowledge-based economy (see Tan *et al.,* 2003). The impact of immigrants not only supports the labour market but also augments the declining fertility rate and aging population in Singapore's economy (Hui and Hashmi, 2004). The effects of the immigrant employment in the labour market is given in Figure 2. The immigrant employment is also showing an upward trend since 1992 (Figure 2). In 1992, resident employment accounted for nearly 79% of the total employment and non-residents were only around 20% share of total employment. By 2008, the share of non-residents increased to nearly 36% of the total employment (see also Labour Market 2008, MRSD, MOM). In 2014, the share of non-resident labour force accounts for nearly 38% of the total labour force in Singapore.

The non-resident employment is showing greater dynamics in the labour market as compared to the resident employment in the Singaporean economy, growing at an annual rate of nearly 7.9% in the period from 1992 to 2008. In contrast, the resident employment grew by only an average annual rate of 2.7% in the same period, highlighting the labour constraints in the small open economy. In fact, there was greater inflow of permanent immigrants into the economy in terms of permanent residents to augment the residents, as Singapore's population growth rate is constrained by a falling fertility rate. From 1997 to 2006, total employment of permanent residents grew at the rate of 8.4% compared to 1.5% for Singaporean citizens (see Employment of Singapore Citizens, Permanent Residents and Foreigners 1997~2006, MRSD, MOM). However, since 2008, both the resident and non-resident labour force is slowing down due to government policy to moderate the flow of foreign workers into the economy. The non-resident labour force is still growing at an average rate of 4.9% compared to the slower rate of 2.1% for the period 2008~2014. This clearly indicates that the economy still relies on foreign workers to drive the industrial activities in the domestic economy.

Figure 2. Total labour force in Singapore

(Thousand of people, 1991~2014)



(Note) Labour force is given as the population actively looking for employment in the labour market. The Residents is the resident labour force that includes citizens and permanent residents actively looking for employment in the labour market. Non-Residents is the non-resident labour force that includes foreign workers on short-term and long-term employment visa actively looking employment in the labour market.

(Source) Ministry of Manpower, Singapore website. 2015.

Table 2. Foreign employment working visa pass types in Singapore

(2010~2015)

Pass Type	Dec 2010	Dec 2011	Dec 2012	Dec 2013	Dec 2014	June 2015
Total Foreign Workforce	**1,113,200**	**1,197,900**	**1,268,300**	**1,321,600**	**1,355,700**	**1,368,200**
Employment Pass (EP)	12.9%	14.6%	13.7%	13.2%	13.2%	13.2%
S Pass	8.9%	9.5%	11.2%	12.2%	12.5%	12.7%
Work Permit (Total)	77.7%	75.2%	74.3%	73.7%	73.1%	72.6%
- Work Permit (Foreign Domestic Worker)	18.1%	17.2%	16.5%	16.2%	16.4%	16.6%
- Work Permit (Construction)	22.3%	22.1%	23.1%	24.1%	23.8%	23.6%
Work Permit (Without Foreign Domestic Worker and construction)	37.4%	35.9%	34.7%	33.4%	32.9%	32.5%
Other Work Passes[2]	0.5%	0.6%	0.7%	0.9%	1.1%	1.4%

(Source) Singapore Ministry of Manpower, 2015

The share of various types of foreign workers in Singapore by employment pass types are given in Table 2. The share of skilled workers (employment pass types) only account for about 13% in the period from 2010 to 2015. The semi-skilled workers (s-pass types) account for nearly 11% in the same period. The majority of the foreign workers are still in the unskilled category of work-permit employment types that accounts for nearly 74% (including foreign domestic workers and workers in construction). It accounts for nearly 34% excluding the foreign domestic workers and workers in the construction sector. This clearly indicates that Singapore's economy relies on unskilled workers as much as on skilled workers to drive the domestic economy. An interesting policy question is the balance between domestic and foreign workers and balance between the skilled and unskilled foreign workers to maintain the long-term growth of the domestic economy. Given the lack of data, this study adopts a general equilibrium model calibrated to the Singaporean economy.

III. The Model

The welfare-based immigration surplus is defined as an increase in income of the native population in the host country as a result of immigration due to lower cost of labour, increase in capital investments, and overall productivity improvements from skilled immigrants (Borjas 1995). The study by Borjas (1995) shows that after a 10% increase in the workforce from immigrant workers, the GDP of the US economy increased by nearly 0.105%. He also highlights that the immigration of skilled workers will generate a higher immigration surplus due to the complementarity of skilled labour and capital investments.

DLLP (2007) revisited Borjas' model by calibrating a three-sector general equilibrium model with endogenous growth to the European Union economies, and redefined immigration surplus in terms of the increase in welfare levels among the natives in the post-immigration era. These studies conclude that unskilled immigration has a negative impact on the size of the immigration surplus, lending support to immigration policies favouring skilled immigrants. Skilled immigrants tend to increase the long-term growth by stimulating more skill-intensive R&D activities in the innovation sector. There are gains in growth and the immigration surplus increases further when there is complementarity between skilled workers and physical capital.

In this study, we extend the DLLP (2007) to a four-sector model and calibrate it to the Singaporean economy. This study models four key sectors in the Singaporean economy: a labour-intensive service sector which is assumed to produce a homogenous good; a capital-intensive manufacturing sector which produces differentiated goods with growing varieties; an innovation sector, which is assumed to be the engine of growth of the economy that conducts the necessary research activities for new product development; and a financial sector. Since there is no closed-form solution to our general model, we will adopt a numerical method and narrow down our scope to the steady-state analysis. In our discussion, we briefly provide an overview of the DLLP model as the full model is available at DLLP (2007).

A. Framework

The general equilibrium framework accounts for three important components:

consumer preferences, firm production, and institutional framework[2]. In Singapore's context, we consider four sectors: a labour-intensive service sector (s) that produces a homogenous good; a capital-intensive manufacturing sector (m) that produces differentiated goods with growing varieties; a high-technology innovation sector (i) that conducts the necessary research activities for new product development; and a financial sector. All sectors employ three factors of inputs: skilled labour (H), unskilled labour (L), and physical capital (K), which is accumulated from the value added in the service sector. Given the respective nature of the final products, we assume a competitive market structure for the service sector and a monopolistic one for the manufacturing sector. The labour markets are assumed to clear at the equilibrium wages, skilled wage (w_H), and unskilled wage (w_L) respectively.

B. The demand side

Assume that there are two types of workers present in the economy, skilled (*H*) and unskilled (*L*). Both supplying fixed quantities of labour and each choosing to maximise a Cobb-Douglas form of intertemporal utility function given by:

$$U_l(t) = \int_t^{\infty} e^{-\rho(\tau - t)} \left\{ \frac{\left[\left(C_{ml}\right)^{\theta_m} \left(C_{sl}\right)^{\theta_s} \right]^{1-1/\sigma} - 1}{1 - 1/\sigma} \right\} d\tau; \quad \sum_{i=m,s} \theta_i = 1, \ \sigma \neq 1; \tag{1}$$

where ρ is the subjective rate of time preference[3], σ is the elasticity of intertemporal substitution in any two periods measuring an individual's willingness to substitute current consumption for future consumption, C_{sl} indicates the total amount of services consumed by type l workers, and C_{ml} represents a real consumption index for the manufacturing goods corresponding to type l workers. Given the monopolistic market structure in the manufacturing sector, we assume the real consumption index is given as follows:

$$C_{ml} = \left[\int_0^n (x_{jl})^{\alpha} \, dj \right]^{1/\alpha}; \quad 0 < \alpha < 1 \ , \tag{2}$$

[2] The DLLP model assumes that the natives own all the capital and thus immigrants do not augment the capital stock immediately after gaining entry.

[3] $\rho \geq 0$, the two limiting cases are: while the future is completely ignored when $\rho \to \infty$, and we do not discount the future consumption if $\rho = 0$.

where n is the total number of manufactured goods available to the consumers, $\varepsilon = 1/(1-\alpha)$ is the elasticity of substitution between varieties and x_{jl} is the total real consumption level of variety j by type l workers.

The consumers' optimisation problem consists of two stages. In the first stage, total consumption in the current period is maximised over the amount of services and manufacturing goods, given total nominal household expenditures for each type of household as, $C_l = \int_0^n \left(p_{mj} x_{jl}\right) dj + p_s C_{sl}$.

where $C = C_L + C_H$ gives the total nominal expenditure. In the second stage, the consumers' optimisation problem is extended to an infinite horizon.

Consumers seek to maximise their intertemporal utility and subject it to their optimal demand functions and their budget constraints. The standard dynamic solution yields the following,

$$\frac{\dot{C}_l}{C_l} = (1-\sigma)\frac{\dot{P}}{P} + \sigma(r-\rho); \quad l = L, H \tag{7},$$

where $P = \left(P_m\right)^{\theta_m} p_s^{\theta_s}$ is the total consumption price index. Aggregating over the two types of workers, we have:

$$\frac{\dot{C}}{C} = (1-\sigma)\frac{\dot{P}}{P} + \sigma(r-\rho) \tag{8},$$

and the corresponding budget constraint is given by:

$$\dot{A} = rA + w_L L + w_H H - C. \tag{9}$$

In a symmetric equilibrium, where all manufacturing firms face identical demand and production costs, equating all individual prices to p_m and quantities demanded to x and hence the market values to v we have:

$$A = A_L + A_H = nv + p_s K \ . \tag{10}$$

C. The supply side

1. Service sector

Assume the production process in the service sector employs the three factor inputs and follows a two-level nested CES production function[4] given by,

$$S = T_s \left\{ \gamma_{1s} L_s^{\eta_s} + (1-\gamma_{1s}) \left[\gamma_{2s} H_s^{\xi_s} + (1-\gamma_{2s}) K_s^{\xi_s} \right]^{\frac{\eta_s}{\xi_s}} \right\}^{\frac{1}{\eta_s}} \tag{12}$$

where T_s is the Total Factor Productivity (TFP) of the service sector, $\gamma_{1s,}(1-\gamma_{1s})\gamma_{2s}$, and $(1-\gamma_{1s})(1-\gamma_{2s})$ are the factor shares of the unskilled workers, skilled workers, and physical capital, respectively. The empirical evidence by Hammermesh (1993) suggests the complementarities between the skilled labour and physical capital when we observe $\xi_y < 0$. Let the capital depreciation rate be δ, assuming the accumulated capital earns the risk-free rate r, the rental price of the physical capital is given by $R = p_s\left(r + \delta - \frac{\dot{p}_s}{p_s}\right)$. The representative firm's problem[5] is to minimise the total cost function $\Phi_s = w_H H_s + w_L L_s + RK_s$ for a given level of output $\int$, as specified in the above production function, which again can be solved using a standard dynamic programming framework. The respective unit factor requirements of ι_{Ls}, ι_{Hs} and ι_{Ks} of the three inputs can be obtained by applying Shepherd's lemma to the minimum unit cost function $\phi_s(w_L, w_H, R)$.

Given the homogenous nature of the product, we assume a competitive market structure for the service sector, thus, it follows that the price of the product equals its marginal cost,

$$p_s = \phi_s(w_L, w_H, R) \tag{13}$$

[4] The general CES production function will collapse to the Cobb-Douglas form $Y = T_s L^{\gamma_{1s}} H^{\gamma_{2s}(1-\gamma_{1s})} K^{(1-\gamma_{1s})(1-\gamma_{2s})}$ when both η_s and ξ_s tend to zero.

[5] Detailed derivation can be found in Appendix 2

2. Manufacturing sector

Assuming there are n manufacturing firms in the economy, each produces one specific good and follows a nested CES production function analogous to Equation (12) as follows:

$$x_q = T_m \left\{ \gamma_{1m} L_{mq}^{\eta_m} + (1-\gamma_{1m}) \left[\gamma_{2m} H_{mq}^{\xi_m} + (1-\gamma_{2m}) K_{mq}^{\xi_m} \right]^{\frac{\eta_m}{\xi_m}} \right\}^{\frac{1}{\eta_m}}; \quad q \in [0,n] \tag{14}$$

where the parameters T_m, γ_{1m}, γ_{2m} are similarly defined as those in the service sector, η_m and ξ_m are the industry-wide substitution parameters. The minimum unit cost function $\phi_m(w_L, w_H, R)$ can be derived analogously as before.

In a symmetric equilibrium, where $p_{mq} = p_m$ for all $q \in [0,n]$, all firms are identical. Thus, we arrive at the following equilibrium:

$$P_m = n^{1/(1-\varepsilon)} p_m; \tag{15}$$

$$p_m = \phi_m / \alpha; \tag{16}$$

$$x = \frac{\theta_m C p_m^{-\varepsilon}}{P_m^{1-\varepsilon}}; \tag{17}$$

$$\pi = (1-\alpha) p_m x. \tag{18}$$

where x denotes the identical quantity demanded for each variety, thus the total quantity demanded for the manufacturing goods is given by nx, denote this quantity by X, and π is the identical profit level for each firm in the sector. Since the elasticity of substitution, ε, is greater than unity[6], the manufacturing price index P_m is a decreasing function of the number of varieties available.

3. Innovation sector

Similarly, we set the innovation sector by first assuming the production technology of

[6] Since $\varepsilon = 1/(1-\alpha)$ and $0 < \alpha < 1$.

introducing new varieties, including both new inventions and upgrades on the existing products, follows a two-level nested CES function

$$\dot{n} = T_i \Lambda \left\{ \gamma_{1i} L_i^{\eta_i} + (1-\gamma_{1i}) \left[\gamma_{2i} H_i^{\xi_i} + (1-\gamma_{2i}) K_i^{\xi_i} \right]^{\frac{\eta_i}{\xi_i}} \right\}^{\frac{1}{\eta_i}} ; \quad q \in [0, n] \; ; \qquad (19)$$

where the parameters are similarly defined as in the service and manufacturing sector, and the dot over n indicates the increment of varieties over time. The unit cost function and factor requirements can be calculated analogously to the other two sectors. We follow DLLP's (2003) construct of the innovation capital and define it as the density of the available number of varieties across the entire working population, which is given by $\Lambda = n / N$ [7]. In this way, the amount of innovation capital is independent of the absolute number of varieties available, and according to Li (2000), the scale effect of the workforce size on the growth rate is eliminated as well.

4. Financial market

As mentioned earlier, the market value of a typical piece of innovation is denoted by v, the zero NPV rule requires this value to be equated with its unit cost, i.e.,

$$v = \frac{\phi_i(w_L, w_H, R)}{\Lambda} \; . \qquad (20)$$

Under the usual no-arbitrage condition in the financial market, both types of workers, as shareholders, earn the risk-free rate of return, which equals to the sum of dividend gains and capital gains, i.e.,

$$r = \pi / v + \dot{v} / v . \qquad (21)$$

[7] N is defined as $N = L + H$, which is normalised to unity in the pre-migration state.

5. Market clearing conditions

Equating the corresponding demand and supply in the service and manufacturing sector, we arrive at the following market-clearing conditions for the outputs in the economy:

$$S = C_s + \delta K + \dot{K} , \tag{22}$$

$$p_m X = P_m C_m , \tag{23}$$

Given exogenous endowment levels of the labour supply, L and H, the model specification is then completed with the equilibrium conditions for both labour markets and the capital market:

$$\begin{pmatrix} L \\ H \\ K \end{pmatrix} = \begin{pmatrix} \iota_{Li}/\Lambda & \iota_{Lm} & \iota_{Ls} \\ \iota_{Hi}/\Lambda & \iota_{Hm} & \iota_{Hs} \\ \iota_{Ki}/\Lambda & \iota_{Km} & \iota_{Ks} \end{pmatrix} \begin{pmatrix} \dot{n} \\ X \\ Y \end{pmatrix} \tag{24}$$

where $\iota_{bd},\ b = L,H,K;\ d = i,m,s$ are the respective unit factor requirements of the three factor inputs in the three sectors.

6. Welfare-based immigration surplus

The steady-state welfare of the native workers resulting from immigration is undertaken by comparing the prior and posterior steady-state welfare of the native workers resulting from immigration. Since the consumption level depends on return on net assets and labour income for both skill types, we shall first analyse the asset accumulation process in the post-immigration era. Taking immigrant workers into account, the two types of labour are redefined as:

$$L = N_L + M_L ; \quad H = N_H + M_H ; \tag{25}$$

where $N_l,\ M_l,\ l = L,H$ denote the number of native and immigrant workers for both skill types.

We will assume no skill differentials to exist between the natives and immigrants

within each skill group, i.e., there is perfect substitutability between the native and the immigrant workers, and there is no discrimination against the immigrants in the indigenous labour market. We will assume immigrants do not bring physical capital into the economy, and they will accumulate net assets once they settle down in the domestic economy. The household budget constraints for natives and immigrants are given by:

$$\dot{A}^N = rA^N + w_L N_L + w_H N_H - C^N, \tag{26}$$

$$\dot{A}^M = rA^M + w_L(L - N_L) + w_H(H - N_H) - C^M, \tag{27}$$

where the superscripts $p = N, M$ denote native and immigrant, respectively. Given $A = A_L + A_H = A_L^N + A_L^M + A_H^N + A_H^M$ and $C = C_L + C_H = C_L^N + C_L^M + C_H^N + C_H^M$, we have the aggregate household budget constraint:

$$\dot{A} = rA + w_L L + w_H H - C, \tag{28}$$

which takes the same form as in the pre-migration stage. Thus, under our assumptions the only impact on the native economy comes from the augmentation of the labour supply. We now consider the welfare separately by decomposing the net assets into the four different types of workers.

Immediately after receiving the immigration influx, the total assets in the economy remain at a given level defined by[8] $\bar{A} = \overline{nv} + \bar{p}_s \bar{K} = \bar{N}\phi_i + \bar{p}_s \bar{K}$. It then moves to a new steady state value of $A = N\phi_i + p_s K$ with settlement of new immigrants. Defining the total migration rate m as the proportion of both skilled and unskilled immigrants to the native workforce, i.e., $m = \frac{M_L + M_H}{\bar{N}}$, we can now express the total population after immigration as $N = (1+m)\bar{N}$. Though the immigrants do not alter the physical capital stock in the economy when they first enter the country, they do contribute to the subsequent accumulation and, hence, have a share in it. Assuming the share of the newly accumulated physical capital is distributed proportionally to the size of the total workforce, the total share of physical capital for immigrant and native workers are given by $\frac{mp_s}{1+m}(K - \bar{K})$ and $\frac{p_s(m\bar{K} + K)}{1+m}$ in the post-migration era. Given that the change of share values of new ideas and inventions differ from the accumulation of physical

[8] Where $N = N_L + N_H$ is the total size of working population in the pre-migration era.

capital, we assume that in the new steady state with immigration, the shares owned by native and immigrant workers are divided according to their respective population sizes, where $\bar{N}\phi_i$ is owned by the natives and $m\bar{N}\phi_i$ is owned by the immigrants. The sum of equity and physical capital gives us the total net assets in the post-immigration era for the native workers, given as:

$$A^N = \bar{N}\phi_i + \frac{p_s(m\bar{K} + K)}{1+m} \tag{29}$$

We can then divide the total net assets owned by the natives in the pre- and post-immigration steady state among the native skilled and unskilled workers, by assigning weights according to their labour income shares as:

$$\bar{A}_l = \frac{\bar{w}_l N_l}{\bar{w}_L N_L + \bar{w}_H N_H}\bar{A}\ , \tag{30}$$

$$A_l^N = \frac{w_l N_l}{w_L N_L + w_H N_H}A^N; \quad l = L, H\ . \tag{31}$$

Once we have the steady-state values of the labour income and net assets for both skill types, we can proceed to the welfare calculations. The nominal consumption levels before and after immigration influx for both groups are given as:

$$\bar{C}_l = \bar{r}\bar{A}_l + \bar{w}_l N_l\ , \tag{32}$$

$$C_l^N = rA_l^N + w_l N_l; \quad l = L, H\ . \tag{33}$$

As our calculation of the immigration surplus will be based on the change of steady-state welfare levels in the pre- and post-immigration era, we first calculate the steady-state welfare using the Cobb-Douglas utility function of the native workforce as defined earlier. Assume in the post-immigration era, the economy reaches its new steady state at time T; the steady-state welfare value is obtained by changing the lower bound of the infinite-horizon inter-temporal utility function from t to T and calculating the resulting integral, which is given as follows[9]:

[9] Detailed derivations can be found in the mathematical appendix.

$$
\begin{aligned}
U_l^N &= \int_T^{\infty} e^{-\rho(\tau-T)} \left\{ \frac{\left[\left(C_{ml}^N\right)^{\theta_m} \left(C_{yl}^N\right)^{\theta_y} \right]^{1-1/\sigma} - 1}{1-1/\sigma} \right\} d\tau \qquad l = L, H \\
&= \frac{1}{1-1/\sigma} \left[\frac{(\theta_m^{\theta_m}\theta_y^{\theta_y})^{1-1/\sigma} (C_l^N / \tilde{P})^{1-1/\sigma} n(T)^{\theta_m(1-1/\sigma)/(\varepsilon-1)}}{\rho - \theta_m(1-1/\sigma)g/(\varepsilon-1)} - \frac{1}{\rho} \right] \\
&= U_l^N(C_l^N, n(T), g)
\end{aligned}
\tag{34}
$$

where $\tilde{P} = p_m^{\theta_m} p_s^{\theta_s}$, the growth rate of varieties $\dot{n}/n$ is at its steady state value of g, the particular solution of this differential equation, $n(t) = n(T)e^{g(t-T)}$, is used in the above derivation. In the absence of immigration, the steady-state welfare level at time T is obtained by substituting the corresponding nominal consumption level, number of varieties and the growth rate into the above expression, i.e., $U_l^N(\bar{C}_l, \bar{n}(T), \bar{g})$. In order to use our numerical solutions for the steady-state variables, we define our measure of immigration surplus in terms of an equivalent permanent consumption change as follows:

$$
\begin{aligned}
\textit{immigration surplus} &= \frac{U_l^N(C_l^N, \bar{n}, g) - U_l^N(\bar{C}_l, \bar{n}, \bar{g})}{\Delta U_l^N} \\
&= \frac{(C_l^N)^{1-1/\sigma} / \chi(g) - (\bar{C}_l)^{1-1/\sigma} / \chi(\bar{g})}{[(1.01\bar{C}_l)^{1-1/\sigma} - (\bar{C}_l)^{1-1/\sigma}] / \chi(\bar{g})}; \qquad l = L, H
\end{aligned}
\tag{35}
$$

where $\chi(y) = \rho - \theta_m(1-1/\sigma)y/(\varepsilon-1)$, $y = \bar{g}, g$ are the pre- and post-immigration steady-state growth rates, ΔU_l^N is the change of welfare level as a result of 1% permanent change in the nominal consumption level in the pre-immigration era, $\bar{n}$ is the number of varieties, which is assumed to be fixed in the pre- and post-immigration steady states so that the size of the immigration surplus does not depend on the absolute number of varieties available in the economy. With calibrated parameters and numerical solutions from the earlier steady-state set-up of the model, we can indeed estimate the sign and magnitude of the immigration surplus in Singapore's economy.

The above model does not have a closed-form solution and, thus, we adopt a numerical method and narrow down our scope to the steady-state analysis.

IV. Calibration

After constructing the four-sector general equilibrium model and setting up the numerical solution for the steady-state values, we now proceed to calibrate the various parameters specified in our model to the Singapore context and try to analyse the potential impact of immigration policy on the Singaporean economy in the long run.

The first step requires us to identify the classifications of the service and manufacturing sectors in the Singaporean economy. According to the Singapore Standard Industrial Classification (SSIC) 2005, the wholesale and retail trade, hotel and restaurants, information and communications, and financial and business services are together classified as service-producing industries. We will assume the services provided to the consumers can be treated as a homogenous good for simplicity. Manufacturing, construction, and utilities are classified as good-producing industries by SSIC 2005. We presume that the development of new ideas in the innovation sector is not for direct consumption, but continuously drives product differentiation and environmental-friendly and cost-effective production techniques in the good producing industries. The innovation sector in the study consists of the chemical and petroleum, electrical, electronic, and precision and instrumental industry. The rest of the manufacturing industries are considered as manufacturing sector.

Next, we classify the skilled and unskilled immigrants according to the type of employment visa they are holding. Employment Pass (EP) is granted to skilled immigrant workers with a recognised qualification and a minimum fixed monthly income of S2500 US dollars. S-Pass is designed for specialised semi-skilled immigrants, such as technicians, with a minimum education level of a diploma and a minimum fixed monthly income of S1800 US dollars. Work Pass (WP)[10] is targeted at the unskilled immigrant workers with a maximum monthly income of S1800 US dollars. Thus, we categorise EP and S-Pass holders as the skilled immigrants, and WP holders as the unskilled immigrants in the Singaporean economy see the Appendix for the statistics on types of foreign workers in the Singaporean economy.

On the demand side, utility weights θ_s and θ_m are estimated using the average proportion of annual private consumption expenditure devoted to services and goods producing industries from year 2005 to 2009[11], at the 2000 market prices, which gives

[10] A dependency ceiling and a levy are imposed to protect the native workers.
[11] Data and calculation can be found in Appendix B.

us the values of 0.44 and 0.56, respectively. We follow DLLP's (2003) choice of inter-temporal elasticity of substitution, $\sigma = 0.4$, which is obtained from the range of 0.32 to 0.45 in Ogaki and Feinhart (1998). The taste parameter of the differentiated manufacturing goods (α), is chosen to be consistent with DLLP (2003), at a value of 0.7.

Table 3. Parameter values used in calibration

Parameters	Values	Sources
δ	0.1	Canova et al (2000)
α	0.7	Keuschnigg and Kohler (1999)
ρ	0.01	Levine, Lotti and Pearlman (2003)
ϕ_i	1.18	Levine, Lotti and Pearlman (2003)
σ	0.4	Ogaki and Reinhart (1998)
$\theta_s,\ \theta_y = 1-\theta_s$	0.44, 0.56	Calibrated
$\gamma_{1s},\ \gamma_{2s}$	0.43, 0.88	Calibrated
$\gamma_{1m},\ \gamma_{2m}$	0.5, 0.8	Calibrated
$\gamma_{1i},\ \gamma_{2i}$	0.47, 0.72	Calibrated

(Note) The factor share parameters within each sector are obtained from the Singapore Yearbook of Manpower Statistics and Report on Labour Force in Singapore 2008, Ministry of Manpower. The other key elasticity parameters are obtained from the sources indicated above at Table 3.

(Source) Singapore Yearbook of Manpower Statistics and Report on Labour Force in Singapore 2008, Ministry of Manpower.

On the supply side, we adopt the microeconomic approach of calibration upon obtaining the factor shares in each sector, in which the parameter values are consistent with the empirical data. The factor share parameters within each sector are obtained from the Singapore Yearbook of Manpower Statistics and Report on Labour Force in Singapore 2008, Ministry of Manpower. The factor shares for unskilled and skilled workers are s_{LS}= 0.43 and s_{Hs}= 0.5 in the services sector; s_{Lm}= 0.5 and s_{Hm}= 0.4 in the manufacturing sector and s_{Li}= 0.47 and s_{Hi}= 0.38 in the innovation sector[12]. The factor

[12] Innovation sector in our study consists of the chemical and petroleum industry, electrical industry, electronic industry, and precision and instrumental industry

share parameters within each sector, $\gamma_{jl}, j = 1,2;\ l = s,m,i$ can now be calculated accordingly. Annual depreciation rate, δ, is chosen to be 0.1, which is consistent with DLLP (2003) and Canova et al (2000).

A. Results

1. Large unskilled workers and low growth

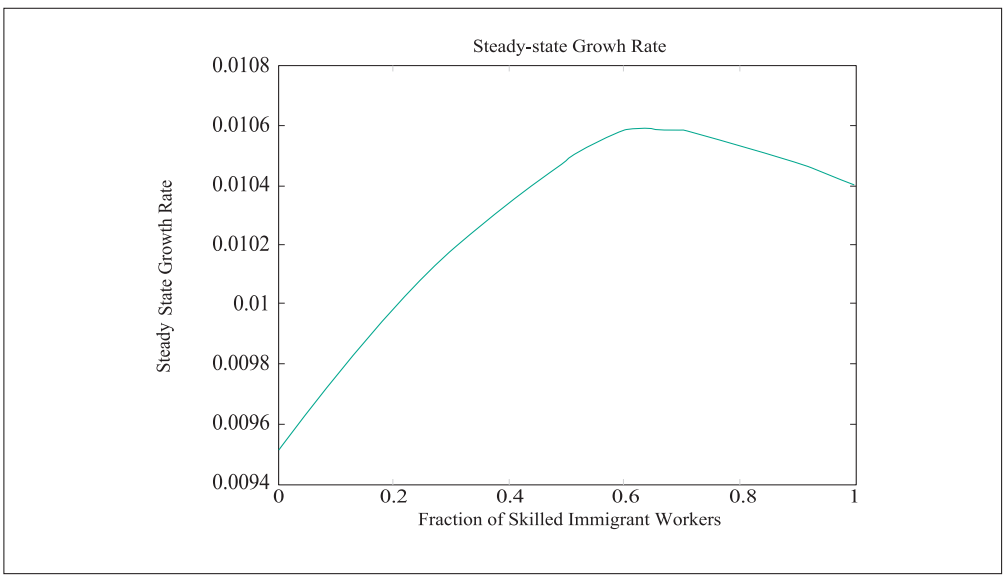
The key parameters for the large unskilled workers in the economy are defined by the factor share of skilled and unskilled workers. The factor shares for unskilled and skilled workers are $s_{Ls} = 0.43$ and $s_{Hs} = 0.5$ in the services sector; $s_{Lm} = 0.5$ and $s_{Hm} = 0.4$ in the manufacturing sector and $s_{Li} = 0.47$ and $s_{Hi} = 0.38$ in the innovation sector. The high factor shares for unskilled workers (s_{Ls}, s_{Lm}, s_{Li}) reflect high level of unskilled workers in these sectors. In particular, the high factor share for innovation sector (s_{Li}=0.47) reflects that large influx of unskilled foreign workers in chemical and petroleum, electrical, electronic, and precision and instrumental industries. The employment share in the pre-immigration state is taken as 0.45 for skilled workers and 0.55 for unskilled workers. The employment share of foreign immigrants is maintained at 0.40 in the post-immigration state.

The steady state set-up is used to obtain the numerical solutions for our model. Assuming uniform skill-composition in each sector, we will analyse the effect of an increase in the total factor share of the skilled immigrant workers on the growth rate, the size of the innovation sector and the changes in relative wage rates in the steady state. It is to estimate the sign and magnitude of the immigration surplus in the Singaporean economy. We will also explore the possible complementarities between skilled labour and physical as suggested by Hammermesh (1993). Given no empirical evidence of crowding-out effect of immigrants on the native employment by Hunt and Gauthier-Loiselle (2008), Peri (2009), as well as Ortega and Peri (2009), and the initial assumption that immigrants do not alter the capital stock immediately after gaining entry, we will keep the factor shares of the native labour and physical capital constant. Hence the increase in the fraction of skilled immigrants in the simulation is achieved by decreasing that of the unskilled immigrants and vice versa.

The simulation results of the steady-state growth rate with increasing inflow of skilled immigrants (decrease in the share of unskilled foreign workers) are given in Figures 3 to Figure 6 below.

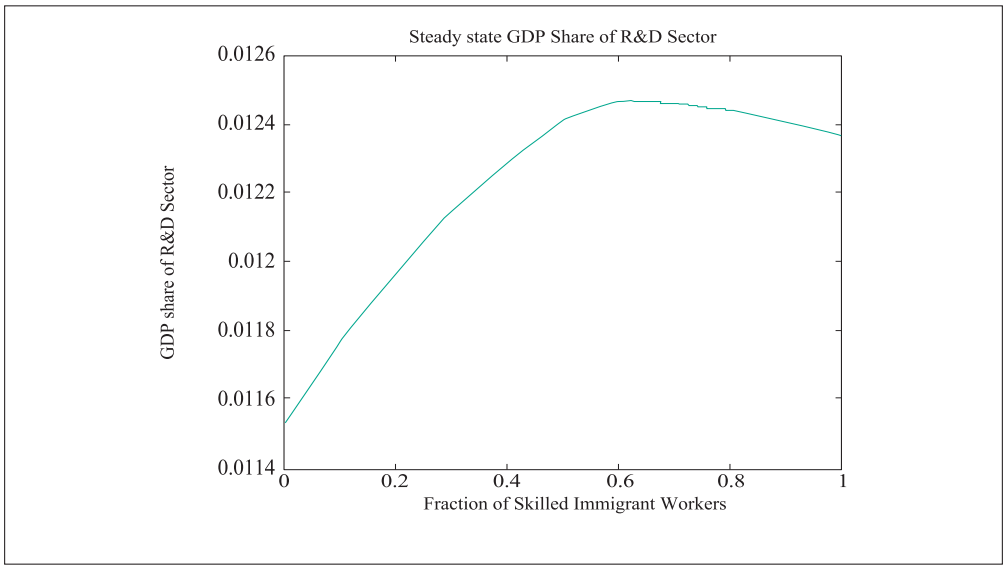
As can be seen Figures 3 and 4, there is a positive effect of the skilled immigrants on the steady-state growth rate of around 1.1%. It also increases the size of the innovation sector when their fraction within the total immigrant workforce is increased from 0 to 60%. The inflow of skilled immigrants relative to unskilled workers tends to encourage more research activities and promotes long-term growth. However, the increase in skilled immigrants in the economy tends to increase the growth rate and size of the R&D sector at a diminishing rate, and both variables started to decline when the fraction of the skilled immigrants exceeds a threshold of 60%. The diminishing return is expected to set in once the reward from the complementarities between the physical capital and the skilled immigrants is fully exploited. The crowding-out effect on the total physical capital causes the steady-state growth rate and the size of the innovation sector to decrease after reaching the threshold. The maximum percentage growth gain is achieved when the physical capital is fully exploited by the skilled workers in the economy, which corresponds to 60% of the skilled workers among the immigrants.

Figure 3. Steady state growth rate with high unskilled workers



(Note)The steady state growth rate reflects the equilibrium growth rate in the model.
(Source) Author's creation. Estimated from the current model.

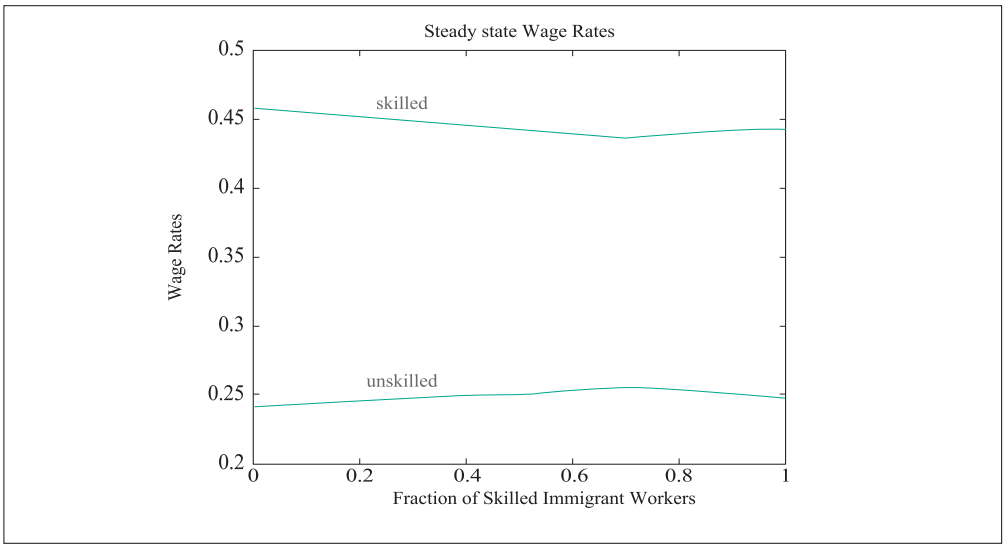
Figure 4. Steady state GDP share of R&D sector with high unskilled workers



(Note)The steady state growth rate reflects the equilibrium growth rate in the model.
(Source) Author's creation. Estimated from the current model.

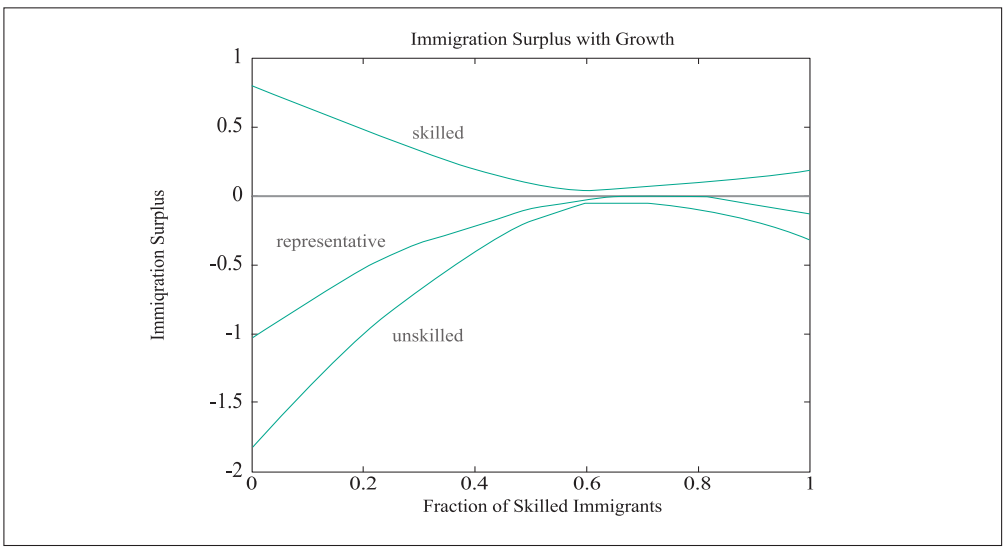
The simulation results of the magnitude of the wage gap and immigration surplus for the Singaporean economy for the above parameters are given in Figures 5 and 6, respectively. Figure 5 shows the relative wage rates for the skilled and unskilled workers in the economy following the immigration. When more skilled foreign workers enter the economy, the increase in total supply drives the skilled wages down, and thereby narrows the wage gap between the skilled and unskilled workers. The results indicate that the wage gap between the two skill types is narrowed when the fraction of skilled immigrants is below 60%. However, the gap widens after reaching the threshold level of 60% of skilled immigrants. The widening of the wage gap with higher share of the skilled immigrants could be explained by the greater substitution of the skilled for unskilled workers. When the fraction of skilled immigrants exceeds the 60% threshold, skilled workers become abundant in the economy and their wage rate decreases to a sufficiently low level. This enables the employers to seize the opportunity to substitute the relatively cheaper skilled human capital for the unskilled labour. This will increase the demand for skilled workers and drive their wages marginally higher. The resurgence in demand for skilled workers increases their wage rate accordingly, and the fall in demand for unskilled labour drives their wage rate to a lower level, thus creating a

Figure 5. Steady state wage gap with high unskilled workers



(Note) The steady state wage is the equilibrium wage given for skilled and unskilled workers, which is estimated from the model.
(Source) Author's creation. Estimated from the current model.

Figure 6. Immigration surplus with growth and high unskilled workers



(Note) The immigration surplus reflects the surplus (gains) to respective types of workers in the labour market. The representative is given as the average workers in the labour market.
(Source) Author's creation. Estimated from the current model.

widening wage gap.

Based on Figure 6, Immigration Surplus (IS) for local workers differs by their respective skill types. The IS of skilled native worker remains positive and reaches its maximum of an equivalent permanent consumption increase of 0.80% when the immigrant workers are completely unskilled, while that of the unskilled workers remains negative and increases when the fraction of skilled immigrants is increased. Furthermore, the decrease in skilled IS and the increase in unskilled IS prior to the 60% threshold indicates a redistribution effect from the native skilled workers to the native unskilled workers, which comes from the narrowing of the wage gap, and *vice versa* for the opposite movement in IS when the fraction exceeds its 60% threshold. It is evident that the skilled immigrant workers have positive impact on the size of the immigration surplus and the unskilled ones exert negative effects when the fraction of skilled immigrants is held below 60%, and *vice versa* when the fraction is increased further. Table 4 below summarises the estimated key values of IS for different groups in the Singaporean economy, where F_s indicates the fraction of the skilled workers within the immigrant workforce.

Table 4. Estimated key values in the Singapore economy

Skill Type	Immigration Surplus with Growth		
	$F_s = 0$	$F_S = 0.6$	$F_s = 1$
Skilled	0.80	0.030	0.18
Unskilled	-1.84	-0.056	-0.31
Representative	-1.03	-0.026	-0.13

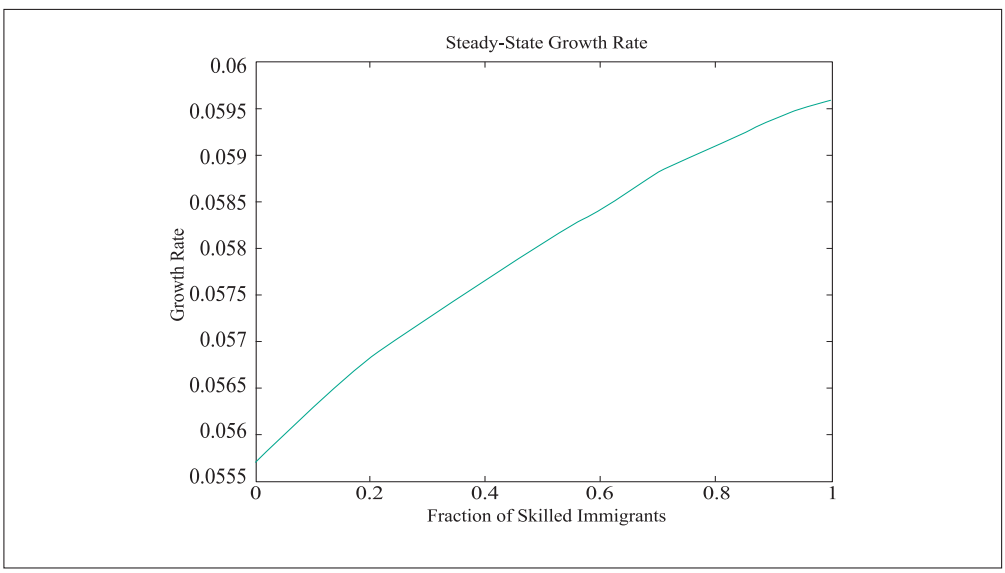
(Note) The immigration surplus reflects the surplus (gains) to respective types of workers in the labour market. The representative is given as the average workers in the labour market.
(Source) Author's creation. Derived from the current model.

2. Moderating foreign workers

We moderated the flow of foreign workers by maintaining the share foreign at 30% of the total labour force. The skilled employment share in the pre-immigration state is also taken to be higher at 0.55 and 0.45 for unskilled workers. This reflects the current government policy to increase the number of skilled workers in the economy and concurrently moderating the flow of unskilled foreign workers.

The factor shares for unskilled and skilled workers are s_{LS}= 0.14 and s_{Hs}= 0.46 in the services sector; s_{Lm}= 0.14 and s_{Hm}= 0.30 in the manufacturing sector and s_{Li}= 0.1 and s_{Hi} = 0.25 in the innovation sector. The high factor shares for skilled workers (s_{Ls}, s_{Lm}, s_{Li}) reflect high level of skilled workers in these sectors. Further, we also allocated higher factor shares for capital for all the 3 sectors. The capital shares are s_{Ks}= 0.4 , s_{KM}= 0.55 , and s_{Ki}= 0.65 for services, manufacturing and innovation sectors respectively. This is in line with the current policy of increasing the capital accumulation in the key sectors.

Figure 7. Steady state growth rate with low unskilled workers

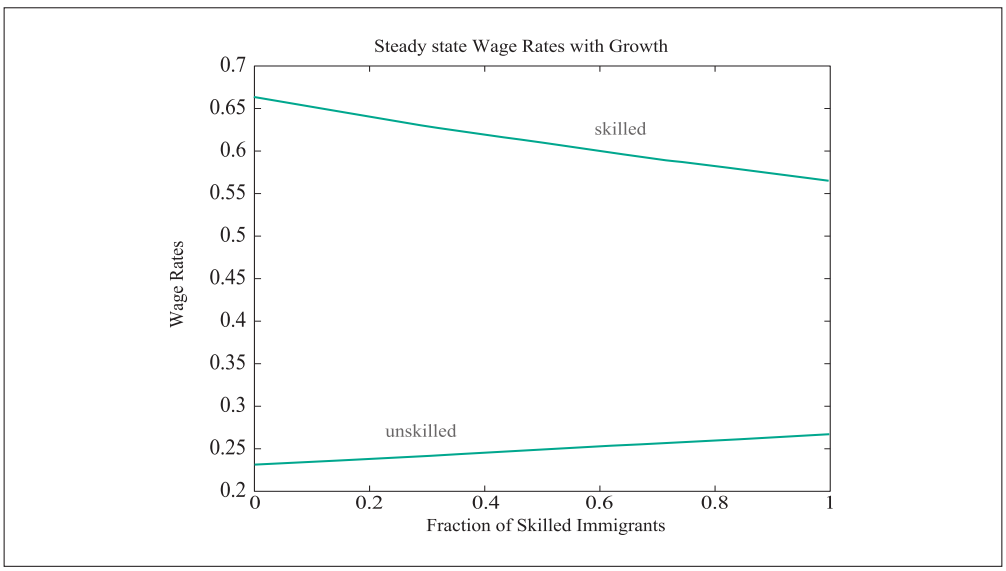


(Note) The steady state growth rate reflects the equilibrium growth rate in the model.
(Source): Author's creation. Estimated from the current model.

The simulation results for the moderating foreign workers with high capital intensity are given in Figures 7~9. It is interesting to observe that a high share of skilled workers produce higher steady-state growth rate of nearly 5%, and the economy also experiences less diminishing returns due to the increasing share of skilled immigrants on the output growth, and conversely on the innovation sector (see Figure 7). This result is mainly driven by the high share of capital accumulation in the innovation sector. Therefore, there is a greater complementarity between skilled and capital investments, which is not fully exploited. The greater inflow of skilled immigrants tends to complement capital and increase the innovation activities, which leads to higher steady-state growth.

The simulation result of the wage gap is reflected in Figure 8. It is interesting to observe that the wage gap between the skilled and unskilled labour narrows as the foreign share is maintained at 40% of the workforce. This is mainly attributed to the increase in supply of skilled workers in the economy due to the inflow of skilled immigrants and the reduction of unskilled foreign workers in the economy. We also observe that the factor shares of unskilled workers increases moderately as their demand increases due to higher output growth.

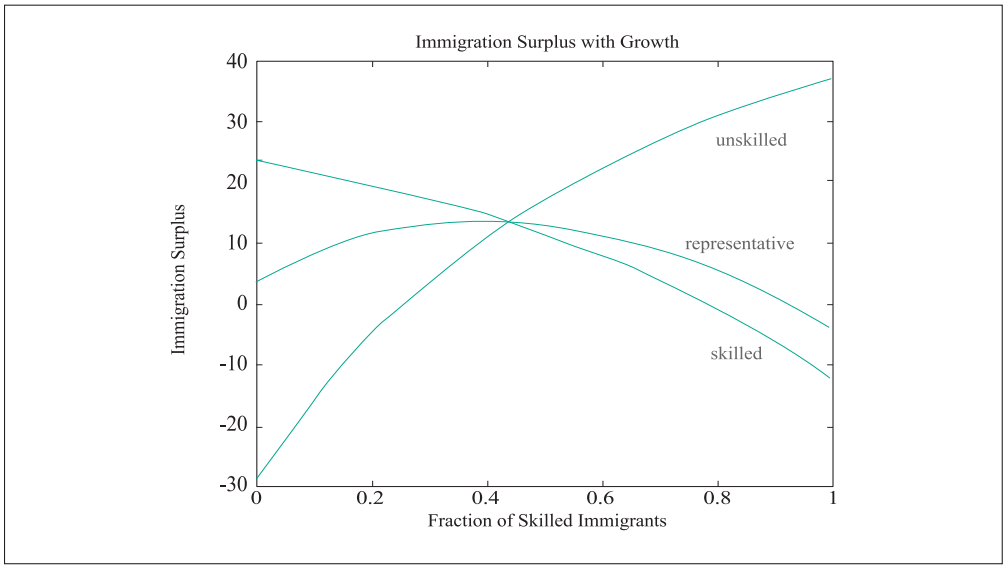
Figure 8. Steady state wage gap with low unskilled workers



(Note) The steady state wage is the equilibrium wage given for skilled and unskilled workers, which is estimated from the model.

(Source) Author's creation. Estimated from the current model.

Figure 9. Immigration surplus with growth and low unskilled workers



(Note) The immigration surplus reflects the surplus to respective types of workers in the labour market. The representative is given as the average workers in the labour market.
(Source) Author's creation. Estimated from the current model.

The simulation result of the immigration surplus in a high capital accumulation with moderate foreign workers is given in Figure 9. As compared to the simulation with high share of unskilled workers, it is interesting to observe that the IS of unskilled workers tends to increase with a large flow of skilled immigrants in the economy. This is in line with the rising demand for the unskilled workers as the innovation increases with higher manufacturing and services activities, thereby increasing their wage rates. The IS for skilled workers declines as the share of skilled foreign workers increase, which is mainly due to the decline in their wage as the supply of skilled workers increases.

V. Conclusion

The study explores the impact of labour market integration with the global economy on the economic growth of a small open economy. The result of the model indicates that

inflow of skilled immigrants does exert positive effects on the domestic economy but at a diminishing rate. Skilled immigrants tend to encourage more research activities in the economy, leading to promote long-term growth. We also observed that the diminishing returns set in when the reward from the complementarity effect between the physical capital and the skilled immigrants is fully exploited. We summarise two key results of the study that have important policy implications for Singapore's labour market policy:

The results highlight that moderating foreign workers at 40% of the workforce with high capital intensity produces positive output growth. In this equilibrium, we also observe higher steady-state growth with a higher share of skilled foreign workers. The rising share of skilled foreign workers reduces the skilled wage rate as well as the wage gap between the skilled and unskilled workers in the economy.

The results also indicate that the positive impact of immigrants and, particularly, skilled immigrants depends on innovation activities in the economy. For a given level of capital stock in the economy, there is a diminishing return from having additional skilled foreign workers in the economy. There is a threshold level of skilled immigrants that will have positive impacts on the innovation sector and growth of the economy.

The outcome of this study are similar to the study by Thangavelu (2016) on the impact of foreign workers on the productivity of the Singapore manufacturing sector that adopts panel regression framework. The results clearly indicate that foreign workers make productive contributions to manufacturing productivity, but the impact is lower compared to local workers. However, the analysis indicates that the inflow of foreign labour has little impact on the wage rate of local workers. We show that foreign workers do bring about supply-side effects on the wages of local skilled and unskilled workers. A recent study by Ottaviano and Peri (2008) examined the complementary and substitution effects between local and foreign workers for the US economy. The data on different skill types of local and foreign workers is not available for the Singaporean economy and could be a possibility for extensions of the current study. Further, the regression framework was not able to examine the welfare implications and the impact on the innovation sectors of the domestic economy. We carefully examined the impact of skilled and unskilled workers on the innovation activities of the economy.

Investments in local human capital are also vital for the long-term growth of Singapore's economy. In a globalised environment, workers must constantly upgrade their skills to stay relevant. At present, most training programs are designed for and targeted at low-skilled local workers. This enables them to improve their productivity levels and command higher wages, thereby reducing wage inequality. With the shift

toward higher value-added activities, Singapore will need to implement general training schemes for the entire workforce. Constant re-training and skill-upgrading is necessary to meet the rapidly evolving demands of the labour market. These investments in local human capital will grant productivity gains, thereby improving the long-term growth potential of the Singaporean economy.

The declining capital-labour ratio in the manufacturing sector is of great concern to the Singaporean economy (Thangavelu 2016). The declining capital-labour ratio is also in line with high inflows of foreign labour, thereby suggesting that large inflows of foreign workers might affect the investment decisions of firms to adopt new technologies. As indicated by Peri (2009), a large inflow of foreign workers is likely to increase the unskilled-biased technology investment, as observed in the US economy. Peri's (2009) results indicate that the productivity of foreign workers increases with less capital investment, thereby indicating that the foreign workers are more productive with less capital and a technology-intensive production structure. In contrast, local workers are more productive with high capital investment, indicating that there is more complementarity between capital investments and local human capital. Thus, the skilled foreign workers do affect the technology adoption decisions of firms, and hence, their competitiveness.

The results of the study generally support the recent Singaporean government's policy recommendations in increasing productivity growth and reducing reliance on foreign workers. However, for a small open economy, policies on capital and labour mobility will be crucial to sustain the competitiveness of the economy. The Singaporean economy has effectively managed to balance capital and labour mobility to enhance the overall competitiveness of the economy since its independence. As the domestic economy moves toward a knowledge-based economy, the impact of foreign capital and labour on the innovation activities of the small-open economy will be crucial. Even with the large inflow of skilled workers, Thangavelu (2010) argues that the positive impact of immigrants and depends on domestic innovation activities. Having said that, there is a diminishing return from having additional skilled foreign workers in the economy for a given level of capital stock in the economy.

It indicate that to create sustainable growth, the government must create complementarity effects between domestic innovation activities and flow of skilled foreign workers into the economy. Recent evidence indicates that the innovation and capital investment activities are declining in the Singaporean economy. Further, the economy is transitioning to service activities as the service share of GDP is rising to

more than 60% of GDP. As compared to manufacturing activities, domestic-oriented service activities will have fewer innovation activities. In this case, the government must increase the innovation and export activities of the service sector by linking them to the global production value chain and increasing the human capital development of the local workforce. This will be crucial as the Singaporean economy moderates its inflow of foreign workers and increases its competitiveness in the global economy.

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Appendix

Types of foreign workers in Singapore

1. Employment Pass (EP)

a. Employment Pass (EP) Holders: The employment pass is targeted at skilled foreign workers employed as professionals and executives in Singapore. The eligibility criteria for EP is that a skilled foreign worker (a) earn a fixed monthly salary of more than 2,500 US dollars and (b) have a recognised qualification
(see MOM website).

b. There are three categories of EP:
   i. P1 pass is for foreign workers earning a fixed-monthly salary of more than 7,000 US dollars.
   ii. P2 pass is for foreign workers earning a fixed-monthly salary between 3,500 US dollars and 7,000 US dollars and possessing recognised qualifications.
   iii. Q1 pass is for foreign workers earning a fixed-monthly salary between 2,500 US dollars and 3,500 US dollars and possessing recognised qualifications.

2. S-Pass

a. S-Pass applies to mid-level skilled workers such as technicians and semi-skilled workers applying for professional and specialised jobs.

b. S-Pass applicants are assessed in terms of a point system that includes salary, educational qualifications, skills, job type, and experience.

c. Foreign workers are eligible to apply for S-Pass if they earn a monthly salary of at least 1,800 US dollars and possess recognised qualifications with a minimum level degree or diploma.

d. The employment of S-Pass is subject to a quota (dependency ceiling) of 25% of the company's total workforce.

3. Work Pass (WP)

a. Work Pass (WP) applies to foreign workers earning a monthly basic salary of no more than 1,800 US dollars.

b. The prospective employer must first apply for a WP from the Ministry of Manpower before employing a foreign worker (minimum age of 16 years).
c. Skilled Work Pass applies to foreign workers with at least a recognised national trade certificate (NTC-3 [Practical] Trade Certificate) or equivalent that is relevant to the worker's occupation.
d. Employer pays a lower levy for skilled WP foreign workers.

[Information as of 2011]