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Labor Productivity and Quality Change in Singapore: Achievements in 1974–2011 and Prospects for the Next Two Decades

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Abstract

Labor productivity growth in Singapore that has grown at a rate of over 3.0 percent per year since 1970s considerably slowed down to 0.5 percent on average per annum in the latter half of the 2000s. The purpose of this paper is to ask, first, to what extent Singapore's labor productivity performance is explained by the changes in the characteristics composition of its workforce, and then, what the prospect may hold. Using our newly constructed cross-classified labor dataset, we estimate a volume index of quality-adjusted labor input and an aggregate measure of labor quality change in the Singaporean economy for the period of 1974–2011. Having understood the current dynamics of the workforce, we further project labor productivity and potential economic growth for the coming two decades. In this paper, workers are distinguished by the five characteristic dimensions: gender, educational attainment, age, employment status, and residency. Our findings establish the role of labor quality changes in Singapore's economic growth as highly significant over the long run. During the period of 1974–2011, labor quality improved at a rate of 2.19 percent on average per annum, accounting for 37 percent of labor input growth to the 6.78 percent average yearly economic growth.

Our estimates of recent labor quality growth, however, are considerably lower than what have been shown in some previous studies. Moreover, our projections suggest that its prospect in the foreseeable future remains bleak. The downward trend of labor quality growth since the mid-2000s is mainly due to the sharp increase in the number of low-skilled foreign workers. For the next two decades, our projections in the business-as-usual scenario imply a further decrease of labor quality growth. Consequently labor productivity growth will also slow down, from 2.04 percent on average per year in the 2000s, to 1.68 percent and 1.19 per cent in the 2010s and 2020s respectively. Coupled with the downward trend in hours worked, potential GDP growth is projected as 3.10 percent on average per annum in the 2010s and 1.86 percent in the 2020s. Compared with the past experience of 5.47 percent in the 2000s, this represents a considerable slowdown in Singapore's economic growth for the next two decades, if there is no appropriate policy response or boost to TFP growth.

Policies, which successfully upgrade the resident workers' skills and/or induce the substitution of IT capital investment for the low-skilled non-resident workers, will lift the projection of labor productivity growth to 2.64 percent and 1.82 percent on average per annum in the 2010s and the 2020s respectively. However, the projected growth rate of potential GDP is little improved. At 3.22 percent in the 2010s and 2.06 percent in the 2020s, our projections even with successful policies are closer to the lower end of the target range set by the Economic Strategies Committee of Singapore's government for the 2010s. We conclude that the room to boost growth by improving labor quality is very limited, and policies targeting TFP growth may be more fruitful.

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Contents

1 Introduction 2
2 Measurement of Labor Productivity, 1974–2011 4
2.1 Methodology 4
2.2 Cross-classified Labor Data 6
2.3 Labor Input and Quality Change 7
2.4 Comparison with Previous Research 11
2.5 Decomposition of Labor Quality 14
3 Projection of Labor Productivity Growth, 2010–2030 15
3.1 Methodology and Baseline Assumptions 15
3.2 Business-as-usual Scenario 17
3.3 Policy Scenarios 21
3.3.1 Increases in Educational Attainment of Residents 21
3.3.2 Further Restrictions of Foreign Worker Levy 23
3.3.3 Synthetic Effect 25
4 Conclusion 28
5 Appendix: Construction of Cross-classified Labor Data 30
5.1 Data Sources 30
5.2 Number of Workers 30
5.2.1 Number of Non-Resident Workers NR2 and NR3 32
5.2.2 Profile of Foreign Workers of NR2 33
5.2.3 Profiles of Non-Resident Workers in NR1 and NR2 after 2005 35
5.2.4 Workers Commuting from Abroad to Work NR3 36
5.2.5 Skilled versus Unskilled Foreign Labor 37
5.3 Hours Worked per Worker 38
5.3.1 Conscripts 40
5.4 Hourly Wage 40
5.4.1 Compensation of Employees in SSNA 42
5.5 Sensitivity Checks based on Alternative Assumptions 43
5.5.1 Wages for Own-account and Unpaid Family Workers 43
5.5.2 Profile of Non-Resident Workers 43
6 Appendix: Supplementary Tables 45
7 References 55

1 Introduction

The targets for Singapore over the next decade are to achieve labor productivity growth of 2.0–3.0 percent and potential GDP growth of 3.0–5.0 percent (ESC 2010). These policy goals were proposed by the Economic Strategies Committee (ESC), a government arm of Singapore established in 2009 for developing strategies to maximize the growth potential of the economy. In our judgment, these are challenging goals given that Singapore's aggregate per hour labor productivity only grew by 0.54 percent on average per year during 2005–2010.[1] Compared with the 3.54 percent growth achieved during the first half of the 2000s, this represents a considerable slowdown, the main reason for which is the increasing dependency on low-skilled foreign workers in recent economic growth. In our estimates, their number has been rising in recent years, accounting for 31 percent of total employment in 2010, up from 24 percent in 2005.

In light of this, the ESC recommends a gradual increase of the Foreign Worker Levy[2] in order to boost labor productivity. The intention of the Levy is to limit the growth of low-income non-resident workers, while it is also expected to affect the skills of Singaporean residents. In addition, the government believes that the lack of incentives for firms to invest in (non-human) capital will "affect [the] efforts to upgrade the skills and wages of lower-income Singaporean workers" (ESC 2010, p6). To counteract this shortcoming, the Singaporean government has announced its willingness to further invest in human capital of its residents, by increasing the scale of its Continuing Education and Training programs. There are also efforts to expand the intake of the country's institutions of higher education.[3]

A reduction in the number of low-skilled foreign workers and the upgrade of skills of resident workers, if successfully achieved, should enhance labor productivity of the Singaporean economy. Within the growth accounting framework, there are three channels through which average labor productivity growth for the whole economy can be achieved: (1) improvement in labor quality (achieved through accumulation of human capital and/or a shift in the labor composition from low-skilled to high-skilled workers), (2) greater use of capital relative to labor input (commonly known as "capital deepening," defined as capital services per hour worked), and (3) technological progress in production (commonly known as "total factor productivity"). Among these three channels, capital deepening has traditionally played a significant role in Singapore's labor productivity improvement, explaining 83 percent of the average labor productivity growth during the period of 1970–2010.[4] This is considerably larger than what other Asian countries have experienced, which were 69 percent in Republic of China (Taiwan), 67 percent in Korea, and 59 percent in Hong Kong during the same period.[5] It also exceeds Japan's

[1] See Table 4 in this study.
[2] The Foreign Worker Levy is "a pricing mechanism to regulate the number of foreign manpower" (Ministry of Manpower), under which employers are required to pay a levy for their work permit holding employees. As the levy is applied to work permit holders (and not to more highly-paid employment pass holders), it is, in effect, a tax on low waged workers.
[3] For example, the Singapore Institute of Technology opened in 2009.
[4] The growth accounting estimates are based on the database constructed in a joint project between the Asian Productivity Organization (APO) and Keio Economic Observatory, Keio University. See APO (2012).
[5] On the other hand, it is well known that TFP growth played a minor, if not negative, role in Singapore's

experience of 79 percent. The scheduled increases of the Foreign Worker Levy over the next decade are expected to have an impact in future capital deepening. By increasing the wage that a firm pays to hire low-skilled foreign workers, the government attempts to promote more private investment in (non-human) capital among firms, and in turn raise output per hour worked.

The purpose of this paper is to understand the forces behind the changes in Singapore's labor productivity performance within the growth accounting framework and to evaluate the effectiveness of the recommended policies. To this end, we construct a cross-classified labor dataset for Singapore so as to estimate a volume index of quality-adjusted labor input (QALI) and an aggregate measure of labor quality change for the period of 1974–2011. Based on our understanding and findings, we then project labor productivity and potential economic growth into the next two decades. There has been previous research conducted on measuring labor quality in Singapore such as Young (1995), Jorgenson and Vu (2010), and Monetary Authority of Singapore Economic Policy Group (MAS 2010). However the two recent studies have been based on aggregated data, in which the workers' attributes are not sufficiently distinguished with workers' residency and age being omitted. The resulted bias has become more pronounced in recent years, due to a rapid change in the composition of residents and non-resident workers. Consequently, our estimates of labor quality growth in this paper are considerably smaller than those in the earlier studies. Furthermore, our view that the prospect of labor quality growth in the foreseeable future will remain bleak is also at odds with that of the previous studies. For the purpose of projecting future labor productivity in Singapore, the impact of an expected ageing labor force should be taken into consideration, especially after the end of the 2010s.

In this paper, data on employed workers in Singapore has been disaggregated to reflect each worker's gender, education attainment, age, employment status, and residency. Section 2 provides our estimates for past labor quality growth, including a description of the methodology used and the data construction process,, followed by a comparison with earlier research and a decomposition of labor quality growth. In section 3, we attempt to project future labor productivity growths under the business-as-usual base scenario, against which the effects of Singapore's economic policy are tested and quantified by varying the policy parameters. Section 4 concludes. The paper is appended with section 5 which documents in detail the process of how the cross-classified labor dataset is constructed, covering number of persons employed, hours worked per worker, and hourly wage. Also included in this section is sensitivity analysis of our results under alternative assumptions used in construction of our dataset. The supplementary tables of our estimates are presented in section 6.

economic growth. Young (1995) estimated that the average annual growth rates of TFP for Singapore were －0.9 percent in the 1970s and －0.5 percent in the 1980s, when growth of labor quality was taken into account. Table 5 in this study provides the comparison of the estimates.

2 Measurement of Labor Productivity, 1974–2011

2.1 Methodology

Our methodology for deriving labor input follows the approach set out by Jorgenson and Griliches (1995), in which an index number of aggregate labor input was constructed, based on labor compensation data for male workers, classified by educational attainment. An extended version of the approach to the industry level for the U.S. economy is available in Jorgenson, Gollop, and Fraumeni (1987, Ch.3), where data were finely disaggregated into age, sex, occupation, class of employment, as well as educational attainment. In this section we describe our framework of labor input indexes adapted to the data for Singapore.

To account for the heterogeneity in hours worked, we distinguish workers by five attributes with the following notations:

$geasr$	subscripts for gender(g), education(e), age(a), employment status(s), and residency(r)[6]
N_{geasr}	employment matrix, number of workers in category $geasr$
H_{geasr}	hours worked by all workers in category $geasr$
H_l	abbreviation for H_{geasr}
h_l	hours worked per worker of category l ($H_l = N_l h_l$)
w_l	hourly wage of category l
L_l	labor input of category l
P_l^L	price of labor input of category l
V_l^L	nominal labor compensation of category l ($\mathrm{V}_l^L = \mathrm{P}_l^L L_l = H_l w_l$)

We e aggregate the volume of labor input using a Törnqvist-Theil quantity index of the individual components:

(1) $\Delta \ln \mathrm{L} = \sum_l \bar{v}_l^L \Delta \ln \mathrm{L}_l$,

where the weights $\bar{v}_l^L$ are the two-period average share of each type of labor income in total labor income. To quantify the impact of substitution among different types of labor input, we assume that labor input for each category L_l is proportional to hours worked H_l:

(2) $L_l = \varphi_l H_l$,

where the constants of proportionality φ_l transform hours worked into flows of labor services. This induces that the price of labor input for each category is proportional to hourly wage w_l:

(3) $P_l^L = \mathrm{w}_l / \varphi_l$,.

We assume that labor services are the same at all points in time for each category of hours worked. For example, an hour worked by a self-employed male resident worker, aged 40, with four years of college education, represents the same labor input in 1974 as in 2010.

Under assumption of Equation (2), the labor quantity index in Equation (1) is expressed

[6] The residents are Singapore citizens or non-citizens who have been granted permanent residence in Singapore and non-residents are non-citizens and non-permanent residents of Singapore, i.e. employment pass holders, work permit holders, student pass holders, dependent pass holders and long-term social visit pass holders.

in terms of hours worked:

(4) $\Delta \ln \mathrm{L} = \sum_l \bar{v}_l^L \Delta \ln \mathrm{H}_l$.

Observations of the constants φ_l are not required to define aggregate labor input. This value of L measures the quality-adjusted labor input (QALI), since L aggregates hours worked by different types of workers, which are then weighted by reflecting their marginal productivities, approximated by their respective hourly wages.[7] The corresponding price of labor input P^L is the ratio of the value of labor compensation to the volume index. The total value is simply:

(5) $V^L = P^L \mathrm{L} = \sum_l P_l^L \mathrm{L}_l = \sum_l V_l^L$.

Finally, the labor quality index measures the part of labor input volume which is not explained by the number of hours worked observed:

(6) $\mathrm{Q} = \mathrm{L}/H$,

where

(7) $\mathrm{H} = \sum_l \mathrm{H}_l = \sum_l N_l h_l$

is the unweighted sum of each type of hours worked. To estimate the quality-adjusted labor input volume L and labor quality Q, observations of N_l, h_l, and w_l are required.

Following the methodology introduced in Jorgenson, Gollop, and Fraumeni (1987), the labor quality index is disaggregated into first- to fourth-order indices to facilitate the investigation of the sources of increases in labor quality. This disaggregation is formulated as

(8)
$$\begin{aligned}\Delta \ln \mathrm{Q} = {} & \Delta \ln Q_G + \Delta \ln Q_E + \Delta \ln Q_A + \Delta \ln Q_S \\ & + \Delta \ln Q_{GE} + \Delta \ln Q_{GA} + \Delta \ln Q_{GS} + \cdots + \Delta \ln Q_{AS} \\ & + \Delta \ln Q_{GEA} + \Delta \ln Q_{GES} + \Delta \ln Q_{GAS} + \Delta \ln Q_{EAS} \\ & + \Delta \ln Q_{GEAS} \ ,\end{aligned}$$

where $\Delta \ln Q_G$ is an example of a first order index (for gender), $\Delta \ln Q_{GE}$ a second order index (for gender and education), and so on. Uppercase subscripts are used to signify that only one index exists for each dimension. For example, only one Q_G exists, whereas H_g, defined in (9), exists for each gender, male and female.

We now explicitly define the first order index and second order index. For the dimension of gender we have

(9) $\mathrm{H}_g = \sum_e \sum_a \sum_s \mathrm{H}_l$

and

(10) $\Delta \ln \mathrm{L}_G = \sum_g \bar{v}_g^L \Delta \ln \mathrm{H}_g$,

where the weights $\bar{v}_g^L$ are the two-period average share of each type of labor income in total labor income. Then, the first order index for gender is defined as

(11) $\Delta \ln \mathrm{Q}_G = \Delta \ln \mathrm{L}_G - \Delta \ln H$.

Similarly, the first order indices can be calculated for the other eas dimensions. The second

[7] The System of National Accounts 2008 came to refer to the quality-adjusted labor input as a measure of labor inputs (United Nations 2009, Chapter 19), in addition to the conventional metrics of full-time equivalents (FTE) and total actual hours worked. It is described that the volume index of QALI is "weighted together using average hourly wages for a worker falling into each category. The premise behind this approach is that workers are hired only until their marginal price (that is, their wages, including on-costs) is less than the marginal revenue expected to result from their production." (Para 19.56).

order index is defined as

(12) $\Delta \ln \mathrm{Q}_{GE} = \Delta \ln \mathrm{L}_{GE} - \Delta \ln \mathrm{Q}_{G} - \Delta \ln \mathrm{Q}_{E} - \Delta \ln H,$

where

(13) $\mathrm{H}_{ge} = \sum_a \sum_s \mathrm{H}_l$

and

(14) $\Delta \ln \mathrm{L}_{GE} = \sum_{ge} \bar{v}_{ge}^{L} \Delta \ln \mathrm{H}_{ge}$.

Similar second order indices can be calculated for each pair of the $geas$ dimensions, giving a total of six second order indices.

In this study, we decompose average labor productivity (ALP) growth while incorporating the changes of labor quality growth that we are able to obtain from the construction of the cross-classified labor data. The growth rate of ALP, defined as the output over total hours worked H, is decomposed using the following equation:

(15)
$$\Delta \ln \mathrm{ALP} = \overline{\mathrm{v}_{KIT}} \Delta \ln \frac{K_{IT}}{H} + \overline{\mathrm{v}_{KNIT}} \Delta \ln \frac{K_{NIT}}{H} + \overline{\mathrm{v}_{LR}} \Delta \ln \mathrm{Q}_{R} + \overline{\mathrm{v}_{LNR}} \Delta \ln \mathrm{Q}_{NR} + \left(\overline{\mathrm{v}_{LR}} \Delta \ln \frac{H_R}{H} + \overline{\mathrm{v}_{LNR}} \Delta \ln \frac{H_{NR}}{H} \right) + \Delta \ln \mathrm{TFP} \ ,$$

where $\overline{\mathrm{v}_{KIT}}$, $\overline{\mathrm{v}_{KNIT}}$, $\overline{\mathrm{v}_{LR}}$, and $\overline{\mathrm{v}_{LNR}}$ are the two-period average shares of income for IT capital, non-IT capital, resident workers, and non-resident workers, respectively (which sum to one under the assumptions of constant returns to scale and competitive markets). The first two terms on the right hand side represent the contribution of capital deepening separated into IT and non-IT capital per hour worked. The third and fourth terms measure the contributions of labor quality of resident and non-resident workers respectively. The fifth item in parenthesis indicates the impacts of the compositional changes between resident and non-resident workers; this effect is zero if the average wage rates for residents and non-resident workers are the same. The final term denotes total factor productivity growth.

When labor quality growth for residents and non-residents cannot be separately identified, a more general form given by equation (16) is used instead, with no explicit compositional change.

(16) $$\Delta \ln \mathrm{ALP} = \overline{\mathrm{v}_{KIT}} \Delta \ln \frac{K_{IT}}{H} + \overline{\mathrm{v}_{KnIT}} \Delta \ln \frac{K_{nIT}}{H} + \overline{\mathrm{v}_{L}} \Delta \ln \mathrm{Q} + \Delta \ln \mathrm{TFP} \ .$$

2.2 Cross-classified Labor Data

The labor database constructed in this paper consists of average annual measures of number of workers N_{geas}, hours worked per worker h_{geas}, and hourly wage w_{geas}, cross-classified by the following five characteristic dimensions: gender (g), educational attainment (e), age (a), employment status (s), and residency (r). Each of these dimensions contains a set of disaggregated components reflecting data availability in Singapore, as presented in Table 1. These classifications are defined to take full advantage of the data publicly available, without making extreme assumptions in the process of reconciling the data from different sources

and compiling the time-series data. For the period from 1974 to 1993 we have a total of $2 \times 5 \times 5 \times 4 \times 1 = 200$ categories, while for the period from 1993 to 1998 we have a total of $2 \times 7 \times 12 \times 4 \times 1 = 672$ categories. By separately estimating the profile of non-residents workers for the period after 1999, we have a total of $2 \times 7 \times 12 \times 4 \times 2 = 1344$ categories in the most recent time period.

Table 1: Classification of Labor Categories

Types of categories	Classification		
	1974–1993	1993–1998	1999–2010
Gender (g)	1) Male; 2) Female		
Education attainment (e)	1) No formal qualification/Lower primary; 2) Primary/Lower secondary; 3) Secondary; 4) Upper secondary; 5) Diploma/Degree	1) No formal qualification/Lower primary; 2) Primary; 3) Lower secondary; 4) Secondary; 5) Upper secondary; 6) Polytechnic diploma; 7) Degree	
Age (a)	1) 15-19; 2) 20-29; 3) 30-39; 4) 40-49; 5) 50 and over	1) 15-19; 2) 20-24; 3) 25-29; 4) 30-34; 5) 35-39; 6) 40-44; 7) 45-49; 8) 50-54; 9) 55-59; 10) 60-64; 11) 65-69; 12) 70 and over	
Employment status (s)	1) Employer; 2) Employee; 3) Own account worker; 4) Contributing family worker		
Residency (r)	1) Residents and Non-Residents		1) Residents; 2) Non-residents

The main data sources used are three: (1) the decennial *Census of Population*, (2) the *General Household Survey* (GHS), which is published every five years by the Singapore Department of Statistics), and (3) the *Labour Force Survey* (LFS), which is published annually by the Ministry of Manpower. The process of transforming publically available two-dimensional statistical data into a multi-dimensional, cross-classified labor database requires statistical manipulations as well as several adjustment processes. The appendix in section 5 describes the details.

In particular, Singaporean statistical publications often lack sufficient information on non-resident workers, and have undergone frequent changes in the methodology used for data construction. Given the rapid growth of Singapore in the past few decades, characterized by the recent inflow of foreign workers, official labor input data are biased by omitting non-resident workers.[8] Thus, it is necessary for us to follow an intricate process in order to compile a comprehensive database that reflects *all* workers in Singapore. The details of this adjustment process are described in section 5.2.

2.3 Labor Input and Quality Change

Table 2 and Figure 1 present the time-series estimates of quality-adjusted labor input volume (QALI), calculated by using the Törnqvist-Theil quantity index, and other aggregated indicators for the whole period studied in this paper.[9] Over almost four decades from 1974 to 2011, while employment and hours worked nearly quadrupled, we find that labor input in 2011

[8] See section 2.4 for a discussion on possible biases that previous studies suffer from, due to their lack of necessary adjustments.

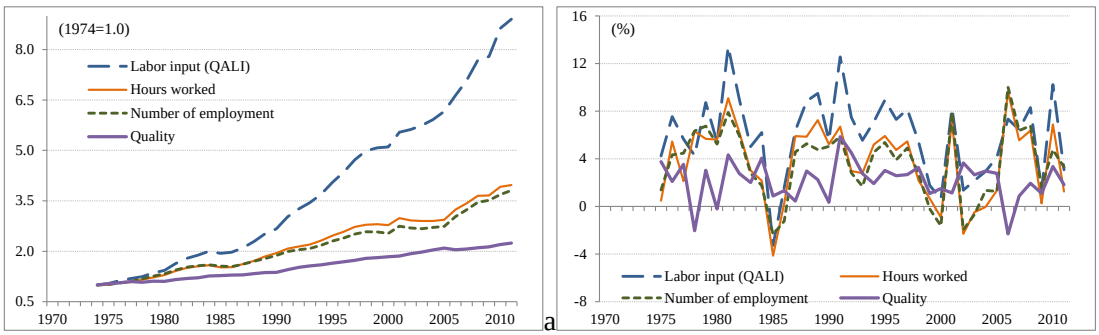
[9] Some supplementary tables are provided in appendix section 6.

was 8.9 times its level of 1974 when labor quality is properly accounted for. The wedge between these measurements is driven by labor quality growth, which has cumulatively improved labor quality by 160 percent during the same period. On the other hand, although the hourly wage has increased by 4.7 times from 1974 to 2011, 39.2 percent of this increase is explained by the improvement in labor quality, rather than a change in price of labor.

Table 2: Aggregate Labor Input of Singapore Economy

Year	QALI L		Price P^L	Compensation V^L		Quality Q	Employment N	Hours per week h	Hourly wage w		Hours worked H	
	(mil. 2000SGD)	(2000=1)	(2000=1)	(mil. SGD)	(2000=1)	(2000=1)	(thousands)	(hr)	($/hr)	(2000=1)	(mils)	(2000=1)
1974	14,187	0.196	0.430	6,098	0.084	0.545	826	45.6	3.4	0.234	38	0.360
1975	14,802	0.204	0.471	6,969	0.096	0.565	838	45.2	3.8	0.266	38	0.361
1976	15,963	0.220	0.453	7,225	0.100	0.577	875	45.7	3.8	0.261	40	0.382
1977	16,894	0.233	0.449	7,585	0.105	0.598	915	44.6	3.9	0.269	41	0.390
1978	17,632	0.243	0.454	8,011	0.111	0.586	975	44.6	3.8	0.266	43	0.415
1979	19,239	0.266	0.465	8,948	0.124	0.604	1,043	44.1	4.0	0.281	46	0.440
1980	20,309	0.280	0.504	10,243	0.141	0.603	1,099	44.3	4.4	0.304	49	0.465
1981	23,224	0.321	0.532	12,360	0.171	0.630	1,190	44.8	4.8	0.335	53	0.509
1982	25,410	0.351	0.596	15,139	0.209	0.647	1,263	44.9	5.6	0.386	57	0.542
1983	26,721	0.369	0.657	17,549	0.242	0.661	1,298	45.0	6.3	0.434	58	0.559
1984	28,433	0.393	0.689	19,589	0.270	0.688	1,321	45.2	6.8	0.474	60	0.571
1985	27,519	0.380	0.718	19,764	0.273	0.694	1,290	44.4	7.2	0.498	57	0.548
1986	27,957	0.386	0.654	18,295	0.253	0.703	1,275	45.1	6.6	0.460	57	0.549
1987	29,790	0.411	0.648	19,292	0.266	0.706	1,334	45.7	6.6	0.457	61	0.582
1988	32,543	0.449	0.677	22,047	0.304	0.728	1,406	46.0	7.1	0.493	65	0.618
1989	35,786	0.494	0.721	25,797	0.356	0.744	1,475	47.1	7.7	0.537	70	0.664
1990	37,838	0.522	0.790	29,906	0.413	0.747	1,551	47.2	8.5	0.590	73	0.699
1991	42,901	0.592	0.795	34,121	0.471	0.792	1,645	47.6	9.1	0.630	78	0.748
1992	46,234	0.638	0.809	37,410	0.517	0.829	1,692	47.7	9.7	0.670	81	0.771
1993	48,877	0.675	0.856	41,835	0.578	0.852	1,721	48.2	10.5	0.729	83	0.792
1994	52,474	0.725	0.911	47,800	0.660	0.868	1,801	48.5	11.4	0.791	87	0.835
1995	57,381	0.792	0.914	52,417	0.724	0.895	1,901	48.8	11.8	0.817	93	0.885
1996	61,734	0.852	0.949	58,573	0.809	0.918	1,976	49.2	12.6	0.871	97	0.928
1997	66,973	0.925	0.949	63,548	0.877	0.943	2,076	49.5	12.9	0.895	103	0.981
1998	70,733	0.977	0.935	66,112	0.913	0.974	2,134	49.2	13.1	0.911	105	1.002
1999	71,991	0.994	0.908	65,361	0.902	0.985	2,129	49.6	12.9	0.894	106	1.009
2000	72,423	1.000	1.000	72,423	1.000	1.000	2,095	50.0	14.4	1.000	105	1.000
2001	78,644	1.086	0.975	76,657	1.058	1.011	2,267	49.6	14.2	0.986	112	1.074
2002	79,723	1.101	0.966	77,021	1.063	1.049	2,223	49.4	14.6	1.014	110	1.049
2003	81,470	1.125	0.950	77,392	1.069	1.077	2,208	49.5	14.7	1.023	109	1.044
2004	83,900	1.158	0.970	81,347	1.123	1.110	2,238	48.8	15.5	1.076	109	1.044
2005	87,442	1.207	1.003	87,683	1.211	1.141	2,267	48.9	16.5	1.144	111	1.058
2006	94,095	1.299	1.031	96,973	1.339	1.115	2,506	48.7	16.6	1.149	122	1.165
2007	100,357	1.386	1.102	110,588	1.527	1.125	2,671	48.3	17.9	1.240	129	1.232
2008	109,049	1.506	1.086	118,397	1.635	1.147	2,858	48.1	17.9	1.246	137	1.312
2009	110,539	1.526	1.099	121,535	1.678	1.160	2,906	47.4	18.4	1.275	138	1.316
2010	122,454	1.691	1.076	131,822	1.820	1.199	3,047	48.4	18.6	1.291	148	1.410
2011	126,287	1.744	1.097	138,567	1.913	1.222	3,150	47.4	19.3	1.340	149	1.427

Note: The Törnqvist-Theil quantity index is adopted for calculating the growth of QALI and the price of labor input is computed by the implicit Törnqvist-Theil price index.



Note: The left-hand side graph shows the level of each indicator, normalizing 1974 to 1.0. The right-hand side graph shows yearly growth rates.

Figure 1: Aggregate Indices of Labor Input, Hours Worked, and Employment

Over the past four decades, the nature of Singapore's economic growth has been predominantly capital driven. Coupled with a significant contribution from labor input, TFP growth has been poor or even negative. Table 3 shows the average annual growth rates of value added and its sources, namely capital inputs, labor inputs, and TFP.[10] During the whole period of our observation, the capital inputs and labor input have respectively increased by 8.16 percent and 5.99 percent on average per year and contributed to 63.6 percent and 40.7 percent of the GDP growth. Over the long run, the TFP has deteriorated.

Table 3: Growth in Aggregate Value Added and Its Sources

	1974–80	1980–85	1985–90	1990–95	95–2000	2000–05	2005–10	1980–90	90–2000	2000–10	1974–2010
Contribution											
Value added	7.62	6.63	8.28	8.20	5.60	4.66	6.28	7.45	6.90	5.47	6.78
Capital input	5.96	6.29	3.78	4.25	4.58	2.56	2.38	5.04	4.42	2.47	4.31
IT	0.43	0.62	0.83	0.92	0.68	0.59	0.56	0.72	0.80	0.57	0.65
Non-IT	5.53	5.68	2.95	3.34	3.90	1.97	1.82	4.31	3.62	1.90	3.65
Labor input	2.90	2.73	2.87	3.80	2.17	1.81	3.03	2.80	2.98	2.42	2.76
Resident						1.35	1.90			1.64	
Non-residents						0.57	1.14			0.85	
Labor quality	0.86	1.30	0.67	1.65	1.04	1.27	0.47	0.99	1.34	0.87	1.03
	(28.4)	(46.2)	(23.1)	(43.4)	(47.8)	(70.1)	(14.8)	(34.4)	(44.9)	(34.6)	(37.0)
Resident						0.77	0.88			0.83	
Non-residents						0.60	-0.46			0.09	
Hours worked	2.04	1.42	2.20	2.15	1.12	0.54	2.56	1.81	1.64	1.55	1.73
	(71.6)	(53.8)	(76.9)	(56.6)	(52.2)	(29.9)	(85.2)	(65.6)	(55.1)	(65.4)	(63.0)
Resident						0.58	1.02			0.81	
Non-residents						-0.03	1.60			0.76	
TFP	-1.24	-2.39	1.63	0.15	-1.15	0.29	0.88	-0.38	-0.50	0.58	-0.29
Growth											
Capital input	11.69	11.92	6.99	7.83	8.64	4.99	4.33	9.46	8.24	4.66	8.16
IT	19.22	21.88	19.98	16.59	12.51	10.64	10.52	20.93	14.55	10.58	16.00
Non-IT	11.34	11.37	5.91	6.85	8.19	4.31	3.67	8.64	7.52	3.99	7.49
Labor Input	5.98	6.08	6.37	8.33	4.66	3.77	6.74	6.22	6.49	5.25	5.99
Resident						3.60	5.57		3.83	4.58	4.52
Non-residents						5.32	10.42		-13.67	7.87	5.91
Labor quality	1.70	2.81	1.47	3.61	2.22	2.64	0.99	2.14	2.92	1.82	2.19
Resident						1.93	2.23		5.79	2.08	2.42
Non-residents						5.57	-0.61		-15.38	2.48	0.86
Hours worked	4.28	3.27	4.90	4.72	2.43	1.13	5.74	4.08	3.57	3.43	3.79
Resident						1.66	3.34		-1.96	2.50	2.10
Non-residents						-0.24	11.02		1.71	5.39	5.05
Employment	4.75	3.21	3.68	4.06	1.94	1.58	5.92	3.44	3.00	3.75	3.62
Residents	4.30	1.94	3.62	1.75	0.77	2.11	3.51	2.78	1.26	2.81	2.60
Non-residents	9.56	12.02	4.04	13.27	5.10	0.23	11.20	8.03	9.18	5.72	7.91

Note: Figures in parentheses are contribution shares.

In particular, it should be noted that the role of labor quality improvement in the labor input growth is significant. The growth rate of labor quality change was 2.19 percent per annum on average during 1974–2011. This uplift in labor quality accounted for 37 percent of labor input growth and directly contributed 1.03 percentage point to the 6.78 percent average yearly

[10] The capital input used in this study is based on the capital service estimates in APO (2012), which is aggregated from capital services by ten asset types.

economic growth. Singapore's sustained effort in raising labor quality to contribute over 1 percentage point to economic growth per year over the long run is an outstanding achievement, compared with the experience of other economies. Even during the decade (1960–1973) when Japan achieved high economic growth of 10 percent a year on average, the contribution of labor quality to economic growth was 0.53 percentage point per year.[11] The corresponding figure for the U.S. was 0.37 percentage point on average per year during 1948–1979.[12]

Looking at the sub-periods of our observation in Table 3, it is clear that the labor quality improvement slowed down since the mid-2000s. This downward trend is caused by the rapid deterioration of labor quality in non-resident workers, the average annual contribution of which to labor input decreased to –0.46 percentage point during 2005–2010, down from 0.60 percentage point during 2000–2005. This is mainly due to a sharp increase of low-skilled foreign workers after the middle of the 2000s, as shown from the fact that the hours worked of non-residents increased by 11percent in the latter half of the 2000s in comparison with a decrease of 0.24 percent in the first half of the 2000s.[13]

Table 4 presents average labor productivity (ALP) and its sources, namely, capital deepening, labor quality growth, and TFP growth, using equations (15) and (16), and Figure 2 presents the time-series comparisons by sub-periods. In the 1980s and 1990s, ALP in Singapore grew at 3.37 percent and 3.33 percent per annum respectively, but the ALP growth rates were shaved off by more than one-third to 2.04 percent in the 2000s. This decline in ALP growth is largely explained by the slowdown in the pace of capital deepening. In the first half of the 2000s, the rate of capital deepening was 1.98 percent, compared with 3.27 percent in the late 1990s. Since the mid-2000s, the contribution of capital deepening has turned negative, dragging down ALP growth by 0.80 percentage point. As the role played by capital deepening retreats, the relative contribution of labor quality growth has gradually increased. This motivates the question of whether such growth in labor quality can be expected to continually play a vital role in ALP growth.

Table 4: Decomposition of ALP Growth, 1974–2011

	1974–80	1980–85	1985–90	1990–95	95–2000	2000–05	2005–10	1980–90	90–2000	2000–10	1974–2010
ALP growth	3.35	3.36	3.38	3.49	3.17	3.54	0.54	3.37	3.33	2.04	2.98
Capital deepening	3.73	4.45	1.08	1.69	3.27	1.98	-0.80	2.76	2.48	0.59	2.24
	(111.36)	(132.37)	(31.97)	(48.38)	(103.28)	(55.92)	-(148.82)	(82.02)	(74.50)	(28.79)	(75.07)
IT capital	0.33	0.53	0.62	0.65	0.54	0.53	0.25	0.57	0.60	0.39	0.49
Non-IT capital	3.40	3.92	0.46	1.03	2.73	1.44	-1.05	2.19	1.88	0.20	1.75
Quality change	0.86	1.30	0.67	1.65	1.04	1.32	0.72	0.99	1.34	1.02	1.05
	(25.69)	(38.74)	(19.77)	(47.26)	(32.91)	(37.21)	(133.68)	(29.23)	(40.43)	(50.00)	(35.03)
Resident						0.72	0.76			0.74	
Non-resident						0.60	-0.04			0.28	
Compositional change						0.06	-0.26			-0.10	
TFP growth	-1.24	-2.39	1.63	0.15	-1.15	0.19	0.88	-0.38	-0.50	0.53	-0.30

Note: All figures are annual average growth rates, except for those in parentheses, which are contribution shares.

[11] This is based on the estimates using the Japan's cross-classified labor data in KEO Database constructed at Keio Economic Observatory, Keio University.

[12] See Table 9.5 in Jorgenson, Gollop, and Fraumeni (1987, Ch.9).

[13] Section 5.2.5 in appendix describes the details.

The resurgence in TFP growth that we observe in the late 2000s is also noteworthy. In the latest five years, the Singaporean economy grew at a rate of 6.28 percent on average per annum. Although it was slower than the growth rates of 7.45 percent and 6.90 percent achieved in the 1980s and 1990s respectively (Table 3), it was output growth that was *not* totally explained by input growths. During the 1980s and 1990s, rapid output growth was fuelled by even higher input growths, leaving TFP to grow at –0.38 percent and –0.50 percent respectively. Unlike the 1980s and 1990s, TFP grew at 0.88 percent during 2005–2010. Positive TFP growth is a new feature of the recent Singaporean economy, implying that sustainability of TFP growth may play a critical role in projection of future ALP growth.

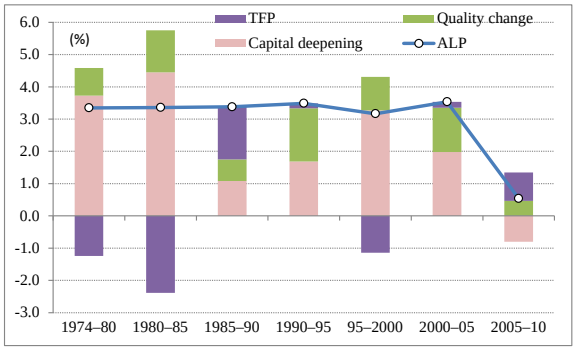


Figure 2: Labor Productivity Growth and Quality Change

2.4 Comparison with Previous Research

A few studies have examined quality changes in labor as a source of economic growth in Singapore before this study. In this section we attempt to compare our results with the previous studies, and identify reasons for why discrepancies may occur. Table 5 presents the comparisons of earlier results with our estimates of the same time periods.

Our estimates during the 1980s are comparable to those of Young (1995), who studied growth in Singapore, along with other Asian economies. In his study a dataset in which the labor force was cross-classified using six dimensions was constructed.[14] The estimates of hours worked growth are identical (1.8 percent on average), and the speed of labor quality growth is almost consistent between two studies (1.5 percent in Young's and 1.0 percent in our estimate). Our estimate for contribution of capital services is 0.9 percentage points larger than Young's 4.1 percent. However, we find that TFP and ALP growths are similar between two studies during this period, because output growth is also 0.6 percentage points higher in our study.[15]

Our results in the 1990s and 2000s are not as comparable with other studies. Compared

[14] Young (1995) estimated the Singaporean working population cross-classified by seven categories as gender, age, education, industry, income, employment status, and occupation, using all available tabulations in Census 1990 and then summed across occupational categories to derive a reduced six-dimensional table (Young 1995, p.653).

[15] Capital and output data in our study are based on SSNA using the 1993 SNA definitions. This is in contrast with the data used in Young (1995) which was based on the 1968 SNA.

with the results presented in Jorgenson and Vu (2010) and MAS (2010),[16] our estimates of labor quality growth vary both in terms of magnitude and trend. In the 1990s, the magnitude of labor quality growth are considerably different, e.g. our estimates of 1.4 percent and 1.6 percent compared with 0.1 percent in MAS (2010) during 1990–1999 and –0.1 percent in Jorgenson and Vu (2010) during 1990–1996 respectively. In terms of time trend, our estimates show that labor quality growth slowed from 1.4 percent on average per year during 1990–1999, to 0.8 percent during 2000–2009. This contrasts with the view put forward in MAS (2010) that there has been a pickup in labor quality growth from 0.1 percent to 0.5 percent in the same periods. Despite the discrepancies between our labor quality growth estimates and movements and those in MAS (2010), we find that our figures for labor input and ALP during 2000–2009 are comparable.

Table 5: Comparison of Factors of Growth in Singapore

	Output	Contribution of Capital	IT	non-IT	Contribution of Labor	Hours	Quality	TFP	ALP
	$\%\Delta Y$	$\%\Delta K$	$\%\Delta K_{IT}$	$\%\Delta K_{NIT}$	$\%\Delta L$	$\%\Delta H$	$\%\Delta Q$		$\%\Delta(Y/H)$
Young (1995)									
1966–70	13.0	6.7			1.7	2.7	-1.1	4.6	10.3
1970–80	8.8	6.8			3.0	2.6	0.4	-0.9	6.2
1980–90	6.9	4.1			3.3	1.8	1.5	-0.5	5.1
(This study)	7.5	5.0	0.7	4.3	2.8	1.8	1.0	-0.4	5.6
MAS (2010)									
1990–99	7.6	4.5	1.1	3.4	2.2	2.1	0.1	0.9	5.5
(This study)	6.7	4.5	0.8	3.7	3.3	1.9	1.4	-1.1	4.8
2000–09	4.9	2.3	0.7	1.6	2.4	1.9	0.5	0.2	3.0
(This study)	4.5	2.5	0.6	1.9	2.2	1.4	0.8	-0.1	3.2
Jorgenson and Vu (2010)									
1965–80	9.7	7.9			1.9			-0.1	9.7
1980–90	7.2	3.8			1.7			1.7	7.2
(This study)	7.5	5.0	0.7	4.3	2.8	1.8	1.0	-0.4	5.6
1990–96	8.3	4.5	1.0	3.6	2.1	2.2	-0.1	1.7	6.1
(This study)	8.1	4.3	0.9	3.4	3.7	2.2	1.6	0.0	5.9
1996–02	4.1	3.5	1.1	2.4	1.3	1.1	0.2	-0.7	3.0
(This study)	3.9	4.1	0.6	3.5	2.0	1.0	1.1	-2.2	3.0
2002–08	6.0	2.7	0.9	1.8	3.0	2.1	0.9	0.4	3.9
(This study)	6.5	2.3	0.6	1.7	2.3	1.6	0.7	1.9	4.8

Our contention is that the inconsistencies of our findings with other studies stem from the difference in the level of aggregation of the cross-classified labor dataset. First, we distinguish each employed worker by five dimensions (gender, age, education attainment, employment status, and residency), whereas Jorgenson and Vu (2010) classifies workers by two dimensions of gender and education attainment. To confirm our intuition, we aggregate employed resident workers only by their gender and education attainment, and confirm that such level of aggregation brings us to underestimate labor quality growth as shown in Figure 3. While labor quality growth was 2.00 percent on average per year during 1993–2011 in our base estimation, it was only 1.40 percent when only two dimensions were used. Failing to reflect changes in age and employment status leads to an underestimation of quality growth.

[16] The data used in the Monetary Authority of Singapore Economic Policy Group (MAS, 2010) is based on Vu's estimates, and is comparable to those in Jorgenson and Vu (2010).

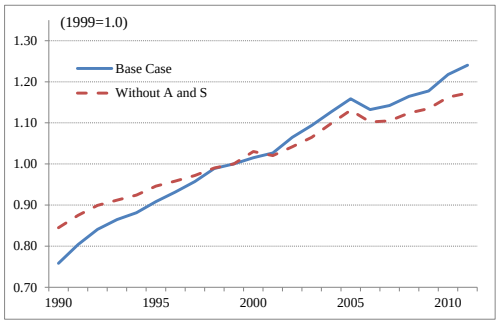


Figure 3: Labor Quality without Age and Status Dimensions for Residents

Second, we attempt to estimate the characteristics of non-resident workers, while Jorgenson and Vu (2010) does not.[17] In recent years, non-residents workers have expanded to account for more than a third of the total number of employed workers (see Table 21), from 16 percent two decades ago. Thus, the method used to estimate the qualifications of the non-resident labor force has a significant effect on overall labor quality growth. Our estimation process allows the non-resident labor force to be treated as a distinct group from the resident labor force. (See section 5 for the details of estimation methods used.) If we had, instead, proportionally applied the characteristics of the resident labor force to non-resident workers, labor quality growth would have been estimated to be 2.45 percent during 1999–2011, overestimating labor quality growth by more than 0.6 percentage points per year compared to our base estimated of 1.79 percent (see Figure 4). Failing to reflect the differences between resident and non-resident workers overestimates labor quality growth.

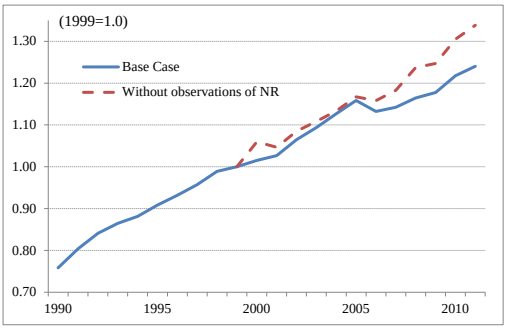


Figure 4: Labor quality without Observations of NR Composition

A combination of these two biases may be able to describe the inconsistency between our estimates and those of Jorgenson and Vu (2010). In the 1990s, the non-resident labor force was a much smaller component of the Singaporean labor force. Therefore, labor quality was underestimated in Jorgenson and Vu as the effect of dropping the age and employment status dimensions dominated.[18] By the 2000s, the non-resident labor force had expanded, and thus, the

[17] Another simplification in MAS (2010) is that the average hours worked per employee is assumed to be constant over periods.

[18] We note, however, that the underestimation due to the lack of age and employment status is not sufficient to describe the difference of magnitude between our estimates and Jorgenson and Vu. The underestimation due to the lack of age and employment status is about 1.2 percentage points per year during 1990–1999, or about 0.6

estimates in Jorgenson and Vu reflected both the overestimation and underestimation described above. This most likely made the estimates comparable to ours. In contrast to the estimates in Jorgenson and Vu, we find no evidence that labor quality growth has increased in the 2000s, as compared to the 1990s. Hence, we are less optimistic about future labor quality growth.

2.5 Decomposition of Labor Quality

Following equations (15) and (16) in section 2.1, we decompose labor quality growth using our cross-classified worker data. Table 6 provides an overview of the first order indices, as well as the second order index showing the interaction between education attainment and age, which was the most significant of all second-order indices, contributing as much as 58.5 percent to labor quality growth from 2005 to 2010.

Table 6: Growth Rate of Labor Quality Indices

	1974–80	1980–85	1985–90	1990–95	95–2000	2000–05	2005–10	1980–90	90–2000	2000–10	1974–2011
Labor input	5.98	6.08	6.37	8.33	4.66	3.77	6.13	6.03	6.49	4.95	5.91
Hours worked	4.28	3.27	4.90	4.72	2.43	1.13	4.99	3.77	3.57	3.06	3.73
Labor quality	1.70	2.81	1.47	3.61	2.22	2.64	1.13	2.25	2.92	1.89	2.18
Gender (g)	-0.06	-0.05	-0.08	0.11	-0.05	-0.18	-0.08	-0.05	0.03	-0.13	-0.06
	-(3.41)	-(1.63)	-(5.52)	(3.04)	-(2.34)	-(6.65)	-(6.90)	-(2.30)	(0.99)	-(6.73)	-(2.53)
Education (e)	1.26	1.07	0.96	2.15	1.80	2.07	0.69	1.17	1.97	1.38	1.40
	(74.37)	(38.20)	(65.06)	(59.46)	(81.02)	(78.28)	(60.79)	(51.85)	(67.68)	(73.03)	(64.32)
Age (a)	0.32	1.17	0.51	0.87	0.24	0.49	-0.25	0.74	0.56	0.12	0.45
	(18.63)	(41.76)	(34.34)	(24.07)	(10.93)	(18.68)	-(21.95)	(33.03)	(19.06)	(6.48)	(20.82)
Employment Status	-0.02	0.61	0.03	0.37	0.01	-0.10	0.08	0.30	0.19	-0.01	0.13
(s)	-(1.13)	(21.87)	(1.86)	(10.15)	(0.35)	-(3.96)	(7.21)	(13.19)	(6.41)	-(0.61)	(6.10)
Education and Age	0.62	0.15	0.10	0.36	0.20	0.40	0.66	0.39	0.28	0.53	0.37
(ea)	(36.57)	(5.49)	(6.47)	(9.86)	(8.92)	(15.21)	(58.51)	(17.22)	(9.50)	(28.21)	(17.01)
Others	-0.43	-0.16	-0.03	-0.24	0.03	-0.04	0.03	-0.29	-0.11	-0.01	-0.12
	-(25.04)	-(5.69)	-(2.20)	-(6.57)	(1.13)	-(1.56)	(2.34)	-(12.99)	-(3.64)	-(0.39)	-(5.72)

Note: All figures are average annual growth rates, except for those in parentheses, which are contribution shares (relative to quality growth).

Throughout the entire period, changes in the education attainment of workers has been the most significant factor in labor quality growth. The second most important contributor has been the experience of workers, as proxied by age; its contribution was most prominent during 1980–1985 but since then its dominance has been superseded by education attainment.

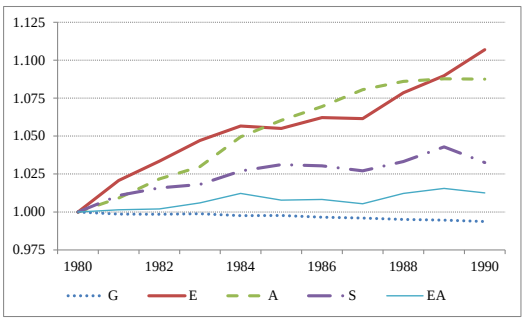


Figure 5: Decomposition of Quality Change, 1980–1990

percentage points in contribution. Therefore, this bias explains only about 0.6/(1.4-0.1)= 46 percent of the difference.

The first order indices show that, rising education attainment of workers by itself explains about 65 percent of the increase in labor quality during the entire period of estimation. Combining with the first order index of age, and the second order index representing the interaction between age and education attainment, a total of 98.6 percent of the increase in labor quality over the past four decades is explained.

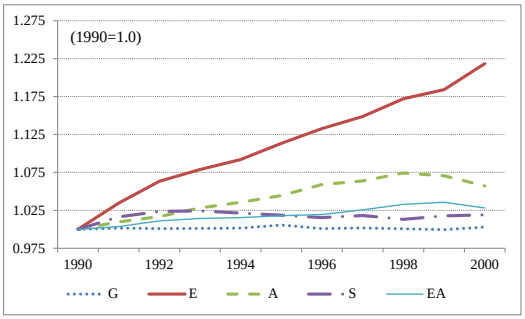


Figure 6: Decomposition of Quality Change, 1990–2000

In recent years after 2000, the contribution of the second order effect of education attainment and age, has become more important. This term shows the contribution to labor quality growth made by experienced workers who at the same time have high education attainment.

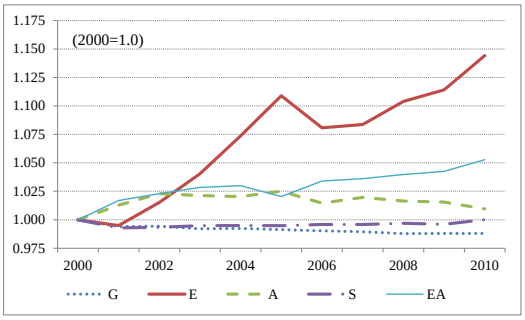


Figure 7: Decomposition of Quality Change, 2000–2010

3 Projection of Labor Productivity Growth, 2010–2030

3.1 Methodology and Baseline Assumptions

In light of the future increases in the foreign worker levy and the advances in the education attainment of resident workers, we attempt to project how such changes will affect labor quality and ALP growths over the course of the next four decades. The estimation process is conducted as follows. First, we project how the size and composition of employed workers will change over the course of the next four decades. Then, we alter the rate of increase of the education attainment of Singaporean residents to simulate future increases in human capital. We anticipate that an increase in the wage of foreign workers affects labor input, both by decreasing the use of unskilled foreign labor, and by increasing investment in non-human capital. We complete our analysis by illustrating the effects of these two policy options in our projection of

future labor productivity growth.

In order to construct the business-as-usual (BAU) scenario, we first estimate the future growth of the Singaporean population, which is cross-classified by the gender (g), age (a) and educational attainment (e), for the period between 2010 and 2050. The total number of future resident population in our BAU scenario is set by the estimate in the middle-scenario (the Scenario 2) of the Institute of Policy Studies, National University of Singapore (IPS, 2011). Following this scenario, we assume a total fertility rate of 1.24 and yearly immigration of 30,000 persons.

The age composition is given by the initial conditions, estimated from the 2010 *Census of Population*, and future changes are projected using the birth and death rates as specified above. On the other hand, while the initial conditions of educational attainment are given in the Census, the future educational attainment of the younger generations are assumed to be set as parameters, and are manipulated based on the various scenarios described below. Under the BAU scenario, we assume that the educational attainment of persons aged 30–34 years old stays constant at 2010 levels.[19] Educational attainment is given by seven categories, so that the categories are harmonized with our estimates from 1974 to 2011.

Next, to estimate the number of employed workers from the population, we calculate the ratio of employed resident workers to resident population for each age group and level of educational attainment in 2010.[20] This ratio is assumed to be fixed throughout the period of 2010 to 2050. We assume, as in the official statistics, that persons older than 15 years old can be employed. Additionally, we assume that persons older than 77 years of age are not employed.

By fixing the ratio of employed persons to the population, while letting the number and composition of the population change, we were able to illustrate the disproportional relationship between population growth and the increase of the number of employed workers. For example, as younger generations gain more education, they are less likely to join the labor force until they have finished their college degrees, thereby decreasing the number of younger employed workers. On the other hand, workers with higher education attainment are likely to work longer hours once they start working. This concludes the construction of the projection for the future employed residents in Singapore, cross-classified by each worker's gender, age and educational attainment.

We next construct projections for non-resident employed workers. We assume that the non-resident labor force maintains the same relative size to the resident labor force under the BAU scenario, as in the IPS study. In 2010, 35.8 percent of employed workers were non-residents workers. In BAU, the future composition of gender, age and educational attainment of the non-resident labor force are fixed to be the same as our 2010 estimates. By combining our projection of resident employed workers with that of non-resident employed workers, we construct a projection of all employed workers in Singapore for the next 40 years. We calculate

[19] Regardless of the scenario used, persons below 12 years of age are assumed to have no education, while persons older than 87 years of age have the same education attainment as that of the persons who were one year younger during the previous year. The education attainment of persons younger than 17 years of age is fixed at 2010 levels. The education attainment of all other individuals is estimated using linear interpolation.

[20] See Table 27 in section 6.

labor input and labor quality growth using the projections obtained above. In BAU, we assume that average hours worked per person and hourly wages are fixed at 2010 levels for each category of workers and that residents and non-residents enjoy the same working hours and compensation.

Finally, we project average labor productivity growth following equation (15). Unlike in section 2.3 where we decomposed ALP growth using past observations, we use equation (15) to stack up sources of growth in order to obtain a projection of ALP growth. As a reference, future TFP growth is set as zero both in the BAU scenario in the next section and the policy scenarios in section 3.3. For capital, in all scenarios, we assume exogenously an IT capital growth of 10.6 percent and non-IT capital growth of 3.7 percent as they were in 2005–2010 (Table 3). The prices of IT capital and non-IT capital are assumed to change annually by –11.4 percent and 2.2 percent, respectively, relatively to the price of labor as a numeraire.[21] Growth rates of capital input and relative prices gradually are assumed to reach zero percent as a steady-state in 2040. In this study, we initially assume that the income shares $\overline{v_{KIT}}$, $\overline{v_{KNIT}}$, and $\overline{v_{LR}} + \overline{v_{LNR}}$ in 2010 are 0.054, 0.497, and 0.449, respectively, and then allow the value shares to change over time based on the assumptions described above. We note that the relative value share of residents and non-resident labor are given endogenously.

3.2 Business-as-usual Scenario

Our projections suggest that, while the current resident population in Singapore is 3.3 million people in 2010, the population would continue to follow a slow growth pattern, reaching 4.5 million in 2037, and just short of 4.9 million in 2050. The overall trend of population growth, as well as those of the three broad age groups (14 and below, 15 to 64, 65 and above), are comparable to those reported by the IPS. The ratio of the working population (persons aged 15–64) to the dependent population (persons aged under 15 and over 64), provides us with a glance of the rapid increase of older population in Singapore. While there were 2.85 working-age people to support one dependent in 2011, this ratio will rapidly drop to 1.86 in 2038, undergoing a yearly growth of –1.6 percent.

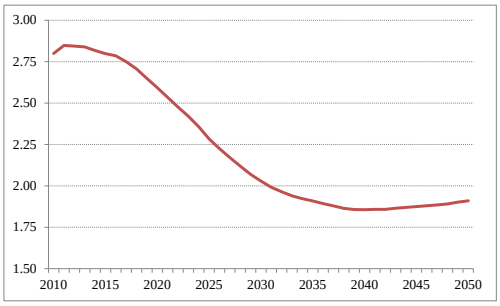


Figure 8: Ratio of Working-Age to Dependent Population, 2010–2050

In Singapore, the number of employed resident workers is about 2.0 million persons in

[21] Thus the relative marginal productivities of labor, non-IT capital and IT capital are changed. The relative price changes are based on the estimates during 2005–2010 in APO (2012)

2010. This will reach 2.5 million in 2043. While roughly 53 percent of the resident population is currently employed, this ratio will fall past to 51 percent in the beginning of the 2040s after reaching a peak of 54 percent around 2020. This suggests that the effect of the younger population with higher education attainment and higher likelihood of them being employed is exceeded by the rapid increase of the elderly population (and consequent growth of the economically inactive population).

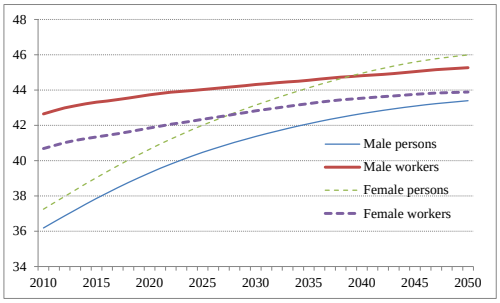


Figure 9: Average Age of Residents, 2010–2050

Table 7: Summary Statistics of Resident Population and Employed Workers, 2010–2050

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Number of residents											
Population (thousands)	3273	3468	3772	4008	4228	4432	4611	4750	4845	4902	4936
Employed (thousands)	1483	1647	1963	2133	2273	2372	2433	2461	2486	2516	2545
Share of employed	45%	48%	52%	53%	54%	54%	53%	52%	51%	51%	52%
Dependency ratio											
Resident population	2.44	2.56	2.80	2.80	2.59	2.28	2.03	1.91	1.86	1.88	1.91
Average age											
Resident population	33.3	-	36.7	38.5	40.0	41.2	42.3	43.1	43.8	44.4	44.7
Employed residents	-	-	41.8	42.4	42.9	43.3	43.7	44.0	44.2	44.5	44.7
Ratio of persons older than 65											
Resident population	7%	8%	9%	11%	14%	17%	20%	21%	22%	22%	22%
Employed residents	2%	2%	3%	5%	6%	7%	8%	8%	8%	8%	8%
Ratio with degree or higher											
Resident population	8%	12%	18%	21%	24%	27%	30%	32%	34%	35%	37%
Employed residents	16%	22%	28%	32%	36%	40%	43%	45%	47%	48%	48%

Note: The estimates during 2000–2010 are actual values.
The total number of future population is based on the estimates in the middle-scenario (the Scenario 2) of IPS (2011).

In our projections, employed workers are projected to age less rapidly. During the period of 2010–2050, the average age of the resident population will increase 8.0 years from 36.7 years to 44.7 years, while the average age of the employed resident population will increase only 2.9 years from 41.8 years to 44.7 years.[22] Figure 9 shows the growth of the average age of resident population and workers by gender. It is noteworthy that, in 2027, the average age of female persons will surpass that of female workers. Table 7 provides a summary of the statistics regarding resident persons and workers discussed above.

In terms of education, Singapore's keen education policy will continue to bear fruits through higher education attainment of its workers over the course of the next few decades as

[22] It should be noted that in our projections, we have assumed that persons older than 77 are not employed.

shown in Figure 10. Around 2040 the education attainment of Singapore's workers will max out, as the younger generations today who have a high proportion of college degrees age and start to face retirement. The population as a whole will continue to accumulate higher human capital, which will help mitigate the decreasing rate of employment due to the ageing population of Singapore.

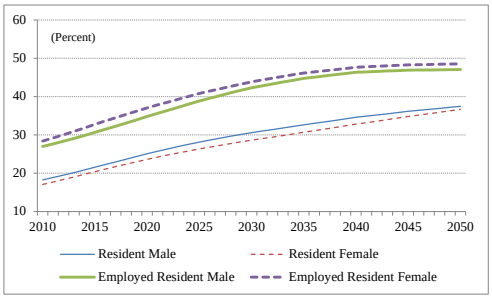


Figure 10: Ratio of Resident Workers with Degree, 2010–2050

Nevertheless, the increase of highly educated Singaporean resident workers will not be able to surpass the speed of ageing. Historically, Singapore experienced a surge of workers with college degrees after the early 1990s. Therefore, today, highly educated individuals are, on average, four years younger than resident workers in general. However, our projections suggest that in 2038 the average age of the highly educated group will catch up, and then overtake, the average age of all resident workers shown in Figure 11. Thus, ageing will not only decrease the ratio of employed workers within the population, as claimed above, but also increase the relative number of experienced workers within the pool of even the most highly educated employed workers.

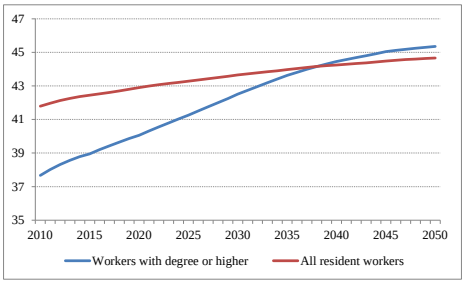


Figure 11: Average Age of Resident Workers, 2010–2050

The results also imply that, the age of less educated workers will decrease, relative to highly educated workers. As younger workers tend to work longer hours, these results suggest that the hours worked generated by less educated workers will continue to dominate a large share of the total hours worked. Total hours worked by educational attainment of workers is shown in Figure 12.

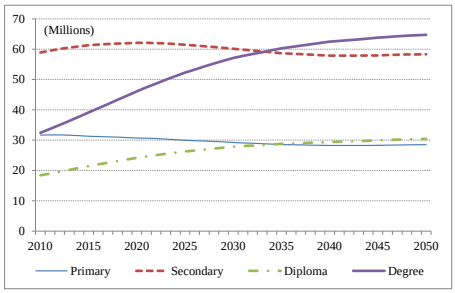


Figure 12: Hours Worked by Broad Educational Groups, 2010–2050

Using the cross-classified information of age and education attainment of all workers in Singapore, we calculate labor input and quality growth for resident workers. The results are presented in the upper half of Table 8. The drop of growth of hours worked shows up prominently after 2010, when our projections begin. Combining our projections for resident workers with that for non-resident workers, we obtain a projection of all employed workers.[23] The lower half of Table 8 presents the results of resident and non-resident workers combined. The average yearly growth of labor quality in our BAU is projected as 1.10 percent (1.40 percent for residents), and that of labor input is 2.52 percent (2.80 percent for residents) for the 2010s. The corresponding figures for the 2020s are 0.91 percent (1.12 percent for residents) and 1.57 percent (1.78 percent for residents). Given that labor quality growth during 2000–2010 was 1.82 percent (2.08 percent for residents), our projections imply a further decrease of labor quality growth in the next two decades.

Table 8: Projection of Labor Input and Quality Growth, 2010–2030

	2000–05	2005–10	2010–15	2015–20	2020–25	2025–30	2000–10	2010–20	2020–30
Resident workers									
Labor Input	3.60	5.57	3.06	2.54	2.03	1.54	4.58	2.80	1.78
Labor Quality	1.93	2.23	1.50	1.31	1.20	1.04	2.08	1.40	1.12
Hours worked	1.66	3.34	1.56	1.23	0.83	0.50	2.50	1.40	0.66
All workers									
Labor Input	3.77	6.74	2.76	2.29	1.80	1.35	5.25	2.52	1.57
Labor Quality	2.64	0.99	1.16	1.04	0.97	0.85	1.82	1.10	0.91
Hours worked	1.13	5.74	1.60	1.25	0.83	0.50	3.43	1.42	0.67

Note: All figures are average annual growth rates. The estimates during 2000–2010 are actual values.

Finally, Table 9 presents the projected growth rates of ALP and its sources using the assumptions stated in section 3.1. Labor quality growth of residents contributes to about 28.6 percent and 30.3 percent of ALP growth in the 2010s and the 2020s, respectively, while the contribution of labor quality growth of non-residents and compositional change is negligible by assumption. The role of labor quality in ALP growth in the BAU is lower than the experience of 50.0 percent during 2000–2010. Although resurgences of capital deepening are expected for the next two decades in our BAU, the ALP growths are expected to slow down to 1.68 percent in the

[23] It is noteworthy that, while growth of hours worked by non-residents increased slightly, it is more than counterbalanced by the drag they impose on the overall labor quality growth. From 2010 to 2015, for example, labor quality growth without non-residents is 1.5 percent, while with non-residents is 1.2 percent, or 0.34 percentage points smaller than the former.

2010s and to 1.19 percent in the 2020s, compared to 2.04 percent in the 2000s.

Table 9: Projection of ALP and Economic Growth (BAU), 2010–2030

	2000–05	2005–10	2010–15	2015–20	2020–25	2025–30	2000–10	2010–20	2020–30
Value added	4.66	6.28	3.42	2.79	2.16	1.56	5.47	3.10	1.86
Hours worked	1.13	5.74	1.60	1.25	0.83	0.50	3.43	1.42	0.67
ALP growth	3.54	0.54	1.82	1.54	1.32	1.06	2.04	1.68	1.19
Capital deepening	1.98	-0.80	1.31	1.10	0.93	0.73	0.59	1.21	0.83
IT capital	0.53	0.25	0.48	0.35	0.24	0.16	0.39	0.42	0.20
Non-IT capital	1.44	-1.05	0.83	0.75	0.69	0.58	0.20	0.79	0.63
Labor quality	1.32	0.72	0.52	0.44	0.39	0.33	1.02	0.48	0.36
Resident	0.72	0.76	0.52	0.44	0.39	0.33	0.74	0.48	0.36
Non-resident	0.60	-0.04	0.00	0.00	0.00	0.00	0.28	0.00	0.00
Compositional change	0.06	-0.26	-0.01	0.00	0.00	0.00	-0.10	0.00	0.00
TFP	0.19	0.88	0.00	0.00	0.00	0.00	0.53	0.00	0.00

Note: All figures are average annual growth rates. The estimates during 2000–2010 are actual values. TFP growth is set as zero.

The force of ageing will become prominent not only in population statistics, but even in the average age of the highly educated resident workers, implying a fundamental limitation in the growth of domestic manpower. The limitation of growth of hours worked will also become a constraint in labor input growth. Our projection of the future economic growth calculated as a sum of the growths of ALP and hours worked is presented also in Table 9. Since the current unemployment rates in Singapore are quite low and stable (at 1.9–2.2 percent according to LFS during 2010–2012), our projection of value added can be interpreted as a potential growth rate of the economy. In our BAU scenario, the growth of potential GDP is 3.10 percent on average per annum in the 2010s and 1.86 percent in the 2020s. Compared to the past experiences of 4.66 percent and 6.28 percent growths for the periods 2000–2005 and 2005–2010, respectively, this represents a considerable slowdown in Singapore's economic growth for the next two decades, if there is a lack of TFP growth or other growth-enhancing policies.

3.3 Policy Scenarios

3.3.1 Increases in Educational Attainment of Residents

In 2010, about 47.1 percent of males and 47.3 percent of females aged 30–34 had a college degree or higher qualification. In light of the government's efforts to further increase the education attainment of the population, we project how an increase in college education can affect labor quality growth.

Assuming that individuals finish their education during their twenties,[24] we manipulate the level of education attainment of persons aged 30–34 years old based on four policy scenarios. Under the BAU assumptions, we assume throughout the period of 2010–2050 that the proportions of males and females having a college degree are the same as in 2010, that is, 47.1 percent of workers 30–34 years old have a college degree. Four other scenarios are prepared,

[24] In Singapore, only 5.2 percent of males and 26.4 percent of females aged 20–24 had a college degree or higher in 2010. It should be noted that many male students take part in National Service before entering college, thereby delaying their graduation from college.

respectively assuming that 50 percent, 55 percent, 60 percent and 65 percent of persons aged 30–34 years old have obtained a college degree in 2030. In each scenario, we assume that the ratio of persons aged 30–34 years old with a college degree in each given year linearly increases from 2010 levels to the prescribed level by 2030. The education attainment of the general population also gradually increases, as each cohort, equipped with the level of education they were given during their early thirties, grows older and the "stock" of college degrees increases.

Table 10: Labor Inputs under Different Education Policy Scenarios for Residents, 2010–2020

	BAU	50%	55%	60%	65%
Labor Input	2.80	2.83	2.88	2.93	2.98
Labor Quality	1.40	1.43	1.48	1.52	1.57
Hours worked	1.40	1.40	1.40	1.41	1.41

Note: All figures are average annual growth rates.

Under these assumptions, Table 10 shows the relationship between education attainment and labor quality growth. Under the BAU assumptions, the average labor quality growth for residents from 2010 to 2020 is 1.40 percent, which is increased to 1.57 percent if 65 percent of workers aged 30–34 years old graduates from college in 2030. The table reflects a linear relationship between higher education attainment and labor quality growth. Between the BAU and the 65 percent scenario, labor input growth increases from 2.80 percent to 2.98 percent. With more workers with higher levels of educational attainment, the growth of total hours worked increases as well, as persons with higher education attainment are more likely to work longer hours. Nevertheless, the differences of the growth rates under the several scenarios are small in magnitude.

Table 11: Projection of ALP and Economic Growth (Education Policy Scenario), 2010–2030

	2000–05	2005–10	2010–15	2015–20	2020–25	2025–30	2000–10	2010–20	2020–30
Value added	4.66	6.28	3.47	2.86	2.26	1.68	5.47	3.16	1.97
			(0.05)	(0.07)	(0.1)	(0.12)		(0.06)	(0.11)
Hours worked	1.13	5.74	1.60	1.26	0.85	0.52	3.43	1.43	0.68
			(0.01)	(0.01)	(0.02)	(0.02)		(0.01)	(0.02)
ALP growth	3.54	0.54	1.86	1.60	1.40	1.16	2.04	1.73	1.28
			(0.04)	(0.06)	(0.08)	(0.1)		(0.05)	(0.09)
Capital deepening	1.98	-0.80	1.30	1.09	0.92	0.71	0.59	1.20	0.81
			(-0.01)	(-0.01)	(-0.02)	(-0.02)		(-0.01)	(-0.02)
IT capital	0.53	0.25	0.48	0.35	0.24	0.15	0.39	0.42	0.20
			(0.00)	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)
Non-IT capital	1.44	-1.05	0.82	0.74	0.68	0.56	0.20	0.78	0.62
			(0.00)	(-0.01)	(-0.01)	(-0.02)		(-0.01)	(-0.02)
Labor quality	1.32	0.72	0.57	0.51	0.49	0.45	1.02	0.54	0.47
			(0.05)	(0.07)	(0.1)	(0.12)		(0.06)	(0.11)
Resident	0.72	0.76	0.57	0.51	0.49	0.45	0.74	0.54	0.47
			(0.05)	(0.07)	(0.1)	(0.12)		(0.06)	(0.11)
Non-resident	0.60	-0.04	0.00	0.00	0.00	0.00	0.28	0.00	0.00
			(0.00)	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)
Compositional change	0.06	-0.26	-0.01	0.00	0.00	0.00	-0.10	0.00	0.00
			(0.00)	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)
TFP	0.19	0.88	0.00	0.00	0.00	0.00	0.53	0.00	0.00

Note: Figures in parenthesis are percentage point difference from the BAU growth rate. The estimates during 2000–2010 are actual values. TFP growth is set as zero.

Table 11 shows the projection of productivity growth under the assumption that 65

percent of workers have obtained a college degree or higher by the time they are 30–34 years old in 2030. As the difference from the BAU scenario, the contribution of labor quality changes to ALP growth increases by 0.06 percentage points and 0.11 percentage points on average per annum in the 2010s and the 2020s, respectively. Although capital deepening deteriorates by 0.01 to 0.02 percentage points in both periods as a result of the small increases of hours worked, the annual growth rates of ALP improves by 0.05 percentage points and 0.09 percentage points in the 2010s and the 2020s, respectively. The potential economic growth rate will also improve by a similar margin in the next two decades, if the government's efforts to further increase the education attainment of the resident labor force are successful.

3.3.2 Further Restrictions of Foreign Worker Levy

In Singapore, a foreign worker levy is applied to non-resident workers, as a policy tool for the government to adjust the size and structure of the foreign labor force through the use of the price mechanism. Depending on the industry and skill level of the foreign worker, the employer must pay the government up to $500 dollars per month to legally employ a foreign worker.[25] In the 2010 Budget Speech, the government announced its policy of further increasing the foreign worker levy as a means of limiting the future inflow of foreign labor.

As a second policy scenario, we simulate the effect of a future increase in the foreign worker levy through the use of two basic assumptions. Firstly, we assume that the foreign worker levy works like a minimum wage, cutting off employment of non-resident workers with an hourly wage lower than the threshold, thereby decreasing the number of non-resident workers, and altering its gea composition. Secondly, the employer, who is discouraged from hiring these workers with lower wages, is assumed to invest in capital, especially IT capital. He or she attempts to maintain the equivalent output that would have been achieved without the foreign worker levy by increasing IT capital input.[26] We estimate the substitution effects under the Cobb-Douglas production function with the parameters based on our estimates of respective factor income shares during 2005–2010. The demand-side effects caused by the introduction of this policy are ignored, i.e. demand decrease by the increase of the production cost brought by the substitution of IT capital for the cheaper non-resident low-skilled workers or demand increase by investment to realize the required capital deepening.

Figure 13 provides the relationship between the level of minimum wage and percentage of non-resident workers who lose their jobs, based on our estimated profile for non-resident workers in 2010. Despite the rigid cutoffs, the relationship between the minimum wage level and loss of employment maintains a relatively linear relationship at lower levels (around $2.0 to $10.0) of the cutoff.

[25] The number of foreign workers to domestic workers in the firm is another determinant of the foreign worker levy that each firm has to pay.
[26] The substitution between low-skilled non-resident workers and resident workers is not assumed.

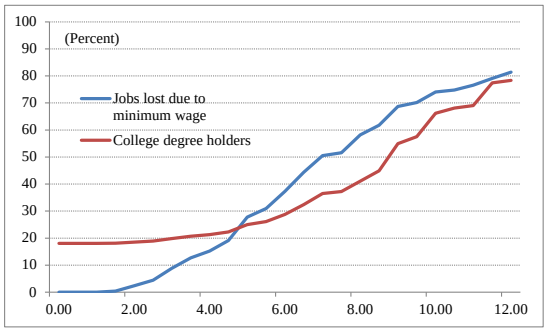


Figure 13: Minimum Wage and Changes in Jobs Lost and Degree Holders

The relationship between the level of minimum wage and the ratio of non-residents with a diploma or degree is also presented in Figure 13. Under BAU, 18.1 percent of non-resident workers have a either a diploma or degree. With a minimum wage of $19.50, this ratio reaches 100 percent. It is noteworthy that, unlike the ratio of persons who lose jobs, the relationship is not linear at levels lower than the minimum wage.

Table 12 shows the average growth rate of labor input and labor quality from 2010 to 2020 under various levels of minimum wage. As non-resident workers make up 35.8 percent of all employed workers under BAU, the effect of a minimum wage (placed only on non-resident workers) on overall labor quality can be significant in magnitude. A $5.00 minimum wage decreases employment of non-residents by 27.7 percent and increases labor quality growth from 1.10 percent to 1.78 percent, equivalent to a 62 percent jump. This effect is counterbalanced by a reduction in labor input growth rate from 2.52 percent to 2.35 percent, a 7 percent decrease.

Table 12: Labor Indices under Different Minimum Wage Scenarios, 2010–2020

	BAU	$1.00	$2.00	$3.00	$4.00	$5.00	$6.00	$7.00	$8.00	$9.00	$10.00
Labor Input	2.52	2.52	2.52	2.49	2.45	2.35	2.25	2.08	1.96	1.77	1.66
Labor Quality	1.10	1.10	1.16	1.32	1.48	1.78	2.02	2.36	2.55	2.81	2.94
Hours worked	1.42	1.42	1.36	1.17	0.97	0.57	0.23	-0.27	-0.58	-1.04	-1.28

Note: All figures are annual growth rates.

On the one hand, the minimum wage increases labor quality growth as workers who had been making relatively small contributions to labor input would be first to be axed, and in turn the relative contribution by other workers increases. On the other hand, the minimum wage decreases the growth of hours work, as some non-resident workers become unemployed. As a whole, the drop in total hours worked is greater than the increase in labor quality, and labor input growth deteriorates as higher levels of minimum wage are introduced. This is consistent with the trend lines in Figure 14: with a higher minimum wage, the number of non-residents who lose their jobs increases proportionally, but the relative amount of highly educated workers who remain increases less than proportionally.

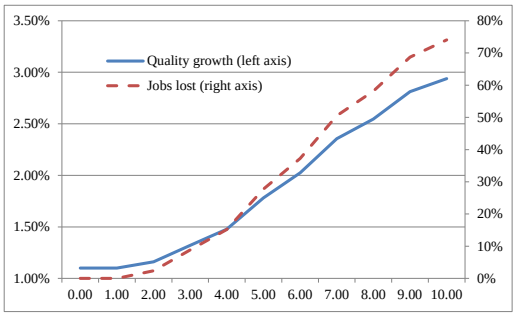


Figure 14: Minimum Wage Level and Labor Quality Growth, 2010–2020

Assuming that the minimum wage is gradually introduced over the course of 2010–2030, we project future ALP growth for the scenario in which five dollar and six dollar minimum wages are introduced at the end of 2020 and 2030, respectively. Under this scenario, the number of foreign workers is 28 percent and 37 percent lower in the respective periods when compared with the BAU scenario. Table 13 presents the results of the simulation. During the period from 2010 to 2020, non-resident labor quality increases by 0.14 percentage points, and IT capital deepens by 0.19 percentage points. Non-IT capital also deepens by 0.44 percentage points, as the growth of total hours worked decreases. As a whole, we find that ALP growth increases by 0.91 percentage point. Similarly, in the 2020s, ALP grew at the speed of 0.54 percentage points higher per year. However, from the point of view of potential economic growth, such substitution policy has minor impacts (0.06 percentage points in the 2010s and 0.09 percentage points in the 2020s) because the decrease in total hour worked offsets the ALP improvement.

Table 13: Projection of ALP and Economic Growth (Wage Policy Scenario), 2010–2030

	2000–05	2005–10	2010–15	2015–20	2020–25	2025–30	2000–10	2010–20	2020–30
Value added	4.66	6.28	3.45	2.86	2.26	1.64	5.47	3.16	1.95
			(0.04)	(0.07)	(0.11)	(0.08)		(0.06)	(0.09)
Hours worked	1.13	5.74	0.86	0.29	0.33	0.11	3.43	0.57	0.22
			(-0.74)	(-0.96)	(-0.51)	(-0.39)		(-0.85)	(-0.45)
ALP growth	3.54	0.54	2.59	2.58	1.94	1.53	2.04	2.59	1.74
			(0.77)	(1.04)	(0.62)	(0.47)		(0.91)	(0.54)
Capital deepening	1.98	-0.80	1.83	1.83	1.44	1.10	0.59	1.83	1.27
			(0.52)	(0.72)	(0.5)	(0.36)		(0.62)	(0.43)
IT capital	0.53	0.25	0.64	0.57	0.47	0.30	0.39	0.60	0.38
			(0.15)	(0.22)	(0.23)	(0.14)		(0.19)	(0.19)
Non-IT capital	1.44	-1.05	1.19	1.25	0.97	0.80	0.20	1.22	0.88
			(0.37)	(0.51)	(0.27)	(0.22)		(0.44)	(0.25)
Labor quality	1.32	0.72	0.64	0.60	0.42	0.38	1.02	0.62	0.40
			(0.12)	(0.16)	(0.03)	(0.04)		(0.14)	(0.04)
Resident	0.72	0.76	0.52	0.44	0.39	0.33	0.74	0.48	0.36
			(0.00)	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)
Non-resident	0.60	-0.04	0.12	0.16	0.03	0.05	0.28	0.14	0.04
			(0.12)	(0.16)	(0.03)	(0.05)		(0.14)	(0.04)
Compositional change	0.06	-0.26	0.12	0.16	0.08	0.06	-0.10	0.14	0.07
			(0.13)	(0.16)	(0.08)	(0.06)		(0.14)	(0.07)
TFP	0.19	0.88	0.00	0.00	0.00	0.00	0.53	0.00	0.00

Note: Figures in parenthesis are percentage point difference from the BAU growth rate. The estimates during 2000–2010 are actual values. TFP growth is set as zero.

3.3.3 Synthetic Effect

The previous sections 3.3.1 and 3.3.2 respectively evaluated the policy impacts on the

ALP and potential growths when the policy to upgrade the resident workers' skills and the policy to substitute the low-skilled non-resident workers by larger use of IT capital are successfully introduced. The synthetic effect is presented in Table 14 for the ALP decomposition and in Table 15 for the sources of the potential economic growth. The growth rate of ALP under the successful policies to enhance labor productivity is estimated as 2.64 percent on average per annum during the decade of the 2010s. The effect of introducing these two policies increases ALP by 0.96 percentage points, up from 1.68 percent in BAU.

The MAS (2010) estimates ALP growth for the period 2010–2019 as 2.0–3.0 on average percent per year, under the assumption that TFP grows by 0.4–0.7 percent annually. When the TFP growth is taken out of this calculation to make their estimates comparable with ours, the MAS estimate of ALP growth with no-TFP is 1.6–2.3 percent per year. Despite their overestimates of labor quality changes in the 2000s (as pointed out in section 2.4) and no consideration of the ageing effect of labor forces in the 2010s, their estimates are very close to ours: their lower estimate is close to our estimate in the BAU scenario and their upper estimate is 0.3 percent points smaller than our estimates in the policy scenarios.

However, there is a considerable difference in the estimate of the mid-term potential GDP growth. The MAS (2010) evaluated it as 3.0–5.0 percent on average per annum during 2010–2019, by simply combined their ALP growth estimates of 2.0–3.0 percent with the estimate of the labor force growth of 1.0–2.0 percent by the Economic Strategies Committee (ESC). Although our BAU estimate of the growth in overall hours worked (1.43 percent per year) is posted in the middle of the ESC estimate, we can point out that this baseline estimate of hours worked is incompatible with an ambitious target of labor quality growth. To achieve a higher target of labor quality and ALP growth, the low-skilled non-resident workers are required to decrease (mainly by promoting more use of capital to substitute it, not by increasing low-skilled jobs of residents) and that brings about the decrease in overall hours worked and somewhat offsets the ALP's contribution to economic growth. Our estimate shows overall hours worked decreases by 0.84 percentage points from the BAU, thus the ALP improvement which expects to increase potential GDP by 0.96 percentage points is mostly offset by the decrease of hours worked. Therefore the projected growth rate of potential GDP still remains as 3.22 percent even in our policy scenario, which is still close to the bottom of the ESC's potential GDP target range of 3.0–5.0 percent. We conclude that the room to enhance growth by improving labor quality is already limited in Singapore and that policy targeting to boost TFP growth may be more fruitful.

Table 14: Projection of ALP and Economic Growth (Policy Scenario), 2010–2030

	2000–05	2005–10	2010–15	2015–20	2020–25	2025–30	2000–10	2010–20	2020–30
Value added	4.66	6.28	3.50	2.94	2.36	1.75	5.47	3.22	2.06
			(0.08)	(0.15)	(0.2)	(0.19)		(0.12)	(0.2)
Hours worked	1.13	5.74	0.87	0.30	0.34	0.13	3.43	0.58	0.24
			(-0.73)	(-0.95)	(-0.49)	(-0.37)		(-0.84)	(-0.43)
ALP growth	3.54	0.54	2.64	2.64	2.02	1.63	2.04	2.64	1.82
			(0.81)	(1.1)	(0.69)	(0.56)		(0.96)	(0.63)
Capital deepening	1.98	-0.80	1.83	1.81	1.41	1.07	0.59	1.82	1.24
			(0.52)	(0.71)	(0.48)	(0.33)		(0.61)	(0.41)
IT capital	0.53	0.25	0.64	0.57	0.47	0.29	0.39	0.60	0.38
			(0.15)	(0.21)	(0.22)	(0.14)		(0.18)	(0.18)
Non-IT capital	1.44	-1.05	1.19	1.24	0.95	0.77	0.20	1.22	0.86
			(0.36)	(0.49)	(0.26)	(0.2)		(0.43)	(0.23)
Labor quality	1.32	0.72	0.69	0.67	0.52	0.49	1.02	0.68	0.51
			(0.17)	(0.23)	(0.13)	(0.16)		(0.2)	(0.14)
Resident	0.72	0.76	0.56	0.51	0.49	0.45	0.74	0.54	0.47
			(0.05)	(0.07)	(0.1)	(0.11)		(0.06)	(0.1)
Non-resident	0.60	-0.04	0.12	0.16	0.03	0.05	0.28	0.14	0.04
			(0.12)	(0.16)	(0.03)	(0.05)		(0.14)	(0.04)
Compositional change	0.06	-0.26	0.12	0.16	0.08	0.07	-0.10	0.14	0.07
			(0.13)	(0.16)	(0.08)	(0.07)		(0.15)	(0.08)
TFP	0.19	0.88	0.00	0.00	0.00	0.00	0.53	0.00	0.00

Note: Figures in parenthesis are percentage point difference from BAU growth rate. The estimates during 2000–2010 are actual values. TFP growth is set as zero.

For the decade of the 2020s, the Singaporean economy will be forced to grow more slowly, as the ALP and the potential GDP growths are projected to be 1.82 percent and 2.06 percent respectively (Table 14). The economic growth in the 2020s is expected to further slow down by 1.16 percentage points in comparison with the 2010s, which consists of 0.58 percentage points caused by the slowdown of capital deepening, 0.34 percentage points by the smaller increase in hours worked, and 0.17 percentage points by the little room available to improve labor quality in an ageing labor force. The estimated speed of ALP growth is almost equivalent to the expected speed of decline in the ratio of working population to dependent population (1.6 percent per year) as described in section 3.2. To improve economic welfare in an ageing society, the growth strategy in the 2020s should be focused more on enhancement of TFP.

Table 15: Projection of Growth and Its Sources, 2010–2030

	2000–05	2005–10	2010–15	2015–20	2020–25	2025–30	2000–10	2010–20	2020–30
Contribution									
Value added	4.66	6.28	3.50	2.94	2.36	1.75	5.47	3.22	2.06
			(0.08)	(0.15)	(0.2)	(0.19)		(0.12)	(0.2)
Capital input	2.56	2.38	2.31	1.98	1.62	1.14	2.47	2.15	1.38
			(0.11)	(0.16)	(0.19)	(0.11)		(0.13)	(0.15)
IT	0.59	0.56	0.69	0.59	0.48	0.30	0.57	0.64	0.39
			(0.11)	(0.16)	(0.21)	(0.12)		(0.14)	(0.17)
Non-IT	1.97	1.82	1.62	1.40	1.14	0.84	1.90	1.51	0.99
			(0.00)	(-0.01)	(-0.02)	(-0.02)		(-0.01)	(-0.02)
Labor input	1.81	3.03	1.19	0.95	0.74	0.61	2.42	1.07	0.67
			(-0.02)	(-0.01)	(0.01)	(0.08)		(-0.02)	(0.05)
Resident	1.35	1.90	1.11	0.93	0.77	0.62	1.63	1.02	0.69
			(0.05)	(0.08)	(0.11)	(0.13)		(0.07)	(0.12)
Non-residents	0.57	1.14	0.08	0.02	-0.03	-0.01	0.85	0.05	-0.02
			(-0.07)	(-0.09)	(-0.09)	(-0.05)		(-0.08)	(-0.07)
Labor quality	1.27	0.47	0.33	0.65	0.39	0.48	0.87	0.49	0.44
			(0.71)	(0.94)	(0.5)	(0.45)		(0.83)	(0.48)
Resident	0.77	0.88	0.09	0.08	0.16	0.24	0.83	0.08	0.20
			(0.03)	(0.02)	(0.03)	(0.07)		(0.02)	(0.05)
Non-residents	0.60	-0.46	0.24	0.57	0.23	0.24	0.07	0.41	0.24
			(0.68)	(0.92)	(0.47)	(0.39)		(0.8)	(0.43)
Hours worked	0.54	2.56	0.87	0.30	0.35	0.13	1.55	0.58	0.24
			(-0.73)	(-0.95)	(-0.49)	(-0.37)		(-0.84)	(-0.43)
Resident	0.58	1.02	1.02	0.85	0.60	0.38	0.80	0.94	0.49
			(0.02)	(0.06)	(0.07)	(0.06)		(0.04)	(0.07)
Non-residents	-0.03	1.60	-0.16	-0.55	-0.26	-0.25	0.78	-0.36	-0.26
			(-0.75)	(-1.01)	(-0.56)	(-0.43)		(-0.88)	(-0.5)
TFP	0.29	0.88	0.00	0.00	0.00	0.00	0.58	0.00	0.00
Growth									
Capital input	4.99	4.33	4.12	3.40	2.70	1.87	4.66	3.76	2.28
			(0.18)	(0.25)	(0.3)	(0.17)		(0.21)	(0.23)
IT	10.64	10.52	10.98	9.73	8.40	5.65	10.58	10.35	7.03
			(1.41)	(1.86)	(2.25)	(1.21)		(1.64)	(1.73)
Non-IT	4.31	3.67	3.25	2.67	2.09	1.51	3.99	2.96	1.80
			(0.00)	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)
Labor Input	3.77	6.74	2.72	2.29	1.94	1.57	5.25	2.50	1.76
			(-0.05)	(0.00)	(0.14)	(0.22)		(-0.02)	(0.18)
Resident	3.60	5.57	3.20	2.76	2.33	1.89	4.58	2.98	2.11
			(0.14)	(0.22)	(0.3)	(0.35)		(0.18)	(0.33)
Non-residents	5.32	10.42	0.88	0.25	-0.39	-0.16	7.87	0.57	-0.27
			(-0.78)	(-1.03)	(-1.24)	(-0.67)		(-0.9)	(-0.95)
Labor quality	2.64	0.99	1.85	1.99	1.60	1.44	1.82	1.92	1.52
			(0.68)	(0.95)	(0.63)	(0.59)		(0.82)	(0.61)
Resident	1.93	2.23	1.63	1.51	1.47	1.37	2.08	1.57	1.42
			(0.13)	(0.2)	(0.27)	(0.33)		(0.17)	(0.3)
Non-residents	5.57	-0.61	1.35	2.00	0.49	0.75	2.48	1.68	0.62
			(1.35)	(2)	(0.49)	(0.75)		(1.68)	(0.62)
Hours worked	1.13	5.74	0.87	0.30	0.34	0.13	3.43	0.58	0.24
			(-0.73)	(-0.95)	(-0.49)	(-0.37)		(-0.84)	(-0.43)
Resident	1.66	3.34	1.57	1.25	0.85	0.52	2.50	1.41	0.69
			(0.01)	(0.02)	(0.02)	(0.03)		(0.01)	(0.03)
Non-residents	-0.24	11.02	-0.47	-1.75	-0.88	-0.91	5.39	-1.11	-0.90
			(-2.13)	(-3.03)	(-1.73)	(-1.42)		(-2.58)	(-1.57)
Employment	1.58	5.92	0.85	0.23	0.34	0.14	3.75	0.54	0.24
			(-0.81)	(-1.05)	(-0.51)	(-0.37)		(-0.93)	(-0.44)
Residents	2.11	3.51	1.66	1.29	0.87	0.53	2.81	1.47	0.70
			(0.00)	(0.01)	(0.02)	(0.02)		(0.01)	(0.02)
Non-residents	0.23	11.20	-0.69	-2.11	-0.99	-0.94	5.72	-1.40	-0.96
			(-2.35)	(-3.39)	(-1.84)	(-1.44)		(-2.87)	(-1.64)

Note: Figures in parenthesis are percentage point difference from BAU growth rate. The estimates during 2000–2010 are actual values. TFP growth is set as zero.

4 Conclusion

We observe that the downward trend of labor quality growth in the recent economic

growth of Singapore was mainly due to a sharp increase of low-skilled foreign workers since the mid-2000s. Our projections in the BAU scenario imply a further decrease of labor quality growth in the next two decades. The average yearly growth of labor quality is projected as 1.10 percent for the 2010s and 0.91 percent for the 2020s, compared with 1.82 percent during 2000–2010. The ALP growths are also expected to slow down to 1.68 percent in the 2010s and to 1.19 percent in the 2020s, compared with 2.04 percent in the 2000s. The future growth of total hours worked is also weakened. The force of ageing will become prominent not only in population statistics, but even in the age of highly educated resident workers, implying a fundamental limitation in the growth of domestic manpower. The limitation of growth of hours worked will also become a constraint on labor input growth. Reflecting the downward trends in both ALP and hours worked, the potential GDP growth is projected as 3.10 percent on average per annum in the 2010s and 1.86 percent in the 2020s, compared with the past experiences of 5.47 percent in the 2000s. Economic growth in Singapore is expected to slow down considerably for the next two decades, in the absence of TFP growth or other growth-enhancing policies.

We simulate different policy scenarios, whereby policies to upgrade the resident workers' skills and to substitute the low-skilled non-resident workers by larger use of IT capital are successfully introduced. Our projections show that ALP growth will be 2.64 percent on average per annum in the 2010s (0.96 percentage points higher than the 1.68 percent in BAU) and 1.82 percent in the 2020s (0.63 percentage points higher than the 1.19 percent in BAU). Our estimate of the yearly ALP growth for the next decade is in the middle of the ESC's target of 2.0–3.0 percent. However, our projection shows that overall hours worked decreases by 0.84 percentage points from the BAU. Thus the ALP improvement which expects to increase potential GDP by 0.96 percentage points is mostly offset by the decrease of hours worked. Therefore the projected growth rate of potential GDP remains as 3.22 percent even in our policy scenario, which is close to the bottom of the ESC's potential GDP target range of 3.0–5.0 percent. We conclude that the room to enhance growth by improving labor quality is already limited and that TFP growth will be the key to improve welfare especially in the 2020s.

5 Appendix: Construction of Cross-classified Labor Data

In this section we document the data sources, assumptions and the procedures we use to compile our labor database, starting from the estimation of number of workers, hours worked, and finally, hourly wage.

5.1 Data Sources

The main data sources used for constructing the database are the decennial *Census of Population* (1970, 1980, 1990, and 2000), the *General Household Survey* (GHS) (1995 and 2005)[27] published by Singapore's Department of Statistics, the *Labour Force Survey* (LFS), and the *Yearbook of Manpower Statistics* (YMS) published by the Ministry of Manpower. The comprehensive LFS was introduced in 1974[28] by the Ministry of Labour (the predecessor of the Ministry of Manpower) and has been conducted annually except in the implementation years of the Census and GHS. The LFS is a survey based on samples of households and its reference period is the full calendar week prior to the date of the survey interview conducted in June of the survey years.[29]

The LFS covers persons aged 15 years and over,[30] but it excludes workers living in construction worksites, dormitories and workers' quarters at the workplace and persons commuting from abroad to work in Singapore. To achieve full coverage of the labor force in Singapore, data on residents (i.e. Singapore citizens and permanent residents) from the survey are combined with foreign workforce data compiled from administrative records (work passes issued by the Ministry of Manpower) and published in the YMS.[31] The *Yearbook of Labour Statistics* (the predecessor of YMS) has been published annually since 1976.

5.2 Number of Workers

The complete set of the cross-classified data required for our study is not provided in any of the publically available statistics published in the Census, GHS, or LFS.[32] On the number of workers, data on each gender cross-classified by education and age N_{gea}, by age and

[27] The GHS is a mini-Census which provides the most comprehensive source of information on the profile of Singapore's population and household, conducted in between the decennial Census of Population.

[28] LFS 1973 provides a limited number of tables on number of workers and labor compensation but no data on hours worked.

[29] To obtain estimates of unemployment, the Ministry of Manpower conducts small surveys in March, September, and December, covering at least 6,000 households each, in comparison with 25,000 households in the comprehensive mid-year survey.

[30] LFS 1973–1977 and Census 1980 refers to persons aged 10 years and over, while the LFS after 1978 refers only to persons aged 15 years or over. Although it is better to include all workers to define labor input in reconciliation of the difference in coverage, we exclude the workers in age group of 10–14 years during 1973–1977, since the data is not available after 1978. However the gap is not significant. The share of the number of workers aged 10–14 years is 0.8 per cent in 1974 and 0.4 per cent in 1977.

[31] The number of total employed persons (residents and non-residents) combined with foreign workforce data is reported in LFS, although the profiles of the workers are not.

[32] Employed persons are defined as the persons who worked for one hour or more either for pay, profit or family gains; or who had a job or business to return to but were temporarily absent because of illness or injury, vacation, bad weather, mechanical breakdown, labor management dispute, temporarily laid off with salary or other reasons during the reference period. See Ministry of Manpower (2011).

employment status N_{gas}, and by education and employment status N_{ges} are typically provided in these publications. Using these three tables, we estimate the data with full-dimension $\widehat{N}_{geas}$ by minimizing the sum of squared errors as follows:

$$(17) \quad \min \sum_{ea}\left(\widehat{N}_{geas} - N_{gea}\right)^2 \text{ subject to } N_{ges} = \sum_a \widehat{N}_{geas} \text{ and } N_{gas} = \sum_e \widehat{N}_{geas} ,$$

in each category classified by gender and employment status. This estimation assumes the relative stability on age-education relationship in terms of number of workers among different types of employment status. Alternatively, we can estimate $\widehat{N}_{geas}$ as

$$(18) \quad \min \sum_{as}\left(\widehat{N}_{geas} - N_{gas}\right)^2 \text{ subject to } N_{gea} = \sum_s \widehat{N}_{geas} \text{ and } N_{ges} = \sum_a \widehat{N}_{geas} ,$$

in each gender and education attainment, assuming the relative stability on the age- employment status relationship among the different types of education attainment. We choose between the two estimates of $\widehat{N}_{geas}$ inform equations (17) and (18), by rejecting the method that results in a larger sum of errors.[33]

Splicing the cross-classified data estimated into time-series requires further adjustments, since the coverage and concepts have altered over time periods. To illustrate the conceptual rifts among different data sources and time periods, Figure 15 compares the female share of employment from the profiles estimated in the time-series LFS (1973–79, 1981–89, 1991–94, 1996–99, 2001–04, and 2006–10), GHS (1995 and 2005), and Census (1980, 1990, and 2000). It is clear that the Census 2000 and GHS 1995 and 2005 have smaller shares of female workers, and that LFS after 2006 has a different trend in comparison with LFS before 2004.

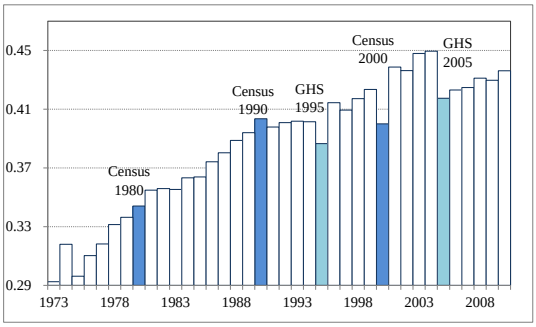


Figure 15: Female Share of Employment (Before Adjustment)

Although full metadata is not available, we can identify, with our best knowledge, that there are some differences among the different data sources which can be seen in Table 16 and Figure 15.[34] In Table 16, we map out the adjustment processes for non-residents living in non-dwellings (hereafter NR2) and non-residents persons commuting daily to work from Malaysia (NR3).

[33] In our measurement period during 1974–2010, the method (17) provided smaller numbers of sums of errors in all periods except for 1974.

[34] In Table 2, we refer to NR2 workers as people living in non-dwellings, raising the examples of construction workers living onsite. Non-dwellings range from workers' quarters on farms to dormitories built by the Building and Construction authority, which suggests the diverse careers that NR2 workers are engaged in.

Table 16: Coverage of Workers in Census, GHS, and LHS

Statistics		(R) Residents		(NR) Non–residents (#5)		
				Stay in Singapore		
		Singapore citizens and permanent residents	Singapore Armed Forces (including conscripts) (#6)	(NR1) Living in private households	(NR2) Living in non–dwellings (e.g. construction workers living at worksites)	(NR3) Persons commuting daily to work from Malaysia (#4)
Census 1970, 1980, and 1990		○	○	○	× (#1)	× (#1)
Census 2000	Total	○	○	○	○	○
	Profile of workers	○	○	× (#2)	× (#2)	× (#1)
GHS 1995		○	○	○	× (#1)	× (#1)
GHS 2005	Total	○	○	○	○	○
	Profile of workers	○	○	× (#2)	× (#2)	× (#1)
LFS 1974–2004		○	○	○	× (#1)	× (#1)
LFS 2006–11	Total	○	○	○	○	○
	Profile of workers	○	○	× (#2, #3)	× (#2, #3)	× (#1, #3)

Note: Adjustments #1 through #5 are described in 5.2.1 and 5.2.2, 5.2.3, 5.2.4, 5.2.5, and 5.3.1, respectively.

5.2.1 Number of Non-Resident Workers NR2 and NR3

Foreigners can work in Singapore if they obtain the permits issued by the Ministry of Manpower and are categorized as Employment Pass Holders (EPH) or Work Permit Holders (WPH). Higher-skilled EPHs including their spouses and dependents, and lower-skilled WPHs who are domestic workers (maids) can be covered by the Census since they are usually provided with accommodation or live in rented housing. However, the Census fails to include non-maid WPHs (e.g. construction workers) since most live in non-residential dwellings (e.g. labor lines or quarters). Therefore foreign workers have been underrepresented in Census 1970, 1980, and 1990.

To address this shortcoming, Census 2000 was augmented by the results of a survey to investigate this group of foreign workers.[35] In this survey, the Singapore Department of Statistics created a sampling frame of enterprises employing foreign workers with the help of Ministry of Manpower. The information reported by the employer of the enterprises employing foreign workers was merged with the Census results for residents to provide the overall profile of workers. This revision had a large impact on the numbers of non-resident and total workers in comparison with the past Censuses. Although the estimates were not separately published, the number of foreign workers that were newly covered by Census 2000 may be about 25 per cent of the non-residents and about 7 per cent of total workers (roughly 150 thousand persons) in 2000.[36] As a result of this change of coverage, backward revisions to the estimates of non-resident workers in the past Censuses, as well as those from LFS, are required.

The estimated profiles of workers in LFS do not cover foreign workers of type NR2 for

[35] In Census 2000, the sample comprised some 6,400 firms engaging 88,000 WPHs. See the *Administrative Report, Census of Population 2010* for details.

[36] The number of workers in the construction sector is estimated as 130,730 in LFS 1999, 124,925 in LFS 2001, and 274,015 in Census 2000. Therefore, construction workers living at worksites account for about 150 thousand in 2000.

all periods, while the Ministry of Manpower started to cover the foreigners of both NR2 and NR3 in the total number of non-resident workers only since LFS 2006, with their estimates based on the administration records. LFS after 2006 also reported the total number of non-residents starting from the 1990s. Although the details in the conceptual differences are not fully described in the reports, comparisons of the estimates between LFS original and revised series enables us to recognize the impact of this revision with the expanded coverage of foreign workers.

Two revisions in coverage can be identified from Figure 16, which presents the comparisons of total number of workers (residents and non-residents) aged 15 years and over[37] of all years of LFS. First, total number of workers in the 1980s was revised in issues of LFS published after 1991 (based on the concept of Census 1990)[38]. Then the coverage was changed again in LFS 2006 (based on the concept of Census 2000) and the time series of total number of workers was harmonized back to 1991. As a result of the second revision, total number of workers swelled by 243.4 thousand in 1999 and 220.6 thousand in 2001. The increase seems numerically consistent with the revision on NR2 in Census 2000. We therefore treat the increments as estimates for the sum of NR2 and NR3, which are then used to supplement the original estimates of the total number of non-resident workers in Census 1980 and 1990, and LFS 1991–1994, 1996–1999, and 2001–2004.

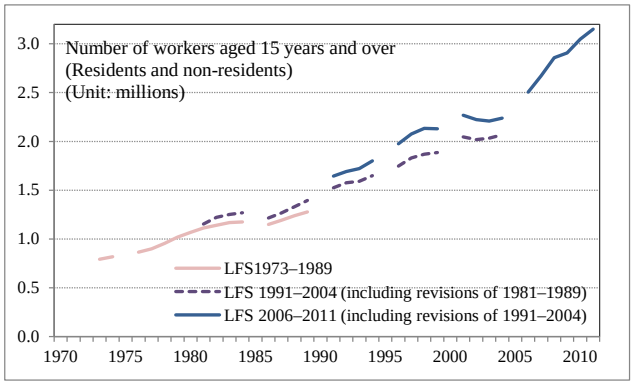


Figure 16: Number of Total Workers between Original and Revised LFS

5.2.2 Profile of Foreign Workers of NR2

To incorporate the revisions to NR2 workers into our estimates of cross-classified data of employment, a profile of their characteristics is required. But such profile data exclusively for NR2 workers is not available in any of the published Census or LFS. Only Census 2000 provides the tables on number of non-resident workers (for the sum of NR1 and NR2) classified by gender and age N_{ga}^{NR}, and by gender, education and, employment status N_{ges}^{NR}. We need to separate NR2 from these data and further estimate the NR2 worker matrix with full dimensions.

First, we estimate the employment matrix with full dimensions for resident workers (R)

[37] We have excluded the estimates for the workers aged 10–14 years for comparison purpose.

[38] As an indication of this, LFS 1991 shows revised total population estimates for data from the 1980s (LFS 1991, table 1). The additional workers that were included in our estimates due to this revision were proportionally distributed across the $geas$ composition of the (R) and NR1 component of the labor force.

only for the periods of 1999 and 2001–2004 based on LFS data. LFS 2006–2010 provides estimates on number of resident workers by gender and education attainment N_{ge}^{R} and by gender and age N_{ga}^{R}. Setting both tables as the constraints and using the profile of resident workers by gender, education, and age in Census 2000 $\mathrm{N}_{gea(2000)}^{R}$ as the initial value of the profile to be estimated, we estimate $\widehat{\mathrm{N}}_{gea}^{R}$ for the periods of 1999 and 2001–2004 as:

(19) $\min \sum_{ea}\left(\widehat{\mathrm{N}}_{gea}^{R}-\mathrm{N}_{gea(2000)}^{R}\right)^{2}$ subject to $\mathrm{N}_{ge}^{R}=\sum_{a}\widehat{\mathrm{N}}_{gea}^{R}$ and $\mathrm{N}_{ga}^{R}=\sum_{e}\widehat{\mathrm{N}}_{gea}^{R}$.

Second, we define the profile for NR1 workers only as the difference between the original LFS profile of total workers and the estimated profile for resident workers only in the same periods:

(20) $\widehat{\mathrm{N}}_{gea}^{NR1}=N_{gea}-\widehat{\mathrm{N}}_{gea}^{r}$.

Third, we estimate $\widehat{\mathrm{N}}_{gas}^{NR}$ in 2000, based on the available profiles for non-resident workers of NR1 and NR2, $\mathrm{N}_{ga}^{NR1+NR2}$ and $\mathrm{N}_{gs}^{NR1+NR2}\left(=\sum_{e}\mathrm{N}_{ges}^{NR1+NR2}\right)$ in Census 2000, as

(21) $\min \sum_{as}\left(\widehat{\mathrm{N}}_{gas}^{NR1+NR2}-\mathrm{N}_{gas}^{R}\right)^{2}$ subject to $\mathrm{N}_{gs}^{NR1+NR2}=\sum_{a}\widehat{\mathrm{N}}_{gas}^{NR1+NR2}$ and $\mathrm{N}_{ga}^{NR1+NR2}=\sum_{s}\widehat{\mathrm{N}}_{gas}^{NR1+NR2}$,

using the profile of resident workers by gender, age, and employment status as the initial value.

Then we estimate the non-resident worker matrix with full dimensions, by minimizing the sum of differences between the non-resident profile for NR1 and NR2 to be estimated and the profile for total workers ($\widehat{N}_{geas}$ estimated in (17) or (18)) in each category classified by gender and employment status:

(22) $\min \sum_{ea}\left(\widehat{\mathrm{N}}_{geas}^{NR1+NR2}-\widehat{N}_{geas}\right)^{2}$ subject to $\mathrm{N}_{ges}^{NR1+NR2}=\sum_{a}\widehat{\mathrm{N}}_{geas}^{NR1+NR2}$ and $\widehat{\mathrm{N}}_{gas}^{NR1+NR2}=\sum_{e}\widehat{\mathrm{N}}_{geas}^{NR1+NR2}$.

Finally, we define the non-resident profile for NR2 workers in 2000, taking the difference of the profiles estimated in (20) and (22),

(23) $\widehat{\mathrm{N}}_{gea}^{NR2}=\widehat{\mathrm{N}}_{gea}^{NR1+NR2}-\widehat{\mathrm{N}}_{gea}^{NR1}$.

The profile $\widehat{\mathrm{N}}_{gea}^{NR2}$ can be estimated only in 2000, based on the information in Census 2000.[39] This estimated profile for NR2 only is considerably different from the original profile for total workers N_{gea}. It suggests that NR2 workers are younger than the overall profile of workers, with the vast majority of male NR2 workers younger than 40 years old, and females younger than 35. While roughly 1 out of ten male NR2 workers have a diploma or a degree, most male workers and virtually all female workers have low education attainment. Assuming that this profile of NR2 workers is stable over time, we allocate the total number of NR2 into the employment matrix with full $geas$ dimensions in LFS 1974–2004, Census 1980 and 1990, and GHS 1995.

Estimations for NR2 workers could only be obtained for 2000, due to data limitations described over. Nevertheless, it should be noted that the number of NR2 workers relative to other employed workers does change. As the number of hours workers per week and hourly

[39] Negative values in the estimated matrix are replaced with 0 and readjusted to be balanced.

compensation also change over the years, this data limitation does not inhibit the quality changes of NR2 workers from being reflected in our final estimations.

5.2.3 Profiles of Non-Resident Workers in NR1 and NR2 after 2005

Although the LFS conducted before 2004 covered non-residents who stayed in Singapore, the following LFS after 2006 and GHS 2005 only provide estimated profiles of resident workers. Moreover, only the total number of non-resident workers, corresponding to NR1+NR2+NR3 in our notation, is estimated in LFS after 2006, based on administrative records provided by the Ministry of Manpower. To fully cover all workers in our cross-classified database, we allocate the total number of non-resident workers into the different types of categories, applying the profile of 2004 $\widehat{\mathrm{N}}_{gea}^{NR1}$ estimated in (20) for NR1 and the profile of 2000 $\widehat{\mathrm{N}}_{gea}^{NR2}$ estimated in (23) for NR2.

The number of foreign workers in this period was estimated using outside sources and relevant time series data. First, the number of foreigners commuting from Malaysia, NR3, was estimated using the methodology described below in 5.2.4. Then, the number of NR2 workers was extrapolated using the growth rate of GDP at constant prices. Finally, NR1 was subtracted from the total of all foreign workers reported in the LFS.

Using the processes described in 5.2.1, 5.2.2, and 5.2.3 to adjust the differences in coverage, the female share of employment presented in Figure 15 is revised as Figure 17. The relatively stable trend in female share, particularly after 2005, suggests that the estimation process introduced above, as well as the assumptions regarding the coverage of workers of the respective statistics presented in Table 16, is reasonable.[40]

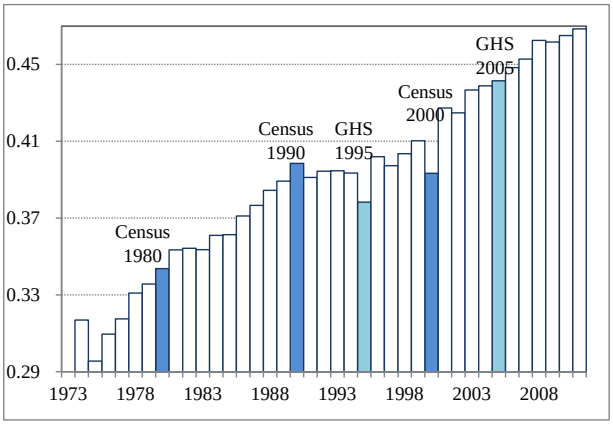


Figure 17: Female Share of Employment (After Adjustment of NR)

[40] We acknowledge that there are still jumps in the time series, particularly for GHS 1995 and Census 2000. Some of this inconsistency may be due to the difference of survey method used by different government offices. While the LFS is conducted by the Ministry of Manpower, based on sampling of households, the Census and GHS are conducted by the Department of Statistics using administrative records. Additionally, there may have been economic events which coincided with the Census and GHS years. In particular, the year 2000 coincides with a severe economic downturn, which may have promoted workers with less stable forms of employment to lose their jobs.

5.2.4 Workers Commuting from Abroad to Work NR3

The profiles of workers commuting from Malaysia to work in Singapore (NR3) are excluded from all of the surveys, as described in Table 16. Only the total number of employment in LFS after 2006 may include the estimates of total foreign workers, compiled from work passes issued by the Ministry of Manpower, which however may exclude foreign workers without valid permissions. As far as we know, estimates of the number of NR3 workers are not available in the official statistics of Singapore or Malaysia. We have constructed time-series estimates based on piecemeal information available.

According to Hui (2002) and other studies, the Singaporean government created daily work passes in 1978, which implies that workers could not legally commute daily to Singapore prior to this year. Therefore we assume that there were no NR3 workers prior to 1978.

Following this period, the Singaporean press has been publishing articles suggesting the number of workers commuting to Singapore from unspecified sources from time to time. Given the "extremely limited" (Mui 2008) availability of information on labor migration, and more broadly, of foreign workers in Singapore, and in light of the use of newspaper articles in other studies regarding foreign labor in Singapore, we believe our estimation process is justified.

Table 17: Estimates of Workers Commuting from Malaysia

Year	Estimate	Source
1974–77	0	Hui, Weng–Tat (2002). "Regionalization, Economic Restructuring and Labour Migration in Singapore," International Migration, Vol. 35 (1).
1981	11,818	From an Malaysian survey, as cited in Stahl, Charles W. (1984). "Singapore's Foreign Workforce: Some Reflections on Its Benefits and Costs," International Migration Review, Vol. 18 (1).
1991	27,500	Straits Times (Feb. 14, 2001)
1995	50,000	Battistella G., Huguet J.W. and M. Abella (1995). "Data on International Migration in Asia," Asian and Pacific Migration Journal, Vol. 4 (4).
1997	50,000	New Straits Times (Jun. 13, 2008)
2001	30,000	Asian Migration News (Aug. 15, 2001); Straits Times (Aug. 14, 2001)
2010	100,000	Straits Times (May 28, 2010)

The data sources referred to in constructing an estimate of workers commuting from Malaysia are listed in Table 17. Our estimated suggest a moderate increase in workers from Malaysia over the course of the 1980s and 1990s. The number of such workers has expanded rapidly in the last decade, which is consistent with the general trend of an increase in non-resident workers in recent years.

We allocate the estimated number of NR3 into the employment matrix with full dimensions, using the profile of non-resident workers $\widehat{\mathrm{N}}_{geas}^{NR1+NR2}$ estimated in (22). Figure 18 provides an overview of the number of foreigners in Singapore, after the adjustment procedures introduced above. In 2010, 35.6 percent of employed workers were foreigners, out of which 9.2 percent were NR3 workers. NR3 workers have maintained about 2.6 percent share of employed workers during the 2000s. This is a mere 1.4 percentage point increase from the 1980s, when NR3 workers had a 1.2 percent share.

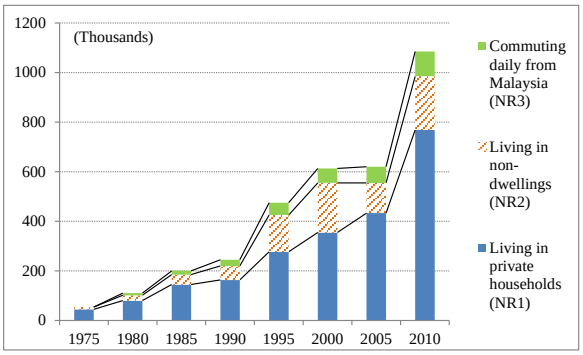


Figure 18: Estimates of Non-Resident Workers in Singapore

5.2.5 Skilled versus Unskilled Foreign Labor

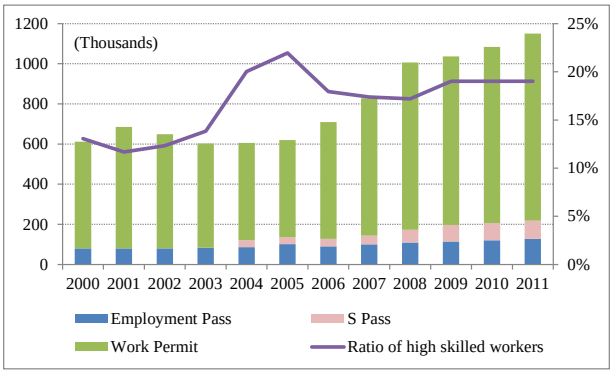
Figures from the administrative records show that, in 2005, 28.9 percent of the labor force was foreign. By 2010, this figure had expanded to 35.8 percent. Given the rapid increase in foreign workers in Singapore over the past decade, the allocation of the $geas$ profile of non-residents workers in this period will have significant consequences on the final estimate of quality adjusted labor input for recent years.

The Singaporean government issues two major kinds of visas for non-resident workers to be employed in Singapore – the Employment Pass (EP) and Work Permit (WP).[41] As the type of visa issued is dependent on the level of wages paid to the worker, workers with employment passes are more highly compensated and highly skilled. According to our best estimates, in 2000, some 13.1 percent of non-resident workers had an employment pass, and 13.3 percent of non-resident workers had a college degree or higher. Given this close resemblance between the ratio of employment pass holders and non-resident workers with a college degree, we assume that non-resident workers with a college degree were issued an employment pass, and all other workers were issued a work permit. We divide the non-resident labor force into higher skilled workers and lower skilled workers by their level of education attainment, using our estimates of the $geas$ profiles of non-residents.

Our estimation process described above has enabled us to obtain the $geas$ profile of NR1 workers for 1999 and 2001–2004, using equation (20), and the profile of NR2 workers in 2000, using equation (23). Hence, by splitting the non-residents by those with- and without-college degrees, we prepare four types of profiles for non-residents workers – NR1 workers with degrees, NR1 workers without degrees, NR2 workers with degrees and NR2 without degrees. Finally, we combine the higher and lower skilled non-resident workers based on our estimates of the number of employment passes and work permits issued in that year. Figure 19 provides our best estimates of the types of visas issued each year, for 2000 to 2011.[42]

[41] In recent years, a third type of qualification (S Pass) has also been issued for mid-level skilled foreigners. In this paper, we assume that S Passes are a subset of work permits.

[42] In 2010, the Straits Time published an estimate of the numbers of Employment Passes, S Passes, and Work Permits issued in the previous year, the sum of which was almost exactly equal to the number of non-resident workers in the administrative records (see the article written by Zakir Hussain on February 2, 2010). Using this value as a basis, we extrapolated the number of different types of visas issued using figures from various Straits



The number of the respective visa holders is shown on the left axis.
The ratio of high skilled visa holders within foreign workers is shown on the left axis.

Figure 19: Estimates of Number of Visas Issued

For the period from 1999 to 2004, exclusive of 2000, the estimated *geas* profile for NR1 workers are applied to the NR1 workers. Then, the profile of NR2 workers with- and without-degrees are added so that the overall ratio of non-residents degree holders equals the ratio of employment passes in that year.[43] There are no adjustments applied to 2000, as we have assumed that the Census provides information for all non-resident workers.

For the period after 2005, the NR1 profile of workers with- and without-degrees in 2004 are applied to the NR1 workers so that the ratio of NR1 degree holders agrees with the ratio of employment pass holders in that year. Similarly, the NR2 profile of 2000 is applied analogously to NR2 and NR3 workers.

For the period before 1999, we lack a basis for judging the number of employment passes and work permits issued. The overall profile of NR2 in 2000 is applied to total number of NR2 and NR3 in each year (the profile of NR1 workers is already given in the respective statistics published during this period)

5.3 Hours Worked per Worker

There are six main concepts of hours of work that are estimated in various sources of labor statistics: actual hours, usual hours, contractual hours, legal hours, paid hours, and hours offered (by employers). Singapore's LFS data are based on the concept of usual hours worked: i.e., normal hours during a typical workweek of the year, plus regular overtime worked whether paid or unpaid.[44] In measuring labor input as a factor of production, actual hours worked may be preferred but we approximate the average annual hours worked by the mid-year estimates of usual weekly hours worked multiplied by 48 weeks per year as a crude assumption.

To segregate data of usual hours worked h_{geas} into the dimensions required in our

Times articles (see May 20, 1999; August 24, 2006; March 24, 2011) and academic papers (ADB 2006, Teo and Piper 2009, and Yue 2011).

[43] It should be noted that the ratio of employment passes issued are not fixed within NR1, NR2, and NR3. We have only fixed the ratio within non-residents workers as a whole.

[44] For a multiple jobholder, the hours spent in all the jobs are included.

framework need some estimation procedures. For the periods of LFS 1999, 2001–04 and 2006–10, the weekly average hours worked per worker in each gender classified by education attainment and age h^w_{gea} and by employment status h^w_{gs} are available.[45] Using these data we calculate the weekly hours worked $H^w_{gea} = N_{gea}h^w_{gea}$ and $H^w_{gs} = N_{gs}h^w_{gs}$. With these constraints as sub-totals, $\hat{H}^w_{geas}$ is estimated by the following calculations:

$$(24) \quad \min \sum_{eas}\left(\hat{H}^w_{geas} - \hat{N}_{geas}\right)^2 \text{ subject to } H^w_{gea} = \sum_s \hat{H}^w_{geas} \text{ and } H^w_{gs} = \sum_{ea} \hat{H}^w_{geas}.$$

Finally, we obtain the average hours worked per worker with full dimensions: $\hat{h}^w_{geas} = \hat{H}^w_{geas}/\hat{N}_{geas}$.

For the periods of LFS 1974–1984, Census 2000, and GHS 1995 and 2005, the number of employed persons by range of hours worked per worker during the reference week (*k*) is available in each gender by age N_{gak} and by employment status N_{gsk}. We consider weekly hours worked by gender and age $H^w_{ga} = \sum_k N_{gak}m^w_k$ using the mean of the range of hours worked (e.g. m^w_k =19.5 hours in the range of weekly hours *k*=15–24). Similarly hours worked by gender and employment status is defined as $H^w_{gs} = \sum_k N_{gsk}m^w_k$. Based on these two constraints, we estimate $\hat{H}^w_{gas}$ as follows:

$$(25) \quad \min \sum_{as}\left(\hat{H}^w_{gas} - N_{gas}\right)^2 \text{ subject to } H^w_{ga} = \sum_s \hat{H}^w_{gas} \text{ and } H^w_{gs} = \sum_a \hat{H}^w_{gas}.$$

Thus we obtain the average hours worked per worker by $\hat{h}^w_{gas} = \hat{H}^w_{gas}/N_{gas}$. Only in GHS 2005 we obtain $H^w_{ge} = \sum_k N_{gek}m^w_k$ and $\hat{H}^w_{geas}$ is estimated using (25), followed by:

$$(26) \quad \min \sum_{eas}\left(\hat{H}^w_{geas} - \hat{N}_{geas}\right)^2 \text{ subject to } \hat{H}^w_{gas} = \sum_e \hat{H}^w_{geas} \text{ and } H^w_{ge} = \sum_{as} \hat{H}^w_{geas}.$$

In LFS 1986–98, data on hours worked is not available. For this period, we estimate $\hat{h}^w_{ga}$ and $\hat{h}^w_{gs}$ using the benchmark estimates in 1984 and 2000, and then estimate $\hat{h}^w_{gas}$ by following (25).

Given that the same value of $\hat{h}^w$ is applied to both resident and non-resident workers, it is ideal that $\hat{h}^w$ also reflects the hours worked of all workers. Therefore, as in section 5.2, we attempt to adjust the level of average weekly hours worked so that it is consistent across years, despite the frequent changes in the coverage of the statistical publications. Noting that only LFS 1974–1985, 1999, and 2001–2004 provided data on hours worked while covering both residents and non-residents, we assume that the values of $\hat{h}^w$ estimated in these years accurately reflect the hours worked of all workers. For 1986–1998, we estimate the average level of $\hat{h}^w$ by extrapolating the values estimated in the years mentioned above, using the time-series trends of average weekly paid hours worked (standard hours and paid overtime) per employee h^w from establishment surveys conducted by the Manpower Research and Statistics Department of the Ministry of Manpower, reported in the YMS. Similarly, for 2005–2011, we use the time-series trends of LFS. An adjustment constant, estimated for each year, is multiplied to the individual yearly estimates of $\hat{h}^w_{geas}$, so that the average weekly hours worked equals this extrapolated

[45] The data on hours worked per worker for residents only is available for the period of 2006–10.

value. A comparison between our final estimates for average weekly hours worked and that of the establishment survey is provided in Figure 20.

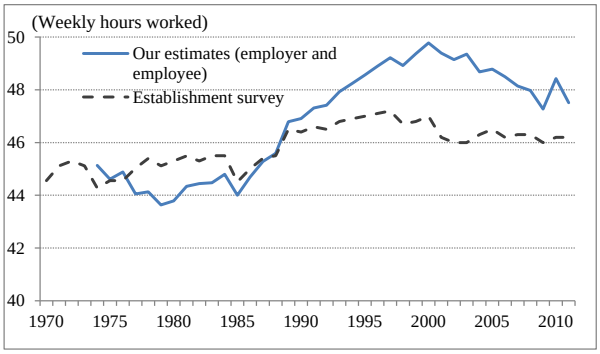


Figure 20: Weekly Average Hours Worked per Employee, 1970–2011

5.3.1 Conscripts

Conscription in Singapore, called the National Service, requires all male Singaporean citizens and second-generation permanent residents who have reached the age of 18 to enroll in the military. They serve a two-year period as Full Time National Servicemen (NSFs), either in the Singapore Armed Forces (SAF), Singapore Police Force (SPF), or the Singapore Civil Defence Force (SCDF).

The LFS and Census include the number of National Servicemen, as well as the workers in the Singaporean Armed Forces, in statistical tables regarding the attributes of workers. This enabled the inclusion of these workers in the employment matrix regarding the number of workers. On the other hand, the information on hours worked and compensation provided in the LFS and Census does not include National Servicemen. Therefore, we apply the same hours worked per week and hourly compensation to National Servicemen as resident workers in the same $geas$ category.

5.4 Hourly Wage

Estimates of the total compensation of workers during a full calendar month prior to the survey (gross monthly income) can be obtained from LFS in Singapore. For employees, these estimates provides the total value of "salaries, allowances, overtime, commission, tips and bonuses" (LFS2010, p.57) as well as the employee's social security (Central Provident Fund) contributions. For employers and own account workers, income is defined as the difference between total receipts and business expenses.

Similar to hours worked per workers, complete information on the hourly wages necessary to fill the employment matrix is not available, and thus, estimations procedures are necessary. The LFS and Census typically do not provides average wage values, but rather the number of workers by their respective level of wages in broad brackets (e.g. "$600 to $700"), for each of dimensions e, a and s. Therefore, the average value of each bracket (i.e. $650) is

allocated as the compensation for all workers in that bracket. In allocating a value for the highest yet open bracket (e.g. "$6000 and Over"), a dollar value is initially allocated so that the total compensation of employees would match about 60–70 percent of the estimates of compensation of employees in the Singapore System of National Accounts. It is not surprising that the income of the educated high-earners is most sensitive to the dollar value allocated to the highest income bracket. Thus, this dollar value is adjusted as necessary to keep the yearly trend of hourly compensation w_{geas} stable.

In estimating the yearly total compensation for each component of the employment matrix, we attempt to reflect the diversity of hourly compensation for each dimension in the employment matrix, g, e, a, and s, for each given year. Therefore, two steps are followed in the estimation process, in which

(27) $\min \sum_{es}\left(\widehat{\mathrm{V}}_{ges} - H_{ges}\right)^2$ subject to $\mathrm{V}_{ge} = \sum_s \widehat{\mathrm{V}}_{ges}$ and $\mathrm{V}_{gs} = \sum_e \widehat{\mathrm{V}}_{ges}$

is first calculated, followed by

(28) $\min \sum_{aes}\left(\widehat{\mathrm{V}}_{geas} - H_{geas}\right)^2$ subject to $\mathrm{V}^{w}_{ges} = \sum_s \widehat{\mathrm{V}}_{geas}$ and $\mathrm{V}_{ga} = \sum_{es} \widehat{\mathrm{V}}_{geas}$.

Finally, we obtain the average hourly compensation per worker with full dimensions: $\widehat{\mathrm{w}}_{geas} = \widehat{\mathrm{V}}_{geas}/\widehat{\mathrm{H}}_{geas}$.

Our estimations for hourly compensation are based primarily on estimates provided by LFS. For years in which the Census/GHS was conducted in place of LFS (1990, 1995, 2000, and 2005), the average wage level of the previous and following years was used so that wages trends were consistent with those suggested by the LFS (the Census tends to suggest slightly higher hourly wages).

Some assumptions are made for wage levels of those workers whose details are not provided by LFS. Firstly, as the compensation levels for non-resident workers are not provided by the annual labor force survey, the same wage levels as those allocated to resident workers are used. Additionally, the wages for contributing family workers were not provided in LFS prior to 1995. Therefore, the ratio of the hourly wage of own account workers to that of contributing family workers in the 1990 Census is applied to pre-1995 wage estimation to calculate the compensation of the latter in those years.

As hourly wage for each category is sensitive to subtle shifts in total compensation and total hours worked, adjustments are made as deemed necessary for smaller categories of workers. For example, in 1975, the initial estimates for total compensation of male workers with a degree or diploma suggested that these workers, who made up 2.7 percent of all employed male workers, received 13.9 percent of total compensation of workers, implying an hourly wage equal to 660 percent of those without formal schooling. As our estimates of these male workers after 1977 suggest that their hourly wage is never more than 400 percent of those without a college degree, the hourly compensation of workers with a college degree in 1975, as well as 1974 and 1976 were adjusted to bring them in line with the trend.

5.4.1 Compensation of Employees in SSNA

The Singapore System of National Accounts (SSNA) provides the estimates of compensation of employees. Conceptually the coverage of this statistic is larger than that of our estimates based on LFS and the Census, since it includes employers' social contributions, and wages and salaries in kind (e.g. imputed cost of childcare and housing services that can be used by the household to which the employee belongs). However it may work to check our aggregate estimates. Figure 21 presents a comparison of the monthly compensation of employees, $\sum_{geas} \text{Lhw}_{geas}$ (s=1 and 2), between our original estimates and the implied SSNA estimates (i.e. annual values divided by 12). As the figure suggests, the ratio between two estimates is relatively constant over years.

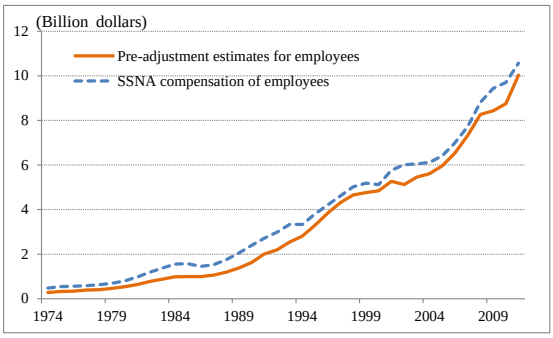


Figure 21: Compensation of Employees: Pre-adjustment Estimates and SSNA

To make our estimates compatible with the national accounts in SSNA, we adjust the hourly wage rates of employees (including employers), so that the sum of compensation of these workers would equal the SSNA compensation of employees for each year. Given the discussion of wages for own-account and unpaid family workers, in section 5.5.1, we keep the wages for these workers as they are. After adjustments, the wages of own account workers is 55.8 percent of that of employees, while the wages of contributing family workers is about 29.7 percent, as the ratios of wage differences measured by the Fisher indices for the period of 1974–2011 (Figure 22).[46]

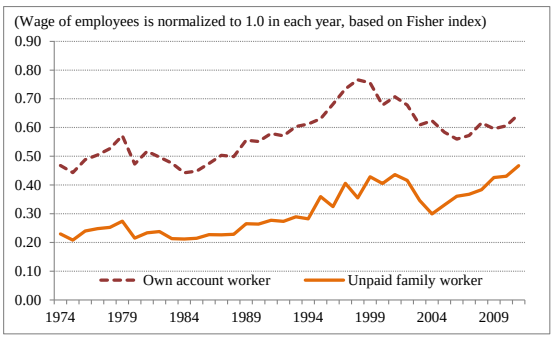


Figure 22: Wages of Own Account and Contributing Family Workers

[46] See Table 26 in section 6.

5.5 Sensitivity Checks based on Alternative Assumptions

5.5.1 Wages for Own-account and Unpaid Family Workers

As the wage rates for own-account workers and unpaid family workers are provided in official statistics (the exclusion of the wage ratio for unpaid family workers prior to 1995 has been adjusted for using the methodology introduced in section 5.4), our dataset relies on these figures for estimating the wage rates of workers with their respective employment status.

Nevertheless, wage rates for own-account and unpaid workers can be biased or crude estimates, even in official statistics. In case of own-account workers, their compensation is an arbitrary portion of mixed income which they receive for their labor as well as for their capital, and thus estimates may be overstated. On the other hand, compensation for unpaid family workers may be paid in non-monetary form (benefits in kind), and thus, the monetary compensation may understate the actual compensation of these workers.[47]

To test the significance of this potential inaccuracy of wages for own-account and unpaid family workers on our estimates, we compile an alternative measure of labor input and labor quality by ignoring employment status and applying the same aggregate wage rates of employees to all workers of the same gea attributes. .

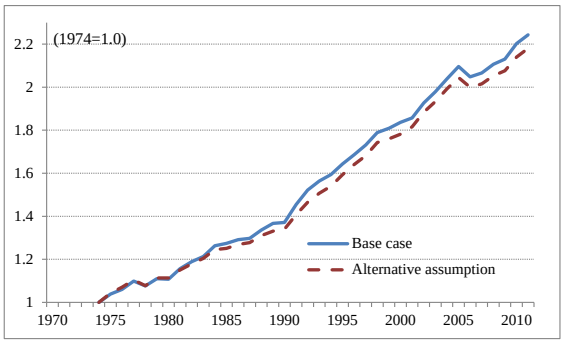


Figure 23: Labor Quality under Alternative Wages for Non-Employees

The labor input index created using this alternative estimation closely resembles the original labor input index. It implies that the estimation of wage ratios for own-account and unpaid family workers has a limited effect on the final estimate of labor input. Labor quality growth from 1974–2010 in our base assumptions is 2.13 percent per year, while under these assumptions described above is 2.05 percent. The trend lines of labor quality under our base assumptions and the new one described above are also comparable, as shown in Figure 23.

5.5.2 Profile of Non-Resident Workers

In section 2.3.5 we estimate the profile of non-resident workers using our estimates of

[47] LFS does not provide details about how the compensation for unpaid family workers was calculated.

the number of employment passes and worker permits issued in each year. Although these estimates of the number of visas issued are our best estimates, they are based on unofficial sources. As a sensitivity test for our estimates, we test two alternative assumptions regarding the profile of non-resident workers in Singapore.

In the first case, the *ratio* of highly skilled non-resident workers is kept constant after 2004. In the period after 2004, we distribute NR1 and NR2 workers using the ratio of highly skilled workers in 2004, i.e. 20.0 percent.

In our second assumption, we keep constant the *number* of highly skilled non-resident workers. For 1999 to 2004, we keep the original estimates for NR1, but adjust the ratio of NR2 workers with- and without-degrees so as to keep the number of college degree holders constant at 2000 levels. From 2005 onwards, we change the educational composition of both NR1 and NR2 workers so that the number of highly skilled workers is the same as they were in 2004. That is, the number of non-resident degree holders is constant throughout 1999 to 2011 in this scenario.

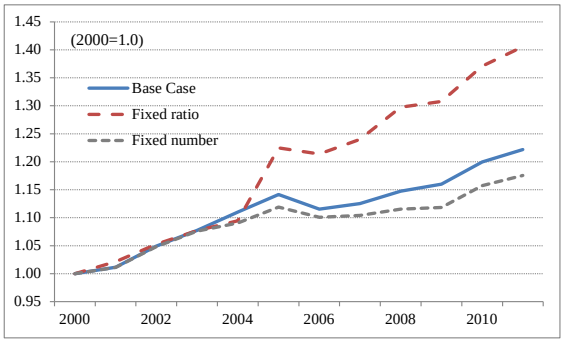


Figure 24: Labor Quality under Alternative Scenario for Non-Residents

Our base-case scenario, which adjusts for the number of college degree numbers using data on visas issued, gives an estimate of labor quality growth which is smaller than under the first scenario (fixed ratio of degree holders) but larger than the second (fixed number), as shown in Figure 24. As Figure 19 suggests, the ratio of highly skilled workers have decreased after 2005, but the absolute number of such workers have increased (as the absolute size of non-resident workers have expanded).

6 Appendix: Supplementary Tables

Table 18: Educational Attainment of Employed Workers

Year	Less than Lower Primary		Primary/Lower Secondary		Secondary		Upper Secondary		Diploma/Degree	
1974	40.0		31.5		19.8		6.2		2.5	
1975	34.9		31.9		24.0		6.8		2.5	
1976	32.2		31.6		25.1		8.0		3.1	
1977	29.4		32.9		26.2		8.1		3.4	
1978	29.0		34.1		26.5		7.7		2.7	
1979	28.5		31.8		28.0		8.4		3.2	
1980	24.9		36.0		27.0		8.8		3.4	
1981	24.6		32.9		29.7		9.0		3.8	
1982	25.1		31.0		29.9		9.5		4.4	
1983	23.6		31.3		29.9		10.2		4.9	
1984	21.3		32.5		30.6		10.3		5.2	
1985	23.3		31.7		28.8		10.7		5.5	
1986	22.6		30.6		30.1		11.3		5.4	
1987	23.6		30.4		28.8		11.5		5.7	
1988	20.2		30.5		30.6		12.7		5.9	
1989	19.8		29.9		30.5		13.3		6.5	
1990	18.9		32.5		29.3		10.0		9.2	
1991	18.3		31.1		29.4		9.3		11.9	
1992	16.6		30.4		29.1		10.6		13.3	
1993	16.2		29.8		29.2		10.5		14.3	
1994	16.6		28.4		29.2		10.6		15.1	
1995	16.0		27.3		29.3		10.6		16.9	
1996	16.7		25.2		29.1		10.7		18.3	
1997	16.5		26.0		27.3		9.4		20.8	
1998	15.8		25.2		27.1		9.2		22.7	
1999	16.2	(13.7)	24.3	(21.9)	26.6	(28.6)	9.2	(10.1)	23.7	(25.8)
2000	13.0	(9.6)	24.8	(20.6)	25.3	(27.4)	9.9	(11.8)	27.0	(30.7)
2001	15.6	(12.9)	22.0	(19.6)	27.1	(27.8)	9.9	(11.1)	25.4	(28.6)
2002	14.7	(12.0)	21.3	(19.2)	27.3	(27.4)	10.6	(12.1)	26.1	(29.3)
2003	14.2	(11.7)	20.0	(18.6)	26.5	(25.9)	11.0	(12.1)	28.3	(31.6)
2004	14.1	(11.7)	19.1	(18.0)	24.6	(24.8)	10.8	(12.0)	31.4	(33.5)
2005	10.6	(7.0)	19.8	(18.8)	23.1	(23.2)	15.0	(17.9)	31.5	(33.1)
2006	13.7	(10.6)	19.2	(17.5)	24.0	(24.1)	11.2	(12.6)	31.9	(35.2)
2007	14.1	(10.7)	19.0	(16.9)	23.9	(23.8)	11.2	(12.7)	31.9	(35.9)
2008	14.1	(10.1)	17.4	(14.0)	23.8	(23.5)	11.9	(14.2)	32.8	(38.2)
2009	14.0	(10.1)	17.2	(13.9)	24.1	(24.3)	10.8	(12.6)	33.9	(39.1)
2010	12.5	(7.7)	17.5	(14.4)	21.3	(20.0)	10.4	(11.9)	38.3	(45.9)
2011	12.3	(7.2)	17.4	(14.1)	21.4	(20.1)	10.2	(11.7)	38.6	(46.8)

Note: All figures are yearly shares in percentages. Figures in parenthesis are shares within resident workers.

Table 19: Age Distribution of Employed Workers

Year	Under 20	20–29	30–39	40–49	50 & Over
1974	14.3	38.6	20.1	14.3	12.7
1975	13.4	38.7	20.4	14.9	12.6
1976	13.5	39.2	19.4	14.8	13.0
1977	12.5	38.8	20.3	15.5	12.9
1978	12.4	40.7	21.2	14.5	11.3
1979	11.9	39.7	21.7	14.7	12.0
1980	12.1	40.4	22.5	13.8	11.2
1981	11.0	40.8	22.7	14.3	11.2
1982	9.9	40.2	23.7	14.9	11.3
1983	8.8	40.4	24.9	14.4	11.5
1984	7.4	39.1	26.7	15.2	11.5
1985	6.5	38.6	28.0	15.4	11.4
1986	5.4	38.5	29.1	15.5	11.5
1987	4.8	37.5	30.7	16.1	10.9
1988	4.7	36.7	31.0	17.0	10.7
1989	4.8	36.0	30.8	17.1	11.4
1990	4.8	35.9	31.7	16.8	10.8
1991	4.8	33.8	31.4	18.3	11.7
1992	4.3	33.0	31.5	19.1	12.1
1993	3.7	32.0	31.3	20.9	12.2

Note: All figures are yearly shares in percentages.

Table 20: Age Distribution of Employed Workers: 1993–2011

Year	15-19		20-24		25-29		30-34		35-39		40-44		45-49		50-54		55-59		60-64		65-69		70&Over	
1993	3.7		14.7		17.2		16.6		14.7		12.5		8.4		5.7		3.4		1.8		0.9		0.5	
1994	3.1		14.2		17.2		16.7		15.3		12.2		8.9		5.6		3.6		1.8		0.9		0.5	
1995	2.7		13.7		17.5		17.2		15.4		12.7		9.4		5.1		3.5		1.6		0.8		0.4	
1996	2.6		12.0		16.3		17.0		15.6		13.3		10.7		5.3		4.0		1.7		1.0		0.5	
1997	2.2		11.8		16.7		16.6		15.0		13.4		10.9		6.2		3.9		1.8		0.9		0.5	
1998	1.9		11.0		16.5		16.6		15.4		13.9		11.0		6.7		4.0		1.8		0.9		0.5	
1999	2.1	(2.1)	10.9	(8.4)	16.6	(14.1)	16.4	(14.8)	14.9	(16.4)	13.5	(14.3)	10.9	(12.9)	7.1	(8.0)	3.9	(4.7)	2.1	(2.4)	1.0	(1.2)	0.5	(0.7)
2000	2.0	(1.8)	12.2	(8.2)	19.0	(14.3)	16.9	(15.0)	14.7	(15.9)	12.6	(15.2)	9.8	(12.5)	6.8	(8.9)	3.2	(4.2)	1.7	(2.3)	0.8	(1.1)	0.4	(0.6)
2001	2.1	(2.0)	11.3	(8.1)	15.7	(13.2)	15.4	(13.6)	14.9	(16.6)	13.8	(14.7)	11.2	(13.5)	8.4	(9.7)	3.6	(4.2)	2.3	(2.6)	0.9	(1.2)	0.5	(0.7)
2002	1.7	(1.4)	10.5	(7.5)	15.4	(12.6)	15.4	(13.8)	14.6	(16.2)	13.7	(14.6)	11.5	(13.8)	8.8	(10.0)	4.6	(5.5)	2.3	(2.6)	1.0	(1.2)	0.5	(0.7)
2003	1.6	(1.5)	10.4	(7.6)	15.1	(12.3)	15.3	(13.9)	14.1	(15.5)	13.5	(14.3)	11.8	(14.0)	9.1	(10.2)	5.1	(6.0)	2.4	(2.6)	1.0	(1.3)	0.6	(0.8)
2004	1.7	(1.5)	10.4	(7.8)	15.1	(11.9)	15.2	(13.7)	13.4	(14.6)	13.6	(14.5)	12.2	(14.6)	9.1	(10.3)	5.6	(6.8)	2.3	(2.5)	0.9	(1.2)	0.6	(0.7)
2005	1.5	(1.2)	10.0	(7.2)	15.5	(12.3)	16.0	(14.5)	13.4	(14.5)	14.0	(15.0)	11.4	(13.6)	9.3	(10.6)	5.4	(6.6)	2.2	(2.5)	0.9	(1.2)	0.6	(0.7)
2006	1.8	(1.6)	10.6	(7.8)	14.6	(11.2)	15.0	(13.2)	12.6	(13.4)	13.4	(14.3)	11.7	(14.1)	9.7	(11.3)	6.1	(7.6)	2.6	(3.0)	1.2	(1.5)	0.7	(0.9)
2007	1.9	(1.8)	10.4	(7.1)	14.8	(11.1)	15.3	(13.4)	12.6	(13.5)	13.1	(13.9)	11.3	(13.8)	9.8	(11.5)	6.1	(7.9)	2.9	(3.5)	1.2	(1.6)	0.7	(1.0)
2008	1.9	(1.7)	10.9	(7.2)	15.0	(10.7)	15.1	(12.7)	12.6	(13.9)	12.9	(13.7)	10.9	(13.7)	9.7	(11.8)	5.9	(7.9)	3.2	(4.1)	1.2	(1.6)	0.7	(1.1)
2009	1.7	(1.5)	10.7	(6.8)	15.3	(10.9)	15.1	(12.7)	12.5	(13.7)	12.7	(13.4)	10.6	(13.3)	9.7	(11.9)	6.0	(8.1)	3.5	(4.7)	1.3	(1.8)	0.8	(1.2)
2010	2.0	(1.9)	10.9	(7.2)	15.2	(10.7)	15.0	(12.5)	12.4	(13.6)	12.1	(12.5)	10.5	(13.2)	9.5	(11.6)	6.5	(8.8)	3.7	(4.9)	1.3	(1.8)	0.9	(1.3)
2011	1.8	(1.6)	11.1	(7.4)	15.0	(10.2)	14.8	(12.1)	12.0	(13.0)	12.1	(12.5)	10.4	(13.1)	9.7	(11.9)	6.6	(9.1)	4.0	(5.5)	1.5	(2.2)	1.0	(1.5)

Note: All figures are yearly shares in percentages. Figures in parenthesis are shares within resident workers.

Table 21: Number of Employed Workers in Singapore

Year	Employed workers	(R) Residents	(NR) Non-Residents			
			Total	(NR1) Living in private households	(NR2) Living in non-dwellings	(NR3) Commuting from Malaysia
1974	826	765	62	53	8	0
1975	838	785	53	44	9	0
1976	875	815	60	50	11	0
1977	915	845	70	55	15	0
1978	975	893	82	63	17	3
1979	1043	947	96	71	19	6
1980	1099	990	109	79	21	9
1981	1190	1061	129	93	24	12
1982	1263	1113	150	108	29	13
1983	1298	1125	174	126	33	14
1984	1321	1121	200	148	36	16
1985	1290	1091	200	144	40	16
1986	1275	1115	160	100	44	16
1987	1334	1154	180	113	49	18
1988	1406	1203	203	128	54	20
1989	1475	1250	225	144	58	23
1990	1551	1307	244	162	57	25
1991	1645	1345	300	179	93	28
1992	1692	1370	322	206	84	32
1993	1721	1382	340	210	92	37
1994	1801	1416	385	233	110	42
1995	1901	1426	474	276	149	50
1996	1976	1465	512	283	177	52
1997	2076	1500	576	331	192	54
1998	2134	1494	640	376	214	50
1999	2129	1518	611	368	190	53
2000	2095	1483	612	354	201	58
2001	2267	1583	685	464	191	30
2002	2223	1574	650	444	166	40
2003	2208	1605	603	428	124	50
2004	2238	1632	606	435	113	58
2005	2267	1647	619	432	122	66
2006	2506	1797	709	495	139	75
2007	2671	1842	829	582	164	83
2008	2858	1852	1006	718	202	85
2009	2906	1869	1037	742	209	86
2010	3047	1963	1084	768	216	100
2011	3150	1999	1151	816	230	105

Unit: Thousands.

Table 22: Relative Hourly Wages by Educational Attainment, 1974–1993

Year	Male					Female				
	Less than Lower Primary	Primary/Lower Secondary	Secondary	Upper Secondary	Diploma/Degree	Less than Lower Primary	Primary/Lower Secondary	Secondary	Upper Secondary	Diploma/Degree
1974	1.00	1.15	1.92	2.45	4.67	1.00	1.31	2.05	2.70	7.59
1975	1.00	0.98	1.65	2.33	4.48	1.00	1.15	2.01	2.94	6.13
1976	1.00	0.95	1.38	2.19	4.16	1.00	1.19	1.80	2.73	5.71
1977	1.00	1.02	1.44	2.05	3.91	1.00	1.08	1.53	2.15	4.22
1978	1.00	1.03	1.39	1.94	3.70	1.00	1.08	1.47	2.03	4.01
1979	1.00	1.03	1.37	1.90	3.52	1.00	1.09	1.46	2.01	3.82
1980	1.00	0.94	1.56	2.07	3.52	1.00	0.96	1.58	2.09	3.70
1981	1.00	1.05	1.41	2.02	3.22	1.00	1.09	1.48	2.10	3.47
1982	1.00	1.05	1.40	1.96	2.96	1.00	1.09	1.48	2.04	3.18
1983	1.00	1.06	1.46	1.96	2.84	1.00	1.10	1.54	2.05	3.05
1984	1.00	1.07	1.46	1.92	2.62	1.00	1.10	1.52	1.97	2.77
1985	1.00	1.14	1.54	1.89	2.62	1.00	1.18	1.63	1.97	2.82
1986	1.00	1.14	1.50	1.84	2.53	1.00	1.17	1.57	1.90	2.72
1987	1.00	1.15	1.53	1.81	2.50	1.00	1.19	1.61	1.88	2.68
1988	1.00	1.16	1.49	1.78	2.42	1.00	1.19	1.57	1.84	2.59
1989	1.00	1.19	1.59	2.10	3.27	1.00	1.20	1.63	2.12	3.41
1990	1.00	1.10	1.58	2.02	3.07	1.00	1.11	1.67	2.17	3.46
1991	1.00	1.05	1.52	1.83	3.06	1.00	1.08	1.79	2.27	3.70
1992	1.00	1.23	1.71	2.17	3.18	1.00	1.26	2.03	2.61	4.06
1993	1.00	1.20	1.70	2.30	3.64	1.00	1.31	2.04	2.68	4.28

Table 23: Relative Hourly Wages by Educational Attainment, 1993–2011

	Male							Female						
Year	Less than Lower Primary	Primary	Lower Secondary	Secondary	Upper Secondary	Polytechnic Diploma	Degree	Less than Lower Primary	Primary	Lower Secondary	Secondary	Upper Secondary	Polytechnic Diploma	Degree
1993	1.00	1.12	1.25	1.69	2.29	2.29	4.53	1.00	1.17	1.41	2.04	2.68	2.98	4.87
1994	1.00	1.14	1.26	1.70	2.28	2.24	4.12	1.00	1.18	1.34	1.97	2.76	2.86	4.36
1995	1.00	1.08	1.26	1.70	2.26	2.32	4.18	1.00	1.11	1.31	1.91	2.69	2.83	4.70
1996	1.00	1.09	1.31	1.68	2.04	2.19	3.56	1.00	1.08	1.40	2.24	3.04	3.24	4.79
1997	1.00	1.13	1.32	1.66	2.02	2.25	3.51	1.00	1.20	1.50	2.40	3.13	3.26	4.94
1998	1.00	1.12	1.34	1.73	2.03	2.26	3.64	1.00	1.12	1.47	2.55	3.31	3.51	5.22
1999	1.00	1.10	1.30	1.68	1.99	2.23	3.70	1.00	1.17	1.48	2.49	3.35	3.58	5.31
2000	1.00	1.15	1.30	1.77	2.13	2.49	3.77	1.00	1.16	1.35	2.33	3.16	3.78	5.02
2001	1.00	1.09	1.30	1.71	2.06	2.42	3.78	1.00	1.19	1.55	2.56	3.69	3.91	5.71
2002	1.00	1.05	1.29	1.68	2.05	2.33	3.71	1.00	1.11	1.52	2.31	3.68	3.48	5.21
2003	1.00	1.05	1.30	1.65	2.25	2.44	2.76	1.00	1.15	1.49	2.25	3.61	3.42	5.82
2004	1.00	1.07	1.34	1.69	2.05	2.36	4.09	1.00	1.21	1.51	2.25	3.35	3.46	5.45
2005	1.00	1.11	1.32	1.79	2.34	2.44	4.25	1.00	1.16	1.34	2.13	3.22	2.89	4.81
2006	1.00	1.04	1.30	1.74	2.24	2.45	4.41	1.00	1.05	1.35	2.14	3.12	2.90	4.91
2007	1.00	1.08	1.34	1.80	2.23	2.47	4.43	1.00	0.95	1.38	2.11	2.99	2.89	4.84
2008	1.00	1.06	1.31	1.76	2.23	2.51	4.38	1.00	1.01	1.27	2.18	3.16	3.01	5.13
2009	1.00	1.01	1.25	1.74	2.26	2.38	4.25	1.00	0.97	1.27	2.15	3.26	3.06	5.03
2010	1.00	1.07	1.26	1.69	1.72	2.58	4.48	1.00	1.07	1.24	1.94	2.34	3.00	4.94
2011	1.00	1.07	1.32	1.84	1.97	2.80	4.22	1.00	1.13	1.31	2.20	2.50	3.43	5.17

Table 24: Relative Hourly Wages by Age, 1974–1993

	Male					Female				
Year	Under 20	20–29	30–39	40–49	50 & Over	Under 20	20–29	30–39	40–49	50 & Over
1974	1.00	4.48	7.75	7.25	6.10	1.00	1.51	2.05	1.70	1.19
1975	1.00	4.50	7.80	7.32	6.04	1.00	1.50	2.07	1.71	1.17
1976	1.00	4.47	7.65	7.16	6.01	1.00	1.51	2.06	1.72	1.18
1977	1.00	4.48	7.77	7.27	6.09	1.00	1.51	2.09	1.74	1.20
1978	1.00	4.49	7.78	7.24	6.07	1.00	1.51	2.08	1.72	1.20
1979	1.00	4.50	7.82	7.25	6.08	1.00	1.51	2.11	1.73	1.20
1980	1.00	4.51	7.83	7.33	6.14	1.00	1.51	2.09	1.73	1.22
1981	1.00	3.81	6.49	6.27	5.25	1.00	1.51	2.09	1.83	1.33
1982	1.00	3.37	5.64	5.60	4.70	1.00	1.51	2.09	1.92	1.46
1983	1.00	3.08	5.09	5.16	4.30	1.00	1.50	2.08	2.00	1.53
1984	1.00	2.86	4.70	4.88	4.07	1.00	1.50	2.08	2.04	1.60
1985	1.00	2.71	4.39	4.64	3.87	1.00	1.50	2.09	2.09	1.67
1986	1.00	2.58	4.16	4.48	3.72	1.00	1.50	2.09	2.14	1.75
1987	1.00	2.49	3.98	4.32	3.57	1.00	1.50	2.09	2.17	1.78
1988	1.00	2.37	3.77	4.14	3.43	1.00	1.50	2.09	2.21	1.83
1989	1.00	2.34	3.69	4.10	3.39	1.00	1.50	2.09	2.23	1.85
1990	1.00	2.28	3.66	4.08	3.35	1.00	1.56	2.19	2.36	1.91
1991	1.00	2.38	3.80	4.26	3.57	1.00	1.51	2.10	2.16	1.79
1992	1.00	2.48	4.01	4.46	3.78	1.00	1.53	2.12	2.16	1.80
1993	1.00	2.55	4.19	4.63	3.98	1.00	1.54	2.14	2.15	1.80

Table 25: Relative Hourly Wages by Age, 1993–2011

Year	Male												Female											
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70 and over	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70 and over
1993	1.00	1.66	3.05	3.80	4.16	4.41	4.36	4.22	3.79	3.12	2.81	2.90	1.00	1.85	2.42	2.90	3.08	3.01	2.95	2.79	2.42	1.97	1.69	1.90
1994	1.00	1.75	3.26	4.07	4.45	4.70	4.64	4.56	4.08	3.29	3.00	2.83	1.00	2.25	2.82	3.26	3.30	3.07	2.85	2.55	2.26	1.81	1.40	1.39
1995	1.00	1.98	3.97	4.73	5.00	5.29	5.18	5.03	4.45	3.68	3.24	3.38	1.00	1.98	3.89	4.81	5.07	5.29	5.17	4.97	4.44	3.66	3.21	3.31
1996	1.00	2.18	4.58	5.38	5.57	5.89	5.70	5.47	4.79	4.02	3.45	3.89	1.00	2.20	4.61	5.54	5.69	5.93	5.76	5.45	4.84	4.09	3.45	3.85
1997	1.00	2.30	4.67	5.59	5.82	5.91	5.90	5.66	4.78	4.02	3.40	3.73	1.00	2.29	4.69	5.73	5.91	5.90	5.88	5.59	4.78	4.01	3.40	3.71
1998	1.00	2.38	5.10	6.29	6.70	6.79	6.69	6.46	5.45	4.57	3.86	4.14	1.00	2.40	5.11	6.46	6.79	6.75	6.65	6.36	5.44	4.55	3.86	4.10
1999	1.00	2.46	5.61	7.19	7.46	7.66	7.59	7.35	6.71	5.62	4.74	4.97	1.00	2.50	5.70	7.42	7.57	7.63	7.56	7.26	6.70	5.60	4.74	4.93
2000	1.00	2.50	6.05	7.50	7.71	7.68	7.55	7.38	6.62	5.93	4.91	5.20	1.00	2.73	6.10	7.65	7.87	7.84	7.61	7.79	7.06	5.79	4.94	5.06
2001	1.00	2.54	5.97	7.48	7.80	7.56	7.28	7.34	6.47	5.38	4.53	4.65	1.00	2.59	6.29	7.82	7.93	7.55	7.26	7.26	6.48	5.40	4.54	4.62
2002	1.00	2.58	6.29	8.07	8.40	8.17	7.82	7.39	6.91	5.73	4.86	4.98	1.00	2.62	6.46	8.34	8.49	8.12	7.77	7.31	6.89	5.71	4.82	4.90
2003	1.00	2.58	6.55	8.92	9.64	8.99	8.55	8.25	7.80	6.49	5.71	5.18	1.00	2.63	6.69	9.07	9.65	8.85	8.43	8.11	7.71	6.42	5.64	5.10
2004	1.00	2.63	6.64	8.56	9.54	9.38	8.62	8.03	7.67	6.38	5.60	5.09	1.00	2.65	6.40	8.68	9.65	9.27	8.52	7.94	7.63	6.34	5.56	5.02
2005	1.00	2.54	6.47	8.45	9.21	9.08	8.51	8.05	7.36	6.39	5.21	4.61	1.00	2.78	6.59	8.89	9.82	9.27	8.71	8.20	7.94	6.51	6.19	5.42
2006	1.00	2.56	6.51	8.72	9.83	9.47	8.83	8.18	7.62	6.38	5.65	4.82	1.00	2.46	6.31	8.89	10.33	9.42	8.99	8.10	7.91	6.45	6.05	5.17
2007	1.00	2.57	5.28	7.29	8.36	8.19	7.42	6.74	6.45	5.40	4.88	4.01	1.00	2.51	5.15	7.47	8.90	8.30	7.69	6.74	6.83	5.58	5.29	4.37
2008	1.00	2.54	5.53	7.36	8.65	8.30	7.65	6.94	6.58	5.68	4.64	3.70	1.00	2.31	5.03	7.07	8.72	7.87	7.38	6.49	6.52	5.56	4.74	3.79
2009	1.00	2.59	5.83	7.77	9.17	9.04	8.52	7.62	6.93	6.03	5.04	3.88	1.00	2.50	5.56	7.95	9.98	9.16	8.82	7.61	7.35	6.33	5.56	4.29
2010	1.00	2.54	5.71	7.19	8.69	8.69	8.14	7.43	6.77	6.42	5.23	4.34	1.00	2.50	5.55	7.41	9.50	8.94	8.60	7.58	7.36	6.95	5.84	4.83
2011	1.00	2.57	4.01	5.29	6.29	6.48	5.95	5.49	4.86	4.57	3.61	3.19	1.00	2.56	3.89	5.47	6.96	6.77	6.32	5.63	5.29	4.98	4.07	3.61

Table 26: Relative Hourly Wages by Employment Status, 1974–2011

	Male				Female			
Year	Employer	Employee	Own Account Worker	Contributing Family Worker	Employer	Employee	Own Account Worker	Contributing Family Worker
1974	2.63	1.00	0.47	0.14	2.78	1.00	0.50	0.23
1975	2.57	1.00	0.46	0.14	3.16	1.00	0.47	0.23
1976	2.23	1.00	0.53	0.15	3.11	1.00	0.50	0.22
1977	2.58	1.00	0.55	0.17	3.18	1.00	0.55	0.26
1978	2.30	1.00	0.58	0.18	3.13	1.00	0.55	0.22
1979	2.27	1.00	0.64	0.22	2.85	1.00	0.63	0.26
1980	1.98	1.00	0.49	0.16	1.08	1.00	0.46	0.19
1981	2.10	1.00	0.58	0.18	1.88	1.00	0.55	0.22
1982	2.09	1.00	0.55	0.17	2.26	1.00	0.55	0.22
1983	1.84	1.00	0.54	0.17	2.03	1.00	0.49	0.20
1984	1.85	1.00	0.48	0.17	2.27	1.00	0.49	0.19
1985	1.87	1.00	0.49	0.18	1.92	1.00	0.48	0.19
1986	1.70	1.00	0.53	0.18	1.76	1.00	0.47	0.19
1987	1.61	1.00	0.55	0.19	1.73	1.00	0.52	0.21
1988	1.73	1.00	0.55	0.20	1.90	1.00	0.56	0.23
1989	1.56	1.00	0.58	0.20	1.62	1.00	0.55	0.22
1990	1.43	1.00	0.57	0.19	1.48	1.00	0.53	0.21
1991	1.70	1.00	0.61	0.22	1.82	1.00	0.60	0.22
1992	1.63	1.00	0.59	0.19	1.71	1.00	0.57	0.21
1993	1.81	1.00	0.59	0.18	2.16	1.00	0.68	0.24
1994	1.74	1.00	0.60	0.23	2.03	1.00	0.68	0.24
1995	1.61	1.00	0.63	0.28	1.79	1.00	0.70	0.27
1996	1.50	1.00	0.66	0.28	1.64	1.00	0.73	0.25
1997	1.49	1.00	0.71	0.32	1.57	1.00	0.79	0.44
1998	1.50	1.00	0.73	0.34	1.64	1.00	0.87	0.25
1999	1.52	1.00	0.73	0.32	1.82	1.00	0.87	0.30
2000	1.46	1.00	0.67	0.29	1.68	1.00	0.81	0.26
2001	1.38	1.00	0.65	0.35	1.70	1.00	0.88	0.31
2002	1.36	1.00	0.61	0.32	1.76	1.00	0.88	0.26
2003	1.38	1.00	0.56	0.27	1.75	1.00	0.91	0.29
2004	1.41	1.00	0.55	0.24	1.76	1.00	0.87	0.29
2005	1.33	1.00	0.53	0.25	1.56	1.00	0.85	0.27
2006	1.45	1.00	0.53	0.25	1.64	1.00	0.79	0.27
2007	1.50	1.00	0.54	0.28	1.65	1.00	0.77	0.31
2008	1.47	1.00	0.59	0.32	1.60	1.00	0.84	0.26
2009	1.48	1.00	0.55	0.30	1.61	1.00	0.89	0.36
2010	1.51	1.00	0.55	0.34	1.68	1.00	0.94	0.32
2011	1.43	1.00	0.59	0.35	1.72	1.00	1.00	0.42

Table 27: Employment Rate by Educational Attainment and Age, 2010

	Male						
	No Formal Qualification	Primary	Lower Secondary	Secondary	Upper Secondary	Polytechnic Diploma	Degree
15–19	5.3	0.9	21.2	24.1	18.8	13.0	0.0
20–24	26.5	21.6	63.3	65.4	51.9	55.1	43.7
25–29	46.7	62.7	91.1	81.2	69.5	85.8	76.1
30–34	58.6	92.7	92.0	88.1	81.4	93.3	92.4
35–49	86.5	84.6	93.1	87.1	84.7	96.8	96.0
40–44	86.3	89.4	90.4	93.3	94.9	93.5	94.6
45–49	84.8	89.4	84.2	89.1	99.0	91.9	95.4
50–54	80.8	81.2	84.0	88.2	93.7	91.0	92.1
55–59	73.8	79.2	87.3	86.9	92.4	89.7	90.5
60–64	56.1	66.1	70.6	69.2	70.0	67.9	77.5
65–69	46.8	46.7	60.4	52.2	47.3	57.5	70.8
70 & over	16.1	15.6	25.0	20.9	19.7	21.0	29.1

	Female						
	No Formal Qualification	Primary	Lower Secondary	Secondary	Upper Secondary	Polytechnic Diploma	Degree
15–19	4.3	0.3	8.9	15.4	12.1	12.8	0.0
20–24	22.6	24.2	27.4	48.7	47.8	51.9	59.1
25–29	42.4	27.4	48.4	74.3	57.0	74.2	77.5
30–34	47.6	50.2	62.5	74.2	58.3	84.7	79.3
35–49	47.9	54.6	61.1	71.3	62.3	84.2	79.9
40–44	58.3	59.4	54.3	74.7	64.8	79.7	78.6
45–49	56.9	54.7	57.7	71.9	68.1	77.4	77.6
50–54	52.1	48.6	54.7	66.1	72.0	84.0	77.3
55–59	41.8	42.6	50.7	59.1	65.3	81.5	70.5
60–64	29.0	28.0	38.7	46.3	47.8	49.0	50.3
65–69	20.7	20.5	24.4	31.3	33.0	34.4	28.5
70 & over	6.1	7.3	5.0	9.0	12.4	8.0	11.7

Note: Figures are the ratio of resident persons who have been employed, in percentages.

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