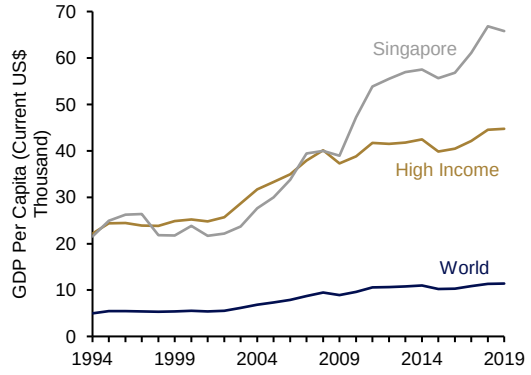
Special Feature B

The Role of the Labour Force in Singapore's Economic Growth

1 Introduction

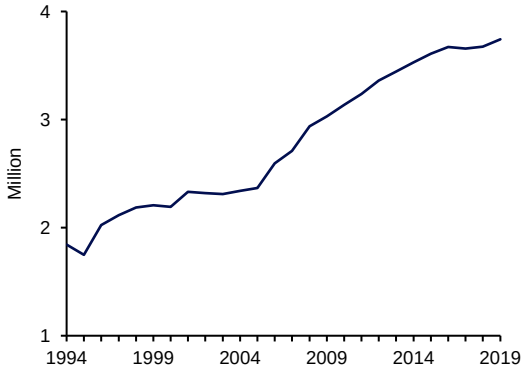
Real GDP in Singapore has been on a firm, sustained growth path over the past three decades, relative to other high-income economies. The level of GDP per capita exceeded the average in these economies (according to the World Bank's measure) in 1994, and the gap has widened considerably in the 2010s. From 1994 to 2019, GDP per capita rose by 205% in Singapore, compared to 102% on average for other high-income countries **(Chart 1a)**. Over the past three decades, the domestic workforce has also expanded considerably, growing by 104% over the 1994–2019 period **(Chart 1b)**. The rise in the quantity of workers has been accompanied by a steady increase in quality, as measured by educational attainment. The proportion of Singapore residents aged 25 and above with a university degree rose from 7.2% to 32.3% during that period.

Chart 1a Economic Growth



Source: World Bank

Chart 1b Labour Force Growth



Source: DOS

From the perspective of growth theories in economics, labour force expansion and human capital accumulation are important supply-side drivers of long-term economic growth (see for example Barro and Lee, 1993 and Jones, 1996). To better understand the empirical importance of these channels in Singapore's context, this Special Feature applies econometric techniques to estimate the contributions of the labour force to trend GDP growth in Singapore since the mid-1990s. The growth contribution of the overall labour force is decomposed into labour force expansion and human capital components, with the former further broken down into contributions from high- and low-skilled workers, and from residents and non-residents.

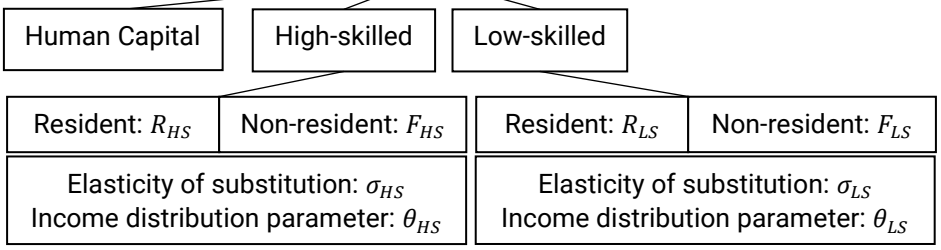
2 Model

The contribution of labour inputs to overall economic growth can be represented using a standard Cobb-Douglas aggregate production function, where capital and effective labour (i.e., adjusted for quality) are factor inputs:

$$Y = AK^{\alpha}L^{(1-\alpha)} \tag{1}$$

In Equation (1), Y is GDP growth, K is capital, L denotes the amount of effective labour inputs, and A represents Total Factor Productivity (TFP). Effective labour inputs can in turn be described by the following equation:[1]

$$L = HL_{HS}^{\phi}L_{LS}^{(1-\phi)} \tag{2}$$



Effective labour inputs L comprise human capital, denoted by H, as well as high- (HS) and low-skilled (LS) labour, which can be supplied by both resident and non-resident workers. There is by now a wealth of international empirical evidence showing that human capital, in the form of education, training and other forms of learning, lifts the wages and productivity of individual workers. Given the considerable increase in average educational attainment among the resident population, the economic returns from investments in human capital (measured by the human capital contribution to long-term growth) is likely to be significant.

R_s and F_s are resident and foreign labour input respectively, with the subscript s representing either high- or low-skilled workers. In Singapore's context, it is important to take into account the fact that resident and non-resident workers are not perfect substitutes, as the government's migrant worker policy aims to bring in non-resident workers who are complementary to the resident workforce. As such, the elasticity of substitution parameters (σ_s) between resident and non-resident workers are incorporated into the model for both high- and low-skilled labour. θ_s is a distribution parameter that relates to the share of resident income in overall labour income. Both parameters are important: if resident and non-resident workers are gross complements ($\sigma_s < 1$), a rise in foreign employment will have a smaller impact on growth than if the two types of workers are gross substitutes ($\sigma_s > 1$). Intuitively, if foreign and resident labour inputs are complements, a rise in foreign labour inputs without a corresponding rise in resident labour input will lead to a smaller increase in productive capacity than if the two inputs are substitutes. If the non-resident share of overall labour income is low (θ_s is high), non-residents will make smaller contributions to effective labour input and overall growth.

3 Estimation

Equation (2) implies that the growth of effective labour inputs can be estimated as the sum of the five components described by Equation (3) below. Lower-case characters are used

[1] The human capital component is equivalent to labour-augmenting productivity in the overall production function.

to denote variables in natural logarithms, and the dot operator $\dot{x}$ denotes the annual change in a variable x.

$$\dot{l}_t = \dot{h}_t + \phi\dot{r}_{HS,t} + \phi\dot{n}_{HS,t} + (1-\phi)\dot{r}_{LS,t} + (1-\phi)\dot{n}_{HS,t} \quad (3)$$

The five components are:

1. Human capital: $\dot{h}_t$
2. High-skilled resident labour: $\dot{r}_{HS,t}$
3. Effective high-skilled non-resident labour, defined as employment growth after controlling for imperfect substitution between resident and non-resident workers: $\dot{n}_{HS,t}$
4. Low-skilled resident labour: $\dot{r}_{LS,t}$
5. Effective low-skilled non-resident labour (defined analogously to high-skilled non-resident labour): $\dot{n}_{LS,t}$

Human capital, $\dot{h}_t$, is quantified using a modified measure of the UN Human Development Index (HDI), which is published annually for a large number of countries in the UN *Human Development Report*. The original HDI is a composite measure of three dimensions of human development, namely, access to and quality of education, life expectancy, and lifetime income. In this study, the quality of education and life expectancy indicators are used to measure human capital. Both higher educational attainment and better health outcomes in the workforce contribute to labour-specific productivity factors. As the lifetime income measure is largely based on GNI per capita, this component is excluded in this analysis to avoid double counting the contributions of GDP growth components.[2]

The resident labour supply components $\dot{r}_{HS,t}$ and $\dot{r}_{LS,t}$ are measured by growth in Professional, Manager, Executive, and Technician (PMET) occupations and non-PMET resident employment respectively. $\dot{n}_{HS,t}$ and $\dot{n}_{LS,t}$ are measured as employment growth of high- and low-skilled non-resident workers respectively, with an additional component to take into account the imperfect elasticity of substitution between the two types of workers. If migrant and resident workers are highly substitutable (σ_s is high), non-resident labour does not require complementary resident labour for production. As such, an accumulation of non-resident labour input will contribute a constant positive marginal product to overall growth. In contrast, if residents and non-residents are complementary (σ_s is low), both inputs are required for effective production. Consequently, continued accumulation of either labour input while the other remains constant leads to diminishing marginal returns.

Calibration of Key Parameters

The elasticity of substitution between resident and non-resident workers, σ_s, is estimated by a panel regression approach using administrative firm-level data for Singapore from 2010 to 2019. A regression of firm-level non-resident to resident employment ratios, conditional on

[2] An alternative measure used for this analysis is the Institute of Health Metrics and Evaluation's (IHME's) Human Capital Index (HCI). Both are standard indicator-based measures of human capital widely used by international organisations and the academic literature, partly because they facilitate cross-country comparisons. While other methods of measuring human capital are available, including monetary-based measures (as surveyed in Liu and Fraumeni, 2020), they are often not comparable across countries.

changes in the relative marginal costs of non-resident to resident workers due to a series of policy shifts, are used to identify σ_s. The elasticity of substitution between resident and non-resident workers is found to be less than one for both high- and low-skilled labour, implying that residents and non-residents are gross complements on average.[3]

Using the insight from Klump *et al.* (2011) that θ_s can be interpreted as an average of income share parameters across time, this parameter is calibrated to match the average share of resident workers' income in overall labour income for each skill type over the 1990–2019 period. Total compensation of employees is used as the denominator while average monthly earnings (including employer CPF contributions) and resident employment are used to compute compensation of resident employees in the numerator. Reflecting the higher resident employment share in PMET compared to non-PMET occupations, the resident share of high-skilled labour income (θ_{HS}) is higher than the resident share of low-skilled labour income (θ_{LS}).

Extracting Supply-side Trends

Multiple large cyclical shocks that occurred over the 1990–2021 period mean that cyclical variation will affect the decomposition of GDP growth using Equation (4). To extract the long-term trends in supply-side growth drivers, the method of Fernald *et al.* (2017) is used, where the growth rate of a variable is decomposed into a long-term trend μ_t^x, a cyclical component c_t^x, and an idiosyncratic component z_t^x, as shown below.

$$\dot{x}_t = \mu_t^x + c_t^x + z_t^x \tag{4}$$

The long-term trend component μ_t^x is interpreted as the supply-side trend and is identified using a two-step method. First, the cyclical component is estimated using a modified Okun's Law that includes optimally selected leads and lags and then subtracted from $\dot{x}_t$. Second, to obtain the trend component, a low-pass filter is used to remove the irregular component, which Stock and Watson (2020) find has substantial advantages over commonly used methods like the Hodrick-Prescott (HP) filter. Notably, it is less subject to problems of over-smoothing, while the decomposition has an economically meaningful interpretation.

This filtering procedure is also applied to all variables in Equation (3). One crucial property of the filter is that it preserves additivity of the trend components among summands. As such, Equation (3) continues to hold even after applying the filtering procedure to each component. However, one disadvantage is that it leads to some truncation on both ends of the time series data, thus shortening the estimates of supply-side growth components to the period from 1995 to 2019.[4]

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[3] These panel regressions using microeconomic data are cross-validated from a time-series method that matches macroeconomic moments on factor income shares, which produced qualitatively similar estimates.

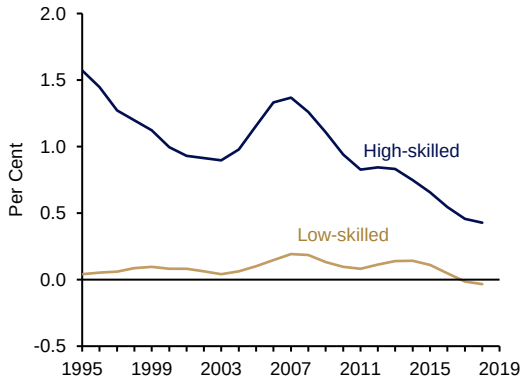
[4] The first step to remove cyclical components truncated one year on each end of the time series, as the optimally selected model includes one year's lead and one lag of the economic slack variable. The bandpass filter applied in the second step of the filtering procedure is two-sided and further shortens the series by two years on each end.

4 Results

Growth in Labour Force Inputs

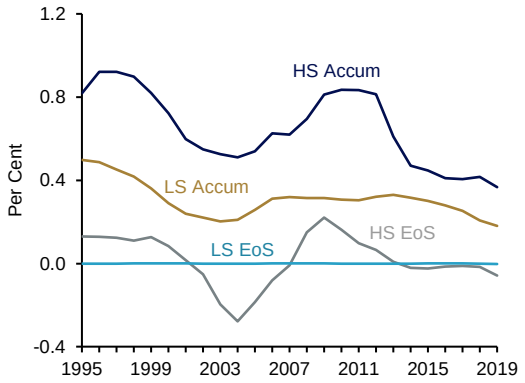
Long-term trends for each of the five components on the right-hand side of Equation (3) are estimated over the 1995–2019 period and shown in **Charts 2a, 2b, and 2c**. Slowing growth in the overall resident population over the past three decades has led to a decline in both high- and low-skilled resident workforce growth over time, while the ageing of the resident population exerted a more significant drag on growth after 2010. The decline in overall resident labour force growth was also partly due to a significant moderation in annual net migration starting from around 2011.

Chart 2a Resident Labour Growth



Source: EPG, MAS estimates

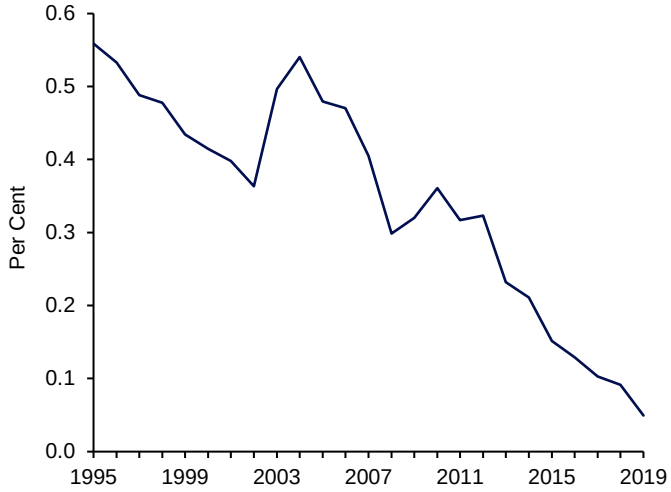
Chart 2b Non-resident Labour Growth



Source: EPG, MAS estimates

Notes: "HS" and "LS" represent the growth of high- and low-skilled labour respectively. "Accum" denotes labour accumulation, while "EoS" stands for the elasticity of substitution component.

Chart 2c Human Capital Growth



Source: UNDP and EPG, MAS estimates

Growth in high-skilled resident labour has consistently exceeded that of low-skilled resident labour, reflecting the rise in the PMET share of the resident workforce. However, the gap between growth in high- and low-skilled resident workforces has narrowed somewhat across the period, reflecting slowing growth in further educational attainment as the population approaches the advanced economy education frontier and as the PMET share of employment stabilises.[5] Nevertheless, while the low-skilled resident workforce has started to decline from around 2017, the high-skilled resident workforce has continued to expand.

Meanwhile, the accumulation of non-resident labour input (indicated by the blue and gold lines for high- and low-skilled non-resident labour respectively) declined from 1995 to 2004, especially for the former workers. The more accommodative foreign labour policy from 2005 to 2010 then led to a temporary boost in non-resident labour growth before policy tightening from 2011 onwards, which led to a renewed decline. Relative to pure employment accumulation components, the contribution of the elasticity of substitution components to effective non-resident labour input (grey and teal lines) has been small in magnitude throughout the time, indicating that it has been broadly in balance with the resident workforce. Given that resident and non-resident inputs are largely complementary, slowing resident labour force growth over the period 2011–19 meant that tighter foreign worker policies resulting in moderation in non-resident workforce expansion itself did not pose an additional drag to overall growth.

Human capital has grown positively throughout the period, reflecting steady improvements in education and health outcomes for the resident population. However, the rate of growth has declined steadily, reflecting Singapore's convergence to advanced economy standards in education and health. Nevertheless, it should be noted that the HDI measure used in this study is likely to have underestimated human capital growth. The reason is that it does not take into account training or skills development of workers already in the labour force, which has become an increasingly important source of human capital gains for a highly educated population.[6]

Contributions to Trend Growth

Next, the contributions of all labour force components are summed to obtain the overall contribution of labour, or effective labour inputs, to trend GDP growth. The components comprise human capital growth, as well as resident and non-resident employment growth among both high- and low-skilled workers (as shown in Equation 3). The contribution of effective labour inputs accounts for both the rising quantity and quality of the Singapore workforce. Trend GDP growth is then estimated, using the same method as was used for the five components of effective labour growth and following Fernald *et al.* (2018).

Overall, the growth in effective labour inputs contributed 2.5% points p.a. to GDP growth over the period 1995–2003, with the contribution remaining relatively steady over 2004–2010, before declining to 1.2% points p.a. over 2011–19 **(Table 1)**. For each of the first two sub-periods, effective labour input growth was responsible for just under one-half of overall GDP growth, and about one-third in the final sub-period. The decline in effective labour input growth over the period 2011–2019 was mainly attributable to slowing growth of the high-skilled resident labour force, as well as declining growth of the non-resident workforce. The

[5] This observation is in line with Nomura and Amano (2012), who find that the growth of labour quality in Singapore has declined moderately since the mid-2000s.

[6] Further, the current framework does not take into account that when labour supply is constrained, firms are likely to increase labour-augmenting technological investments. Acemoglu (2003) shows that this is likely to be an important driver of long-term human capital growth.

former saw their contribution fall from a rate of 1.1–1.2% points p.a. in the first two sub-periods to 0.6% point over the 2011–2019 period, while the latter's (comprising both high- and low-skilled non-residents) contribution fell from 0.8–0.9% point to 0.3% point p.a.

Table 1 Contribution of Effective Labour Input to (Trend) Real GDP Growth (% point p.a.)

		1995–2003	2004–2010	2011–2019
Resident Labour	High-skilled	1.1	1.2	0.6
	Low-skilled	0.1	0.1	0.1
Non-resident Labour	High-skilled	0.4	0.3	0.2
	Low-skilled	0.5	0.5	0.1
Human Capital		0.5	0.4	0.2
Effective Labour Input Contribution		**2.5**	**2.5**	**1.2**
Trend GDP Growth		**5.1**	**5.2**	**3.5**

Note: 1995–2003 marks a period characterised by the declining expansion of high-skilled labour input, 2004–2010 represents a period of accelerating high-skilled labour expansion, and 2011–19 saw a renewed decline in high-skilled labour expansion **(Charts 2a and 2b)**.

For the entire 1995–2019 period, human capital accumulation accounted for 7.3% or about one-thirteenth of trend GDP growth. Meanwhile, labour force expansion accounted for 36.7% or about one-third of trend GDP growth, of which about three-fifths is attributed to residents and two-fifths to non-residents.

5 Conclusion

Looking ahead, as resident labour supply growth slows amid population ageing, continued growth in effective labour inputs can be sustained by a combination of two sources—human capital improvements and the appropriate inflows of complementary non-resident labour inputs. Human capital improvements and total high-skilled labour accumulation have been significant growth drivers for Singapore over the past three decades and largely remained so in the decade preceding COVID-19 from 2011 to 2019. Apart from further increases in formal education in the resident workforce, human capital gains are likely to increasingly derive from on-the-job experience and workforce training, an aspect that has not been taken into account by the analysis of this Special Feature. Consequently, skills upgrading by mid-career workers will be important for increasing the quality of the resident workforce. As the age and education profile of the resident workforce evolves, areas of skills shortage will also shift. As such, workforce policies should continue its focus on developing the human capital of our local workers by upgrading their skills to prepare for jobs of the future. Foreign worker policies should also continue to ensure that the composition of the non-resident workforce remains broadly complementary.

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