FEATURE ARTICLE

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DRIVERS OF LABOUR PRODUCTIVITY GROWTH TRENDS IN SINGAPORE:
AN UPDATE USING VALUE-ADDED PER ACTUAL HOUR WORKED

INTRODUCTION

From 2009 to 2016, Singapore's overall labour productivity, as measured by real value-added per actual hour worked, grew at a compounded annual growth rate of 2.6%. Excluding the rebound from the Global Financial Crisis, productivity growth was 1.5% per annum from 2010 to 2016.

+2.6% p.a.
from
2009 to 2016

FINDINGS

SHIFT-SHARE ANALYSIS

Between 2009 and 2016, productivity improvements within most sectors supported overall productivity growth. Growth was stronger for outward-oriented sectors.

MANUFACTURING

WHOLESALE TRADE

FINANCE & INSURANCE

However, this was partly offset by a shift in hours worked and employment towards less productive domestically-oriented sectors such as Construction and Food Services. Similar patterns were observed for the 2010 to 2016 period.

CONSTRUCTION & FOOD SERVICES

GROWTH ACCOUNTING ANALYSIS

For both periods from 2009 to 2015 and 2010 to 2015, overall productivity growth was supported by improvements in capital intensity.
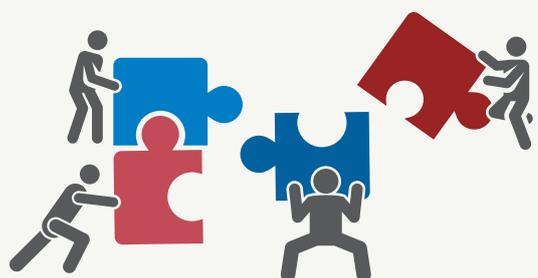
Labour quality improvements also contributed positively to overall productivity growth. This was due to a rise in hours worked by skilled workers which outpaced that of less-skilled workers. This was in turn driven by an increase in the number of skilled workers relative to less-skilled workers.

CONCLUSION

With the implementation of the Industry Transformation Maps, productivity growth in the various sectors is expected to improve in the coming years. It is also important that we push on with efforts to equip workers with the skills that would allow them to move into more productive sectors and enjoy higher wages.

EXECUTIVE SUMMARY

• This article examines the drivers of Singapore's labour productivity growth in recent years.

• <u>First</u>, a shift-share analysis indicates that a shift in hours worked towards less productive sectors, including the Construction and Food Services sectors, negatively contributed to Singapore's labour productivity growth from 2009 to 2016. However, this effect was outweighed by productivity improvements in most sectors, particularly the outward-oriented sectors.

• <u>Second</u>, using growth accounting analysis, we find that productivity growth from 2009 to 2015 was supported by improvements in both capital intensity and labour quality. Similar trends were observed for the period from 2010 to 2015.

The views expressed in this paper are solely those of the author and do not necessarily reflect those of the Ministry of Trade and Industry or the Government of Singapore.

INTRODUCTION

Between 2009 and 2016, Singapore's overall productivity, as measured on a real value-added (VA) per actual hour worked (AHW) basis, grew at a compounded annual growth rate (CAGR) of 2.6 per cent, although part of the gains can be attributed to the strong rebound in 2010 following the Global Financial Crisis (GFC). Excluding the post-GFC rebound, productivity growth was 1.5 per cent on a CAGR basis.[1]

This article examines the drivers of Singapore's labour productivity growth in recent years by decomposing productivity growth using two approaches. A shift-share analysis is first used to investigate the extent to which (i) productivity changes within sectors, (ii) shifts in hours worked across sectors with different productivity levels, and (iii) shifts in hours worked across sectors with different productivity growth rates contributed to Singapore's productivity growth. The second approach uses growth accounting analysis to determine the contributions of changes in capital intensity and labour quality to productivity growth.

Previous shift-share and growth accounting analyses had used real VA per worker as the measure of labour productivity (see for example, Goh & Fan, 2015). However, VA per AHW is recognised internationally to be a better measure of labour productivity as hours worked captures the intensity of labour input more accurately (see OECD, 2001). In Singapore's context, it has also become more relevant in recent years with the rising share of part-time workers in the economy, and cyclical changes in hours worked by full-time employees (see Goh & Lin, 2015).

This article updates the earlier analyses by using real VA per AHW as the measure of labour productivity, and by incorporating data from more recent years.

SHIFT-SHARE ANALYSIS OF LABOUR PRODUCTIVITY GROWTH: AN UPDATE

An earlier shift-share analysis (Goh & Fan, 2015) found that between 2009 and 2014, Singapore's labour productivity growth (measured on a VA per worker basis) was driven by productivity improvements in most sectors, especially the outward-oriented sectors. However, the gains were partially offset by a shift in employment towards less productive sectors, including the Construction and Food Services sectors.

This section updates the earlier analysis by using VA per AHW as the measure of labour productivity, and also extends the analysis to include more recent data. In particular, we examine labour productivity growth from 2009 to 2016.

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[1] *VA per worker grew by 2.1 per cent per annum between 2009 and 2016. Between 2010 and 2016, it grew by 0.6 per cent on a CAGR basis.*

Methodology

Using shift-share decomposition, overall labour productivity growth in the economy can be expressed as the sum of three effects:

- Within Effect: the contribution of productivity growth within sectors to overall productivity growth;

- Static Shift Effect: the contribution of changes in the AHW shares of sectors with *different productivity levels* to overall productivity growth; and

- Dynamic Shift Effect: the contribution of changes in the AHW shares of sectors with *different productivity growth rates* to overall productivity growth.

In equation form, this can be represented as:

$$\frac{P_t - P_{t-1}}{P_{t-1}} = \sum_{i=1}^{n}[(\frac{P_{it} - P_{it-1}}{P_{it-1}}) \times \frac{Y_{it-1}}{Y_{t-1}}] + \sum_{i=1}^{n}[(\frac{P_{it-1}}{P_{t-1}}) \times (\frac{H_{it}}{H_t} - \frac{H_{it-1}}{H_{t-1}})] + \sum_{i=1}^{n}[(\frac{P_{it} - P_{it-1}}{P_{t-1}}) \times (\frac{H_{it}}{H_t}) - (\frac{H_{it-1}}{H_{t-1}})]$$

Where P_t is the productivity level (VA per AHW) of the economy in period t;
$Y_t = \sum_{i=1}^{n} Y_{it}$ is the total VA of the economy in period t;
$H_t = \sum_{i=1}^{n} H_{it}$ is the total AHW of the economy in period t; and
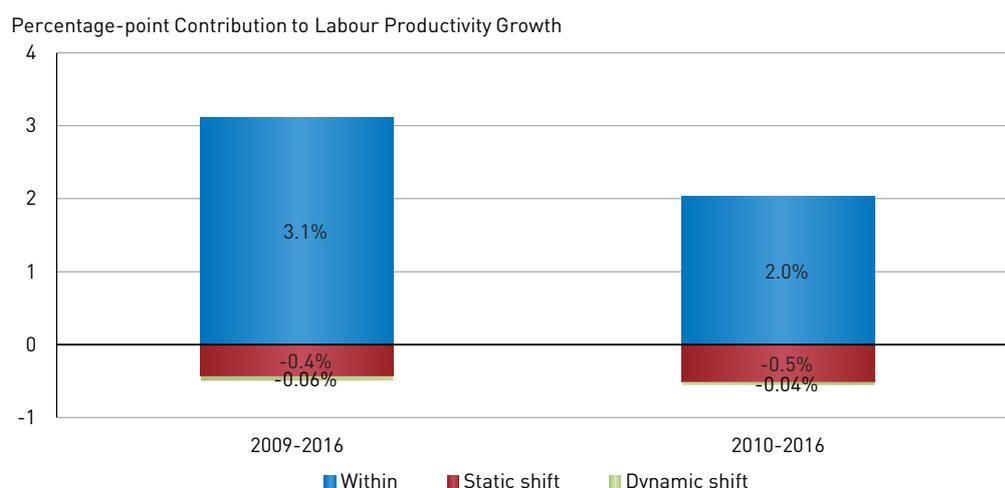$i = 1,..., n$ is the ith sector in the economy.

Decomposition of Overall Labour Productivity Growth

Singapore's labour productivity grew by 2.6 per cent per annum from 2009 to 2016. The shift-share analysis shows that higher productivity growth within sectors (i.e., positive Within Effect) supported overall productivity growth over this period (Exhibit 1). However, the effect was partially offset by an increase in the AHW shares of less productive sectors relative to the more productive sectors (i.e., negative Static Shift Effect). Details are provided below:

- Within Effect: The Within Effect dominated productivity growth dynamics. Productivity improvements in the different sectors contributed 3.1 percentage-points to overall productivity growth each year.

- Static Shift Effect: A rise in the AHW shares of less productive sectors dampened overall productivity growth by 0.4 percentage-points each year.

- Dynamic Shift Effect: This effect was negative, although the magnitude was very small (-0.06 percentage-points per year).

Excluding the GFC rebound, overall productivity grew by 1.5 per cent per annum from 2010 to 2016. A similar decomposition exercise for this period resulted in a smaller, though still positive, Within Effect (+2.0 percentage-points each year). A negative Static Shift Effect also remained, weighing down productivity growth by 0.5 percentage-points each year. In terms of the Dynamic Shift Effect, the effect remained negligible (-0.04 percentage-points per year).

Exhibit 1: Decomposition of Labour Productivity Growth (2009 – 2016, 2010 – 2016)

Percentage-point Contribution to Labour Productivity Growth

	2009-2016	2010-2016
Within	3.1%	2.0%
Static shift	-0.4%	-0.5%
Dynamic shift	-0.06%	-0.04%

■ Within ■ Static shift ■ Dynamic shift
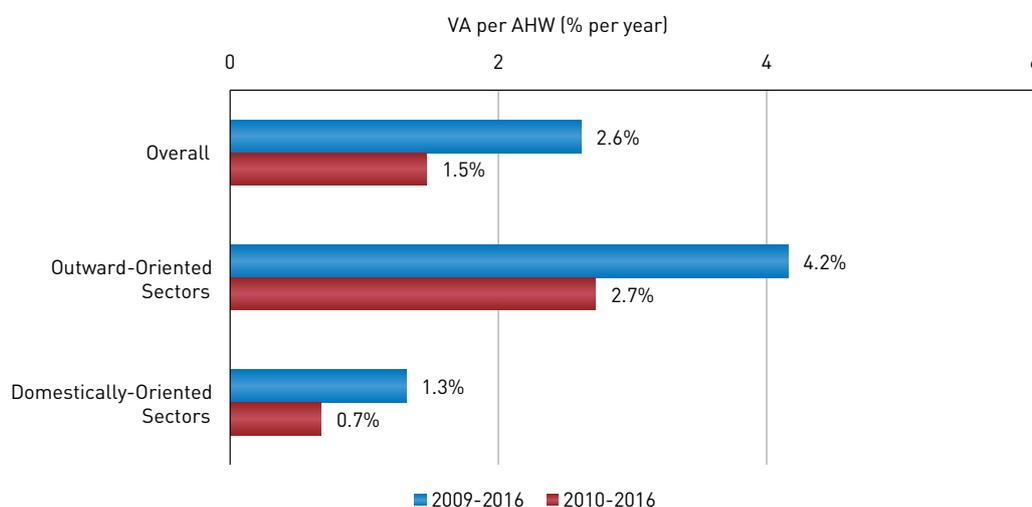
Source: MTI Staff Estimates
Note: The Within, Static Shift, and Dynamic Shift Effects may not sum to the overall productivity growth due to rounding.

Contribution from Within Effect

The Within Effect was the strongest driver of labour productivity growth from 2009 to 2016. Our main observations are as follows:

- The positive Within Effect over this period was driven mainly by the Manufacturing, Wholesale Trade, and Finance & Insurance sectors. The remaining sectors' contributions to the Within Effect were generally small (lower than 0.2 percentage-points each year) and positive. A similar pattern emerged when the analysis was restricted to the period from 2010 to 2016.

- The performance of domestically- and outward-oriented sectors diverged significantly between 2009 and 2016, with the productivity growth of domestically-oriented sectors (1.3 per cent per year) trailing that of outward-oriented sectors (4.2 per cent per year) (Exhibit 2).[2] Notably, the main sectors driving the positive Within Effect (i.e., the Manufacturing, Wholesale Trade, and Finance & Insurance sectors) were all outward-oriented. The trends remained the same for the 2010 to 2016 period. There are various possible reasons why outward-oriented sectors tend to have better productivity performance. For example, to stay competitive in the global market, exporting firms have to constantly improve their products and processes, and be more productive.

Exhibit 2: Broad Sectoral Productivity Growth (2009 – 2016, 2010 – 2016)

VA per AHW (% per year)

	2009-2016	2010-2016
Overall	2.6%	1.5%
Outward-Oriented Sectors	4.2%	2.7%
Domestically-Oriented Sectors	1.3%	0.7%

■ 2009-2016 ■ 2010-2016

Source: MTI Staff Estimates

[2] *The classification of a sector as outward- or domestically-oriented is determined by its direct and indirect export share of total output as estimated using the latest Input-Output tables and tourism receipts. Domestically-oriented sectors refer to Construction, Retail Trade, Food Services, Other Business Services, and Other Services Industries. Outward-oriented sectors refer to Manufacturing, Wholesale Trade, Transportation & Storage, Accommodation, Information & Communications, Finance & Insurance, and Professional Services.*
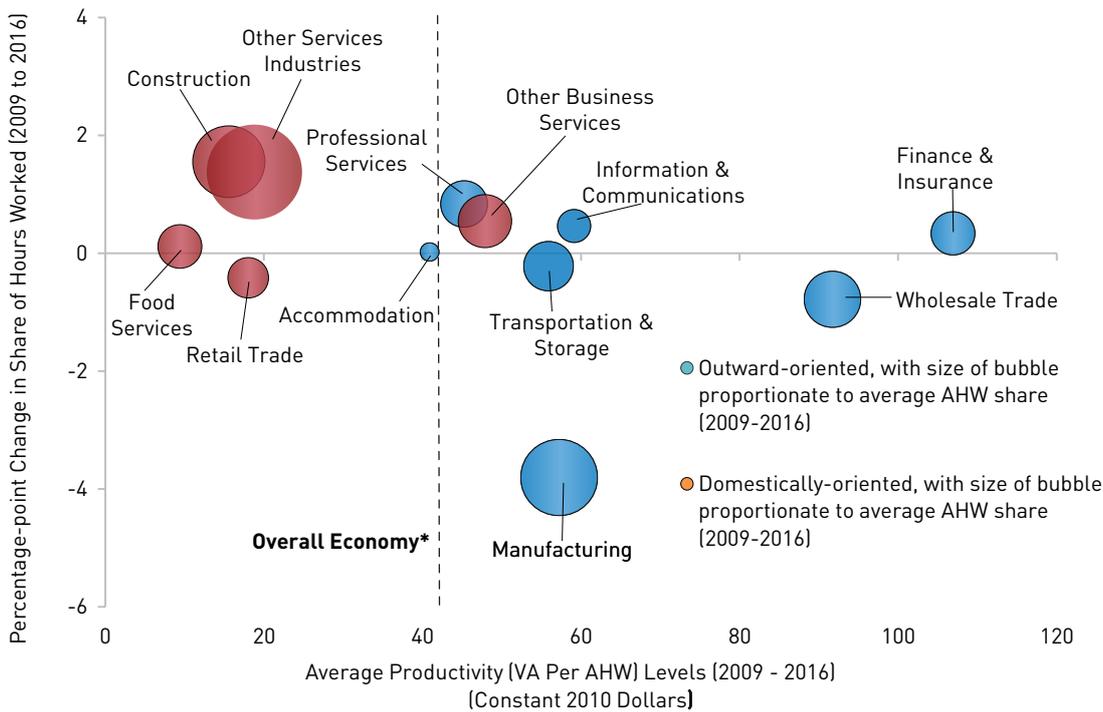
Contribution from Static Shift Effect

From 2009 to 2016, there was a general increase in the AHW shares of less productive, domestically-oriented sectors relative to that of more productive, outward-oriented sectors, thus dampening overall productivity growth (Exhibit 3). The changes in the AHW shares were largely driven by changes in employment shares.

The key observations are as follows:

- Some outward-oriented sectors that were more productive than the overall economy like Manufacturing, Wholesale Trade, and Transportation & Storage saw a decline in their AHW shares. This was driven by a decline in their employment shares.[3] On the other hand, the AHW shares of other outward-oriented sectors – Professional Services, Information & Communications, and Finance & Insurance sectors – increased on the back of a rise in their respective employment shares.

- However, domestically-oriented sectors such as Construction, Food Services and Other Services Industries that were less productive than the overall economy also saw an increase in their AHW shares. The rise in AHW shares was largely due to an increase in employment shares for these sectors. For example, to cater to higher demand, the education, health & social services sector (classified under Other Services Industries) saw an expansion of its manpower needs. For the Construction sector, on the other hand, its employment and AHW shares both peaked in 2014 due to a ramp-up in building and infrastructural works (e.g., public housing and new Mass Rapid Transit (MRT) lines). Since then, both shares have declined.

- On balance, the decline in the AHW shares of more productive outward-oriented sectors like Manufacturing and Wholesale Trade, coupled with the increase in the AHW shares of less productive domestically-oriented sectors, outweighed the positive effect of the increase in the AHW shares of sectors like Information & Communications and Finance & Insurance. This led to an overall negative Static Shift Effect. Similar patterns were also observed for the 2010 to 2016 period.

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[3] *While employment in the Transportation & Storage and Wholesale Trade sectors increased over this period, their gains were insufficient to offset the employment growth in other sectors (especially the less productive sectors), thus resulting in a drop in their employment share.*

Exhibit 3: Change in AHW Share vs Average Productivity Levels by Sector (2009 – 2016)

Source: MTI Staff Estimates
*This excludes ownership of residential dwellings and taxes on products.

Summary

Singapore's overall labour productivity growth between 2009 and 2016 was supported by productivity growth in most sectors. The strongest drivers of overall productivity growth were the outward-oriented sectors, while the productivity growth of domestically-oriented sectors was weak. At the same time, overall productivity growth was dampened by a shift in hours worked towards less productive domestically-oriented sectors such as Construction and Food Services.

The findings point to two broad policy implications. First, to improve overall productivity, we have to press on with efforts to uplift sectoral productivity, especially for domestically-oriented sectors. Second, the Government should persist with economic restructuring efforts to shift our economy towards more productive sectors. This would entail supporting workers in learning skills that would allow them to move into such sectors. In this regard, the Government's efforts under key initiatives such as the Industry Transformation Maps (ITMs) will be valuable in boosting future productivity growth.

GROWTH ACCOUNTING ANALYSIS OF LABOUR PRODUCTIVITY GROWTH: AN UPDATE

Overall labour productivity growth can be driven by improvements in capital intensity, labour quality and total factor productivity (TFP). Capital intensity refers to the amount of machinery, equipment, intellectual property and infrastructure each unit of labour input uses for production. An increase in capital intensity thus enables workers to be more productive. In addition, a more highly skilled workforce also raises labour productivity. As for TFP, it may broadly be interpreted as a measure of how efficient technologies and processes are in combining capital and labour for production, although in practice, it is often computed as a residual.

In its drive to improve productivity, the Government has made concerted efforts to raise both capital intensity and labour quality in Singapore. Schemes that encourage firms to adopt technology and/or innovate include the Technology Adoption Programme, Capability Development Grant and more recently, the Automation Support Package. On labour quality, substantial investments have been made to encourage and enhance learning at various stages in life, for example, through the SkillsFuture initiative.

The earlier study by Goh and Fan (2015) had found that improvements in both capital intensity and labour quality supported overall labour productivity growth (measured by VA per worker growth) between 2009 and 2013. In this section, we incorporate more recent data to examine how changes in capital intensity and labour quality have contributed to labour productivity growth, as measured by VA per AHW growth, in Singapore.

Methodology

Using a growth accounting framework, we decompose VA per AHW into contributions from capital intensity, labour quality, and TFP for the period between 2009 and 2015.[4] (TFP is computed as a residual in this framework.)

We use a Cobb-Douglas production function and assume that inputs are paid their marginal products under competitive markets[5]:

$$Y = A \cdot \prod_i H_i^{b_i} \cdot \prod_j K_j^{c_j}$$

Where Y = real output;
A = Total Factor Productivity (TFP);
H_i = AHW of ith type of labour;
b_i = share of output of the ith type of labour;
K_j = net stock of jth type of capital;
c_j = share of output of jth type of capital; and
$\sum_i b_i + \sum_j c_j = 1$ (i.e., constant returns to scale)

Given that $\Delta Y \approx \sum_i \Delta b_i \Delta H_i + \sum_j c_j \Delta K_j + \Delta A$, we can decompose productivity growth into contributions from changes in labour quality, capital intensity and TFP:

$$\Delta \frac{Y}{H} \approx S_L \cdot \sum_i (s_i - h_i) \Delta H_i + \sum_j c_j (\Delta \frac{K_j}{H}) + \Delta A$$

Where S_L = total wage share of output;
s_i = wage share of ith type of labour; and
h_i = AHW share of ith type of labour

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[4] The timeframe for the growth accounting analysis does not include 2016, as 2016 data for capital stock is not yet available.

[5] See Chinloy (1988).

Similar to the earlier study, we analyse the contributions from five types of capital — Machinery & Equipment (M&E), Computer Software, Research & Development (R&D), Transport Equipment, and non-residential Construction & Works.[6] Capital intensity contributes positively to productivity growth when capital growth outpaces hours worked growth, such that there is more capital for each man-hour.
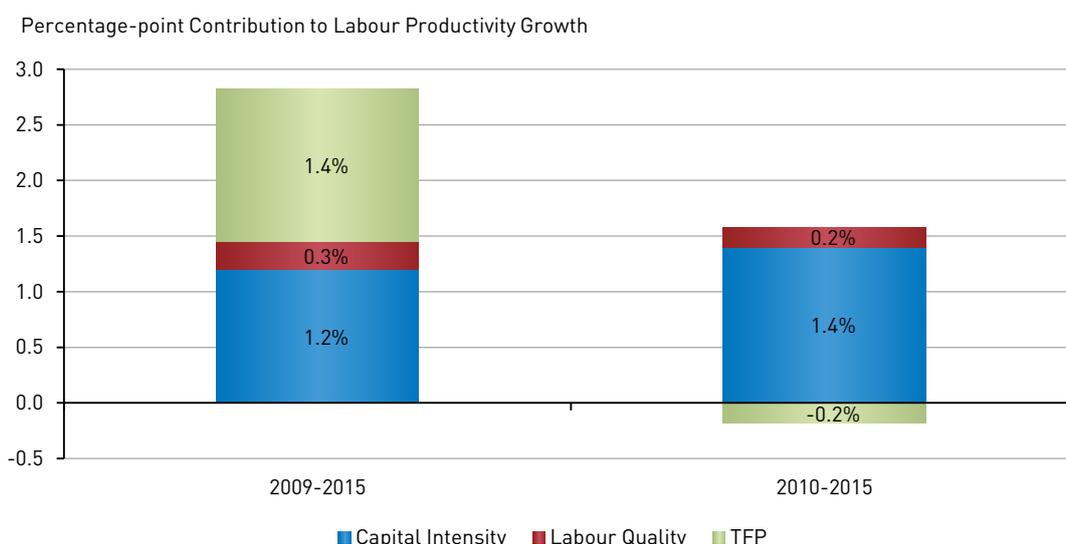
We examine labour quality by categorising labour into skilled and less-skilled labour. Labour quality is proxied by the term $(s_i\text{-}h_i)$, which is positive when the labour type i has higher wages than the other labour types. Hence, overall labour quality improves when the growth in total hours worked by skilled labour (whose wages exceed the economy average) exceeds that of less-skilled labour (whose wages are lower than the economy average), thereby supporting productivity growth.

Decomposition of Overall Labour Productivity Growth

Over the periods of 2009 to 2015 and 2010 to 2015, productivity growth was driven by improvements in both capital intensity and labour quality. Our key observations are as follows (Exhibit 4):

- The contribution from capital intensity to productivity growth, at 1.2-1.4 percentage-points per annum, was the main driver of productivity growth in both periods.

- Improvements in labour quality also supported productivity growth, contributing 0.2-0.3 percentage-points per year to productivity growth in both periods.

- TFP weighed down productivity growth by 0.2 percentage-points per year for the period 2010 to 2015, a reversal from the positive contribution of 1.4 percentage-points seen from 2009 to 2015. However, it should be noted that as TFP was computed as the residual, it is highly sensitive to changes in VA. In this regard, the slowdown in economic growth in recent years would have contributed to a dampening of TFP growth in the later period.

Exhibit 4: Decomposition of Labour Productivity Growth (2009 – 2015, 2010 – 2015)

Percentage-point Contribution to Labour Productivity Growth

Source: MTI Staff Estimates
Note: The contributions from three components – capital intensity, labour quality and TFP – will not sum up to productivity growth for the overall economy as ownership of residential dwellings is excluded from the productivity computation.
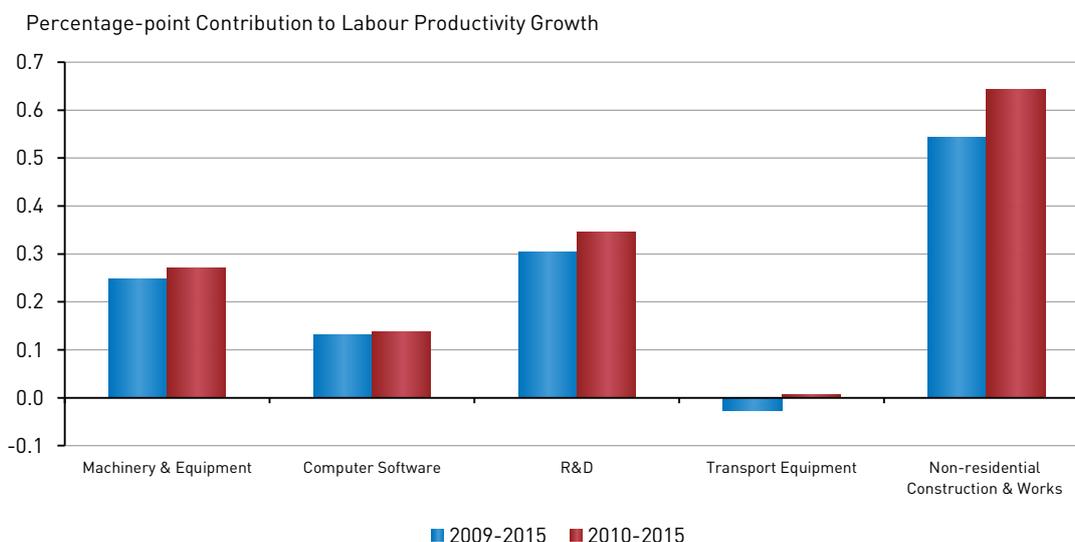
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[6] *We exclude residential buildings as they are not used in firm production. Correspondingly, we also exclude the imputed ownership of residential dwellings from the productivity computation.*

Contribution from Capital Intensity

Next, we examine the contribution of each capital type to productivity growth (Exhibit 5). Our key observations for the two time periods of 2009 to 2015 and 2010 to 2015 are as follows:

- Non-residential construction & works contributed 0.5-0.6 percentage-points per year to productivity improvements over the two periods, the highest across all capital types. The relatively large contribution of non-residential construction & works to productivity growth is consistent with the Government's continued investments in infrastructure, such as new MRT lines and major road improvement works.

- R&D capital stock contributed 0.3 percentage-points per year to productivity improvements over these periods. The relatively significant contribution of R&D capital intensity is in line with sustained R&D investments by the Government under its 5-year Research, Innovation and Enterprise plans.

- Contributions from M&E and Computer Software to productivity growth were 0.2-0.3 and 0.1 percentage-points per year respectively over both periods. Even though the net capital stock of M&E and Computer Software grew at a slower pace in recent years[7], the growth in hours worked also moderated, thereby leading to an increase in capital intensity for these two capital types.

- The contribution from Transport Equipment (including ships, boats, aircrafts and other transport equipment) to productivity improvements was negligible over both periods.

Exhibit 5: Contribution from Capital Intensity to Labour Productivity Growth (2009 – 2015, 2010 – 2015)
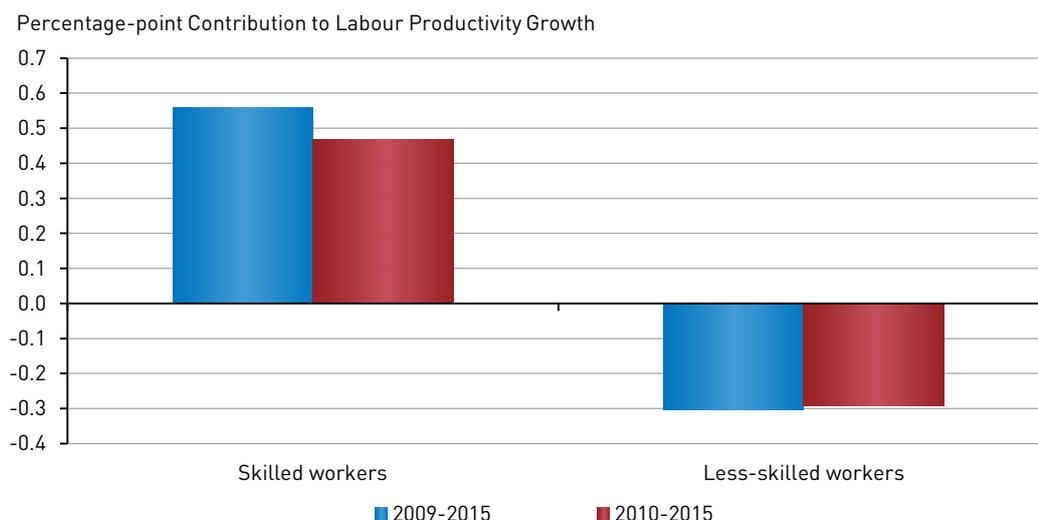
Percentage-point Contribution to Labour Productivity Growth

Source: MTI Staff Estimates

Contribution from Labour Quality

In both periods from 2009 to 2015 and 2010 to 2015, labour quality contributed 0.2-0.3 percentage-points per year to productivity growth. The positive contribution of labour quality was due to an increase in hours worked by skilled workers which outpaced that of less-skilled workers (Exhibit 6). This was in turn driven by a rise in the number of skilled workers relative to less-skilled workers.

[7] *An earlier study (MTI, 2016) found that the uncertain global economic environment was the main driver of a decline in private M&E investments in recent years.*

Percentage-point Contribution to Labour Productivity Growth

Source: MTI Staff Estimates

Summary

Using growth accounting analysis, we find that overall labour productivity growth was driven by improvements in both capital intensity and labour quality between 2009 and 2015. Similar trends are observed for the period from 2010 to 2015. Much of the capital intensity contributions came from non-residential construction & works, as well as R&D. On the other hand, labour quality improvements arose due to an increase in hours worked by skilled workers which outpaced that of less-skilled workers, on the back of a rise in the number of skilled workers relative to less-skilled workers.

CONCLUSION

Based on shift-share analysis, we find that Singapore's overall productivity growth was largely supported by productivity growth of more productive outward-oriented sectors. The weak productivity performance of domestically-oriented sectors, along with a shift in hours worked towards these sectors, has weighed on overall productivity growth. Using a growth accounting approach, we find that overall productivity growth has been supported by improvements in capital intensity and labour quality.

With the implementation of the ITMs, productivity growth in domestically-oriented sectors is expected to improve in the coming years. It is also important that we push on with efforts to equip workers with the skills that will allow them to move into more productive sectors and enjoy higher wages. On its part, the Government will continue to support investments in capital via schemes such as the Automation Support Package, and skills improvements via SkillsFuture initiatives.

REFERENCES

Chinloy, P. (1988). The Effect of Shifts in the Composition of Employment on Labour Productivity Growth: Canada 1971-1979. In A. Dogramaci and R. Färe (Eds.), *Applications of Modern Production Theory: Efficiency and Productivity* (pp. 195-220). Boston, MA: Kluwer Academic Publishers.

MTI (Ministry of Trade and Industry, Singapore) (2016). Recent Trends in Singapore's Real Gross Fixed Capital Formation. *Economic Survey of Singapore First Quarter 2016*, 18-26.

Goh, T. W., & Fan, S. L. (2015). Drivers of Labour Productivity Growth Trends in Singapore. *Economic Survey of Singapore 2014*, 76-87.

Goh, K., & Lin, T. (2015). Trends in Actual Hours Worked and Implications for Labour Productivity. *Economic Survey of Singapore Second Quarter 2015*, 16-23.

OECD (2001). *Measuring Productivity: Measurement of Aggregate and Industry-level Productivity Growth, OECD Manual*. Paris: OECD.

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