THE CONTRIBUTION OF INTANGIBLE ASSETS TO LABOUR PRODUCTIVITY GROWTH IN SINGAPORE, 2009-2019

In Singapore, the share of intangible assets in the economy has risen steadily over time, reflecting an increase in investments in research and development (R&D) and computer software.

Against this backdrop, this article adopts a growth accounting approach at the aggregate and sectoral levels to examine the contribution of capital deepening in intangible assets to labour productivity growth between 2009 and 2019.

INTANGIBLE ASSETS

- **Knowledge Capital**
  - **Innovative Propery**
    - R&D
    - Innovation
    - Intellectual Property
  - **Computer Software & Databases**
    - Software
    - Data
    - Licences
- **Other Intangible Inputs**
  - Branding
  - Organisation Capital
  - Human Capital

OVERALL ECONOMY

Capital deepening in intangible assets (i.e., R&D and computer software) was a major contributor to labour productivity growth from 2009 to 2019, accounting for 1.0 percentage-point (pp) per annum (p.a.) of the 3.0 per cent p.a. growth in labour productivity over this period.

Compared to other advanced economies, capital deepening in intangible assets was a more dominant driver of labour productivity growth in Singapore between 2009 and 2017.

R&D: +0.7pp Computer Software: +0.3pp

SECTORAL

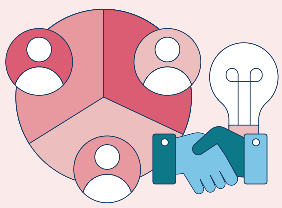
Intangible capital deepening was a strong contributor to productivity growth in the outward-oriented Wholesale Trade, Manufacturing and Finance & Insurance sectors, as well as the domestically-oriented Administrative & Support Services sector, although the relative contributions of R&D and computer software investments differed in these sectors.

Sector	Orientation	R&D	Computer Software
Wholesale Trade	Outward-Oriented	+1.8pp	+1.1pp
Manufacturing	Outward-Oriented	+1.9pp	
Finance & Insurance	Outward-Oriented		+1.6pp
Administrative & Support Services (including firms that lease non-financial intangible assets)	Domestically-Oriented	+3.0pp	

CONCLUSION

The increasing importance of intangible capital is reflected in its contribution to labour productivity growth in Singapore. With accelerating technological advancements, investments in intangible assets can help firms to overcome their physical constraints and tap on the global marketplace.

Under the Singapore IP Strategy (SIPS) 2030, the Singapore Government will continue to support firms in the adoption of intangible assets (including IP) for growth, and complement these efforts by raising the relevant capabilities of our workforce.



EXECUTIVE SUMMARY

- Intangible assets are assets that do not have a physical or financial embodiment, including knowledge capital (e.g., computer software, research and development [R&D], intellectual property [IP]) and other intangible inputs (e.g., branding, content creation, buyer-seller trust, lender-borrower relationships, organisational effectiveness, managerial practices). In Singapore, the share of intangible assets in the economy has risen steadily over time, broadly reflecting an increase in investments in R&D and computer software.

- This article adopts a growth accounting approach at the aggregate and sectoral levels to examine the contribution of capital deepening in intangible assets (i.e., increase in amount of intangible capital per hour worked) to labour productivity growth between 2009 and 2019.

- At the aggregate level, capital deepening in intangible assets was found to be a major contributor to labour productivity growth from 2009 to 2019, accounting for 1.0 percentage-point (pp) per annum (p.a.) of the 3.0 per cent p.a. growth in labour productivity over this period. In turn, the capital deepening in intangible assets was supported by investments in R&D (0.7pp p.a.) and computer software (0.3pp p.a.). Compared to other advanced economies, capital deepening in intangible assets was a more dominant driver of labour productivity growth in Singapore between 2009 and 2017.

- At the sectoral level, intangible capital deepening was found to be a strong contributor to productivity growth in the outward-oriented Wholesale Trade, Manufacturing and Finance & Insurance sectors, as well as the domestically-oriented Administrative & Support Services sector, although the relative contributions of R&D and computer software investments differed in these sectors.

- With accelerating technological advancements, investments in intangible assets can help firms to overcome their physical constraints and tap on the global marketplace. Under the Singapore IP Strategy (SIPS) 2030, the Singapore Government will continue to support firms in the adoption of intangible assets (including IP) for growth, and complement these efforts by raising the relevant capabilities of our workforce.

*The views expressed in this paper are solely those of the authors and do not necessarily reflect those of the Ministry of Trade and Industry (MTI), Agency for Science, Technology and Research (A*STAR), Building and Construction Authority (BCA), Department of Statistics (DOS), Economic Development Board (EDB) or Intellectual Property Office of Singapore (IPOS).*[1]

INTRODUCTION

Intangible assets, including intellectual property (IP), are becoming increasingly important drivers of economic growth and enterprise development in the global economy. Between 1996 and 2021, the value of intangible assets globally rose by 11 per cent per annum (p.a.), to reach an all-time high of US$74 trillion, surpassing the value of physical assets (Brand Finance, 2021).

As Singapore develops into a knowledge-based and innovation-led economy, intangible assets offer an additional source of growth that can enable the Singapore economy to transcend its physical and labour constraints. At the same time, the COVID-19 pandemic has disrupted business models and strengthened the impetus for firms to undertake digital transformation as well as leverage intangible assets to create value.

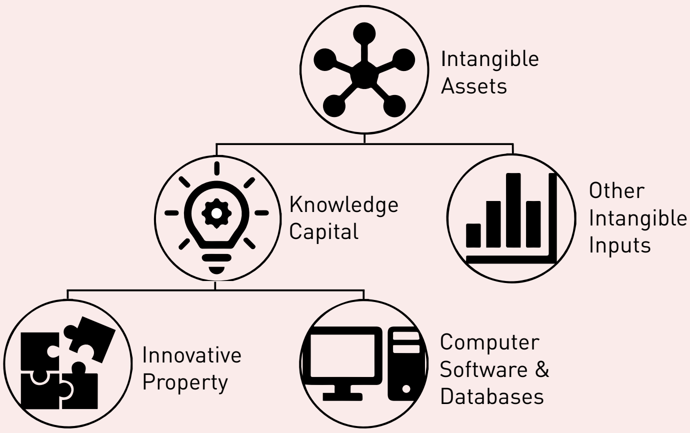
Given the growing importance of intangible assets in driving economic and business value, it is pertinent to have a better understanding of their contribution to Singapore's economy. In this regard, this study adopts a growth accounting approach at the aggregate and sectoral levels to examine the contribution of capital deepening in intangible assets (i.e., increase in amount of intangible capital per hour worked) on labour productivity growth between 2009 and 2019. In so doing, the study identifies the sources of labour productivity growth and offers insights on the growth processes within each sector over this period.

1 We would like to thank A*STAR, BCA, DOS, EDB and IPOS for their inputs to this study. We would also like to thank Ms Yong Yik Wei, Dr Kuan Ming Leong and Mr Lee Zen Wea for their useful suggestions and comments. All errors belong to the authors.

OVERVIEW OF INTANGIBLE ASSETS

Intangible assets include knowledge capital (e.g., computer software, research and development [R&D], IP) and other intangible inputs (e.g., branding, content creation, buyer-seller trust, lender-borrower relationships, organisational effectiveness, managerial practices). Without a physical or financial embodiment, these assets are traditionally treated as intermediate expenses. However, various authors (e.g., Corrado et al., 2009; Haskel & Westlake, 2017) have argued that intangible inputs should be considered as capital (rather than intermediate expenses) given that they are not used up during the production process.

Specifically, Corrado et al. (2009) classified intangible assets into two broad categories – (i) knowledge capital (including innovative property and computer software & databases), and (ii) other intangible inputs.



An elaboration of the various types of intangible assets is as follows:

- Innovative property includes scientific R&D (i.e., based on scientific knowledge) and non-scientific R&D (including product and process innovation, IP [e.g., trademarks and copyrights] and entertainment & literary or artistic originals).

- Computer software & databases broadly refer to investments in informational inputs into computers that are used to produce output, and include computer software development, licences of computer software, as well as investments in and purchases of data.

- Other intangible inputs include branding (e.g., investment in brand equity through advertisements), organisational capital (e.g., managerial effectiveness, efficiency of work processes), and firm-specific human capital (e.g., costs of employer-provided training).

Intangible assets also have four unique economic properties that distinguish them from traditional physical capital – (i) scalability, (ii) sunkenness, (iii) spillovers, and (iv) synergies (see Haskel & Westlake, 2017). These are described below:

- Scalability: Intangible assets are non-rivalrous and can be utilised repeatedly. For example, in the aviation industry, intangible assets such as R&D and design blueprints can be used for multiple airplanes once they are developed. Intangibles-intensive businesses can thus scale up quickly by leveraging the non-rivalrous nature of their IP and brand equity.

- Sunkenness: Intangible assets tend to be firm-specific and difficult to recover. For example, if a firm invests in R&D but fails to make a scientific breakthrough, the firm is unlikely to be able to recoup its R&D investments.[2] This is in part because intangible assets are hard to value due to the absence of complete markets.

- Spillovers: Intangible inputs tend to be non-excludable and generate spillovers. Ideas can be reverse-engineered even with IP rights (e.g., a smartphone maker's patented technology, design and software can be adapted by other smartphone makers). This contrasts with physical assets, which are generally excludable (e.g., factories can restrict access to capital equipment).

- Synergies: Investments in intangibles may generate synergies and complementarities with existing products and ideas. For example, Apple's iPod was the product of several physical and intangible assets, including software (e.g., Advanced Audio Coding standard to store music), entertainment and artistic originals (e.g., licencing agreements with record companies), and branding and design (e.g., the iPod's unique click-wheel).

Given the value of intangible assets to businesses and the economy, there are ongoing efforts to better capture and measure intangible assets in official statistics and through other sources of data. For example, in the United States, to complement data on computer software capital stock in its National Accounts, Corrado et al. (2005) used survey data to estimate the capital stock of R&D, entertainment and artistic originals, brand equity, firm-specific human capital and organisational capital.[3] In Singapore, the Department of Statistics (DOS) has included computer software and R&D capital stock in the National Accounts statistics since 2006 and 2014 respectively.

INTANGIBLE ASSETS IN SINGAPORE AND OTHER ADVANCED ECONOMIES

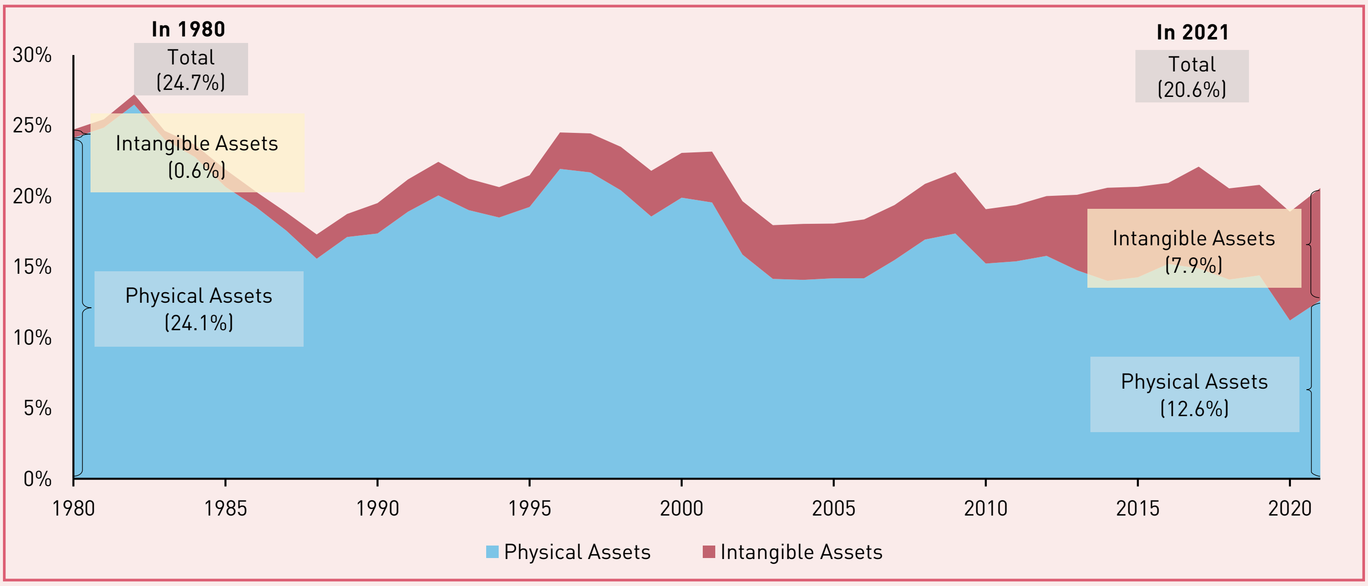
This section presents the trends in the accumulation of intangible assets in Singapore compared to other advanced economies, drawing on three sets of data. For Singapore, these are data on gross fixed capital formation (GFCF) from 1980 to 2021 and data on net capital stock from 2009 to 2019 (latest available for granular types of capital stock), both from DOS. GFCF and net capital stock data for other selected economies are obtained from the World KLEMS database, and cover the period of 2009 to 2017 (latest available).

GFCF DATA

Reflecting the growing importance of intangible assets in Singapore, the share of intangible assets (defined as R&D and computer software) in Singapore's economy has increased over time, with these intangible assets accounting for 7.9 per cent of its gross domestic product (GDP) and 38.6 per cent of its GFCF in 2021 (Exhibit 1). Between 2009 and 2021, growth in GFCF of intangible assets (9.7 per cent p.a.) exceeded the growth in GFCF of physical assets (1.6 per cent p.a.). This was also seen over the shorter time period of 2009 and 2017, with the trends comparing favourably with that observed in other advanced economies such as the United States, Germany and Denmark (Exhibit 2).

2 *By contrast, physical capital used in the process can be liquidated at market value.*
3 *See Goodridge et al. (2016) for a similar approach undertaken in the United Kingdom.*

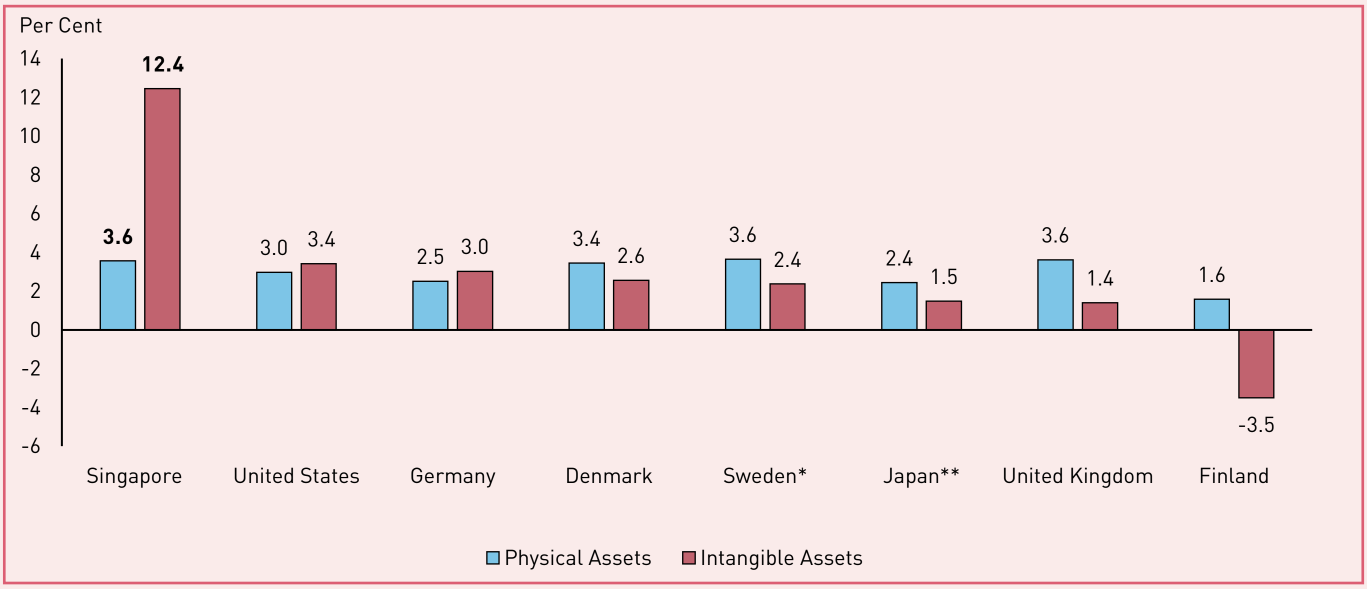
Exhibit 1: Gross Fixed Capital Formation in Physical and Intangible Assets as Share of GDP in Singapore, 1980-2021



Source: DOS, MTI Staff Estimates

Note: Physical assets refer to non-residential construction & works, transport equipment and machinery & equipment, while intangible assets refer to computer software and R&D. Residential buildings and structures are excluded as they are not used in the production process of firms.

Exhibit 2: Growth in Gross Fixed Capital Formation for Physical and Intangible Assets (p.a.), 2009-2017



Source: DOS, World KLEMS and MTI Staff Estimates

Note: Data on GFCF are only available up to 2017 for many advanced economies. Intangible capital in the World KLEMS database include R&D, software & databases and other IP products (e.g., entertainment, literary and artistic originals). For Singapore, intangible assets exclude other IP products because the data is not available.

*: The period of analysis for Sweden was 2009-2016 because 2017 data were unavailable.

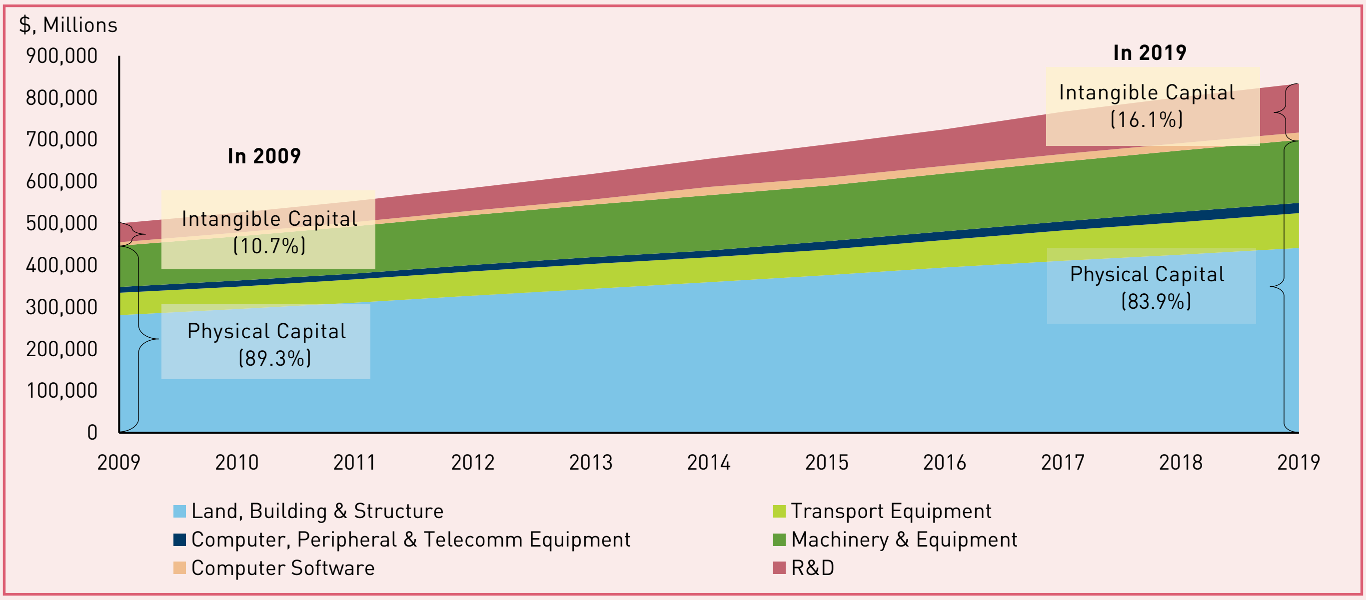
**: The period of analysis for Japan was 2009-2015 because 2016 and 2017 data were unavailable.

NET CAPITAL STOCK DATA[4]

A similar picture emerges using data on Singapore's net capital stock. Over the period of 2009-2019, the net capital stock of intangible assets (similarly defined as R&D and computer software) in Singapore increased by 9.7 per cent p.a., outstripping that for physical assets (4.6 per cent p.a.). By categories, growth in the net capital stock of R&D (10.0 per cent p.a.) and computer software (7.9 per cent p.a.) outpaced that in physical assets – computers, peripheral & telecommunications equipment (5.8 per cent p.a.), land, building & structure[5] (4.6 per cent p.a.), transport equipment (4.6 per cent p.a.), and machinery & equipment (4.3 per cent p.a.).

Consequently, the composition of net capital stock in Singapore saw a gradual shift towards intangible capital between 2009 and 2019, although physical capital continued to account for the bulk of net capital stock in the overall economy as at 2019 (Exhibit 3).

Exhibit 3: Net Capital Stock in Physical and Intangible Assets in Singapore, 2009-2019



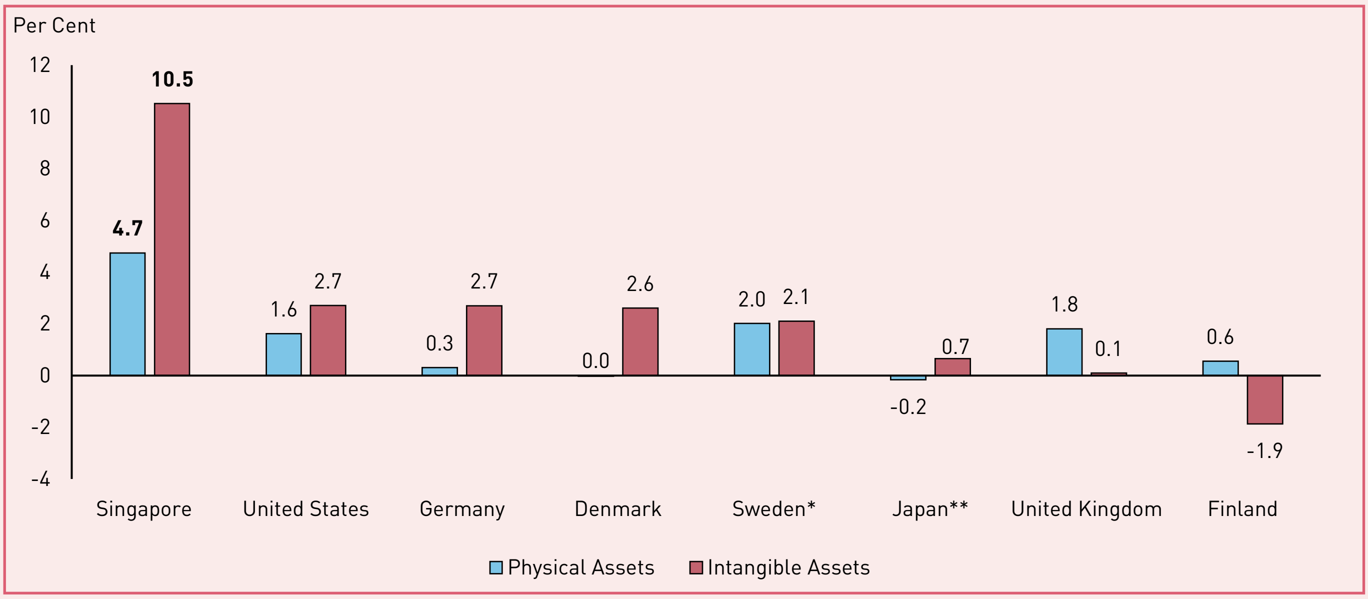
Source: DOS, MTI Staff Estimates

Note: Data on net capital stock present more granular types of capital, but have a shorter time series (2009-2019) as compared to data on GFCF (1980-2021). Net capital stock for land, building & structure excludes residential buildings and structures as they are not used in the production process of firms. The disaggregation between computer, peripheral & telecommunications equipment and machinery & equipment is based on the summation of net capital stock from all sectors because the disaggregation is not available from National Accounts aggregates.

Reflecting its strong growth trend, Singapore's net capital stock of intangible assets rose more quickly than that in advanced economies such as the United States, Germany and Denmark between 2009 and 2017 (Exhibit 4). Concomitantly, the share of intangible assets in Singapore's net capital stock increased more rapidly compared to that in other advanced economies (e.g., United States, Sweden) over this period (Exhibit 5).

4 *The net capital stock data cited in this section is consistent with that used for the subsequent growth accounting decomposition.*
5 *The net capital stock of land, building & structure excludes residential buildings and structures because they are not used in the production process of firms.*

Exhibit 4: Growth in Net Capital Stock for Physical and Intangible Assets (p.a.), 2009-2017



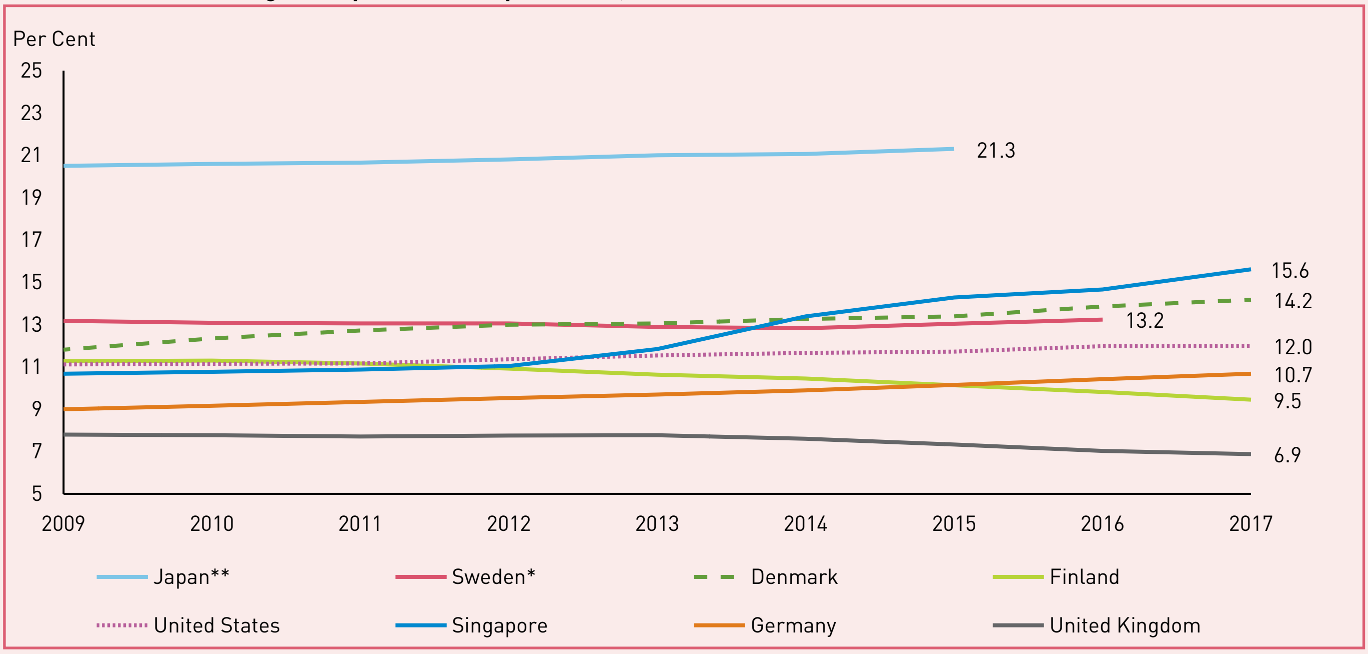
Source: DOS, World KLEMS and MTI Staff Estimates

Note: Data on net capital stock composition are only available up to 2017 for many advanced economies. Intangible capital in the World KLEMS database include R&D, software & databases and other IP products (e.g., entertainment, literary and artistic originals). For Singapore, intangible assets exclude other IP products because the data is not available.

*: The period of analysis for Sweden was 2009-2016 because 2017 data were unavailable.

**: The period of analysis for Japan was 2009-2015 because 2016 and 2017 data were unavailable

Exhibit 5: Share of Intangible Capital in Net Capital Stock, 2009-2017



Source: DOS, World KLEMS and MTI Staff Estimates

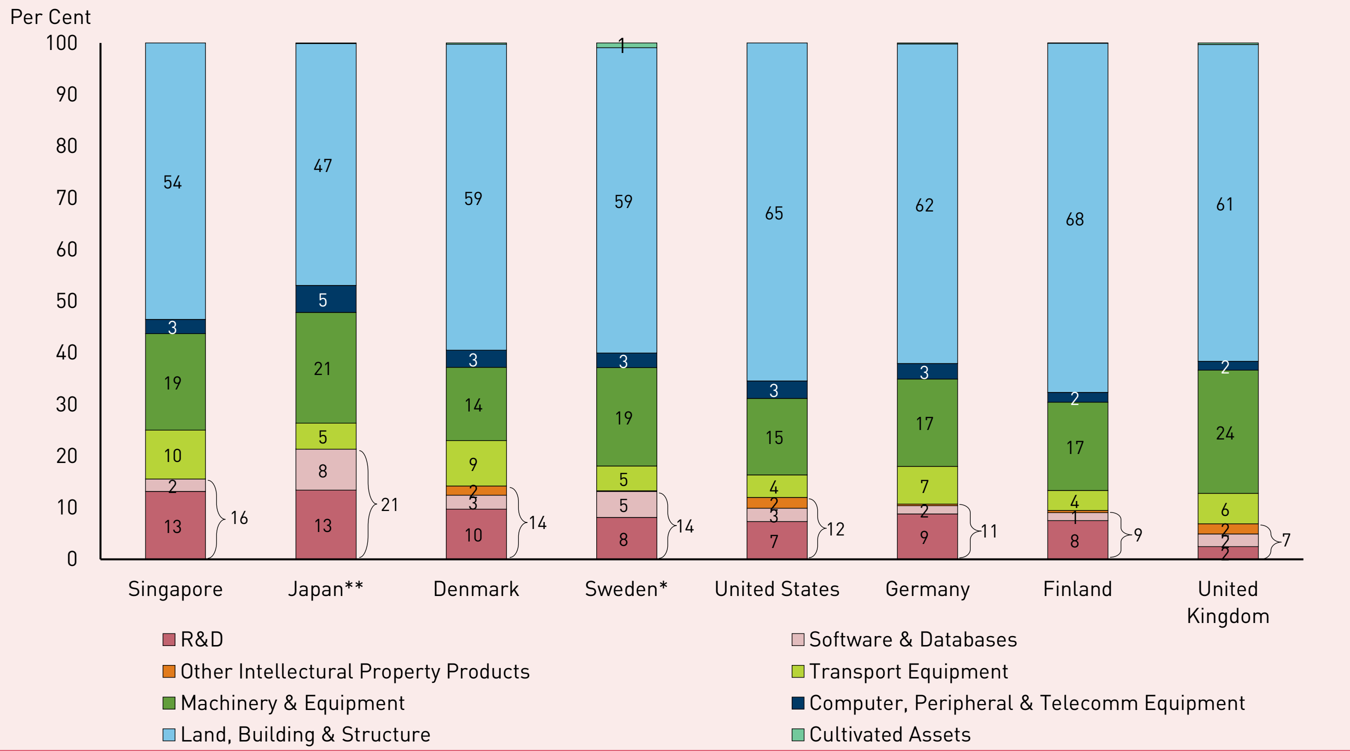
Note: Data on net capital stock composition are only available up to 2017 for many advanced economies. Intangible capital in the World KLEMS database include R&D, software & databases and other IP products (e.g., entertainment, literary and artistic originals). For Singapore, intangible assets exclude other IP products because the data is not available.

*: The period of analysis for Sweden was 2009-2016 because 2017 data were unavailable.

**: The period of analysis for Japan was 2009-2015 because 2016 and 2017 data were unavailable.

In terms of the composition of the intangible assets, R&D generally played a more dominant role in Singapore compared to the other advanced economies (Exhibit 6).

Exhibit 6: Composition of Net Capital Stock, 2017



Source: DOS, World KLEMS and MTI Staff Estimates

Note: Data on net capital stock composition are only available up to 2017 for many economies. Intangible capital in the World KLEMS database include R&D, software & databases and other IP products (e.g., entertainment, literary and artistic originals). For Singapore, intangible assets exclude other IP products because the data is not available. Cultivated assets refer to livestock for breeding and vineyards.

*: 2016 figures were used for Sweden as 2017 data were unavailable.

**: 2015 figures were used for Japan as 2016 and 2017 data were unavailable.

LITERATURE REVIEW

Given the growing relevance of intangible assets across economies, academic studies overseas have focused on their economic contribution, including their relationship with productivity growth. In the United States, Corrado et al. (2009) applied a growth accounting approach and found that the contribution of intangible capital deepening to labour productivity growth doubled from 0.43 percentage-point (pp) p.a. over 1973–1995 to 0.84pp p.a. over 1995–2003, driven by an increase in computer software stock (0.27pp p.a.), firm-specific human and structural resources (0.27pp p.a.), and non-scientific innovative property stock[6] (0.14pp p.a.).

Adopting a similar approach for the United Kingdom, Goodridge et al. (2016) found that a fall in intangible capital stock weighed on labour productivity growth between 2010 and 2014 (-0.16 per cent p.a.). Specifically, intangible capital services from firm-level training (-0.12pp p.a.), copyright (-0.03pp p.a.), design (-0.02pp p.a.) and R&D (-0.02pp p.a.) contributed negatively to labour productivity growth, while software capital services (0.05pp p.a.) contributed positively to labour productivity growth over the period.

6 *Corrado et al. (2009) defined non-scientific innovative property to include non-scientific commercial R&D, costs of developing new motion picture films and other forms of entertainment, investment in new designs, and spending for new product development by financial services and insurance firms.*

The academic literature suggests that the positive relationship between intangible assets and labour productivity growth may arise because intangible capital is often required as complements to other inputs. For example, Brynjolfsson et al. (2021) highlighted that general purpose technologies (GPTs) (e.g., artificial intelligence) often required complementary investment in other intangible assets (e.g., development of new business processes, software upgrading and investment in worker training) in order for the technologies to reap productivity returns. Using firm-level European data, Thum-Thysen et al. (2021) found positive spillover effects for firms that invested simultaneously in different intangible assets, with positive interaction effects for (i) investments in computer software & databases and employee training, (ii) investments in organisational capital and employee training, and (iii) investments in machinery & equipment and R&D.

At the same time, the academic literature also recognises that productivity gains from intangible capital deepening may require a gestation period. For example, Brynjolfsson et al. (2021) highlighted that extensive investment might be necessary to integrate newly-adopted GPTs into an organisation, with complementary investment in other physical/intangible assets and labour inputs required in order to reap rewards. Likewise, investment in early-stage basic research may require time before economic and productivity outcomes materialise (Trajtenberg et al., 1992; Guellec & De La Potterie, 2001). Given the process of investing and learning, the contribution of intangible assets to productivity growth could thus be weaker in the early years of intangible capital accumulation.

METHODOLOGY

Drawing on data from A*STAR, BCA, DOS and EDB, this study examines the contribution of intangible assets to Singapore's labour productivity growth at the aggregate and sectoral levels between 2009 and 2019.[7] This is done by building on earlier growth accounting studies (e.g., Goh & Fan, 2015; Fan & Teo, 2017; Toh & Ting, 2020) and further decomposing capital deepening into intangible and physical capital deepening.

This study focuses on intangible assets in the form of knowledge capital (i.e., computer software and R&D) since other intangible inputs (e.g., branding, organisational effectiveness and managerial practices) are difficult to measure and not captured in administrative data. Intangible inputs that are not measured will be captured in total factor productivity (TFP), which is calculated as a residual in the growth decomposition.

Specifically, the economy is modelled using a Cobb-Douglas production function with constant returns to scale:

$$\mathrm{Y} = \mathrm{A} \prod_i \mathrm{IK}_i^{\mathrm{ic}_i} \prod_j \mathrm{PK}_j^{\mathrm{pc}_j} \prod_k \mathrm{H}_k^{\mathrm{b}_k}$$

Where: Y = real output;

A = TFP;

IK_i, PK_j = net stock of i^{th} type of intangible capital, j^{th} type of physical capital;

ic_i, pc_j = share of output of the i^{th} type of intangible capital, j^{th} type of physical capital;

H_k = actual hour worked (AHW) of k^{th} type of labour;

b_k = share of output of the k^{th} type of labour; and

$\sum_i \mathrm{ic}_i + \sum_j \mathrm{pc}_j + \sum_k \mathrm{b}_k = 1$ (i.e., constant returns to scale).

7 *Based on available data, 2009 to 2019 reflects the longest possible period of analysis. Data on value-added (VA) per actual hour worked (AHW) are available from 2009, while capital stock data for the overall economy and sectors from A*STAR (National R&D and Research, Innovation & Enterprise [RIE] Surveys), BCA (Construction Industry Survey), DOS (Annual Survey of Services) and EDB (Census of Manufacturing Activities) are available up to 2019. The study harmonises all statistics (e.g., VA, employment, AHW, wages, capital stock) to SSIC 2015 (i.e., based on data before the conversion of selected indicators to SSIC 2020 in February 2022).*

Given that $\Delta Y \approx \sum_i ic_i \, \Delta IK_i + \sum_j pc_j \, \Delta PK_j + \sum_k b_k \, \Delta H_k + \Delta A$ under the assumption that inputs are paid their marginal products in competitive markets, labour productivity growth can be decomposed into four components – (i) contribution from intangible capital deepening, (ii) contribution from physical capital deepening, (iii) contribution from changes in labour quality, and (iv) contribution from changes in TFP:

$$\Delta \frac{Y}{H} \approx \sum_i ic_i \left(\Delta \frac{IK_i}{H}\right) + \sum_j pc_j \left(\Delta \frac{PK_j}{H}\right) + S_L \times \sum_k (s_k - h_k) \, \Delta H_k + \Delta A$$

Where: S_L = total wage share of output;
s_k = wage share of k^{th} type of labour;
h_k = AHW share of k^{th} type of labour.

- Capital Deepening: Capital deepening of each capital type contributes positively to productivity growth when capital growth outpaces hours worked growth (i.e., there is more capital for each man-hour). In this article, intangible and physical capital inputs are examined separately:

  - Intangible Capital: For intangible capital deepening, the contributions from (i) R&D, and (ii) computer software are considered.

  - Physical Capital: For physical capital deepening, the contributions from (i) machinery & equipment, (ii) transport equipment[8], and (iii) non-residential construction & works[9] are considered.

- Labour Quality: For this analysis, labour is divided into skilled and less-skilled labour based on occupational types.[10] The quality of each type of labour is proxied by the term $(s_k - h_k)$, which is positive when labour type k has higher wages than the other labour types. Hence, overall labour quality improves (and productivity increases) when the growth in total hours worked by skilled workers (with wages above the economy average) exceeds that of less-skilled workers (with wages below the economy average). A workforce that is more skilled raises productivity because better-trained workers tend to have more capacity to be efficient and innovative, and to produce higher-value products and services.

- TFP: TFP captures the residual output growth that is not attributed to changes in the quantity and quality of measured capital (intangible and physical) and labour inputs. It measures how efficiently inputs are used together in the production process, and encompasses the effects of a wide range of factors, including technological progress and the diffusion of technology across firms. Intangible inputs that are not captured in the data used for the decomposition (e.g., branding, organisational effectiveness, managerial practices) will also be captured in TFP.

Concerns have been raised in the literature that intangible assets may be used by firms to avoid taxes through profit-shifting practices. For example, Tørsløv et al. (2018) suggested that firms shifted intangible capital (e.g., trademarks, patents, logos, algorithms or financial portfolios) from high-tax countries to affiliates in low-tax countries, which would then receive royalties, interest or payment from final customers. Guvenen et al. (2017) noted that such profit-shifting practices could potentially generate a positive correlation between intangible assets and productivity (through profits), which was not premised on genuine productivity improvements.

This study circumvents such potential distortions by excluding (i) intangible assets such as trademarks and logos, and (ii) royalty income and payments for patent use, even though the purchases and sales of patents are included in the estimation of GFCF and net R&D capital stock. As such, transfer payments for the use of trademarks, logos and patents (if any) will not affect the contribution of intangible capital in the growth accounting results. Instead, they will be captured in the residual TFP term (if any).

8 *Transport equipment includes ships & boats,aircrafts and other transport equipment.*
9 *Residential buildings are excluded because they are not used in the production process of firms. The imputed ownership of dwellings is also excluded from the productivity computations.*
10 *Workers who are Professionals, Managers, Executives, and Associate Professionals & Technicians are classified as skilled workers, while workers who are Clerical Support Workers, Service & Sales Workers, Craftsmen & Related Trades Workers, Plant & Machine Operators & Assemblers, and Cleaners, Labourers & Related Workers are classified as less-skilled workers.*

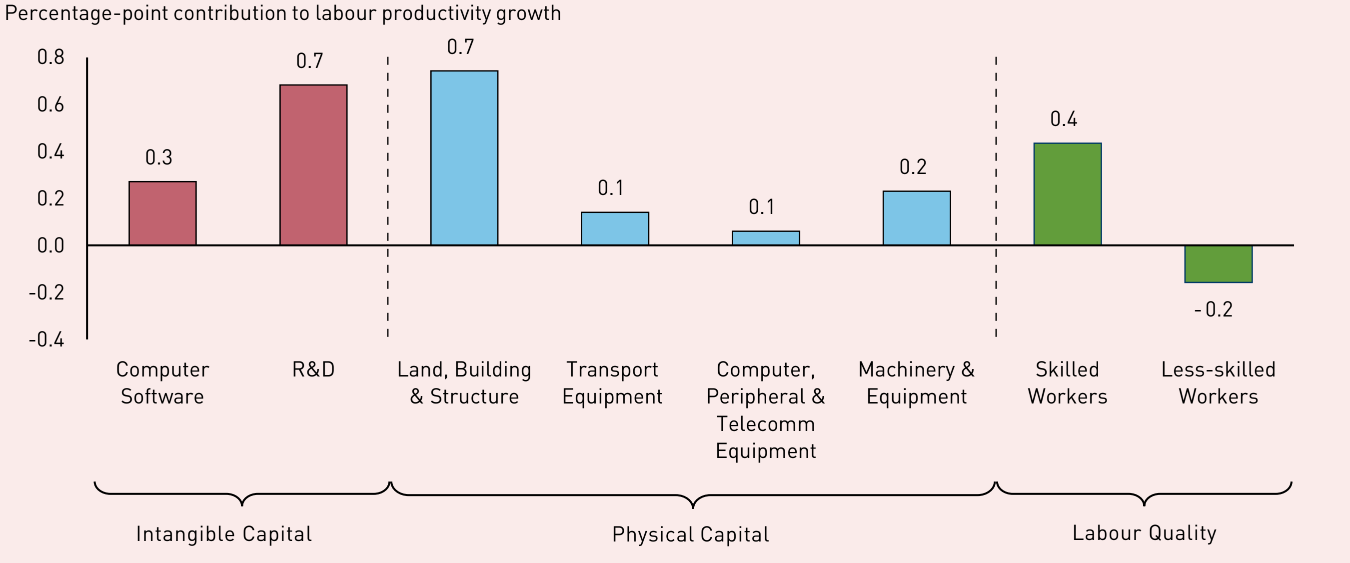
CONTRIBUTION OF INTANGIBLE ASSETS TO SINGAPORE'S LABOUR PRODUCTIVITY GROWTH (2009-2019)

CONTRIBUTION OF INTANGIBLE ASSETS TO OVERALL PRODUCTIVITY GROWTH

Between 2009 and 2019, Singapore's overall labour productivity[11] (real value-added [VA] per actual hour worked [AHW]) grew by 3.0 per cent p.a., supported by intangible capital deepening (particularly R&D) and physical capital deepening (particularly land, building & structure) (Exhibit 7).[12]

- Intangible capital deepening (1.0pp p.a.) was a major contributor to labour productivity growth from 2009 to 2019, driven mostly by R&D capital deepening (0.7pp p.a.), in line with the Government's Science & Technology (S&T) and Research, Innovation & Enterprise (RIE) plans.[13] Capital deepening in computer software also supported productivity growth over the decade (0.3pp p.a.).
- Physical capital deepening (1.2pp p.a.) was also a key driver of labour productivity growth over the decade, with the largest contributor being land, building & structure (0.7pp p.a.), in line with the Government's investment in public infrastructure (e.g., Mass Rapid Transit lines).
- Labour quality improvements (0.3pp p.a.) also supported labour productivity growth from 2009 to 2019. This was driven by an increase in hours worked by skilled workers that outpaced that of less-skilled workers.
- TFP growth (0.6pp p.a.) accounted for the rest of labour productivity growth over this period.

Exhibit 7: Contribution of Intangible Capital Deepening, Physical Capital Deepening and Labour Quality Changes to Overall Labour Productivity Growth, 2009-2019



Source: MTI Staff Estimates

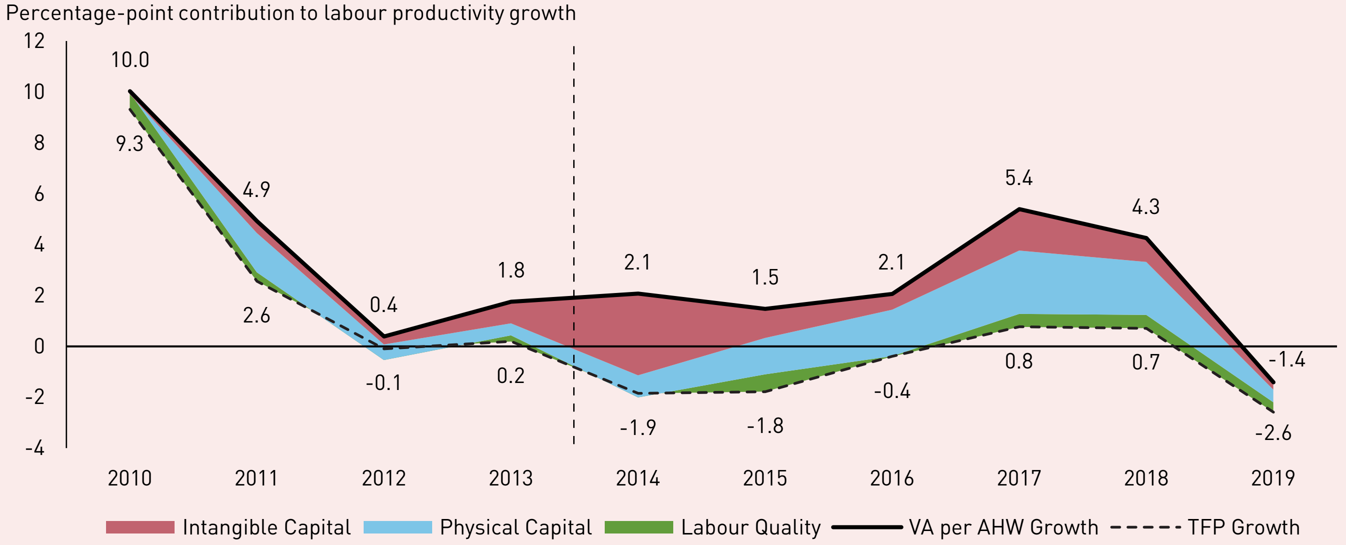
11 Similar to earlier MTI studies (e.g., Toh & Ting, 2020), this excludes ownership of dwellings and taxes on products.

12 For the period of 2010 to 2019 (i.e., excluding the rebound year of 2010), physical capital deepening (1.3pp p.a.) and intangible capital deepening (1.0pp p.a.) remained important drivers of overall labour productivity growth (i.e., 2.3 per cent p.a.). The contribution of labour quality to productivity growth also remained similar (0.2pp p.a.). However, the TFP contribution to productivity growth moderated to -0.3pp p.a., as the exclusion of 2010 data weighed on VA growth over the period of analysis.

13 Under the S&T and RIE plans, the Singapore Government invested S$13.5 billion over 2006-2010, S$16 billion over 2011-2015 and S$19 billion over 2016-2020 to catalyse R&D and innovation activities in Singapore.

Over the years, capital deepening in intangibles has become a more important contributor to labour productivity growth in Singapore. This has been particularly so since 2014 (Exhibit 8). Capital deepening in intangibles was also a more significant driver of labour productivity growth in Singapore compared to other advanced economies like the United States, Denmark and Sweden between 2009 and 2017 (Exhibit 9).

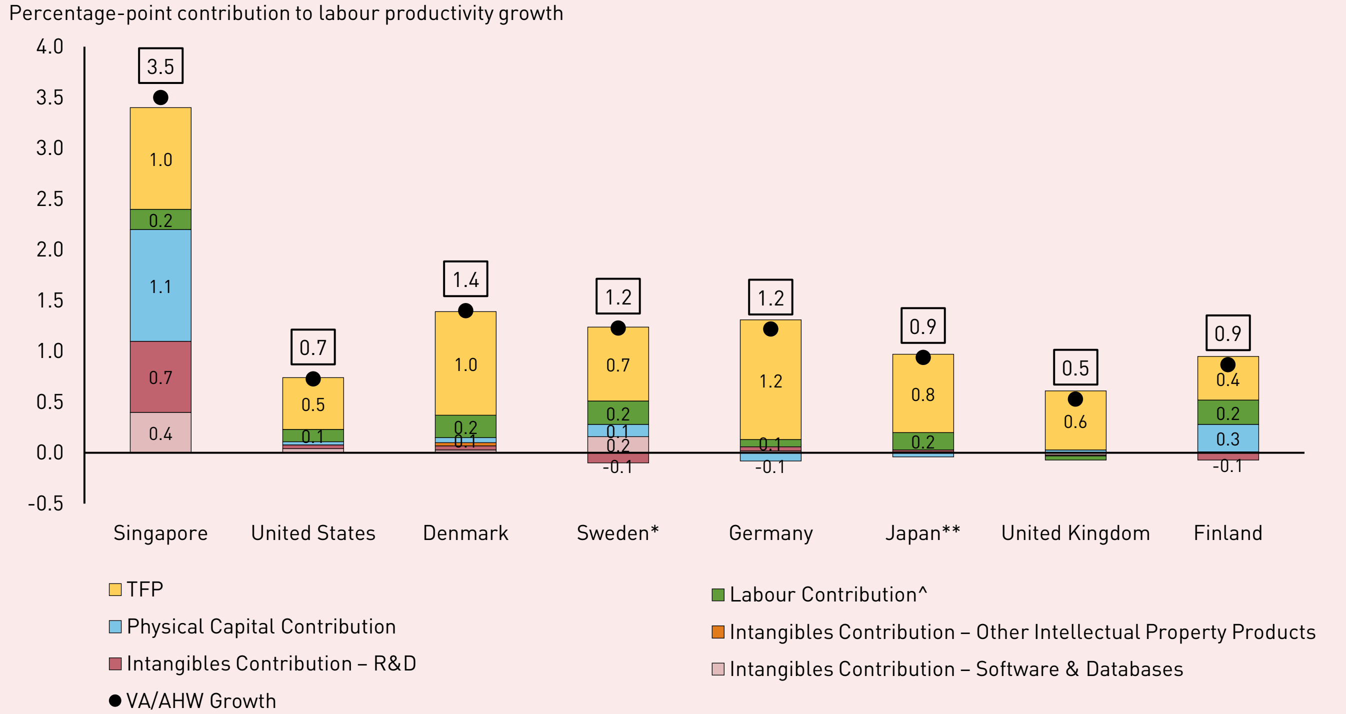
Exhibit 8: Growth in Real Value-Added per Actual Hour Worked (VA per AHW) and TFP Growth, 2009-2019



Source: MTI Staff Estimates

Note: TFP growth computed in this growth accounting analysis is not directly comparable to DOS' Multifactor Productivity (MFP) series because of differences in the decomposition method used. This study (i) used total VA for goods and services producing industries instead of GDP, (ii) used finer categories of capital inputs, (iii) used hours worked instead of employment as a measure of the quantity of labour inputs, and (iv) accounted for skilled and less-skilled workers. As TFP is computed as a residual in the decomposition, it is highly sensitive to changes in total VA (e.g., periods of economic slowdown such as in 2019) and other components of the growth accounting decomposition.

Exhibit 9: Contribution of Intangible Capital Deepening, Physical Capital Deepening and Labour Changes to Labour Productivity Growth in Singapore and Other Advanced Economies, 2009-2017



Source: DOS, World KLEMS and MTI Staff Estimates

Note: Data are only available up to 2017 for many advanced economies. The contribution of other IP products to productivity growth is not available or zero for most economies, except for Denmark (0.03pp p.a. between 2009 and 2017).

*: 2016 figures were used for Sweden as 2017 data were unavailable.

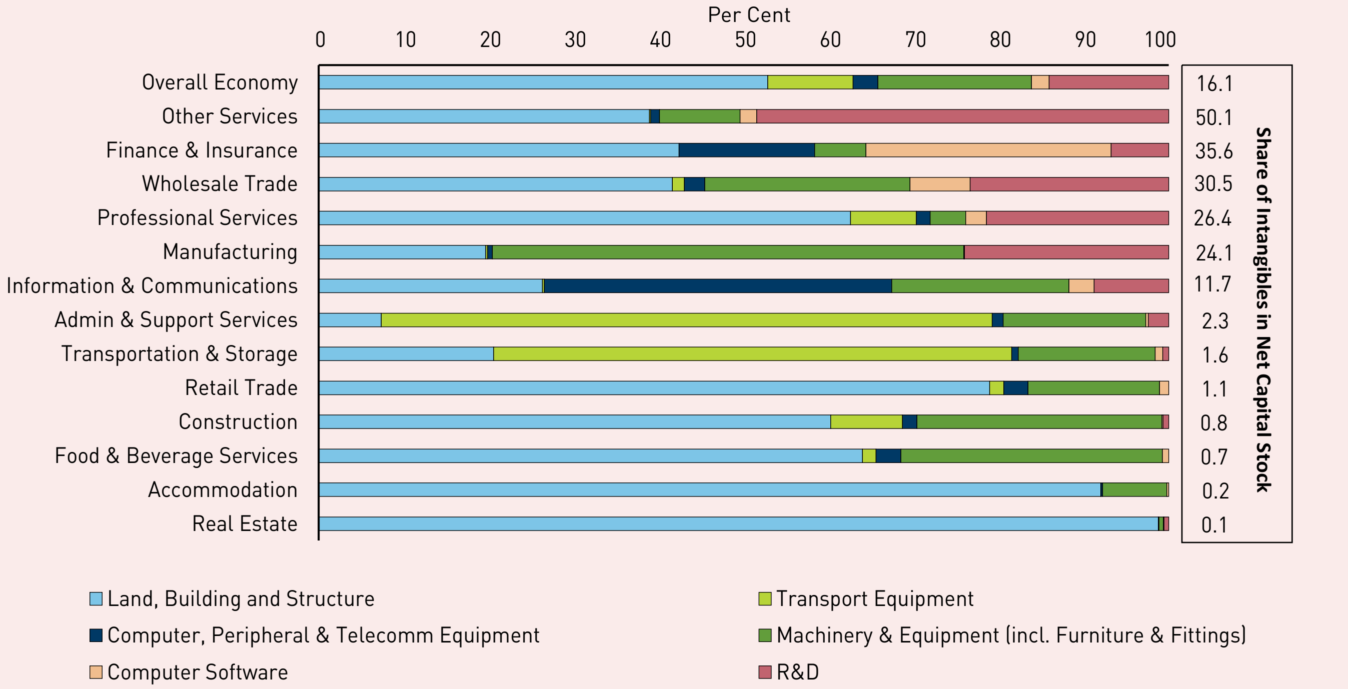
**: 2015 figures were used for Japan as 2016 and 2017 data were unavailable.

^: Labour contribution is quality-adjusted for Singapore.

CONTRIBUTION OF INTANGIBLE ASSETS TO SECTORAL PRODUCTIVITY GROWTH

Industries in Singapore differ in their level of intangible capital investments. In 2019, the outward-oriented Finance & Insurance, Wholesale Trade, Professional Services and Manufacturing sectors were among the most intangible capital-intensive in the economy (Exhibit 10).[14] By contrast, the Real Estate, Accommodation, Food & Beverage Services and Construction sectors were the most reliant on physical capital.

Exhibit 10: Composition of Net Capital Stock by Sector, 2019



Source: A*STAR, BCA, DOS, EDB, MTI Staff Estimates

Notes: For the overall economy, the disaggregation between computer, peripheral & telecommunications equipment (CPTE) and machinery & equipment is based on the summation of net capital stock from all sectors because the disaggregation is not available from National Accounts aggregates. For the services sectors, CPTE, which is classified under DOS' definition of machinery & equipment, is disaggregated into a separate category. For the Finance & Insurance sector, the capital stock of transport equipment is attributed to machinery & equipment because it cannot be separated. For the Manufacturing sector, the capital stock of CPTE and computer software is negligible (0.5 per cent of net capital stock) and is fully accounted for under the former as the two cannot be disaggregated. The net capital stock of R&D for the Retail Trade, Food & Beverage Services, Accommodation and Real Estate sectors is assumed to be negligible because data are unavailable. Negligible R&D expenditure in these sectors is consistent with observations in past studies (e.g., Teo et al., 2020) and the OECD's Analytical Business Enterprise Research and Development (ANBERD) database (e.g., for the disaggregated Business Services sectors).

Examining the relationship between intangible capital deepening and labour productivity growth for the period of 2009 to 2019, the various sectors are observed to fall into either the bottom-left (i.e., low intangible capital deepening and low labour productivity growth) or the top-right (high intangible capital deepening and high labour productivity growth) quadrants of Exhibit 11 below. Broadly, they can be classified into three archetypes:

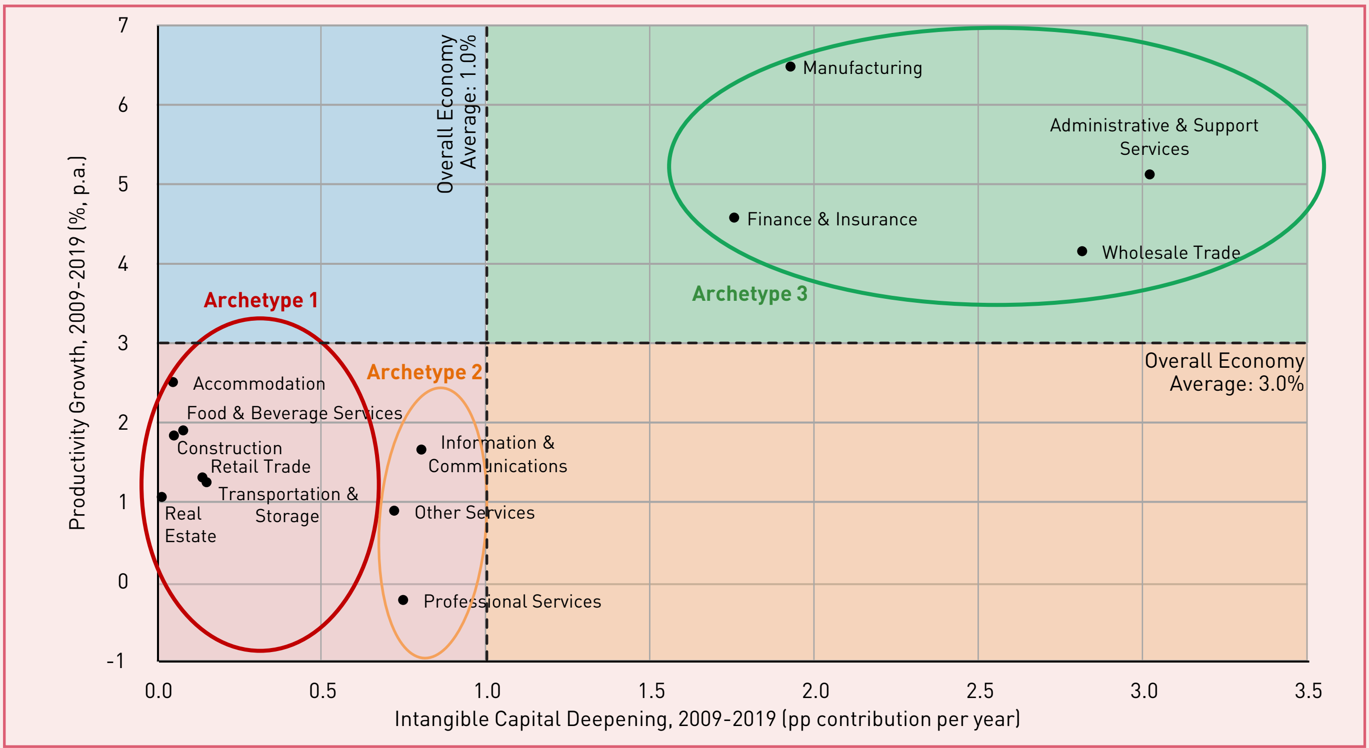
- The first archetype comprises physical capital-intensive sectors (i.e., Real Estate, Accommodation, Food & Beverage Services, Construction, Retail Trade, Transportation & Storage) with low productivity growth, and have seen almost no contribution of intangible capital deepening to productivity growth. For these sectors, physical capital deepening, particularly in land, building & structure, dominated productivity dynamics.

- The second archetype refers to services sectors (i.e., Information & Communications, Professional Services and Other Services) that have seen some intangible capital deepening and hold potential for further intangible capital deepening to boost productivity.

14 *In the Other Services sector, intangibles (primarily R&D) accounted for more than half of its net capital stock in 2019, supported by public expenditure on R&D by Public Research Institutes, Institutes of Higher Learning and the Government.*

- The third archetype includes sectors with strong productivity growth and above-average contributions of intangible capital deepening, such as the outward-oriented Wholesale Trade, Manufacturing and Finance & Insurance sectors, and the domestically-oriented Administrative & Support Services sector (which includes firms involved in the leasing of non-financial intangible assets such as patents). The intangibles-intensive Manufacturing and Wholesale Trade sectors also saw sizeable contributions of physical capital deepening to productivity growth, suggesting possible complementarities between intangible (e.g., R&D) and physical (e.g., machinery & equipment; and land, building & structure) inputs in these sectors.

Exhibit 11: Contribution of Intangible Capital Intensity to Labour Productivity Growth by Sectors, 2009-2019



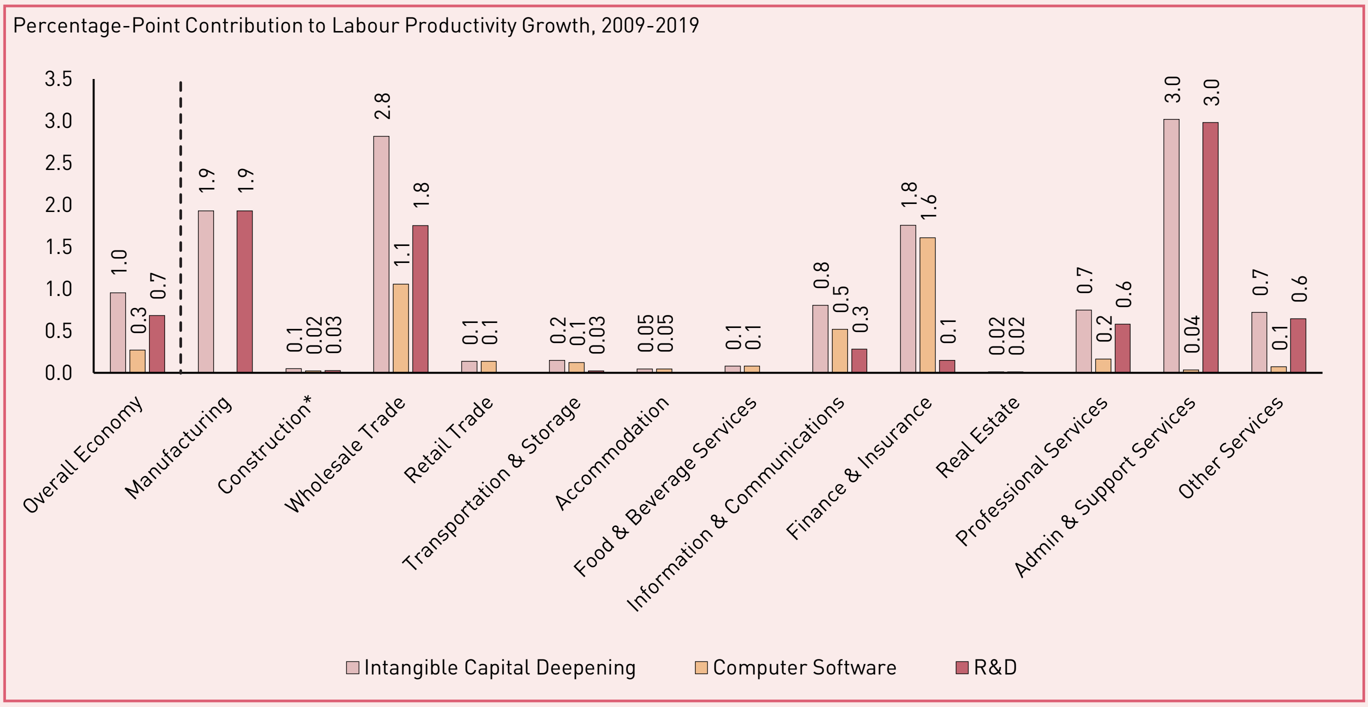
Source: MTI Staff Estimates

Note: As net capital stock for the Construction sector was unavailable for 2009, the growth accounting decomposition for the Construction sector was undertaken for the period of 2010-2019.

Across the sectors, there were differences in the productivity contributions of investments in different intangible inputs (i.e., R&D and computer software) (Exhibit 12). For example, for outward-oriented sectors in the third archetype, productivity growth in the Manufacturing sector was driven primarily by investments in R&D, while that in the Finance & Insurance sector was driven largely by investments in computer software. By contrast, productivity growth in the Wholesale Trade sector benefitted from investments in both intangible capital types.

Between R&D and computer software, investments in the former tended to be the more dominant contributor to labour productivity growth for most sectors over the decade. The key exceptions were the Information & Communications and Finance & Insurance sectors, where the converse was the case.

Exhibit 12: Contribution of Capital Deepening in R&D and Computer Software to Labour Productivity Growth by Sectors, 2009-2019



Source: MTI Staff Estimates

*: As net capital stock for the Construction sector was unavailable for 2009, the growth accounting decomposition for the Construction sector was undertaken for the period of 2010-2019.

CONCLUSION

The share of intangible assets in Singapore's economy has risen steadily over time, reflecting the growing importance of intangible capital such as R&D and computer software in the economy. The increasing importance of intangible capital is also reflected in its contribution to overall labour productivity growth in Singapore. Between 2009 and 2019, intangible capital deepening (1.0pp p.a.) was a key contributor to labour productivity growth (3.0 per cent p.a.), supported by investments in R&D (0.7pp p.a.) and computer software (0.3pp p.a.). At the sectoral level, intangible capital deepening was a strong contributor to labour productivity growth in the outward-oriented Wholesale Trade, Manufacturing and Finance & Insurance sectors, as well as the domestically-oriented Administrative & Support Services sector, although the relative contributions of investments in R&D and computer software differed across the sectors.

With the COVID-19 pandemic accelerating digital transformation and catalysing the shift from physical to intangible assets, firms can increasingly leverage new tools to innovate and create new technologies. To remain competitive, it is imperative for firms to press on with their transformation and restructuring efforts. In particular, investments in, and the utilisation of, intangible assets in their production processes will allow them to overcome their physical constraints and tap on the global marketplace. Under the Singapore IP Strategy (SIPS) 2030[15], the Government will continue to strengthen our position as a global hub for intangible assets (including IP), and support firms in the adoption of these assets for growth. The Government will also complement these efforts by raising the relevant capabilities of our workforce.

Contributed by:

Mr Benjamin Toh, Economist
Ms Jessica Ting, Economist
Economics Division
Ministry of Trade and Industry

15 *The SIPS is a national strategy that aims to (i) strengthen Singapore's position as a global hub for intangible assets (including IP), (ii) attract and grow innovative enterprises using intangible assets (including IP), and (iii) develop good jobs and valuable skills in intangible assets (including IP) (see Intellectual Property Office of Singapore, 2021).*

REFERENCES

Brynjolfsson, E., Rock, D., & Syverson, C. (2021). The Productivity J-curve: How Intangibles Complement General Purpose Technologies. *American Economic Journal: Macroeconomics, 13*(1), 333-72.

Brand Finance (2021). Global Intangible Finance Tracker (GIFTTM) – An Annual Review of the World's Intangible Value. London: Brand Finance.

Corrado, C., Hulten, C., & Sichel, D. (2005). Measuring Capital and Technology: An Expanded Framework. In *Measuring Capital in the New Economy* (pp. 11-46). Chicago, IL: University of Chicago Press.

Corrado, C., Hulten, C., & Sichel, D. (2009). Intangible Capital and US Economic Growth. *Review of Income and Wealth*, 55(3), 661-685.

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

Fan, S. L., & Teo, M. (2017). Drivers of Labour Productivity Growth Trends in Singapore: An Update Using Value-Added per Actual Hour Worked. Economic Survey of Singapore 2016, 88-98.

Goodridge, P., Haskel, J., & Wallis, G. (2016). UK Intangible Investment and Growth: New Measures of UK Investment in Knowledge Assets and Intellectual Property Rights. Newport: Intellectual Property Office.

Guellec, D., & De La Potterie, B. V. P. (2002). R&D and Productivity Growth: Panel Data Analysis of 16 OECD Countries. *OECD Economic Studies*, 2001(2), 103-126.

Guvenen, F., Mataloni, R. J., Rassier, D. G., & Ruhl, K. J. (2017). *Offshore Profit Shifting and Domestic Productivity Measurement* (No. w23324). National Bureau of Economic Research.

Haskel, J., & Westlake, S. (2017). Capitalism Without Capital: The Rise of the Intangible Economy. Princeton, NJ: Princeton University Press.

Intellectual Property Office of Singapore (2021). Singapore IP Strategy 2030 Report. Singapore: Intellectual Property Office of Singapore.

Teo, M., Loo, A., & Kuan, M. L. (2020). Returns to Research & Development (R&D) Among Firms in Singapore. Economic Survey of Singapore Third Quarter 2019, 42-50.

Thum-Thysen, A., Voigt, P., & Weiss, C. (2021). *Complementarities in Capital Formation and Production: Tangible and Intangible Assets Across Europe* (No. 2021/12). EIB Working Papers.

Toh, B., & Ting, J. (2020). Drivers of Labour Productivity Growth in Singapore, 2009–2019. Economic Survey of Singapore Third Quarter 2020, 42-54.

Tørsløv, T. R., Wier, L. S., & Zucman, G. (2018). *The Missing Profits of Nations* (No. w24701). National Bureau of Economic Research.

Trajtenberg, M., Henderson, R., & Jaffe, A. B. (1992). Ivory Tower versus Corporate Lab: An Empirical Study of Basic Research and Appropriability.