

Box A: The Digital Economy: A Potential New Engine for Productivity Growth¹

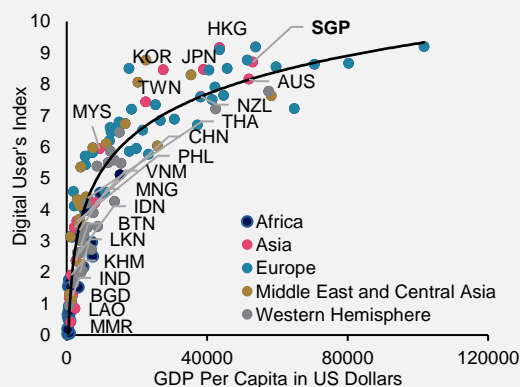
Introduction

Globally, the COVID-19 pandemic and associated safe distancing measures have accelerated the digital revolution. This dynamic is also taking place in Singapore, a country at the forefront of digital usage. An empirical analysis of sector-level labour productivity growth in advanced economies, including Singapore, suggests that digitalisation and innovation, captured through e-commerce, robotisation and research and development (R&D), are associated with higher labour productivity growth. Singapore has scope to expand e-commerce (despite recent rapid growth) and R&D. This would help the country reap more benefits of the digital economy, notably through higher productivity growth, and accelerate economic transformation.

The digital economy landscape in Singapore

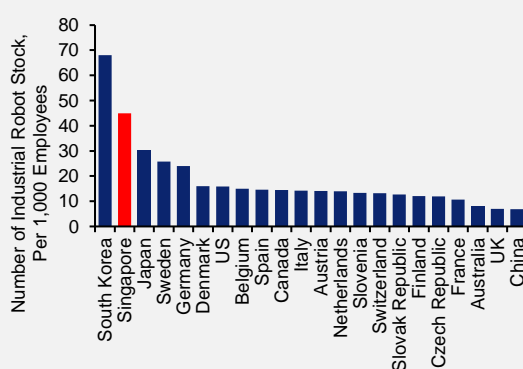
Singapore is at the forefront of digitalisation. The digital user's index, which captures various aspects of mobile and internet usage, highlights Singapore's high digital take-up compared to other Asian countries and among peer advanced economies (**Chart A1**).² Singapore has also become one of the top global users of industrial robots, with its robot density increasing from about 1 operating robot per 1,000 employees in 2008 to 45 in 2018 (**Chart A2**). Most of the industrial robots in Singapore are used in the semiconductor sub-sector, which accounted for 70% of all industrial robots in 2018.

Chart A1 GDP per capita and digital usage, 2016



Source: IMF World Economic Outlook and IMF staff calculations

Chart A2 Robot density in manufacturing, 2018 or latest available data



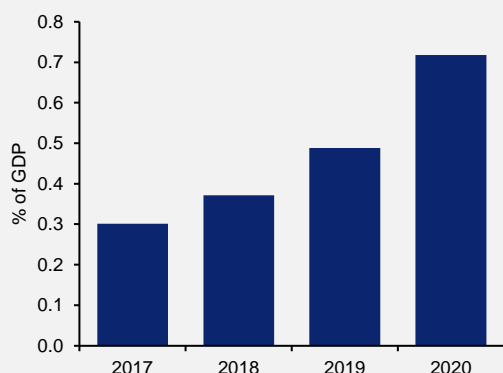
Source: International Federation of Robotics

¹ This Box was contributed by Tidiane Kinda with research assistance from Kaustubh Chahande, both from the IMF. It is based on Chapter III in the 2021 Article IV Consultation Staff Report. The views expressed in this Box are those of the author and do not necessarily represent the views of the IMF, its Executive Board, IMF management or MAS.

² The digital user's index in IMF (2018) averages six indicators: mobile phone subscriptions per 100 persons; percentage of individuals using the Internet; percentage of households with a personal computer; percentage of households with Internet access; fixed broadband Internet access in terms of subscriptions per 100 persons; and mobile-broadband subscriptions in terms of subscriptions per 100 persons.

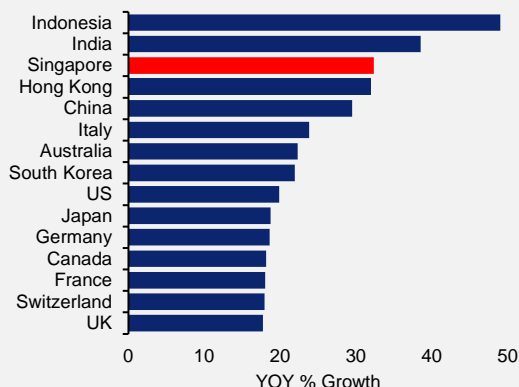
Singapore retains scope to expand e-commerce and R&D, two key elements of digitalisation. From about 0.3% of GDP in 2017, e-commerce sales more than doubled to about 0.7% of GDP in 2020 (Chart A3). Boosted by social distancing during the pandemic, e-sales surged by 32% in 2020, one of the fastest growth rates among peers in Asia and advanced economies (Chart A4).³ Despite the rapid growth, e-sales in Singapore remained under 1% of GDP in 2020, well below the level in peer economies (Chart A5). Yet, Singapore ranks among the countries with the highest readiness for e-commerce, measured by indicators that capture the use of secure internet services, the reliability of postal services for last mile delivery, and access to a financial account for payments (Chart A6).

Chart A3 E-commerce sales in Singapore



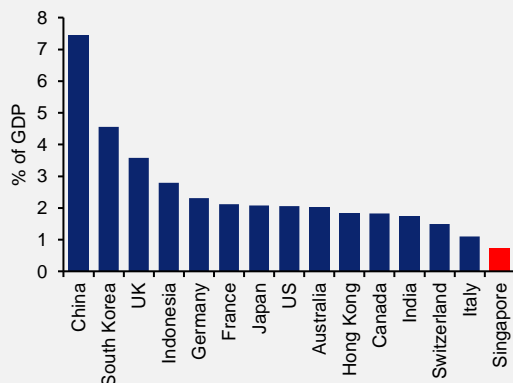
Source: Statista and IMF staff estimates

Chart A4 E-sales growth across economies, 2020

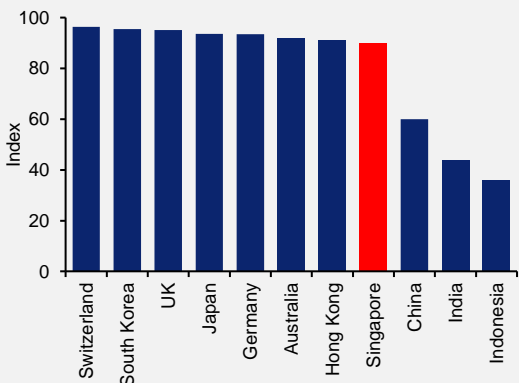


Source: Statista and IMF staff estimates

Chart A5 E-sales across selected economies, **Chart A6** E-commerce Readiness Index 2020



Source: Statista and IMF staff estimates



Source: United Nations Conference on Trade and Development B2C E-commerce Index⁴

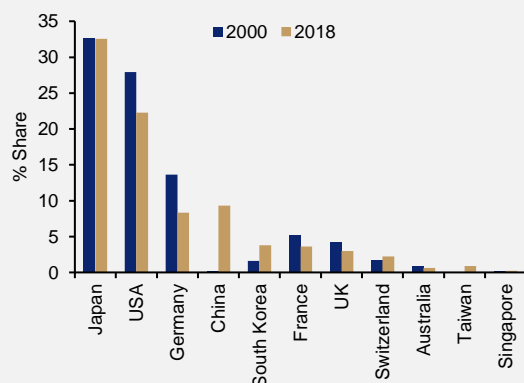
Singapore’s share of all patent applications filed in Japan, Europe, and the United States (“triadic patent families”) is low, mostly reflecting the country’s smaller economy compared to peers (Chart A7). Consistent with low patent filing, the increase in Singapore’s R&D

³ The data on e-commerce sales in this paper are collected from Statista’s Digital Market Outlook. E-commerce sales refer to business-to-consumer digital commerce and do not include digitally distributed services, digital media downloads or streaming services, online booking, business-to-business digital commerce, and consumer-to-consumer digital commerce.

⁴ The B2C E-commerce Index is the simple average of four indicators: (1) the percentage share of individuals in the total population using the Internet; (2) the postal reliability score scaled between 0 and 100; (3) the percentage share of individuals in the total population with a financial account; and (4) an indicator of secure Internet server availability scaled between 0 and 100.

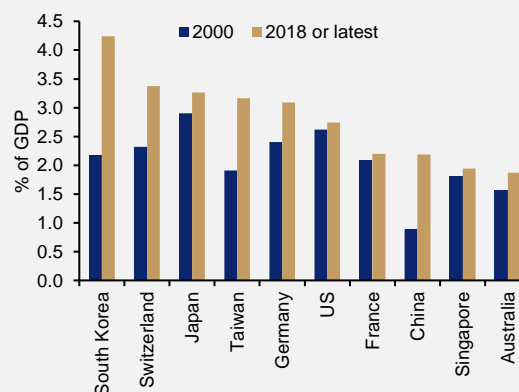
expenditure was modest from 2010 to 2018, contrasting with the rapid growth and higher spending levels in R&D observed in many economies such as South Korea, Switzerland, and Taiwan (**Chart A8**). Nevertheless, Singapore's R&D expenditure of 1.9% of GDP in 2018 remained slightly higher than the median among OECD countries.

Chart A7 Share of patent applications in triadic patent families



Source: OECD statistics

Chart A8 R&D expenditure



Source: World Bank, OECD statistics and IMF staff calculations

Digitalisation, innovation, and productivity growth

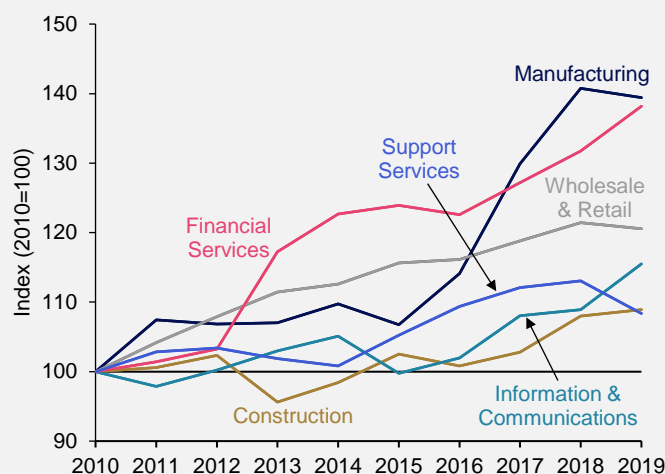
The existing literature, while limited, suggests digitalisation and innovation may influence productivity growth. This finding is supported by emerging empirical evidence highlighting the positive role of digitalisation in fostering productivity.⁵ For instance, Kinda (2019) shows that Asian firms engaged in e-commerce have on average 30% higher total factor productivity than other firms. Graetz and Michaels (2015) find that robots may have increased productivity growth by more than 15%.

The analysis below draws on sector-level cross-country labour productivity data. Data on value added per worker by industry, a proxy for labour productivity, is from the OECD database and matched with data on Singapore from DOS. Data availability limits the sample to 22 advanced economies during 2000–19.⁶

Most services sectors in Singapore have seen relatively slow labour productivity growth in recent years, similar to trends in other advanced economies. While labour productivity growth in the manufacturing sector has been robust since 2015, service sectors, with the exception of financial services as well as information and communications, have experienced modest labour productivity growth during the same period (**Chart A9**). More robust cross-country conditional correlations confirm that most service activities have had lower labour productivity growth compared to the manufacturing sector across the sample of advanced economies, including in Singapore.

⁵ See Falk and Hagsten (2015), World Bank (2016) and Yang *et al.* (2017).

⁶ The sector-level categorisation comprises 6 sub-sectors: manufacturing, construction, wholesale and retail trade, information and communications, finance and insurance and business services. Countries in the sample are Austria, Belgium, Canada, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Netherlands, Norway, Portugal, Singapore, South Korea, Spain, Sweden, Switzerland, United Kingdom, and United States.

Chart A9 Singapore labour productivity by sector

Source: DOS, MOM, and IMF staff calculations

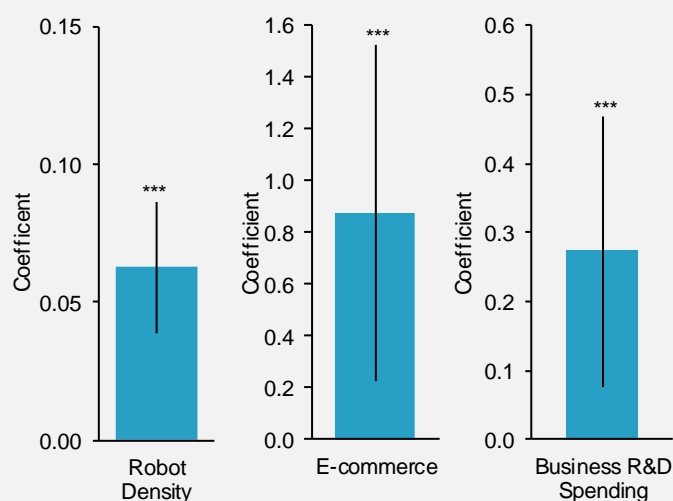
Note: Support services includes professional services, administrative & support services, and other services industries

An empirical strategy can be used to investigate the potential role of digitalisation and innovation on labour productivity growth, through the following equation:

$$\Delta LP_{ijt} = \alpha + \gamma Dig_{ijt} + \delta X_{ijt} + \varphi b_i + \eta I_j + \theta t_t + \epsilon_{it}$$

where ΔLP_{ijt} captures the annual labour productivity growth rate of country i in sector j at time t . Dig_{ijt} represents the digitalisation or innovation proxy either at the country level (e-commerce, robot density) or country-sector level (business R&D expenditure). X_{ijt} includes control variables, such as sectoral inward FDI as a share of GDP, to gauge the extent of inbound know-how transfer; and the trade-to-GDP ratio to capture openness to international trade. b_i , I_j , and t_t represent country, sector, and time fixed effects respectively. Beyond unobservable fixed factors, controlling for country and industry fixed effects allows us to account for time-invariant characteristics such as being a financial centre. By controlling for common shocks across all countries and industries in a given year, time fixed effects allow us to focus on the time-varying structural aspects of digitalisation and innovation that are deemed important for productivity growth. ϵ_{it} is the error term.

The results highlight that digitalisation and innovation are associated with higher labour productivity growth (**Chart A10 and Table A1**). The baseline results show that overall, a larger share of e-commerce to GDP or a higher robot density are associated with higher labour productivity growth. Higher business R&D spending is also associated with higher labour productivity growth. These results are robust to a variety of tests. In addition, as the digital revolution is still unfolding, its impact on productivity may increase over time. However, the cross-country regressions show little evidence that the relationship between digitalisation and productivity growth has strengthened in recent years (**Table A2**).

Chart A10 Estimated impact of digitalisation on labour productivity growth (% point)

Source: Author's estimates

Note: These figures illustrate coefficients and confidence intervals from three sector-level cross-country estimations of the potential effect of digitalisation and innovation on labour productivity growth controlling for sectoral inward FDI, openness to trade, and cross country-industry and time fixed effects. The error bars refer to the 95 percent confidence intervals around the estimated coefficients.

*** Statistically significant at the 1% level

Table A1 Cross-country baseline regressions

Dependent Variable: Labour Productivity Growth (5-year MA)	Specification		
	(1)	(2)	(3)
Robot density	0.063*** (0.012)		
E-commerce sales		0.876*** (0.329)	
R&D spending			0.272*** (0.100)
Inward FDI	0.050*** (0.007)	0.020* (0.011)	0.038*** (0.010)
Trade openness	0.003 (0.002)	0.001 (0.003)	0.001 (0.003)
Constant	4.119*** (1.312)	0.621 (0.953)	0.963 (2.676)
Time fixed effects	Yes	Yes	Yes
Country and sector fixed effects	Yes	Yes	Yes
Observations	1,445	324	912
R ²	0.44	0.85	0.47

Note: Standard errors in parentheses.

* Statistically significant at the 10% level

** Statistically significant at the 5% level

*** Statistically significant at the 1% level

Table A2 Robustness check: possible structural change in digitalisation

Dependent Variable: Labour Productivity Growth (5-year MA)	Specification					
	All Years	Post-2015	All Years	Post-2017	All Years	Post-2015
	(1)	(2)	(3)	(4)	(5)	(6)
Robot density	0.063*** (0.012)	0.025** (0.011)				
E-commerce sales			0.876*** (0.329)	0.706* (0.390)		
R&D spending					0.272*** (0.100)	0.327** (0.140)
Inward FDI	0.050*** (0.007)	0.018** (0.009)	0.020* (0.011)	0.025* (0.015)	0.038*** (0.010)	0.005 (0.012)
Trade openness	0.003 (0.002)	-0.002 (0.003)	0.001 (0.003)	0.001 (0.004)	0.001 (0.003)	0.004 (0.005)
Constant	4.119*** (1.312)	1.493** (0.740)	0.621 (0.953)	1.021 (1.136)	0.963 (2.676)	0.965 (1.274)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country and sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,445	348	324	207	912	179
R ²	0.44	0.87	0.85	0.90	0.47	0.89

Note: Standard errors in parentheses.

* Statistically significant at the 10% level

** Statistically significant at the 5% level

*** Statistically significant at the 1% level

Implications of the results for Singapore: Fostering a smarter economic recovery post-pandemic

The results suggest that boosting e-commerce and R&D would support productivity growth and the transformation towards a smarter economy. The analysis highlights that Singapore has room for a significant expansion of e-commerce and R&D, two elements that are associated with higher labour productivity growth. As such, further digitalisation has the potential to boost aggregate productivity growth and presents an opportunity to lift medium-term growth prospects.

Singapore has introduced many initiatives to support digitalisation. For instance, the E-Commerce Booster Package supports retailers through a one-time support to defray 80% of qualifying costs to go online. The SME Go Digital programme supports SMEs' adoption and use of digital technologies through various channels, including foundational digital solutions for new SMEs (Start Digital Pack); guidance on digital solutions and training required for each development stage of a firm (Industry Digital Plan); provision of business-to-business and business-to-consumer e-commerce platforms to help firms reach global markets (Grow Digital); consultancy services to support firms' use of digital technologies (SME Digital Tech Hub); and pre-approved and proven SME-friendly solutions that can be adopted with the support of government grants such as the Productivity Solutions Grant (PSG). Singapore has

also launched programmes to accelerate the scale and speed of digital innovation (Open Innovation Platform).

While this Box focuses on opportunities for productivity growth that may be associated with the digital economy, policies to accelerate the digital transformation and reap its benefits should give due consideration to attendant challenges. These include labour displacement and a possible rise in inequality (Saadi Sedik and Yoo, 2021). This calls for complementary labour market policies, such as skills upgrading and training to address the distributional challenges associated with the digital revolution. Fortunately, Singapore is already at the forefront of designing such policies.

References

Falk, M and Hagsten, E (2015), "E-Commerce Trends and Impacts Across Europe", *UNCTAD Discussion Paper* No. 220.

Graetz, G and Michaels, G (2015), "Robots at Work", *Centre for Economic Performance Discussion Paper* No. 1335.

International Monetary Fund (2018), "The Digital Revolution in Asia: Disruptor or New Growth Engine (or Both)", Chapter 5 in *Regional Economic Outlook: Asia and Pacific, World Economic and Financial Surveys*.

International Monetary Fund (2021), "Singapore—Staff Report for the 2021 Article IV Consultation", *IMF Country Report* No. 21/159.

Kinda, T (2019), "E-commerce as a Potential New Engine for Growth in Asia", *IMF Working Paper* No. 19/135.

Saadi Sedik, T and Yoo, J (2021), "Pandemics and Automation: Will the Lost Jobs Come Back?", *IMF Working Paper* No. 21/11.

World Bank (2016), "World Development Report: Digital Dividends".

Yang, Z, Shi, Y and Yan, H (2017), "Analysis on Pure E-commerce Congestion Effect, Productivity Effect, and Profitability in China", *Socio-Economic Planning Sciences*, Vol. 57, pp. 35–49.