MTI MINISTRY OF TRADE AND INDUSTRY SINGAPORE

ECONOMIC SURVEY OF SINGAPORE

SECOND QUARTER 2026

August 2026

Ministry of Trade and Industry
Republic of Singapore

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CONTENTS

MAIN INDICATORS OF THE SINGAPORE ECONOMY

OVERALL ECONOMY

	1Q26	2Q26
Real Gross Domestic Product (YoY Growth)	+6.3%	+5.9%
Gross Domestic Product at Current Market Prices	$204.6 billion	$216.3 billion

PRICES

	1Q26	2Q26
Consumer Price Index — All Items (YoY Growth)	+1.5%	+1.8%
Domestic Supply Price Index (YoY Growth)	+9.0%	+32.2%

LABOUR MARKET

	1Q26	2Q26
Change in Employment (QoQ Change)	+13.0 thousand	+14.0 thousand
Overall Unemployment Rate	Mar26 2.0%	Jun26 2.0%
Value-Added per Actual Hour Worked (YoY Growth)	+3.7%	+3.9%

COSTS

	1Q26	2Q26
Unit Labour Cost of Overall Economy (YoY Growth)	-1.2%	-0.4%
Unit Business Cost of Manufacturing (YoY Growth)	+1.1%	-2.4%
Unit Labour Cost of Manufacturing (YoY Growth)	-4.1%	-7.9%

MERCHANDISE TRADE

	1Q26	2Q26
Merchandise Exports	$219,641 million +27.9% YoY Growth	$254,358 million +38.5% YoY Growth
Merchandise Imports	$189,522 million +22.9% YoY Growth	$223,520 million +42.2% YoY Growth

SERVICES TRADE

	1Q26	2Q26
Services Exports	$144,122 million +4.7% YoY Growth	$149,800 million +10.2% YoY Growth
Services Imports	$133,159 million +5.9% YoY Growth	$135,474 million +9.6% YoY Growth

CHAPTER

1

THE SINGAPORE ECONOMY

Chapter 1

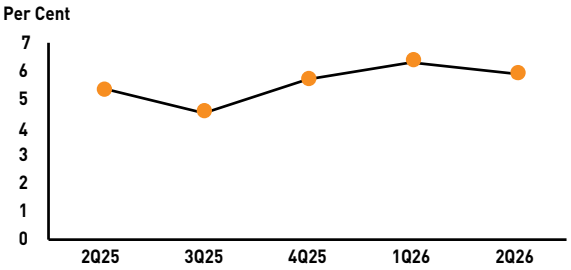
THE SINGAPORE ECONOMY

ECONOMIC PERFORMANCE

Real GDP grew by

5.9% in 2Q26

Quarterly Growth (YoY)



Main Drivers of Growth in 2Q26

Manufacturing

2.1%-point contribution

Wholesale Trade

1.5%-point contribution

LABOUR MARKET

Resident Unemployment Rate

2.9% in June 26

Employment (QoQ Change)

+14,000 employed in 2Q26

Sectors with the Highest Employment Growth in 2Q26

+7,200 employed

Other Services Industries

+7,100 employed

Construction

+2,900 employed

Manufacturing

PRODUCTIVITY

(YoY Growth)

Value-Added per Actual Hour Worked increased by

3.9% in 2Q26

Sectors with the Highest Growth in Value-Added per Actual Hour Worked in 2Q26

15.4%

Wholesale Trade

9.4%

Information & Communications

9.1%

Real Estate

COSTS
(YoY Growth)

Overall Unit Labour Cost decreased by

0.4% in 2Q26

Within the Manufacturing Sector

-2.4%

Unit Business Cost

-7.9%

Unit Labour Cost

PRICES
(YoY Growth)

The Consumer Price Index (CPI) rose by

1.8% in 2Q26

Categories with Largest Price Increases

7.3%

Transport

3.1%

Health

2.1%

Miscellaneous Goods & Services

INTERNATIONAL TRADE
(YoY Growth)

Total Merchandise Exports increased by

38.5% in 2Q26

45.7%

Re-Exports

27.4%

Non-Oil Domestic Exports

25.2%

Oil Domestic Exports

Total Services Exports increased by

10.2% in 2Q26

Services Exports increase was led by...

4.7%-pt

Transport

3.1%-pt

Other Business Services

1.5%-pt

Financial Services

OVERVIEW

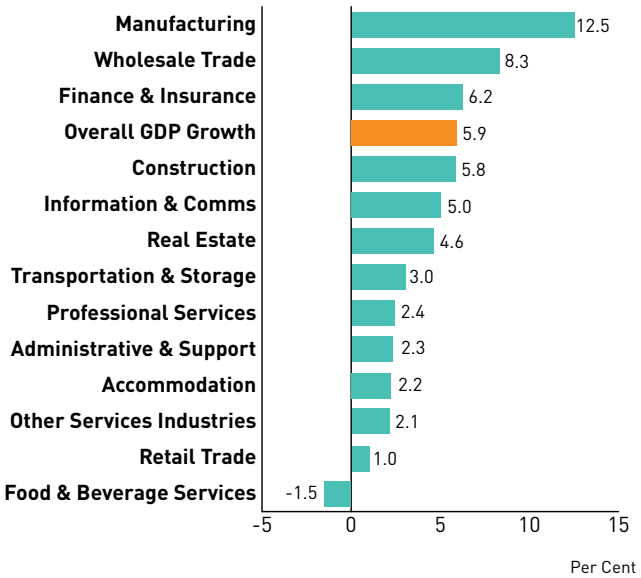
In the second quarter of 2026,

- The Singapore economy grew by 5.9 per cent on a year-on-year basis. The sectors that contributed the most to GDP growth during the quarter were the manufacturing, wholesale trade and finance & insurance sectors.
- The seasonally-adjusted unemployment rates declined slightly for citizens but were unchanged at the overall level and for residents. Meanwhile, the number of retrenchments rose over the same period.
- Total employment rose by 14,000 on a quarter-on-quarter basis, extending the gains in the preceding quarter. Excluding Migrant Domestic Workers (MDWs), total employment increased by 10,700, supported by employment gains for both residents and non-residents.
- The Consumer Price Index-All Items (CPI-All Items) rose by 1.8 per cent year-on-year, picking up from the 1.5 per cent increase in the preceding quarter.

OVERALL PERFORMANCE

The Singapore economy grew by 5.9 per cent on a year-on-year basis in the second quarter of 2026, easing from the 6.3 per cent growth in the previous quarter (Exhibit 1.1). On a quarter-on-quarter seasonally-adjusted basis, the economy expanded by 1.4 per cent, extending the 1.2 per cent growth in the preceding quarter.

Exhibit 1.1: GDP and Sectoral Growth Rates in 2Q 2026



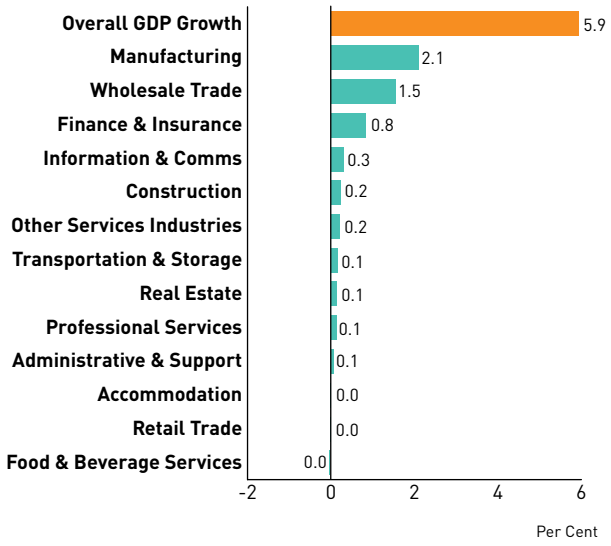
The manufacturing sector expanded by 12.5 per cent year-on-year, accelerating from the 7.3 per cent growth in the previous quarter. Growth in the sector was mainly driven by output expansions in the electronics (33.8 per cent), precision engineering (19.3 per cent) and general manufacturing industries (3.8 per cent) clusters.

The services producing industries grew by 4.9 per cent year-on-year, moderating from the 6.3 per cent growth in the previous quarter. Growth was supported by expansions in all the services sectors except for the food & beverage services sector. Among the services sectors, the wholesale trade (8.3 per cent), finance & insurance (6.2 per cent) and information & communications (5.0 per cent) sectors recorded the strongest growth.

The construction sector grew by 5.8 per cent year-on-year, slower than the 12.9 per cent growth in the previous quarter. Both public and private sector construction output increased during the quarter.

The top three positive contributors to GDP growth in the second quarter were the manufacturing, wholesale trade and finance & insurance sectors (Exhibit 1.2).

Exhibit 1.2: Percentage-Point Contribution to Growth in Real GDP in 2Q 2026 (By Sectors)



SOURCES OF GROWTH

Total demand grew by 13.4 per cent year-on-year in the second quarter of 2026, faster than the 11.9 per cent increase in the preceding quarter (Exhibit 1.3). The growth in total demand was supported by increases in both external and domestic demand during the quarter.

External demand rose by 15.1 per cent year-on-year, extending the 14.7 per cent increase in the previous quarter. Meanwhile, total domestic demand grew at a quicker pace of 8.9 per cent year-on-year, compared to the 4.5 per cent expansion in the preceding quarter.

Within domestic demand, consumption expenditure rose by 3.3 per cent year-on-year, picking up from the 2.4 per cent increase in the preceding quarter. The increase in consumption expenditure was supported by both higher private consumption expenditure (3.5 per cent) and public consumption expenditure (2.9 per cent).

Meanwhile, gross fixed capital formation (GFCF) grew by 8.4 per cent year-on-year, easing from the 9.5 per cent increase in the previous quarter. The increase in GFCF during the quarter was due to increases in both private sector GFCF (9.4 per cent) and public sector GFCF (4.6 per cent). Private sector GFCF rose due to higher investments in private machinery & equipment, construction & works, transport equipment and intellectual property products. Meanwhile, public sector GFCF increased on the back of higher investments in public construction & works, intellectual property products, and machinery & equipment, which more than offset lower investments in public transport equipment.

Exhibit 1.3: Changes in Total Demand*

Per Cent

	2025			2026	
	II	III	IV	I	II
Total Demand	9.4	9.3	9.9	11.9	**13.4**
External Demand	12.3	11.5	12.0	14.7	**15.1**
Total Domestic Demand	1.3	3.2	4.2	4.5	**8.9**
Consumption Expenditure	4.2	3.9	4.6	2.4	**3.3**
Public	6.1	5.4	5.1	-0.4	**2.9**
Private	3.7	3.4	4.5	3.3	**3.5**
Gross Fixed Capital Formation	4.5	4.1	7.4	9.5	**8.4**
Changes in Inventories	-1.8	-0.4	-0.8	-0.1	**2.2**

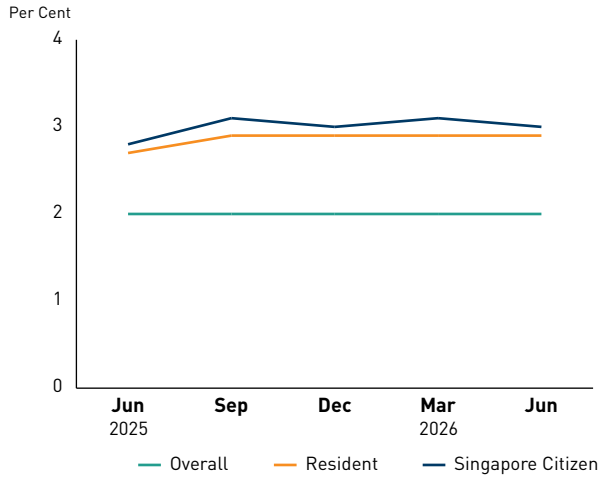
** For inventories, this refers to the contribution to GDP growth.*

LABOUR MARKET

Unemployment and Retrenchment[1]

Compared to March 2026, the seasonally-adjusted unemployment rates in June 2026 remained unchanged at the overall level (at 2.0 per cent) and for residents (at 2.9 per cent), but declined slightly for citizens (to 3.0 per cent from 3.1 per cent) (Exhibit 1.4).

Exhibit 1.4: Unemployment Rate (Seasonally-Adjusted)

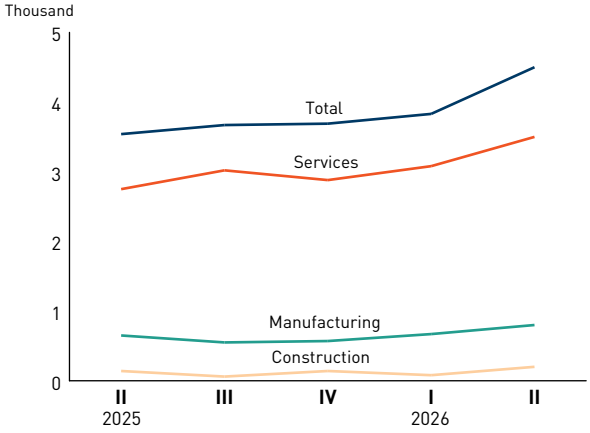


1 *Unemployment and retrenchment figures are based on preliminary data. Retrenchment figures pertain to private sector establishments with at least 25 employees and the public sector.*

In June 2026, an estimated 71,100 residents, including 62,300 Singapore citizens, were unemployed. These were lower than the number of unemployed residents (71,400) and citizens (63,100) in March 2026.[2]

A total of 4,500 workers were laid off in the second quarter of 2026, higher than the 3,830 retrenched in the preceding quarter (Exhibit 1.5). The number of retrenchments increased in the services (from 3,080 to 3,500), manufacturing (from 670 to 800) and construction (from 80 to 200) sectors, with the majority of retrenchments driven by business reorganisation or restructuring.

Exhibit 1.5: Retrenchments



Employment[3]

Total employment expanded by 14,000 on a quarter-on-quarter basis in the second quarter of 2026, extending the gains (+13,000) from the preceding quarter (Exhibit 1.6). Excluding MDWs, total employment rose by 10,700 and was supported by increases in both resident and non-resident employment.

Employment expanded across all broad sectors, with the strongest gains in the construction sector (+7,100), followed by the manufacturing (+2,900) and services (+4,400; +1,100 excluding MDWs) sectors. Employment growth in the services sector was supported by gains in the other services industries (+7,200; +3,900 excluding MDWs), as well as the transportation & storage (+2,200) and financial & insurance services (+1,400) sectors (Exhibit 1.7).

Exhibit 1.6: Change in Total Employment, Quarter-on-Quarter

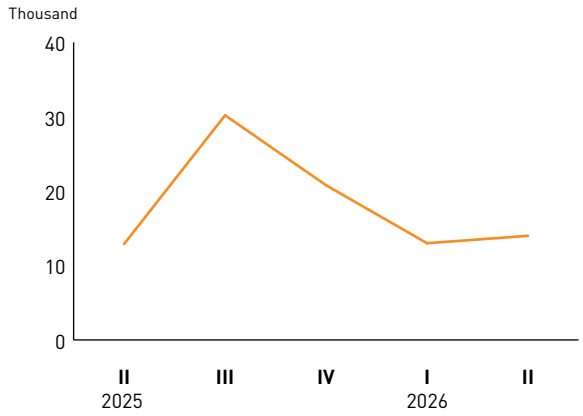
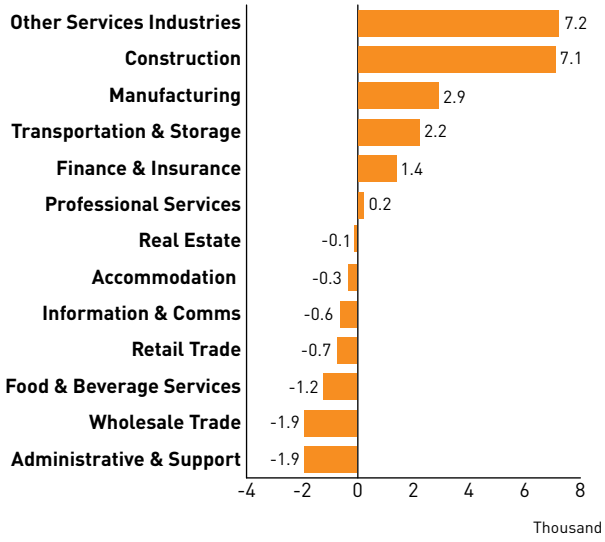


Exhibit 1.7: Changes in Employment by Sector in 2Q 2026



2 *Counts of unemployed persons are based on seasonally-adjusted data on the number of unemployed persons.*
3 *Employment figures are based on preliminary data.*

Hiring Expectations

According to the Economic Development Board's (EDB) Business Expectations Survey for the Manufacturing Sector conducted from June to July 2026, hiring expectations in the sector were positive. Specifically, a net weighted balance of 14 per cent of manufacturers expected to hire more workers in the third quarter of 2026 as compared to the second quarter. Firms in the semiconductors segment of the electronics cluster were the most optimistic, with a net weighted balance of 68 per cent of firms expecting to increase hiring in the third quarter. By contrast, firms in the pharmaceuticals segment of the biomedical manufacturing cluster were the most pessimistic, with a net weighted balance of 42 per cent of firms expecting to reduce hiring in the third quarter.

Similarly, hiring expectations for services firms were positive. According to the Department of Statistics' latest Business Expectations Survey for the Services Sector that was conducted over the same period, a net weighted balance of 10 per cent of services firms expected to increase hiring in the third quarter of 2026 as compared to the second quarter. Among the services sectors, firms in the administrative & support services sector had the strongest hiring sentiments, with a net weighted balance of 23 per cent of firms expecting to increase hiring in the third quarter. By contrast, firms in the information & communications sector were the least optimistic, with a net weighted balance of 0 per cent of firms expecting to increase hiring in the third quarter.

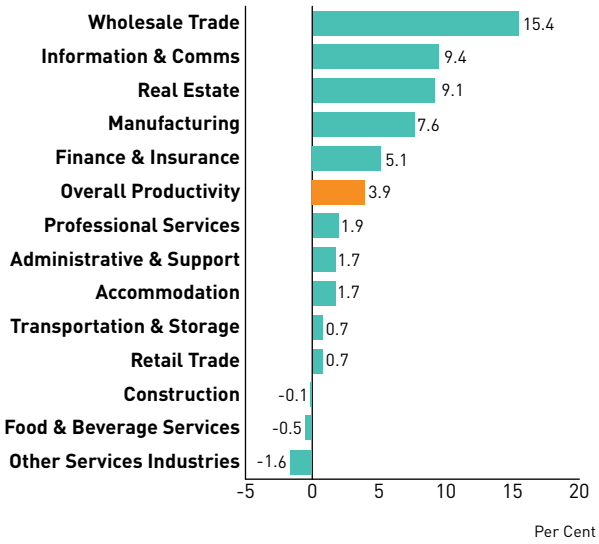
COMPETITIVENESS

Productivity

Overall labour productivity, as measured by real value-added per actual hour worked, rose by 3.9 per cent year-on-year in the second quarter of 2026, following the 3.7 per cent increase in the previous quarter (Exhibit 1.8).[4]

Among the sectors, the wholesale trade (15.4 per cent) sector recorded the strongest productivity growth in the second quarter. Other sectors that saw healthy productivity improvements include information & communications (9.4 per cent), real estate (9.1 per cent), manufacturing (7.6 per cent), and finance & insurance (5.1 per cent). By contrast, productivity fell in the other services industries (-1.6 per cent), as well as the food & beverage services (-0.5 per cent) and construction (-0.1 per cent) sectors.

Exhibit 1.8: Changes in Value-Added per Actual Hour Worked for the Overall Economy and Sectors in 2Q 2026



In the second quarter, labour productivity for the outward-oriented sectors as a whole rose by 6.9 per cent year-on-year, higher than the 6.1 per cent increase in the previous quarter.[5] Meanwhile, labour productivity for the domestically-oriented sectors as a whole fell by 0.1 per cent year-on-year, a reversal from the 1.2 per cent increase in the preceding quarter.

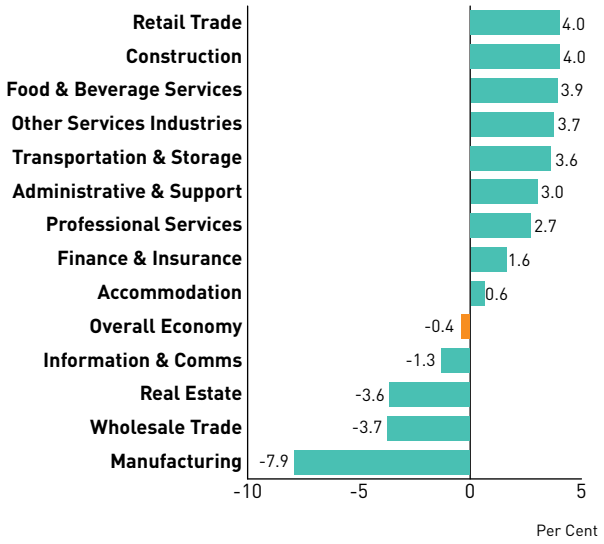
4 *Overall labour productivity, as measured by real value-added per worker, grew by 3.9 per cent in the second quarter of 2026, moderating from the 4.3 per cent increase in the preceding quarter. Real value-added per actual hour worked grew at the same rate as real value-added per worker in the second quarter of 2026, as the average number of hours worked per worker remained unchanged from the previous quarter (0.0 per cent).*

5 *Outward-oriented sectors refer to the manufacturing, wholesale trade, transportation & storage, accommodation, information & communications, finance & insurance and professional services sectors. Domestically-oriented sectors refer to the construction, retail trade, food & beverage services, real estate, administrative & support services and other services sectors.*

Unit Labour Cost and Unit Business Cost

Overall unit labour cost (ULC) for the economy fell by 0.4 per cent on a year-on-year basis in the second quarter of 2026 (Exhibit 1.9), continuing the 1.2 per cent decrease in the previous quarter. The fall in overall ULC during the quarter was due to growth in labour productivity, as measured by real value added per worker, which outstripped the increase in total labour cost per worker.

Exhibit 1.9: Changes in Unit Labour Cost in 2Q 2026



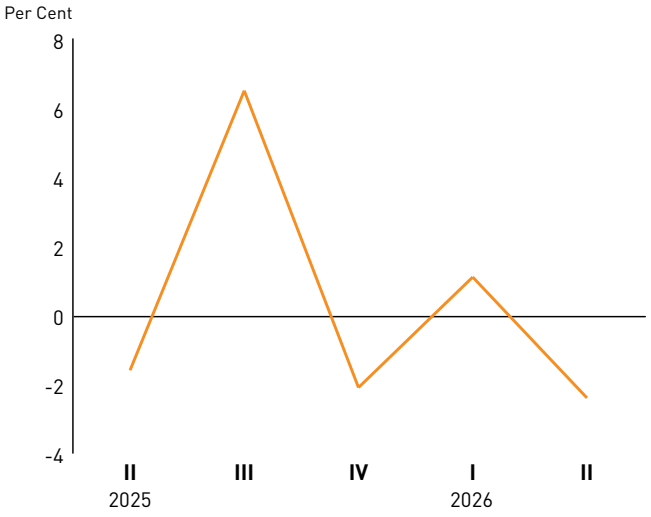
By sectors, the ULC for the construction sector was 4.0 per cent higher year-on-year in the second quarter due to a rise in total labour cost per worker alongside a decline in labour productivity.

The ULC for the services sector as a whole rose by 0.6 per cent year-on-year. Among the services sectors, the largest increase in ULC was in the retail trade sector (4.0 per cent), where an increase in total labour cost per worker occurred alongside a fall in labour productivity. By contrast, the largest decline in ULC was in the wholesale trade sector (-3.7 per cent), as its labour productivity grew faster than the increase in total labour cost per worker.

Over the same period, the ULC for the manufacturing sector fell by 7.9 per cent year-on-year. The decline was due to an improvement in labour productivity that exceeded the increase in total labour cost per worker.

Manufacturing unit business cost (UBC) fell by 2.4 per cent year-on-year in the second quarter, reversing the growth of 1.1 per cent in the previous quarter (Exhibit 1.10). The fall in manufacturing UBC came on the back of decreases in the sector's unit labour costs (-7.9 per cent) and unit services costs (-0.8 per cent), which together outweighed the impact of the increase in unit non-labour production taxes (17.1 per cent).

Exhibit 1.10: Changes in the Manufacturing Unit Business Cost

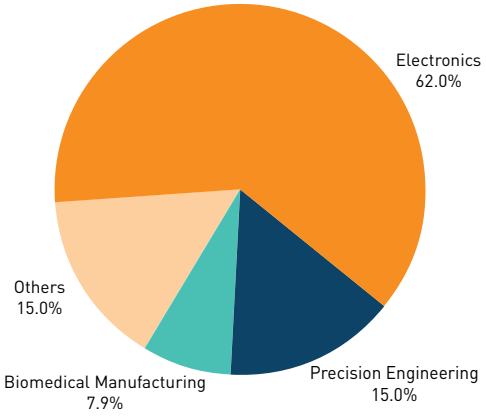


Investment Commitments

Investment commitments garnered by EDB in terms of Fixed Asset Investments (FAI) and Total Business Expenditure (TBE) amounted to $5.4 billion and $1.5 billion respectively in the second quarter of 2026 (Exhibit 1.11 and Exhibit 1.12).

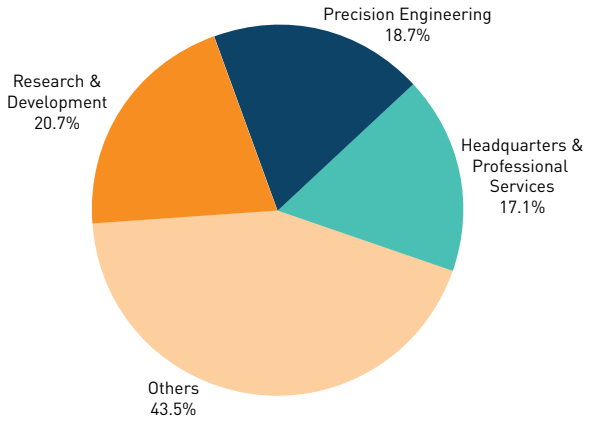
For FAI, the largest contribution came from the manufacturing sector, which attracted $5.0 billion worth of commitments. Of this, the electronics cluster accounted for $3.3 billion worth of commitments in the second quarter. Meanwhile, the services sector garnered $355 million worth of commitments. Investors from the United States contributed the most to total FAI, at $4.3 billion (or 80.4 per cent).

Exhibit 1.11: Fixed Asset Investments by Industry Cluster in 2Q 2026



For TBE, the services sector attracted the highest amount of commitments, at $850 million. Within the sector, the research & development cluster garnered the most TBE commitments, at $300 million. Among the manufacturing clusters, the precision engineering and transport engineering clusters attracted the largest amounts of TBE commitments, at $271 million and $214 million respectively. Investors from the United States were the largest source of TBE commitments, with commitments of $578 million (or 39.8 per cent).

Exhibit 1.12: Total Business Expenditure by Industry Cluster in 2Q 2026



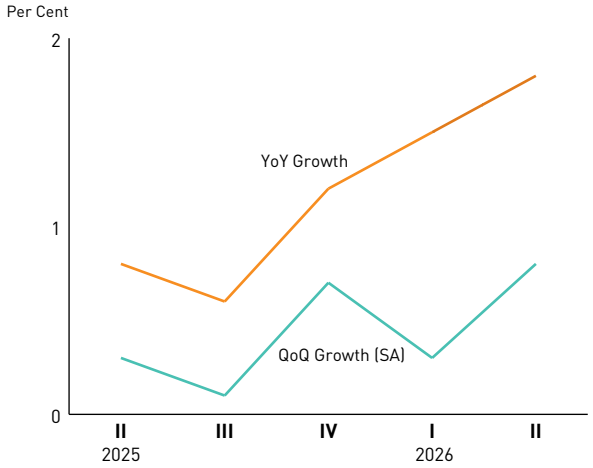
When these projects are fully implemented, they are expected to generate $8.2 billion of value-added and create more than 4,700 jobs in the coming years.

PRICES

Consumer Price Index

The Consumer Price Index-All Items (CPI-All Items) rose by 1.8 per cent on a year-on-year basis in the second quarter of 2026, up from the 1.5 per cent increase in the preceding quarter (Exhibit 1.13). On a quarter-on-quarter seasonally-adjusted basis, CPI-All Items inflation was 0.8 per cent, higher than the 0.3 per cent in the preceding quarter.

Exhibit 1.13: Changes in CPI



Some CPI categories saw price increases on a year-on-year basis in the second quarter of 2026, thus contributing positively to CPI-All Items inflation during the quarter (Exhibit 1.14). Food prices rose by 1.9 per cent due to an increase in the costs of food & beverage serving services such as hawker food and restaurant meals, as well as non-cooked food items such as fish & other seafood. Clothing & footwear prices increased by 0.7 per cent, mainly due to more expensive footwear. Housing & utilities costs edged up 0.3 per cent because of higher accommodation costs. Prices of household durables & services rose by 1.1 per cent on the back of more expensive furniture & furnishings and household services & supplies. Health costs rose by 3.1 per cent as the costs of health insurance and inpatient care services increased. Transport prices climbed by 7.3 per cent due to higher car and petrol prices, as well as an increase in the costs of point-to-point transport services and bus & train fares. Recreation, sport & culture prices increased by 1.3 per cent because of more expensive recreational services and holiday travel. Prices of miscellaneous goods & services rose by 2.1 per cent as a result of price increases for tobacco and personal care items.

By contrast, there were price declines on a year-on-year basis in the following categories. Information & communication costs declined by 2.2 per cent due to cheaper information & communication services. Education costs fell by 0.8 per cent due to enhancements in MOE's Financial Assistance Scheme, as well as lower fee caps at preschools from January 2026 onwards.

Exhibit 1.14: Percentage Changes in CPI over Corresponding Quarter of Previous Year

Per Cent

	2025			2026	
	II	III	IV	I	II
All items	0.8	0.6	1.2	1.5	**1.8**
Food	1.2	1.1	1.2	1.4	**1.9**
Clothing & Footwear	-1.6	-0.8	-0.1	-0.1	**0.7**
Housing & Utilities	1.0	0.3	0.2	0.7	**0.3**
Housing Durables & Services	-0.4	-0.5	-0.2	0.3	**1.1**
Health	2.7	2.0	4.2	4.2	**3.1**
Transport	1.9	2.6	3.4	3.7	**7.3**
Information & Communication	-2.1	-2.4	-2.1	-1.0	**-2.2**
Recreation & Culture	-1.9	-2.1	0.6	1.4	**1.3**
Education	0.5	0.8	1.1	-0.7	**-0.8**
Miscellaneous Goods & Services	-0.3	-0.4	0.2	0.8	**2.1**

INTERNATIONAL TRADE

Merchandise Trade

Singapore's total merchandise trade expanded by 40.2 per cent on a year-on-year basis in the second quarter of 2026, following the 25.5 per cent increase in the preceding quarter (Exhibit 1.15). The increase in total merchandise trade was supported by the growth in both oil trade (+47.4 per cent) and non-oil trade (+39.0 per cent).

Exhibit 1.15: Growth Rates of Total Merchandise Trade, Merchandise Exports and Merchandise Imports (In Nominal Terms)

Per Cent

	2025				2026	
	II	III	IV	ANN	I	II
Merchandise Trade	6.8	8.4	14.5	8.7	25.5	**40.2**
Merchandise Exports	11.6	8.2	15.0	9.6	27.9	**38.5**
Domestic Exports	-4.3	-4.5	8.5	-0.7	2.7	**26.6**
Oil	-19.6	-6.4	1.0	-9.2	-8.3	**25.2**
Non-Oil	7.0	-3.4	12.7	4.8	9.6	**27.4**
Re-Exports	24.1	17.6	19.2	17.2	45.6	**45.7**
Merchandise Imports	1.8	8.6	14.1	7.7	22.9	**42.2**
Oil	-20.3	-4.7	-19.7	-13.3	-7.1	**44.0**
Non-Oil	7.4	11.6	21.4	12.7	29.5	**41.9**

Total merchandise exports expanded by 38.5 per cent in the second quarter, faster than the 27.9 per cent increase in the preceding quarter. This was due to the increase in both domestic exports (+26.6 per cent) and re-exports (+45.7 per cent).

The growth in domestic exports was due to the increase in both oil and non-oil domestic exports (NODX). In particular, oil domestic exports expanded by 25.2 per cent. In volume terms, oil domestic exports contracted by 21.5 per cent.

Meanwhile, NODX grew by 27.4 per cent in the second quarter, accelerating from the 9.6 per cent growth in the previous quarter. The growth in NODX was due to the increase in both electronics and non-electronics domestic exports.

Total merchandise imports rose by 42.2 per cent in the second quarter, picking up from the 22.9 per cent growth in the previous quarter. The growth in imports was due to the increase in both oil and non-oil imports. Specifically, oil imports expanded by 44.0 per cent, while non-oil imports grew by 41.9 per cent due to higher electronics and non-electronics imports.

Services Trade

Total services trade expanded by 9.9 per cent on a year-on-year basis in the second quarter, faster than the 5.3 per cent growth in the previous quarter (Exhibit 1.16). Both the exports and imports of services saw positive year-on-year growth during the quarter.

Services exports rose by 10.2 per cent in the second quarter, up from the 4.7 per cent growth in the preceding quarter. The growth in services exports was largely attributable to the increase in exports of transport services, other business services and financial services. Meanwhile, services imports rose 9.6 per cent, higher than the 5.9 per cent growth in the previous quarter. The growth in services imports was largely due to higher imports of transport services, other business services and telecommunications, computer & information services.

Exhibit 1.16: Growth Rates of Total Services Trade, Services Exports and Services Imports (In Nominal Terms)

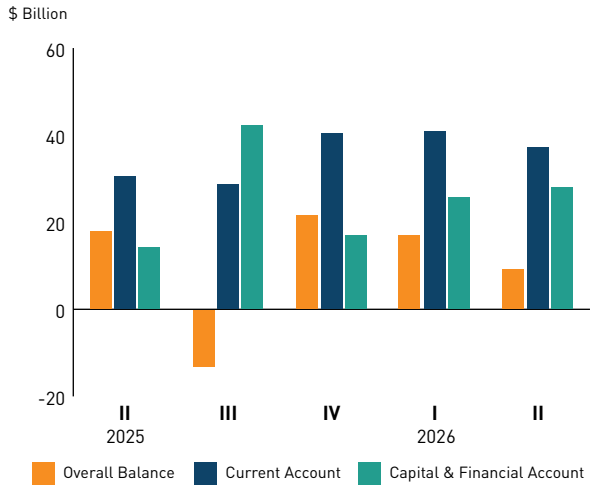
Per Cent

	2025				2026	
	II	III	IV	ANN	I	II
Total Services Trade	3.1	2.0	2.2	3.3	5.3	**9.9**
Services Exports	3.5	2.4	2.3	3.5	4.7	**10.2**
Services Imports	2.8	1.7	2.1	3.2	5.9	**9.6**

BALANCE OF PAYMENTS

Singapore recorded an overall balance of payments surplus of $9.0 billion in the second quarter of 2026, narrowing from the surplus of $16.9 billion in the preceding quarter (Exhibit 1.17).

Exhibit 1.17: Balance of Payments



Current Account

The current account surplus decreased by $3.7 billion to $37.1 billion in the second quarter of 2026, from $40.8 billion in the preceding quarter. The decrease was driven by a widening of the primary income account deficit, which more than offset widening surpluses in the goods and services accounts as well as a narrowing of the secondary income account deficit.

In terms of the components of the current account, the surplus in the goods account widened to $70.4 billion in the second quarter, from $59.0 billion in the preceding quarter, as goods exports rose by more than goods imports.

At the same time, the surplus in the services account widened by $3.4 billion to $14.3 billion in the second quarter. This was largely due to an increase in net receipts for other business services and transport services, which outweighed the rise in net payments for travel services and telecommunications, computer and information services. Meanwhile, the primary income account deficit widened by $19.7 billion to $44.8 billion in the second quarter, as primary income receipts fell while primary income payments rose.

By contrast, the secondary income account deficit narrowed by $1.3 billion to $2.9 billion in the second quarter, as secondary income receipts rose more than secondary income payments.

Capital and Financial Account[6]

The capital and financial account registered a larger net outflow of $27.9 billion in the second quarter of 2026, compared to a net outflow of $25.7 billion in the preceding quarter. This was mainly driven by the reversal of "other investment" from a net inflow position to a net outflow position, which outweighed increased net inflows of direct investment, decreased net outflows of portfolio investment, as well as the switch from net outflows to net inflows for financial derivatives.

"Other investment" recorded a net outflow of $5.1 billion in the second quarter, a reversal from the net inflow of $9.0 billion in the preceding quarter. This shift was driven mainly by the non-bank private sector, which switched from a net inflow position to a net outflow position.

Meanwhile, net inflows of direct investment increased to $16.7 billion in the second quarter, from $14.0 billion in the preceding quarter, as foreign direct investments into Singapore rose by more than the increase in residents' direct investment abroad.

At the same time, financial derivatives switched from a net outflow of $1.7 billion in the first quarter to a net inflow of $2.1 billion in the second quarter.

Net outflows of portfolio investment declined to $41.5 billion in the second quarter, from $47.0 billion in the preceding quarter, on account of reduced net outflows by resident deposit-taking corporations, which more than offset the switch from net inflows to net outflows in the non-bank private sector.

6 *Net inflows in net balances are indicated by a minus (-) sign. For more details regarding the change in sign convention to the financial account, please refer to DOS's information paper on "Singapore's International Accounts: Methodological Updates and Recent Developments".*

CHAPTER

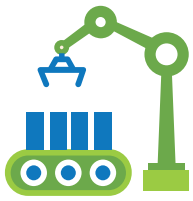
2

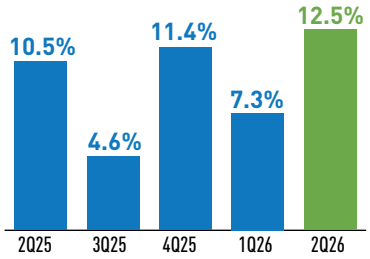
SECTORAL PERFORMANCE

Chapter 2

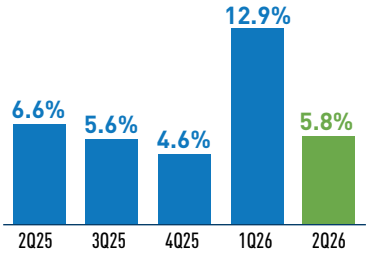
SECTORAL PERFORMANCE

MANUFACTURING
(YoY Growth)





CONSTRUCTION
(YoY Growth)



CLUSTERS IN MANUFACTURING SECTOR
(YoY Growth)

33.8%
Electronics

19.3%
Precision Engineering

3.8%
General Manufacturing Industries

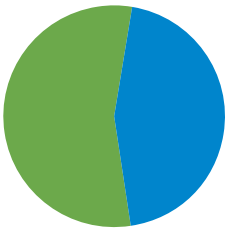
3.3%
Transport Engineering

-13.5%
Chemicals

-17.3%
Biomedical Manufacturing

CERTIFIED PAYMENTS
(% Share)

55.0%
Public



45.0%
Private

CONTRACTS AWARDED
(YoY Growth)

2,122.9%

Industrial

54.1%

Commercial

-5.6%

Residential

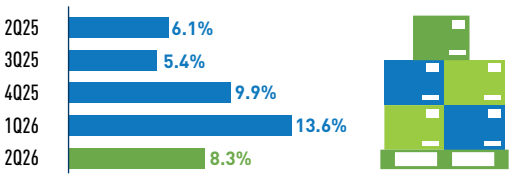
-36.6%

Institutional & Others

-54.8%

Civil Engineering

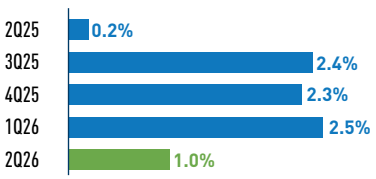
WHOLESALE TRADE
(YoY Growth)



Real Non-Oil Re-Exports Growth
34.2%

Real Non-Oil Domestic Exports Growth
21.3%

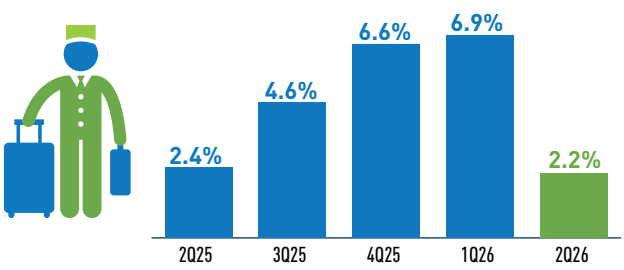
RETAIL TRADE
(YoY Growth)



Retail Sales Index Growth (Non-Motor Vehicles, Parts & Accessories)
1.5%

Retail Sales Index Growth (Motor Vehicles, Parts & Accessories)
0.3%

ACCOMMODATION
(YoY Growth)



OCCUPANCY RATES OF HOTELS
(YoY Change)

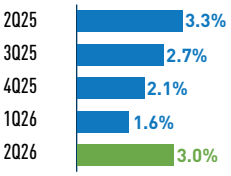
Luxury
-0.9%-pt

Upscale
2.3%-pt

Mid-Tier
-0.8%-pt

Economy
-4.1%-pt

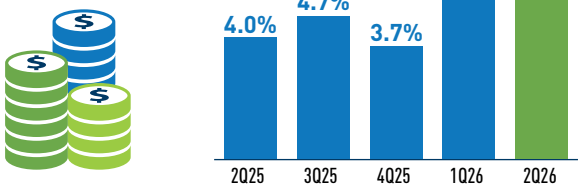
TRANSPORTATION & STORAGE
(YoY Growth)



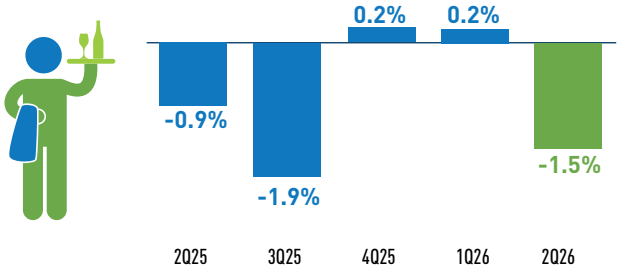
Total Sea Cargo Handled Growth -0.9%

Air Passengers Handled Growth -1.5%

FINANCE & INSURANCE
(YoY Growth)



FOOD & BEVERAGE SERVICES
(YoY Growth)



FOOD & BEVERAGE SALES INDEX GROWTH
(YoY Growth)

Food Caterers
2.4%

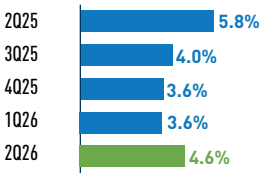
Fast Food Outlets
0.2%

Restaurants
-0.8%

Cafes
-1.9%

Others
-6.7%

REAL ESTATE
(YoY Growth)



PRIVATE RESIDENTIAL REAL ESTATE

Units Transacted (YoY Growth) 19.9%

Certified Payments (YoY Growth) 6.5%

OVERVIEW

In the second quarter of 2026,

- The manufacturing sector expanded by 12.5 per cent on a year-on-year basis in the second quarter of 2026, extending the 7.3 per cent growth in the previous quarter. Growth was largely led by the electronics and precision engineering clusters.
- The construction sector grew by 5.8 per cent year-on-year in the second quarter of 2026, after the 12.9 per cent growth in the previous quarter.
- The wholesale trade sector expanded by 8.3 per cent year-on-year, moderating from the 13.6 per cent growth recorded in the previous quarter.
- The retail trade sector grew by 1.0 per cent year-on-year in the second quarter of 2026, slower than the 2.5 per cent expansion in the previous quarter.
- The transportation & storage sector grew by 3.0 per cent year-on-year in the second quarter of 2026, extending the 1.6 per cent growth in the previous quarter.
- The accommodation sector grew by 2.2 per cent year-on-year in the second quarter of 2026, lower than the 6.9 per cent growth in the preceding quarter.
- The food & beverage services sector contracted by 1.5 per cent year-on-year in the second quarter of 2026, reversing the 0.2 per cent growth in the previous quarter.
- The finance & insurance sector expanded by 6.2 per cent year-on-year, stronger than the 5.3 per cent growth in the preceding quarter.
- The real estate sector expanded by 4.6 per cent year-on-year, following the 3.6 per cent growth in the previous quarter.
- The professional services sector grew by 2.4 per cent year-on-year, following the 2.7 per cent expansion in the previous quarter.

MANUFACTURING

The manufacturing sector expanded by 12.5 per cent on a year-on-year basis in the second quarter of 2026, extending the 7.3 per cent growth in the previous quarter (Exhibit 2.1). Growth was largely led by the electronics and precision engineering clusters (Exhibit 2.2).

Exhibit 2.1: Manufacturing Sector's Growth Rate

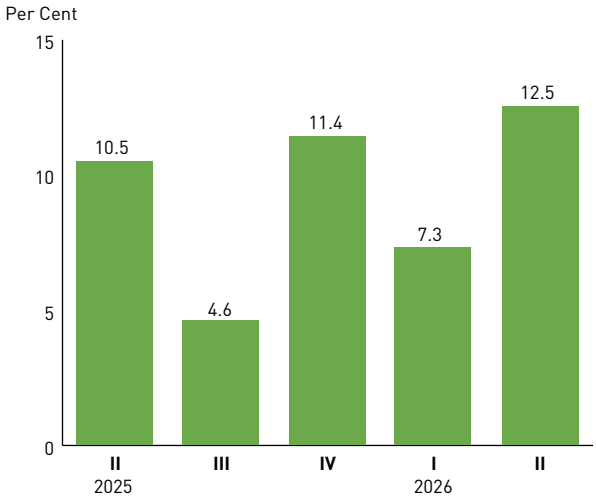
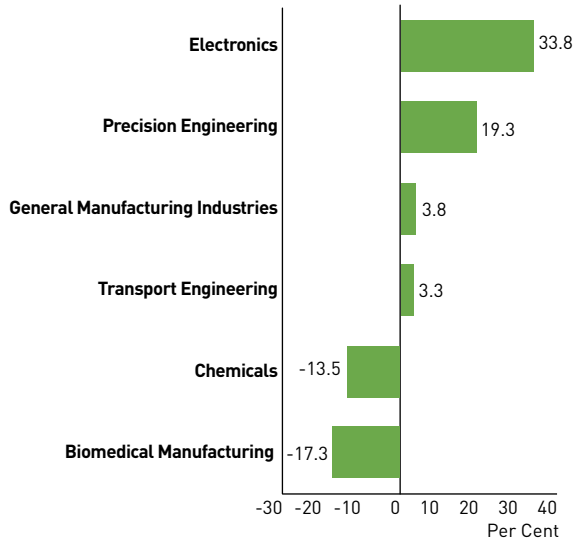


Exhibit 2.2: Manufacturing Clusters' Growth Rates in 2Q 2026



The electronics cluster expanded by 33.8 per cent year-on-year in the second quarter, supported by output increases across all segments except the computer peripherals & data storage segment. The infocomms & consumer electronics and semiconductors segments posted robust growth rates of 51.8 per cent and 35.7 per cent respectively on the back of strong AI-related demand. Output of the other electronic modules & components segment also increased, by 12.4 per cent. In contrast, the computer peripherals & data storage segment contracted by 8.7 per cent.

The precision engineering cluster grew by 19.3 per cent year-on-year in the second quarter. Within this cluster, the machinery & systems segment expanded by 21.4 per cent, on account of higher production of semiconductor equipment. Output of the precision modules & components segment increased by 10.2 per cent, supported by higher production of optical instruments, electronic connectors, metal precision components and dies, moulds, tools, jigs & fixtures.

The general manufacturing cluster grew by 3.8 per cent year-on-year in the second quarter, driven by growth in the miscellaneous industries segment. Output of the miscellaneous industries segment increased by 14.4 per cent, supported by higher production of structural metal products. On the other hand, the food, beverages & tobacco and printing segments contracted by 0.4 per cent and 3.1 per cent respectively.

The transport engineering cluster grew by 3.3 per cent year-on-year in the second quarter. Output of the land and aerospace segments increased by 19.5 per cent and 6.8 per cent respectively, with the latter bolstered by higher production of aircraft parts and sustained maintenance, repair and overhaul (MRO) jobs from commercial airlines. Conversely, the marine & offshore engineering segment contracted by 6.4 per cent on account of a lower production of oilfield and gasfield equipment.

Output of the chemicals cluster contracted by 13.5 per cent year-on-year in the second quarter, weighed down by declines in both the petrochemicals (-45.8 per cent) and petroleum (-17.3 per cent) segments amidst disruptions to feedstock supply. Conversely, output of the other chemicals segment increased by 15.9 per cent with a higher production of fragrances, while the specialties segment grew by 1.3 per cent on account of a higher production of food additives and electronic chemicals, materials & laminates.

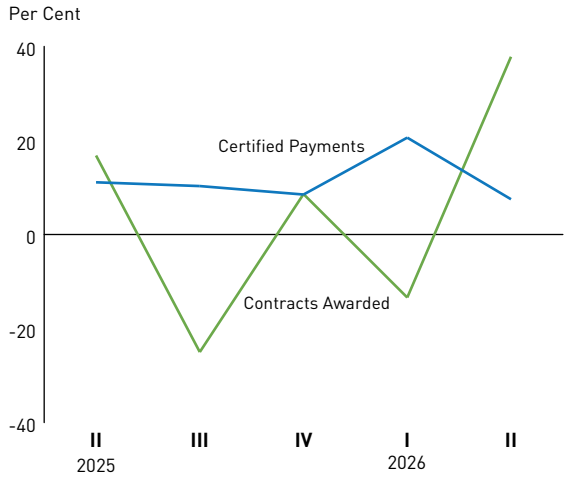
The biomedical manufacturing cluster contracted by 17.3 per cent year-on-year in the second quarter. The pharmaceutical segment contracted by 37.8 per cent due to a lower production of biologics and a different mix of active pharmaceutical ingredients being produced. Output of the medical technology segment declined by 9.5 per cent due to softer demand for medical devices.

CONSTRUCTION

The construction sector grew by 5.8 per cent year-on-year in the second quarter of 2026, after the 12.9 per cent growth in the previous quarter.

In the second quarter, nominal certified progress payments, a proxy for construction output, increased by 7.5 per cent year-on-year, following the 20.6 per cent surge in the previous quarter (Exhibit 2.3). The increase in certified progress payments was supported by both public (6.8 per cent) and private (8.4 per cent) sector construction works. The increase in public certified progress payments came from public residential (10.3 per cent) and institutional & others (9.4 per cent) building works. Meanwhile, the increase in private certified progress payments reflected growth in private commercial (27.5 per cent) and residential (6.5 per cent) building works.

Exhibit 2.3: Changes in Contracts Awarded and Certified Payments

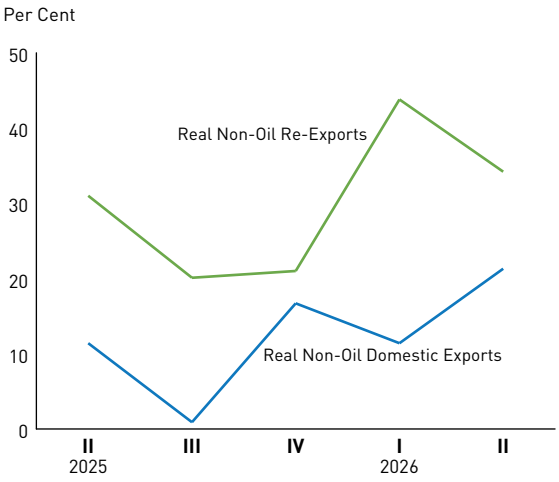


Construction demand in terms of contracts awarded increased significantly by 37.8 per cent year-on-year in the second quarter, reversing the 13.4 per cent contraction in the previous quarter (Exhibit 2.3). The rise in contracts awarded was boosted by strong construction demand in the private sector (119 per cent), which outweighed a fall in public sector construction demand (-20.5 per cent). Private sector construction demand was driven by large increases in contracts awarded for private industrial (2,307 per cent) and commercial (457 per cent) building works. In contrast, the fall in public sector construction demand was led by declines in contracts awarded for public institutional & others (-61.7 per cent) and commercial (-90.3 per cent) building works.

WHOLESALE TRADE

The wholesale trade sector expanded by 8.3 per cent year-on-year in the second quarter of 2026, moderating from the 13.6 per cent growth in the previous quarter. Growth in the sector was led by expansions in non-oil re-export (NORX) and non-oil domestic export (NODX) volumes. In particular, NORX volumes increased by 34.2 per cent year-on-year in the second quarter, following the 43.8 per cent growth in the previous quarter (Exhibit 2.4). This was led by a strong growth in the re-exports of machinery and equipment. Meanwhile, NODX volumes grew by 21.3 per cent during the quarter, picking up from the 11.4 per cent expansion posted in the previous quarter, on the back of a continued increase in domestic exports of machinery and equipment.

Exhibit 2.4: Changes in Real Non-Oil Domestic Exports and Real Non-Oil Re-Exports

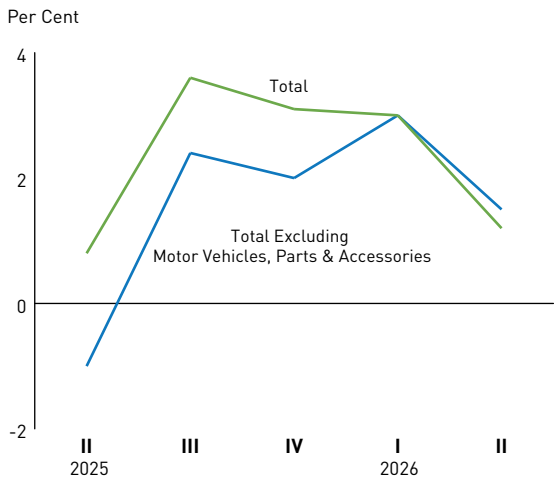


RETAIL TRADE

The retail trade sector grew by 1.0 per cent year-on-year in the second quarter of 2026, slower than the 2.5 per cent growth in the previous quarter.

In the second quarter, overall retail sales volume rose by 1.2 per cent year-on-year, compared to the 3.0 per cent growth in the preceding quarter (Exhibit 2.5). The increase in overall retail sales volume in the second quarter of 2026 was supported by growth in both non-motor vehicle sales (1.5 per cent) and motor vehicle sales (0.3 per cent). Non-motor vehicle sales volume was mainly driven by the wearing apparel & footwear (0.9 per cent) and furniture & household equipment (1.0 per cent) segments. By contrast, sales volumes of petrol service stations (-7.5 per cent) and food & alcohol (-4.8 per cent) shrank.

Exhibit 2.5: Changes in Retail Sales Index in Chained Volume Terms

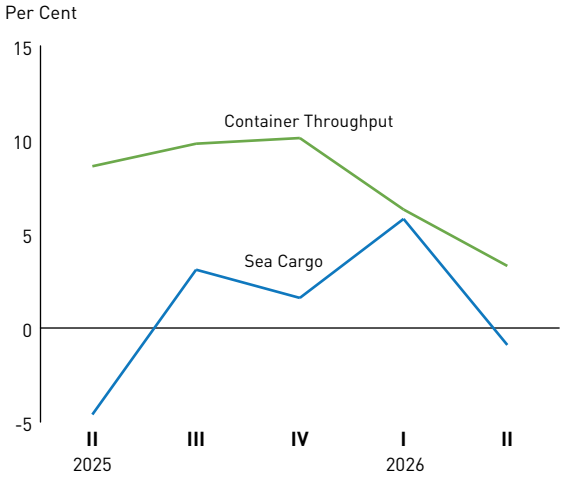


TRANSPORTATION & STORAGE

The transportation & storage sector grew by 3.0 per cent year-on-year in the second quarter of 2026, extending the 1.6 per cent growth in the previous quarter, as the water transport and air transport segments grew.

In the water transport segment, container throughput increased by 3.3 per cent year-on-year in the second quarter, moderating from the 6.3 per cent growth posted in the previous quarter (Exhibit 2.6). Meanwhile, total sea cargo volume handled at our ports declined over the same period (-0.9 per cent), which came on the back of a contraction in oil-in-bulk cargo volumes (-8.4 per cent).

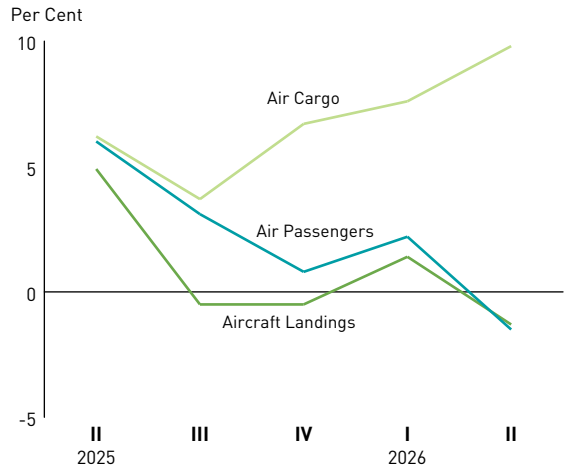
Exhibit 2.6: Changes in Container Throughput and Sea Cargo Handled



In the air transport segment, total air cargo shipments handled at Changi Airport rose by 9.8 per cent in the second quarter, extending the 7.6 per cent expansion in the previous quarter (Exhibit 2.7).

On the other hand, the volume of air passenger traffic (less transit) handled at Changi Airport fell by 1.5 per cent year-on-year in the second quarter, reversing the 2.2 per cent growth posted in the previous quarter. The number of aircraft landings also fell by 1.3 per cent year-on-year to reach 46,183 in the second quarter of 2026, reversing the 1.4 per cent growth in the preceding quarter.

Exhibit 2.7: Changes in Air Passengers Handled, Aircraft Landings and Air Cargo Shipments

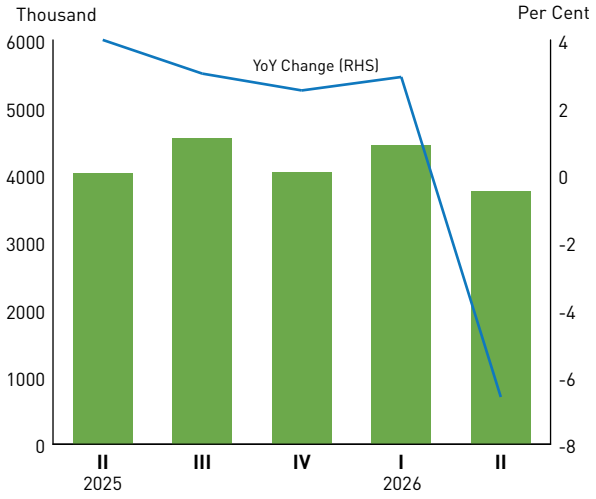


ACCOMMODATION

The accommodation sector grew by 2.2 per cent year-on-year in the second quarter of 2026, lower than the 6.9 per cent growth in the preceding quarter.

In the second quarter, total visitor arrivals contracted by 6.6 per cent year-on-year, reversing the 2.9 per cent growth in the previous quarter (Exhibit 2.8). The number of visitor arrivals in the second quarter of 2026 was around 3.8 million.

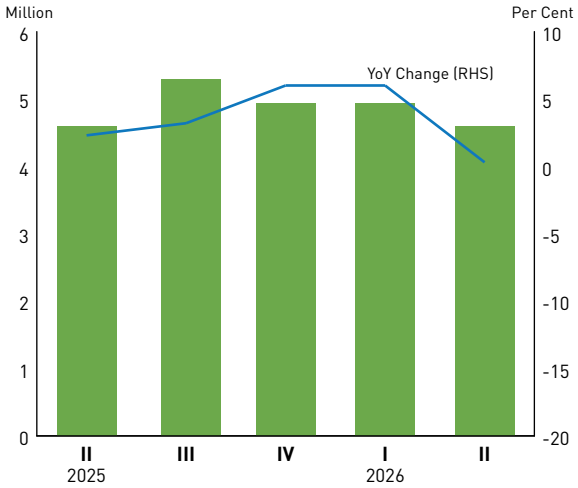
Exhibit 2.8: Visitor Arrivals



Gross lettings at gazetted hotels grew marginally by 0.3 per cent year-on-year in the second quarter, slowing from the 6.0 per cent growth in the previous quarter (Exhibit 2.9). Growth was supported by increases in gross lettings across the luxury (4.9 per cent), upscale (2.9 per cent) and mid-tier (2.0 per cent) segments, which helped to offset a 6.3 per cent contraction in the economy segment.

Reflecting the decline in international visitor arrivals, the average occupancy rate of gazetted hotels fell by 1.1 percentage-points year-on-year to 76.7 per cent in the second quarter of 2026. This was also a decline from the 82.9 per cent recorded in the previous quarter.

Exhibit 2.9: Gross Lettings at Gazetted Hotels

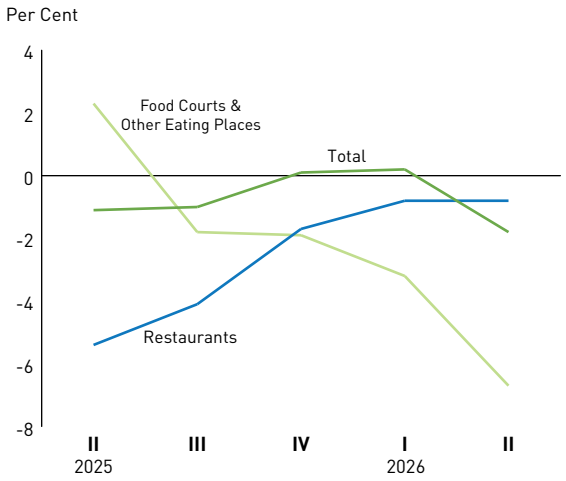


FOOD & BEVERAGE SERVICES

The food & beverage services sector contracted by 1.5 per cent year-on-year in the second quarter of 2026, reversing the 0.2 per cent growth in the previous quarter.

Overall food & beverage sales volume contracted by 1.8 per cent year-on-year in the second quarter, in contrast to the 0.2 per cent expansion in the previous quarter (Exhibit 2.10). This contraction was due to the decline in sales volumes of the food courts & other eating places (-6.7 per cent), cafes (-1.9 per cent) and restaurants (-0.8 per cent) segments, which more than offset the increase in sales volumes of the food caterers (2.4 per cent) and fast food outlets (0.2 per cent) segments.

Exhibit 2.10: Changes in Food & Beverage Services Index in Chained Volume Terms



FINANCE & INSURANCE

The finance & insurance sector expanded by 6.2 per cent year-on-year in the second quarter of 2026, stronger than the 5.3 per cent growth in the preceding quarter.

Growth during the second quarter was mainly driven by the banking segment amid strong credit growth. Overall loans grew by 11.8 per cent year-on-year. Domestic lending growth was broad-based across both consumer and business segments (Exhibit 2.11), while non-resident lending growth was led by the Americas and Europe regions (Exhibit 2.12).

Exhibit 2.11: Growth of Bank Loans & Advances to Non-Bank Residents by Industry in 2Q 2026

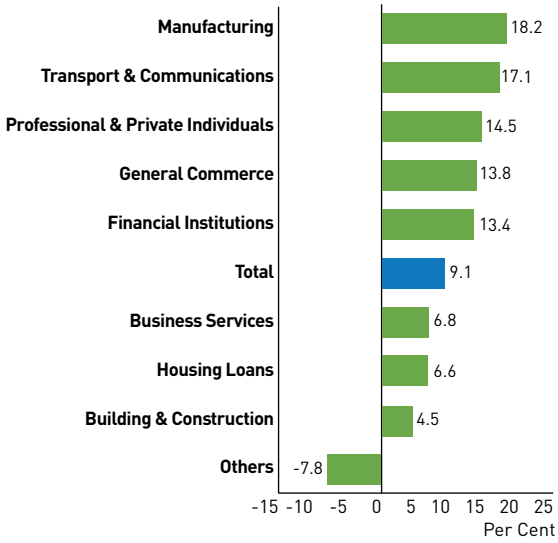
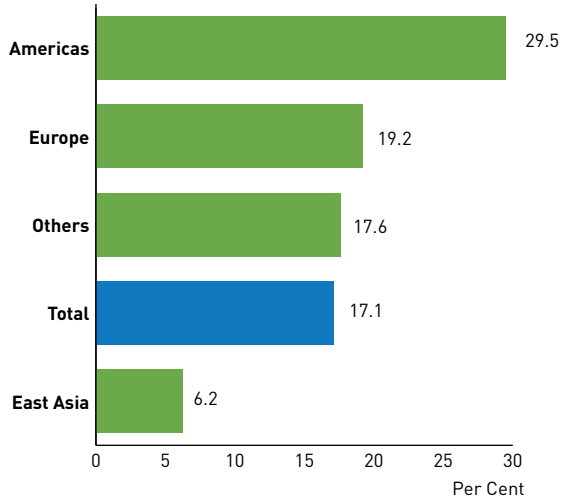


Exhibit 2.12: Growth of Bank Loans & Advances to Non-Bank Non-Residents by Region in 2Q 2026



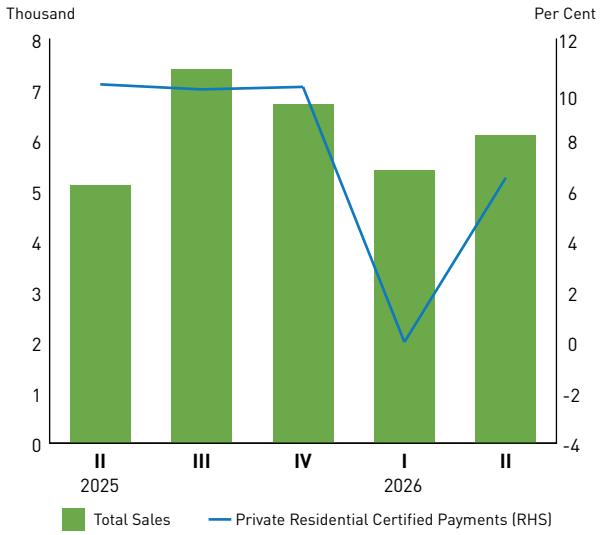
The sentiment-sensitive segments also grew robustly, underpinned by the fund management industry which recorded double-digit year-on-year growth in net fees and commissions. Meanwhile, the insurance segment was supported by firm growth in net premiums for life policies.

REAL ESTATE

The real estate sector expanded by 4.6 per cent year-on-year in the second quarter of 2026, following the 3.6 per cent growth in the previous quarter. Growth in the sector was due to expansions in all segments of the property market.

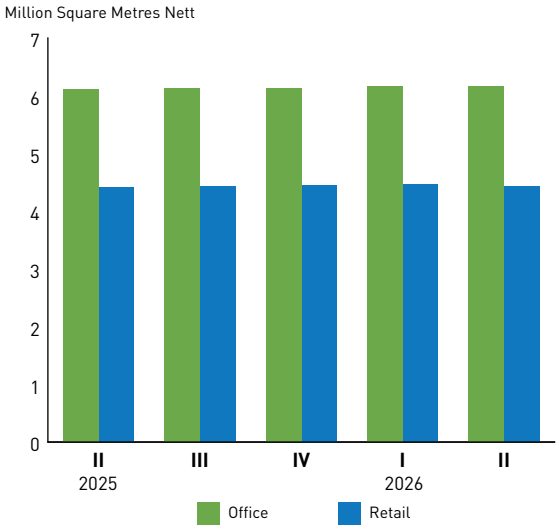
Private residential certified payments[1] grew by 6.5 per cent year-on-year in the second quarter, higher than the 0.0 per cent change in the previous quarter. At the same time, total private residential property sales rose to 6,148 units in the second quarter of 2026, from 5,128 units in the same quarter of 2025 (Exhibit 2.13).

Exhibit 2.13: Total Sales for Private Residential Units and Private Residential Certified Payments



Demand for private commercial office space, as measured by total occupied space, rose by 0.9 per cent year-on-year in the second quarter, following the 1.2 per cent growth in the preceding quarter. Meanwhile, in the private commercial retail space market, demand rose by 0.4 per cent in the second quarter, following the 0.7 per cent expansion in the first quarter (Exhibit 2.14).

Exhibit 2.14: Total Occupied Space for Private Sector Commercial Office and Retail Spaces



Within the private industrial space market, demand expanded by 1.5 per cent year-on-year in the second quarter, following the 1.4 per cent increase in the previous quarter (Exhibit 2.15).

Exhibit 2.15: Total Occupied Space for Private Sector Industrial Space

1 *Private residential certified payments is a proxy for the growth of the private residential property segment.*

PROFESSIONAL SERVICES

In the second quarter of 2026, the professional services sector grew by 2.4 per cent year-on-year, following the 2.7 per cent expansion in the previous quarter. Growth was mainly supported by expansions in the architectural & engineering, technical testing & analysis, and other professional, scientific & technical services segments.[2]

2 *The professional services sector is made up of the following segments: (i) legal, (ii) accounting, (iii) head offices & business representative offices, (iv) business & management consultancy, (v) architectural & engineering, technical testing & analysis, and (vi) other professional, scientific & technical services.*

CHAPTER

3

ECONOMIC OUTLOOK

Chapter 3

ECONOMIC OUTLOOK

OUTLOOK FOR 2026

In May, MTI maintained Singapore's GDP growth forecast for 2026 at "2.0 to 4.0 per cent", based on the expectation that global AI-related demand would cushion the impact of the US-Israel-Iran conflict on the global economy.

Since then, the global AI investment boom has been stronger than expected. This has provided significant tailwinds to AI-related production and exports globally. For the rest of the year, a further acceleration in AI-related capital expenditure is expected to lift the growth prospects of economies plugged into the global technology value chain.

The economic impact of the conflict in the Middle East has also been less severe than initially feared. While the blockade of the Strait of Hormuz has disrupted global supplies of energy and other key intermediate inputs, the drawdown of oil inventories and substitution to alternative energy sources have capped the rise in global energy prices. Nonetheless, continuing tensions in the region, alongside lower levels of global oil inventories, are expected to keep the prices of energy and other key inputs elevated in the second half of the year. Elevated energy and input prices will in turn exert upward pressure on global inflation and weigh on global economic activity. Meanwhile, the US tariffs are expected to continue to weigh on the exports of affected economies.[1]

On balance, taking into account these developments and the GDP performance of the various economies in the second quarter, Singapore's external demand outlook for the year has improved compared to the assessment in May.

In the US, GDP growth in 2026 is expected to remain resilient, supported in part by rising AI-related investment. However, growth could moderate in the second half of the year compared to the first half due to softening consumption growth amidst sustained inflationary pressures. Meanwhile, the Eurozone's GDP growth outlook for the rest of the year has weakened as elevated energy prices could prompt further interest rate hikes and pose a drag on domestic demand.

In Asia, the 2026 economic outlook for China is broadly unchanged from May. GDP growth in China is projected to expand at a slower pace in the second half of the year due to easing exports growth and subdued domestic consumption. Meanwhile, the 2026 GDP growth forecasts for Taiwan and South Korea have been upgraded as the stronger-than-expected AI investment boom is projected to continue boosting their exports. Similarly, the 2026 GDP growth forecasts for most of the key Southeast Asian economies have been upgraded given expected strong growth in their AI-related exports. However, growth in these economies could moderate in the second half of the year compared to the first half due to weaker consumer demand amidst elevated inflationary pressures.

Downside risks in the global economy remain. First, a further escalation and broadening of the conflict in the Middle East could trigger fresh spikes in the prices of energy commodities and other key intermediate inputs. The resulting rise in inflationary pressures and tighter global financial conditions could dampen global growth. Second, additional US tariff actions and the uncertainty surrounding these actions could weigh on business and household sentiments, thereby dampening investment and spending in the affected economies. Third, sudden risk-off sentiments in financial markets regarding global AI-related capital spending could trigger sharp corrections in these markets, with potential spillovers to broader economic activity.

Against this backdrop, the 2026 outlook for sectors of the Singapore economy that are linked to the AI-driven technology cycle has improved, although that for sectors directly affected by supply disruptions arising from the Middle East conflict remains weak.

Among the latter, the chemicals cluster of the manufacturing sector is expected to remain the most adversely affected, as firms in the petroleum and petrochemicals segments continue to cut back on production due to disruptions to crude oil and feedstock supplies. The disruptions will also lead to reduced trading volumes in the fuels & chemicals segment of the wholesale trade sector.

1 *While the US' Section 122 tariffs, which were imposed after its "reciprocal" tariffs were struck down by the Supreme Court of the US, expired on 24 July 2026, the US has implemented Section 301 tariffs ranging from 10 per cent to 12.5 per cent on 60 economies following the conclusion of its investigations on forced labour. The US' Section 301 investigations on 16 economies for excess capacity are still ongoing.*

Meanwhile, elevated fuel costs will dampen demand in the water and air transport segments of the transportation & storage sector. Similarly, growth in the accommodation sector is expected to remain subdued, partly due to elevated travel costs, although resilient demand within the luxury segment and a strong event calendar in the second half of the year are likely to provide some support.

On the other hand, the acceleration in global AI-related capital expenditure should boost growth in the electronics and precision engineering clusters of the manufacturing sector. Notably, demand for AI-related semiconductors (e.g., networking and memory chips) from the data centre end-market is expected to remain strong amidst the rapid rollout of agentic AI across industries, while capacity expansions by semiconductor firms will raise demand for semiconductor equipment. Strong activity in these clusters will generate positive spillovers to the machinery, equipment & supplies segment of the wholesale trade sector.

Among the outward-oriented services sectors, both the information & communications and finance & insurance sectors are expected to register firm growth. Growth in the information & communications sector is projected to be boosted by strong AI-linked enterprise demand. Meanwhile, growth in the finance & insurance sector will be supported by firm credit growth in tandem with the expansion in domestic and regional economic activities. Ongoing efforts to deepen Singapore's capital markets and broaden investor access to international listings should also sustain demand for wealth management services.

As for the domestically-oriented sectors, activity in the construction sector will continue to be supported by a robust pipeline of public and private construction projects. At the same time, healthy developer activities amidst resilient demand for private residential properties, as well as sustained rental demand for commercial properties, will support the growth of the real estate sector. Finally, while dampened consumer sentiments amidst inflationary pressures could weigh on the performance of the retail trade and food & beverage services sectors, government support measures such as the CDC Vouchers should cushion the impact.

Taking into account the better-than-expected performance of the Singapore economy in the first half of the year, as well as the latest global and domestic economic outlook, **MTI has upgraded Singapore's GDP growth forecast for 2026 to "4.5 to 5.5 per cent", from "2.0 to 4.0 per cent".**

FEATURE ARTICLE

MEASURING FIRM-LEVEL ARTIFICIAL INTELLIGENCE USE AND ITS EFFECTS ON FIRM PERFORMANCE AND EMPLOYMENT IN SINGAPORE

Feature Article

MEASURING FIRM-LEVEL ARTIFICIAL INTELLIGENCE USE AND ITS EFFECTS ON FIRM PERFORMANCE AND EMPLOYMENT IN SINGAPORE

OVERVIEW

Artificial Intelligence (AI) is expected to transform firms and labour markets, and lead to productivity growth. However, measuring its economic effects remains difficult as firm-level AI use is rarely observed directly. Addressing this measurement gap is important as policymakers need evidence on how AI is being adopted, which firms are using it, and whether adoption is associated with tangible benefits for workers and firms, as they design AI-related policies.

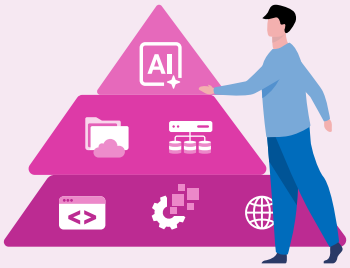
This study develops a firm-level measure of AI use in Singapore using data from online job postings. The constructed measure is then linked to firm-level administrative data to enable the characteristics of AI-using firms to be analysed and the impact of firms' AI use on their performance and employment to be empirically estimated. Job postings provide a useful source of information as AI-related hiring reveals a firm's demand for AI capabilities.

Using the dataset created, the study examines three questions. First, how do firms use AI alongside other digital technologies? Second, what types of firms are more likely to use AI? Third, does AI use improve firm performance and change their workforce composition?

FINDINGS

Finding 1:

AI use is not a stand-alone leap for firms. Instead, it tends to build on the prior efforts of firms to adopt foundational and complementary digital technologies.



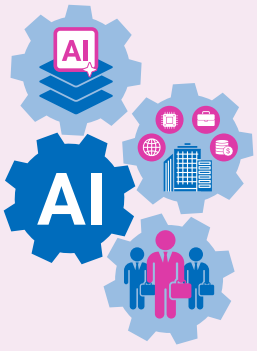
Finding 2:

Firms in digital- and data-intensive sectors/clusters (i.e., information & communications, electronics, professional services and finance & insurance) are more likely to use AI. Larger firms are also more likely to use AI, even after accounting for their sector and age.

Finding 3:

Initial AI use is associated with an increase in firms' revenue and total employment, and these gains continue to rise as AI capabilities deepen. This result could reflect the potential scale and/or innovation effects of AI use.

POLICY TAKEAWAY



These findings suggest three policy lessons to help firms and workers realise economic benefits from AI. First, it is important for firms to strengthen their foundational digital capabilities as this could aid in their AI adoption. Second, support for AI use should be differentiated by sector and firm size. This may entail identifying sector-specific AI use cases with larger returns, or the provision of support to smaller firms that may lack internal capabilities to effectively integrate AI. Third, workforce policy should focus on job transformation and worker training to help workers move toward AI-complementary tasks even as some tasks become automated.

EXECUTIVE SUMMARY

- This study develops a firm-level measure of Artificial Intelligence (AI) use in Singapore based on data from online job postings. Linking the constructed measure to firm-level administrative data, the study then analyses the characteristics of AI-using firms and empirically estimates the impact of firms' AI use on their performance and employment.

- The main findings of the study are as follows. First, using network analysis, the study finds that AI use is not a stand-alone leap for firms. Instead, it tends to build on the prior efforts of firms to adopt foundational and complementary digital technologies.

- Second, using a liner probability model, the study finds that firms in digital- and data-intensive sectors/clusters (i.e., information & communications, electronics, professional services and finance & insurance) are more likely to use AI. Larger firms are also more likely to use AI, even after accounting for their sector and age.

- Third, using a combination of matched staggered difference-in-differences and fixed effects regressions, the study finds that:

    - Initial AI use is associated with an increase in firms' revenue and total employment, and these gains continue to rise as AI capabilities deepen. This result could reflect the potential scale and/or innovation effects of AI use (e.g., AI reduces costs and/or enables the creation of new products, thus allowing firms to expand output). At the same time, the increase in firm-level employment suggests that any worker separations that may occur at the firm are outweighed by new hiring. It may also be the case that AI tends to automate specific tasks rather than entire jobs, thus allowing workers to focus on the remaining and/or new complementary tasks.

    - Firms do not see a statistically significant increase in their productivity and profit within four years of first AI adoption. This could be because the full benefits of AI may only materialise after complementary investments are made, similar to the experience of earlier transformative technologies such as the internet.

    - Employment effects of firms' AI use differ across worker types. Initial gains are found to be concentrated among local higher-earners and mid-career workers, as well as skilled foreign professionals. However, as firms deepen their AI capabilities, the local employment gains broaden across wage and age groups.

- Fourth, heterogeneity analyses show that the impact of firms' AI use varies across sector and firm size. For example, firms in the finance & insurance, wholesale trade and information & communications sectors, as well as micro and medium firms, see larger gains in revenue on average.

- As the study analyses firms' AI use up to 2024, the estimates should be seen as reflecting the early impact of AI diffusion, and would not capture the effects of more recent advances in AI capabilities (e.g., agentic AI) as well as broader enterprise adoption. Future studies could analyse the effects of the different AI use cases that firms are implementing using more recent data that better capture the advances in AI technology and new patterns of adoption.

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.[1]

1 *The author would like to thank Ms Yong Yik Wei, Dr Andy Feng, Dr Tan Di Song, Dr Christopher Saw, the Digital Industry Singapore Office, and the Research and Statistics Unit in the Infocomm Media Development Authority for their useful suggestions and comments. All remaining errors belong to the author.*

INTRODUCTION

Artificial Intelligence (AI) is expected to transform firms and labour markets, and lead to productivity growth. However, measuring its economic effects remains difficult as firm-level AI use is rarely observed directly. Administrative datasets provide broad coverage but typically do not record whether a firm uses AI. On the other hand, surveys can capture direct information on AI adoption but have limitations, such as delayed responses and challenges in ensuring consistent understanding of AI and measuring its usage intensity, especially as AI capabilities are advancing rapidly. Addressing this measurement gap is important as policymakers need evidence on how AI is being adopted, which firms are using it, and whether adoption is associated with tangible benefits for workers and firms, as they design AI-related policies.

This study develops a firm-level measure of AI use in Singapore using data from online job postings. The constructed measure is then linked to firm-level administrative data to enable the characteristics of AI-using firms to be analysed and the impact of firms' AI use on their performance and employment to be empirically estimated. Job postings provide a useful source of information as AI-related hiring reveals a firm's demand for AI capabilities.

Using the dataset created, the study examines three questions. First, how do firms use AI alongside other digital technologies? Second, what types of firms are more likely to use AI? Third, does AI use improve firm performance and change their workforce composition?

LITERATURE REVIEW

The literature offers three lessons for studying firm-level AI use.

First, AI adoption depends on firms' characteristics and capabilities. Studies (e.g., Bonney, et al. (2024), Calvino et al. (2022) and Calvino et al. (2023)) show that AI adopters tended to be larger, more productive, more digitalised and concentrated in the information & communications technology and professional services sectors. They also show that firms were more likely to adopt new technologies during the COVID-19 pandemic (e.g., analytics, cloud, digital commerce and collaborative software) when they already had pre-existing digital capabilities.

Second, AI can improve firm performance, but timing matters. Evidence from AI-related hiring and innovation (e.g., Babina et al. (2024) and Alderucci et al. (2020)) suggests positive associations with sales, employment, market value, productivity and wages, possibly through product innovation. However, these effects may emerge only in the longer term (e.g., five to eight years) after firms have made complementary intangible investments (e.g., new processes, human capital, business models).

This lag is consistent with the concept of "Productivity J-curve" (Brynjolfsson et al. (2021)), which states that transformative technologies can initially depress measured productivity as firms incur adjustment costs upfront, before gains materialise after organisational changes are implemented. Recent evidence on industrial AI by McElheran et al. (2025) similarly finds that short-term productivity and profit losses may precede longer-term gains.

Third, AI's employment effects depend on task reallocation (Acemoglu and Restrepo (2019)). AI may automate some tasks while increasing the demand for workers that are performing complementary and/or newly-created tasks.[2] Survey and job-posting evidence (e.g., Bonney et al. (2024) and Liu and Webber (2026)) suggest that AI-using firms did not reduce overall hiring but could have shifted hiring towards certain occupations. For Singapore, it is important to study the impact of AI use on different groups of workers because many resident workers are in occupations highly exposed to AI (Khan (2024)), with half in high-complementarity occupations (e.g., managers, science and engineering, health and legal professionals) and half in low-complementarity occupations (e.g., clerical support workers).[3]

This study brings these strands together using Singapore firm-level data. A measure of firms' AI use is first constructed using data from online job postings and then combined with firm-level administrative data. Using the dataset created, the study examines how firms are using AI, what types of firms are more likely to use AI, and whether AI use improves firm performance and shifts workforce composition.

2 *AI may also change job content. For instance, Autor and Thompson (2025) show that task automation may raise the expertise requirements of jobs, thus reducing the relative supply of workers who qualify for the jobs. As a result, wages rise while employment falls.*

3 *High-complementarity occupations are those in which AI is more likely to complement human labour in performing the tasks in the occupation, while low-complementarity occupations are those with greater scope for AI to substitute tasks in the occupation that are currently performed by human labour.*

CONCEPTUAL FRAMEWORK

AI can affect firms through three channels: task reallocation, innovation and scale effects. These channels operate at the same time and may have different implications for firm outcomes.

i. Task Reallocation

Task reallocation occurs when AI changes how tasks within a job are performed. AI may substitute for labour in tasks where it is more cost-effective, such as drafting text or classifying documents. Firms may therefore reduce demand for workers in jobs made up largely of tasks that AI can automate.

However, task-level substitution need not translate into job-level displacement. As AI automates some tasks, workers may shift toward the remaining and/or new complementary tasks, such as those requiring human judgement or relationship management. AI can therefore augment workers and raise demand for jobs with complementary task content. The skills required in such jobs would also change. For example, if AI takes over basic bookkeeping, accounting workers may need to focus more on problem solving and judgement.

ii. Innovation

The innovation effect arises when AI enables firms to develop new or improved products and services. AI may also support faster research and development. If these allow firms to enter new markets or expand demand, revenue and employment may rise. Profit may also increase if the new products generate margins that exceed investment and adjustment costs.

iii. Scale

As firms invest in AI and implement complementary organisational changes, they may see improvements in operational efficiency and cost reductions. If demand is sufficiently elastic, lower prices (due to reduced costs) will allow firms to expand output. As firms expand production, they will need more workers, even if they use fewer workers per unit of output (e.g., due to AI automation). This channel leads to higher revenue and employment. However, the impact on profit and labour productivity may be ambiguous, especially in the short term, as firms may face large investment costs upfront while labour productivity improvements may only materialise with a lag.[4]

In the long term, as firms improve their organisational processes and redesign and/or create new jobs to leverage AI effectively, these investments could translate into stronger total factor productivity and labour productivity growth.

DATA

This study uses MyCareersFuture job postings data from 2018 to 2024 to identify AI-using firms in Singapore. Firms are identified as AI-using if they post at least one AI-related job posting on MyCareersFuture during this period. AI-related job postings are postings with job descriptions that contain at least one match against a validated AI vocabulary list.[5,6]

4 *Investment costs related to AI include AI software investments, data infrastructure, workflow redesign, and worker training. Investment costs are not observed in the data used for our empirical study.*

5 *The AI vocabulary list is based on OECD (2025) and accounts for generative AI and pre-generative AI technologies. While there are studies in the literature (Hosseini and Lichtinger (2025)) that apply a large language model classifier on job postings that have first been identified through AI keyword matching to determine whether firms are AI-using, such an approach introduces additional model dependence and is less transparent.*

6 *Employment agencies are excluded as they may be hiring on behalf of other firms on MyCareersFuture.*

A key assumption underpinning this measure is that AI-related hiring reveals a firm's demand for AI capabilities. Specifically, a firm will post an AI-related vacancy when it expects the worker hired to generate economic value, which could come about because the worker complements existing AI capital or helps the firm to build new AI capabilities. Even if no AI-related hiring is observed in subsequent years, firms may continue to build and maintain their AI capabilities.

It should be noted that this measure is not intended to capture every form of AI use. By construct, it likely focuses on firms that are making internal investments in AI capabilities through new AI-related hiring, instead of firms using (i) off-the-shelf AI tools, (ii) external vendors to provide customised AI solutions, or (iii) existing employees to develop AI capabilities without new AI-related hiring. Another caveat is that the measure may classify a firm as AI-using even if a posted vacancy is not filled. Nonetheless, while the measure does not comprehensively cover all forms of AI use, it provides a timely and scalable[7] indicator of revealed AI capability-building at the firm-level when direct measures (e.g., administrative and survey data) are limited.

Subject to the caveats above, the measure can be used to study the *extensive* margin of AI use (i.e., firms using AI for the first time). Apart from this, an AI intensity measure – based on the cumulative maximum number of annual AI-related job postings across time[8] – is also constructed and used to study the *intensive* margin of AI use. The cumulative maximum is preferred to a simple annual count because AI capabilities may accumulate and persist over time.[9] It is also preferred to a cumulative sum[10] of annual AI-related postings over time as subsequent postings may reflect replacement hiring rather than an increase in capabilities.

After identifying firms' AI use based on the job postings data, the AI-use indicator constructed for all firms that posted vacancies on MyCareersFuture over the study period is linked to firm entity and financial data[11], local employment and wage data, foreign employment data, as well as firm-level government grant data from government administrative sources. The merged dataset allows firm outcomes such as revenue, profits and labour productivity (i.e., value-added per worker, VAPW[12]), as well as firm-level employment outcomes such as total employment, local employment by wage and age bands, and foreign employment by pass types to be studied.

Based on this approach, around 8 per cent (1,555 firms) of all firms in the dataset are identified as AI-using.[13]

IDENTIFYING AI-USING FIRMS AND HOW THEY USE AI

i. Methodology

To study how firms are using AI, the AI vocabulary used to identify AI-related job postings is further classified into five use cases: customer engagement, analytics & insights, process automation & operational efficiency, product innovation & enhancement, and generative AI.[14] At the same time, firms' use of other digital technologies (i.e., advanced digital technologies, business software, cybersecurity, data analytics, digital commerce, and digital workplace) is also identified.[15] A network analysis is then conducted on firms' adoption of the various AI use cases and other digital technologies as of 2024.

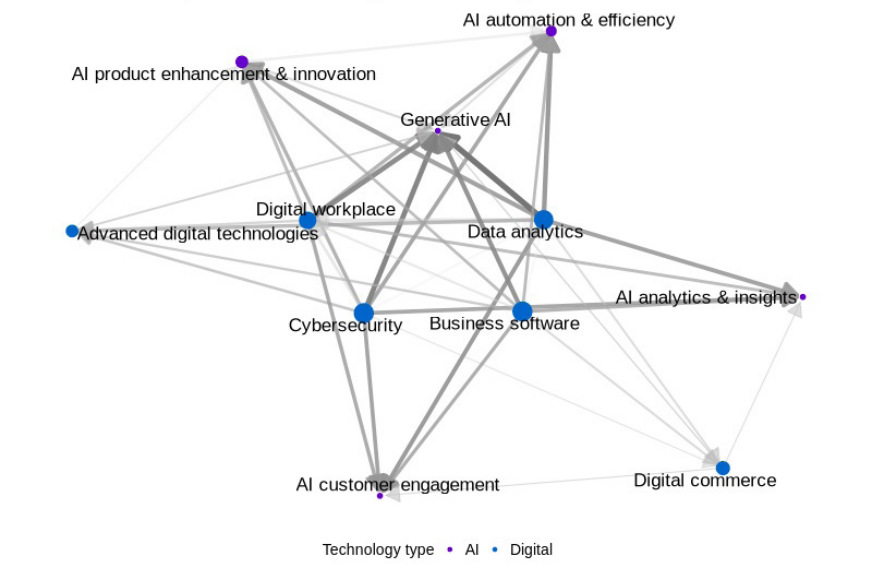
ii. Results

The network analysis shows that other digital technologies not only complement AI technologies but also tend to be adopted before the AI technologies (evidenced by the arrows pointing from the other digital technologies to AI use cases in Exhibit 1). Furthermore, certain digital technologies, including cybersecurity, digital workplace, data analytics and business software, act as foundational capabilities leading to multiple AI use cases.

7 *This indicator can be consistently constructed across firms and years using widely-available job postings data.*
8 *The cumulative maximum refers to the maximum number of annual job postings across time.*
9 *A firm that hires several AI workers in one year may continue to benefit from those workers (e.g., workers are retained, or from the AI processes they built, or from the complementary assets they created), even if the firm posts fewer AI-related jobs in subsequent years.*
10 *The cumulative sum refers to the total sum of annual job postings over time.*
11 *Financial data was not available for all firms as some firms (e.g., solvent exempt private companies) are exempt from filing financial statements with the Accounting and Corporate Regulatory Authority (ACRA). As firms may define different fiscal years (FY) for reporting, ACRA data was used only if the period from start to end of the FY is 12 months, with the data attributed to the calendar year where majority of the period fell. Data denominated in other currencies was converted to the Singapore dollar (SGD) using the annual average Bloomberg exchange rate.*
12 *VAPW is proxied using the sum of profit and wages divided by total employees*
13 *Firms in the dataset are those with job postings on MyCareersFuture (excluding employment agencies) and available firm entity and employment data. Financial data is available only for a subset of these firms.*
14 *The AI keywords are classified using a large language model, with the output further refined by human inspection. Some generic AI keywords may not be classified into any of the use case categories (e.g., artificial intelligence, deep learning, adaptive boosting).*
15 *The keywords for the other digital technologies reference the technologies in Calvino, et al. (2023), and are classified using a large language model.*

This suggests that firms do not adopt AI technologies in isolation. Instead, AI appears to be the next layer of a digital stack that firms progressively build. These findings are consistent with international evidence that firms are more likely to adopt new technologies when they already have existing complementary technologies in place.[16]

Exhibit 1. Network analysis on AI and digital technologies



Note: Each node corresponds to a technology or use case. An edge (line) between two nodes is drawn if the technologies co-occur (i.e., there are firms that use both technologies). Each edge is directed and weighted based on conditional probabilities of occurrence. An arrow is directed from node B to A if it is more likely that technology A is present when B is also present rather than vice versa (i.e., $P(A|B) > P(B|A)$), and the conditional probability exceeds 0.4. The size of the node is proportional to the number of outward arrows.

CHARACTERISTICS OF AI-USING FIRMS

i. Methodology

To examine which firm characteristics are associated with AI use, a cross-sectional linear probability model using the latest data as of 2024 is estimated:

$$AI\ use_i = \beta_1 sector_i + \beta_2 size_i + \beta_3 age_i + \epsilon_i \quad (1)$$

The dependent variable $AI\ use_i$ is an indicator for whether firm i is identified as AI-using.[17] The explanatory variables include the sector ($sector_i$), employment size ($size_i$), and age (age_i) of firm i.[18,19]

ii. Results

The findings from the analysis are as follows.

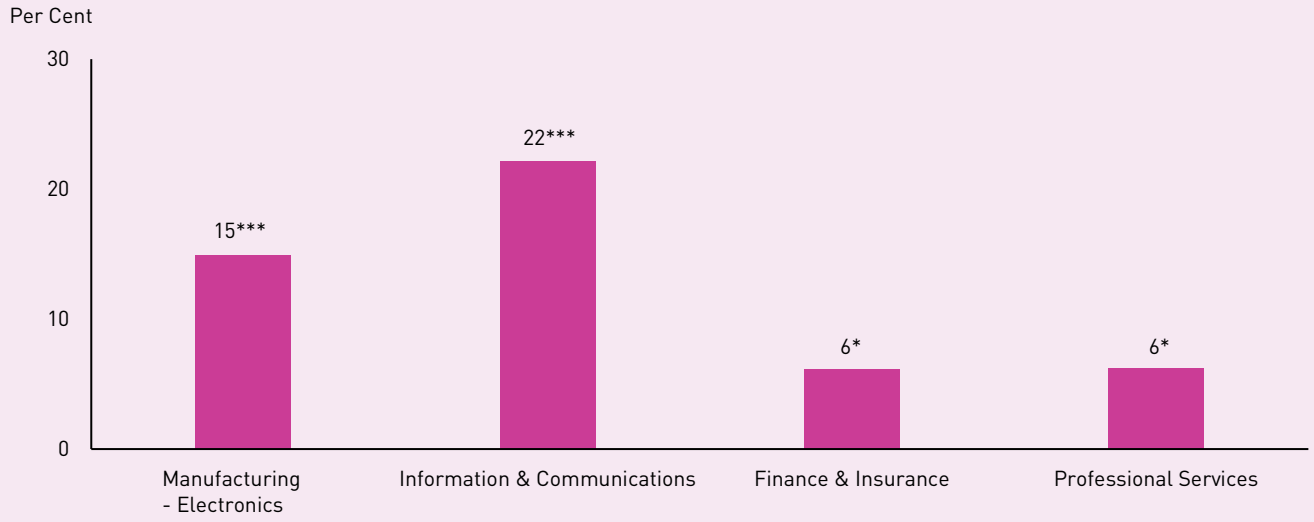
First, AI-using firms are more likely to be from the information & communications, electronics, professional services and finance & insurance sector/cluster (Exhibit 2.1, full results in Annex A). Specifically, information & communications and electronics firms in the base employment size (i.e., 1-10 workers) and age (i.e., <6 years) category have a predicted AI-use probability of 22 per cent and 15 per cent respectively. These sectors share a common feature of being digital- and data-intensive. For example, electronics manufacturing often involves advanced production technologies, making it more feasible for firms to integrate AI for predictive maintenance and quality control.

16 *This finding also motivates the inclusion of a lagged digital-use indicator in the empirical specification used to estimate the causal impact of AI use on firm performance and employment.*
17 *Using AI intensity as the dependent variable yields similar findings.*
18 *The intercept is omitted from the regression specification. All sectors are included and the omitted base categories for size and age are micro firms (1-10 workers) and young firms (age 0-5 years) respectively.*
19 *Robustness checks were conducted using revenue size (instead of employment size) for the smaller sample of firms with available financial data and results are similar. Other robustness checks carried out include using different age and size bands, and results are similar.*

Second, larger firms are more likely to use AI (Exhibit 2.2). This relationship holds even after accounting for sector and age. In particular, large firms with >250 workers are 39 percentage-points (pp) more likely to use AI compared to micro firms in the same sector and age category. This pattern is consistent with larger firms having more financial resources, data and managerial capacity to invest in AI-related capital and skills.

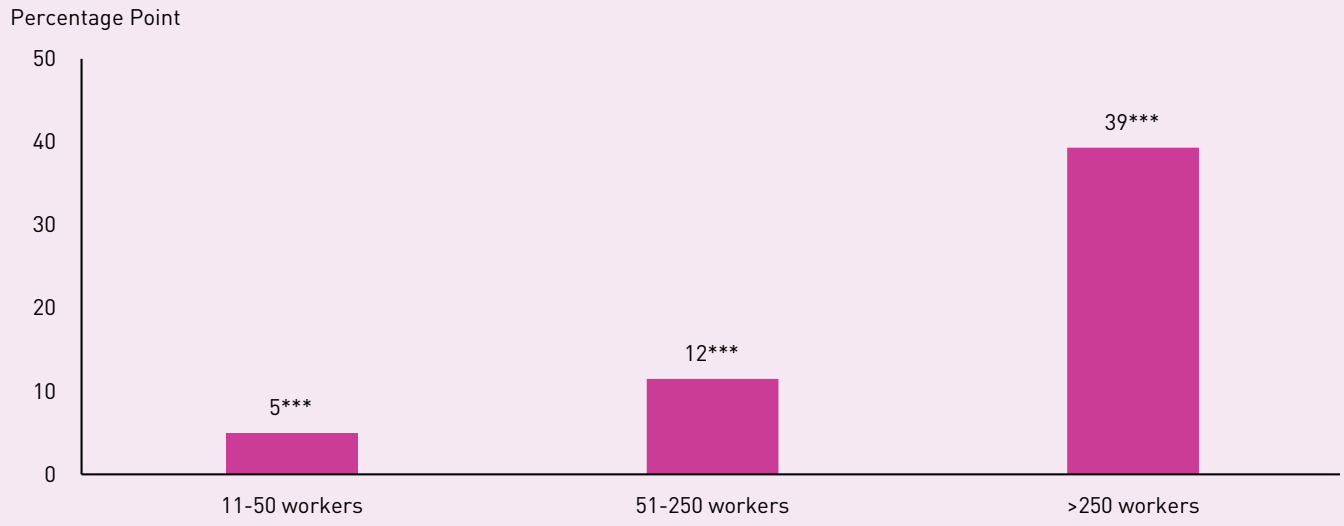
Third, firm age has no statistically significant relationship with the likelihood of AI use. This suggests that AI use is not confined to either younger firms or older incumbents. Instead, AI use appears more closely related to sector and firm size.

Exhibit 2.1. Likelihood of firm AI use for selected sectors



Note: *** p<0.01, ** p<0.05, * p<0.1. All sectors included in regression; only sectors with statistically significant results are shown.

Exhibit 2.2. Likelihood of firm AI use by employment size



Note: *** p<0.01, ** p<0.05, * p<0.1. The base category is firms with 1-10 workers.

IMPACT OF AI USE ON FIRM OUTCOMES AND EMPLOYMENT

i. Methodology

To estimate the causal effect of AI use on firm outcomes and employment, AI-using firms are compared with matched non-AI-using firms. Specifically, coarsened exact matching is employed to ensure that non-AI-using firms (control firms) are comparable to AI-using firms (treated firms) before their first year of AI use.[20] The first year of AI use defines the firm's treatment cohort.[21]

Extensive-margin effects of AI use

At the extensive margin, firm outcomes are estimated using a staggered difference-in-differences regression specification[22]:

$$ln(Y_{it}+1) = \sum_{c=2019}^{2024} \sum_{b=-3}^{5} \beta_{c,t}\, AI\ use\ cohort_i^c \times event\ time_t^b \times treated_i + X_{it\text{-}1} + FE + \varepsilon_{it} \quad (2)$$

Y_{it} is a firm-level outcome for firm i in year t; $AI\ use\ cohort_i^c$ denotes if and when the firm is first flagged as an AI-using firm (i.e., treatment cohort) from year 2019 to 2024[23], $event\ time_t^b$ is measured relative to the cohort's year of treatment (t = 0), with the year before serving as the base reference period and hence omitted (t = -1), and $treated_i$ indicates whether the firm is an AI-using firm. Lagged controls $X_{it\text{-}1}$ include the cumulative amount of government digitalisation or productivity grants[24] received by the firm and a digital-use indicator for whether the firm had ever used digital technologies by that period. Fixed effects FE include firm, year, cohort, firm-cohort, cohort-year, sector-year and sector-cohort effects. Standard errors are clustered at the firm-cohort level. The cohort-specific event-time coefficients $\beta_{c,t}$ are averaged across cohorts to estimate average treatment effects at each event time.

To interpret $\beta_{c,t}$ as the causal effect of AI use, it is important to address the issue of selection bias. This refers to the concern that firms choosing to adopt AI may differ from non-AI-using firms in ways that also predict their subsequent outcomes. In this study, several research design choices help to mitigate this concern. First, matching improves comparability between non-AI-using firms and AI-using firms before treatment. Second, the fixed effects variables in the regression help to absorb time-invariant firm differences, macro and sector-specific time shocks, as well as cohort-specific dynamics. Third, lagged controls for receipt of digitalisation and productivity government grants, and for digital use, in the regression help to account for support received by firms and their digital transformation that may be correlated with both firms' AI use and subsequent outcomes.

Together, these design choices help reduce selection bias but they do not by themselves rule it out. As an additional validity check, the pre-treatment outcomes of matched treated and control firms are examined to assess whether they exhibit parallel trends. This is important as it undergirds the assumption that in the absence of AI use, the treated firms would have followed similar outcome paths as the control firms. To test for parallel trends, the outcomes of the treated and control firms before the first AI use of the former are compared, and all outcomes are found to exhibit parallel trends up to three years before first AI use.[25]

Nonetheless, the estimates should still be interpreted with appropriate caution. As highlighted earlier, the measure of AI use adopted in this study captures firms' revealed demand for AI capability, and not their direct usage or successful implementation of AI. It also more likely identifies firms making internal investments in AI capabilities through new AI-related hiring, instead of firms using off-the-shelf AI tools, external vendors providing customised AI solutions, or existing employees to develop AI capabilities. As such, results are best interpreted as the effects associated with internal AI capability-building, rather than all possible AI uses.

20 *Pre-matching, AI-using firms are more likely to use digital technologies, have greater revenue, profit, average local wages and employment. Matching variables used include sector, digital use, age, total and local employment, average local wages and government grants. Post-matching, there is an improvement in pre-treatment similarities for both the matching variables and variables not used for matching.*

21 *Cohort refers to the first year of AI use for treated firms. Firms in cohort t are matched to control firms using data in year t-1. Control firms may be matched in multiple years to the corresponding cohorts of treated firms. Observations for control firms that are matched to multiple cohorts are replicated and stacked with the corresponding event time assigned and matching weights applied.*

22 *A staggered difference-in-differences specification is used as there is heterogeneous treatment timing (i.e., different cohorts).*

23 *As firm-level data is available for years 2018 to 2024, only cohorts treated from year 2019 to 2024 are studied as data in year t-1 is required for matching.*

24 *Only government grants that are likely confounders (i.e., Productivity Solutions Grant, Market Readiness Assistance, Capability Development Grant, Enterprise Development Grant) are included.*

25 *This is a common check conducted by researchers estimating difference-in-differences regressions. It is not possible to directly test for parallel trends post-treatment as treated firms can never be observed in their non-treated state (i.e., an unobserved counterfactual).*

Intensive-margin effects of AI use

At the intensive margin, outcomes are examined using a fixed effects regression specification:

$$ln(Y_{it} + 1) = \beta_1 AI\ intensity_{it\text{-}1} + X_{it\text{-}1} + FE + \varepsilon_{it} \quad (3)$$

Here, $AI\ intensity_{it\text{-}1}$ is the lagged cumulative maximum number of annual AI-related job postings.[26,27] The other variables are as defined in equation (1).

This regression specification examines whether firms that deepen AI capabilities, proxied by more intensive AI-related hiring, experience larger changes in outcomes.

Heterogeneity analysis

Lastly, heterogeneity analysis by sector and pre-treatment revenue size is conducted using the following regression specification:

$$ln(Y_{it} + 1) = \sum_k \beta_k AI\ using_{it\text{-}1} \times category_i^k + X_{it\text{-}1} + FE + \varepsilon_{it} \quad (4)$$

Here, $AI\ using_{it\text{-}1}$ indicates whether the firm had ever used AI by t-1, and $category_i^k$ denotes the firm's sector or pre-treatment revenue size. The other variables are as defined in equation (1).

ii. Results

Effects of AI use on total employment and financial outcomes

At the extensive margin, AI use is associated with an increase in total employment and revenue. In particular, initial AI use is associated with an increase in total employment and revenue of 4 per cent and 7 per cent respectively in the year of adoption (i.e., $t = 0$), and 8 per cent and 16 per cent respectively one year post-adoption (Exhibit 3, full results in Annex B and C).[28] This could reflect the potential scale and/or innovation effects of AI use. For example, AI may enable firms to improve operational efficiency and increase their output, and/or support the creation of new or better products and services, which may in turn help them enter new markets.

At the intensive margin, the results show that firms continue to expand as they deepen their AI capabilities. A 1 per cent increase in AI intensity is associated with a 0.24 per cent increase in total employment and a 0.22 per cent increase in revenue. It should be noted that while the findings show net employment gains at the firm-level from AI use, there may still be worker separations occurring at the firm, although these are more than offset by new hiring.

On the other hand, there is no evidence of statistically significant gains in profit and VAPW at the firm-level over the immediate four-year post-adoption period.[29] This is consistent with the productivity J-curve interpretation, which suggests that the benefits of AI may fully materialise only after complementary investments and organisational redesign have been implemented. Specifically, firms incur investment and adjustment costs in the short term, not just in terms of their investments in AI software and data infrastructure, but also investments in complementary areas such as workflow redesign, experimentation and worker training. However, measured profit and productivity gains may emerge only after these complementary investments and adjustments are completed and embedded in firms' processes.

26 *A staggered difference-in-differences specification for the intensive margin analysis is not adopted as AI intensity is not static and may change over time.*

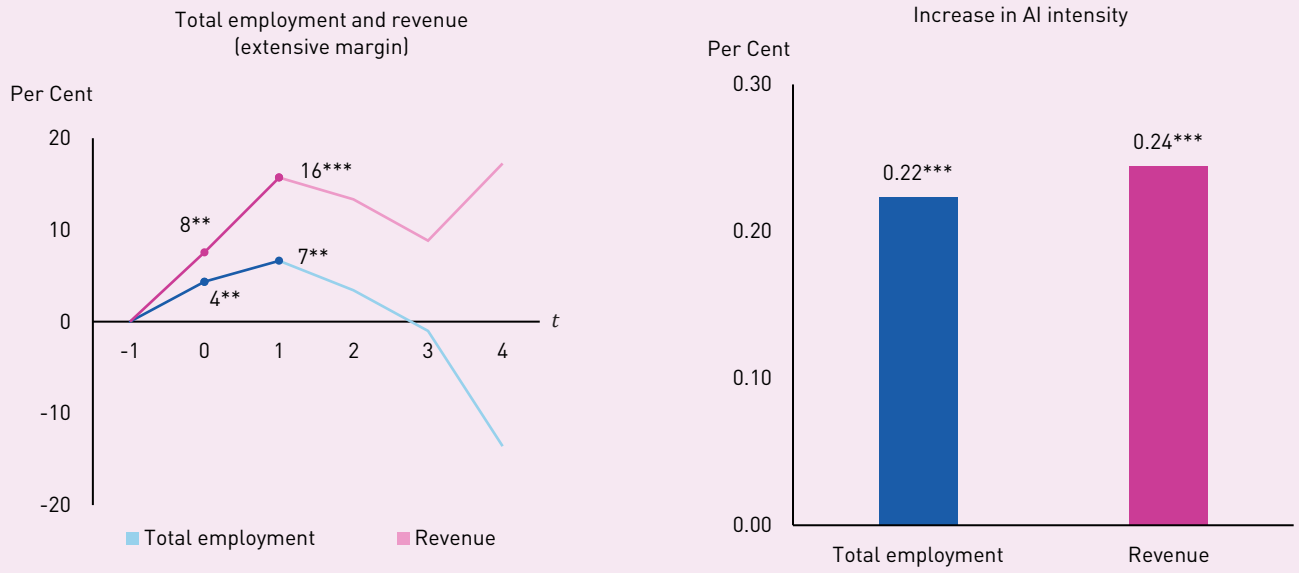
27 *Robustness checks were conducted using alternative measures of AI intensity (i.e., cumulative sum of the number of annual AI-related job postings). Robustness checks were also conducted to check if there was selection into treatment intensity by limiting the sample to treated firms with at most three AI-related job postings in the initial year of AI use (based on AI intensity distribution plots). Lastly, robustness checks were conducted to limit the sample to exclude growth firms (>20 per cent employment Compound Annual Growth Rate (CAGR) over three years for firms with >10 workers, or absolute growth of >3.3 workers over three years for firms with <10 workers), to ensure that the findings are driven by AI use instead of other unobserved firm characteristics (e.g., innovativeness of growth firms). Results of all the robustness checks are in line with the main results.*

28 *Results by AI-using cohorts from 2019 to 2024 were generally positive in year of adoption, although their statistical significance may vary. Exceptions are the 2021 cohort, where revenue was negative but not statistically significant, and the 2023 cohort, where total employment was negative albeit not statistically significant. As the 2023 cohort coincided with the emergence of generative AI technologies, first-time adopting firms could be in more experimental phase without viable AI use cases, leading to noisier estimates.*

29 *Firms' AI use also does not have a statistically significant impact on average local wages over the four-year post-adoption period.*

Beyond these quantitative findings, Singapore firms that embarked on AI transformation under IMDA's Digital Leaders Programme have also reported business improvements from their AI use cases. The two firms showcased in Box 1 below – iHub Solutions and Nanyang Inc – provide concrete examples of how AI use can lead to improvements in firms' outcomes, including revenue and profit, when AI adoption is accompanied by complementary digital investments and workflow redesign.

Exhibit 3. Impact of AI use on total employment and revenue



Note: *** p<0.01, ** p<0.05, * p<0.1. Results that are statistically significant at the 5% level are in solid colours and labelled. Regression for revenue is conducted using the smaller sample of firms with revenue data.

BOX 1. BUSINESS GAINS FROM AI ADOPTION

Examples of Singapore firms that have embarked on AI transformation under IMDA's Digital Leaders Programme

iHub Solutions

Headquartered in Singapore with operations in Malaysia, Hong Kong, the Philippines and Thailand, iHub Solutions is a leading third-party logistics provider offering e-commerce fulfilment, warehousing, last-mile delivery and software integration through its proprietary platforms.

The company's transformation was born from a need to solve margin-sensitive operations and heavy reliance on manual, paper-based coordination. As e-commerce demand surged, iHub recognised the need for digitalisation.

Supported by IMDA's Digital Leaders Programme, iHub redesigned its core workflows by integrating advanced technologies anchored on a robust digital foundation of reliable data into its Virtual Logistics System (VLS) platform. This allowed iHub to deploy an advance digital tracking system to monitor the real-time movement of all works and assets.

iHub subsequently enhanced its VLS platform with a GenAI-powered Virtual Assistant for business intelligence. By translating natural language queries into SQL commands, it enabled non-technical staff to access insights instantly without relying on data specialists. iHub also deployed AI-driven route optimisation, using live orders, customer locations, historical data and Google OR-Tools to assign routes dynamically.

Since launching its VLS Virtual Assistant platform in 2024, iHub has achieved a **20 per cent revenue increase** and **30 per cent profit lift**. Route planning dropped from **15 minutes to 3 minutes**, cutting cycle times by **80 per cent**, while warehouse tracking improved accuracy and reduced losses.

Crucially, iHub's digital transition focused heavily on inclusive workforce upskilling. Rather than let technology replace headcount, their human-centric approach systematically eliminated mundane, tedious tasks and elevated the know-how of their ground staff to use the new digital tools to help them do their work faster and more accurately. In a powerful testament to this inclusive design, a 74-year-old warehouse assistant successfully picked up the new platform, embracing the technology as an effective everyday "teammate" on the warehouse floor.

Nanyang Inc

Since 1965, Nanyang Inc has evolved from a tentage provider to a trusted full-service logistics provider for events ranging from weddings to large-scale exhibitions. As Singapore's event industry grew more competitive, and client expectations for speed and precision soared, the company recognised that its future differentiator would be the intelligent use of digitalisation and AI.

Nanyang Inc's back-office operations faced severe bottlenecks due to their reliance on different silo platforms even as customer demands increased. The lack of integration led to extended response times for complex quotes, high human error rates in inventory tracking, and constrained scalability.

To resolve these hurdles, the company first experimented with a GenAI-powered chatbot to handle web enquiries, which successfully saved the team 82 per cent of the time previously spent on manual responses. Building on this success, Nanyang Inc worked with a tech vendor to develop AutomateAI, a unified platform powered by Google's Vertex AI and BigQuery. This platform fundamentally redesigned their workflow with the use of AI agents to automatically parse natural language customer requests, verify inventory availability, and instantly generate quotations and invoices.

Workforce Transformation and Upskilling

A critical component of this journey was workforce upskilling and the strategic shift of human capital. Nanyang Inc used AI to absorb routine data-entry and system-coordination tasks. This empowered its workers to focus on more complex activities, such as complicated corporate sales, strategic client advisory, and on-site safety management.

The impact of this digital transformation was immediate, delivering a **67 per cent reduction in order processing time**, **850 man-hours saved monthly**, **65 per cent higher customer retention**, and a **257 per cent return on investment** within the first year.

Effects of AI use on local employment by wage and age

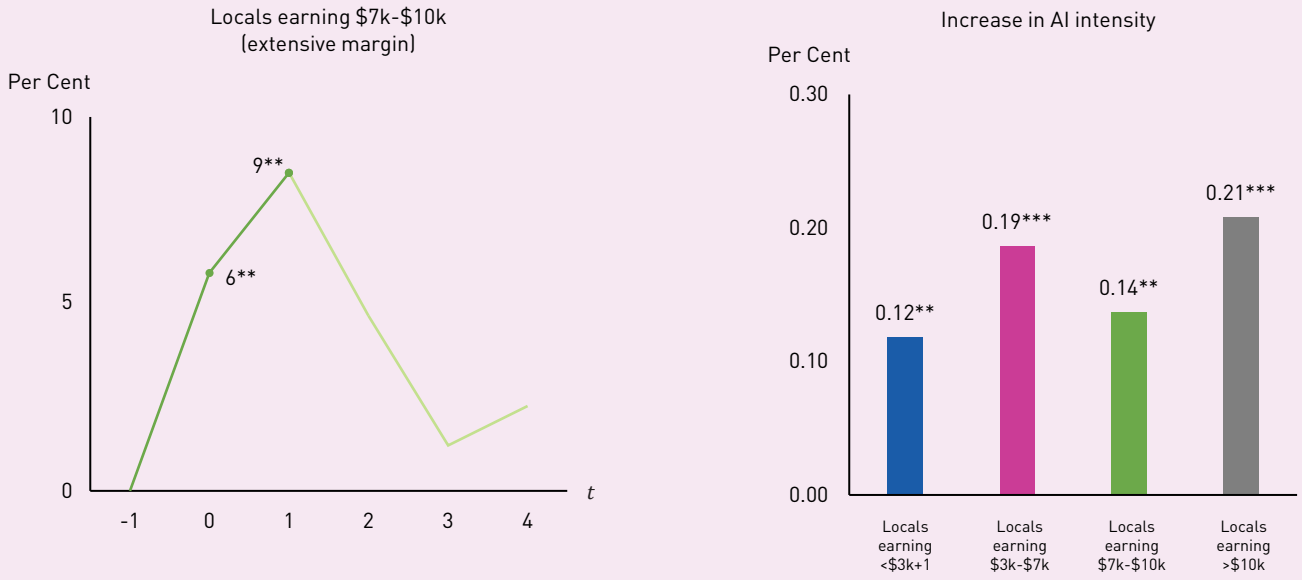
Local employment results by wage and age bands suggest that the initial employment gains from AI use are concentrated among workers who likely have a larger share of AI-complementary tasks or are more adaptable to redesigned workflows.

At the extensive margin, employment gains are concentrated among local higher-earners, particularly those with monthly wages of S$7,000 to S$10,000, and among local mid-career workers aged 35 to 44 (Exhibits 4 and 5, full results in Annex B). No statistically significant employment effect is observed for the other wage and age bands. Foreign employment results by pass types show that initial AI use increases the employment of higher-income and higher-skilled Employment Pass holders, with no statistically significant effect for the other pass types.

These findings are consistent with the task reallocation channel. Higher-income workers are more likely to perform multiple tasks: analytical, managerial, technical, or client-facing. While AI may automate some routine tasks of their jobs, these workers may be well positioned to shift their effort towards the remaining tasks that are complementary to AI, such as judgement and relationship management. Mid-career workers may similarly benefit from a combination of accumulated experience and adaptability. They may have enough firm- or occupation-specific knowledge to apply AI effectively, while remaining flexible enough to adapt to redesigned workflows. In some cases, firms may supplement their workforce capabilities with targeted hiring from abroad, particularly where specialised technical skills or expertise are scarce.

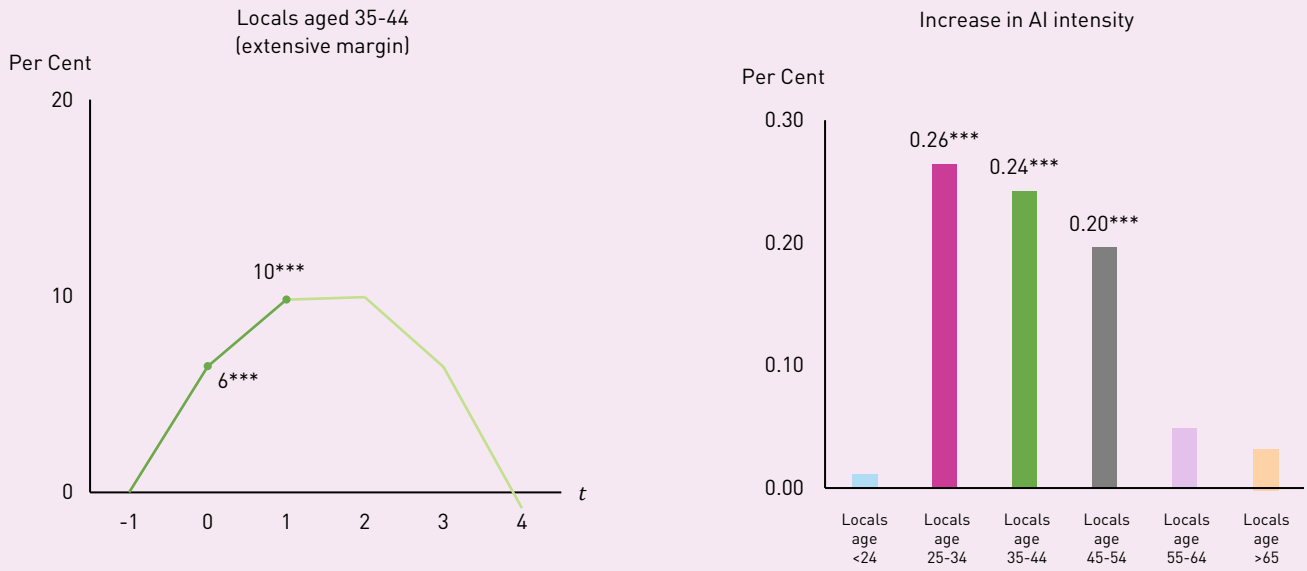
However, the intensive margin analysis shows that as firms deepen their AI capabilities, employment gains broaden across wage and age bands. Specifically, local employment rises across all wage bands and for a broader group of workers aged 25 to 54 as AI intensity increases (Exhibits 4 and 5, full results in Annex C). This may reflect scale effects as AI-using firms expand overall hiring. It may also reflect worker adaptation: when AI becomes embedded in firms' processes, a broader group of workers may undergo skills training or may reorganise around AI-enabled workflows.

Exhibit 4. Impact of AI use on local employment by wage



Note: *** p<0.01, ** p<0.05, * p<0.1. Results that are statistically significant at the 5% level are in solid colours and labelled.

Exhibit 5. Impact of AI use on local employment by age



Note: *** p<0.01, ** p<0.05, * p<0.1. Results that are statistically significant at the 5% level are in solid colours and labelled.

Impact of AI use by sector[30]

The heterogeneity analysis shows that the effects of AI use vary across sectors.

Among the sectors analysed, AI-using firms in finance & insurance, wholesale trade and information & communications experience larger revenue gains compared to the other sectors (Exhibit 6, full results in Annex D).

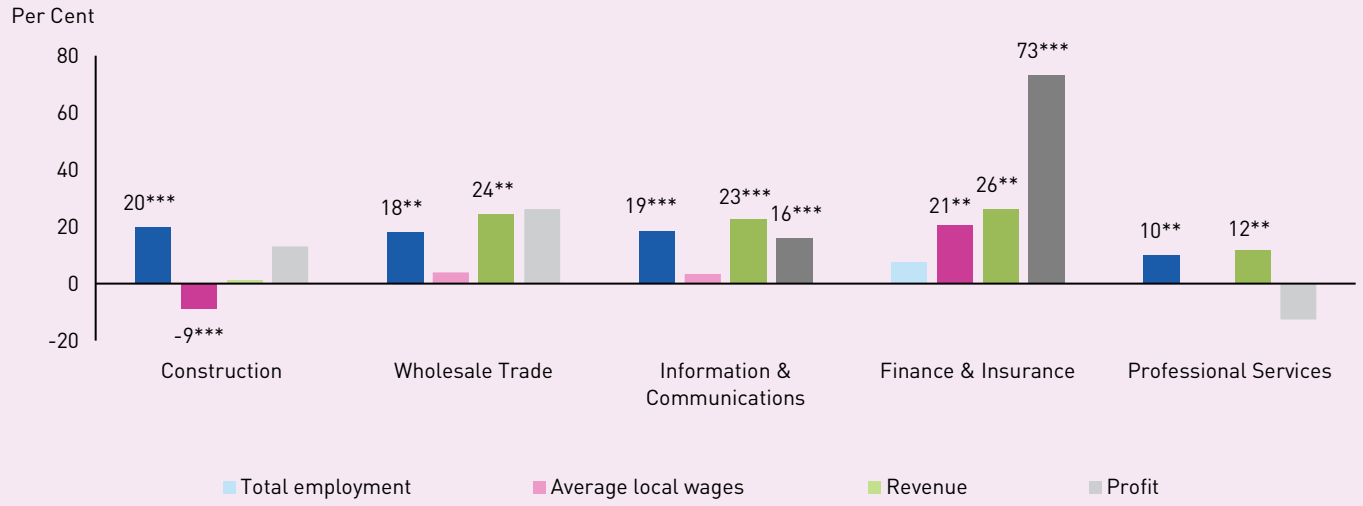
By sectors, AI-using firms in finance & insurance experience the largest increases in revenue and profit among the sectors analysed. AI may be especially valuable in the finance & insurance sector, as it can support the development of new or enhanced products and services, streamline operations or reduce operational costs (e.g., personalised investment products, fraud detection, credit risk scoring). AI-using firms in the sector also see increases in average local wages, as they may shift their workforce composition towards higher-income workers who may generate greater productivity gains with AI.

Meanwhile, AI-using firms in wholesale trade experience increases in revenue and total employment. This may be due to AI improving their ability to conduct demand forecasting, inventory planning and logistics optimisation, thereby resulting in firm expansion.

At the same time, information & communications firms show improvements in revenue, profit and total employment from AI use. This is consistent with AI supporting the development of new or enhanced products and services, personalised customer engagement and improved task efficiency. As markets expand with AI use, firms in this sector may increase their overall worker demand.

30 *Results for sectors not discussed in this section are not statistically significant or at risk of spurious statistical significance due to low sample size.*

Exhibit 6. Impact of AI use by selected sector



Note: *** p<0.01, ** p<0.05, * p<0.1. Results that are statistically significant at the 5% level are in solid colours and labelled. Sectors with low sample size (i.e., less than 30 AI-using firms) or results that are not statistically significant are not shown.

Impact of AI use by firm size

Heterogeneity analysis by firm size suggests that micro, small and medium firms see benefits from AI use (Exhibit 7, full results in Annex E).[31]

Micro AI-using firms experience the largest revenue gains. One possible explanation is that these firms may be more nimble and hence able to implement complementary organisational changes more quickly than larger firms.

Medium AI-using firms show broad gains in not just revenue, but also total employment and profit. This could be because these firms have sufficient resources, expertise and data to make meaningful AI investments, while remaining flexible enough to integrate AI effectively.

Small AI-using firms experience increases in total employment, possibly because they are expanding their workforce in anticipation of AI-enabled output gains. However, relevant organisational changes may still need to be completed before revenue gains fully materialise.

Exhibit 7. Impact of AI use by selected firm size

Note: *** p<0.01, ** p<0.05, * p<0.1. Results that are statistically significant at the 5% level are in solid colours and labelled. Results for large firms (revenue size >$100M) not shown due to low sample size (i.e., less than 30 AI-using firms).

31 *Results for large firms (revenue size >$100M) are not shown due to low sample size (i.e., less than 30 AI-using firms).*

CONCLUSION AND POLICY IMPLICATIONS

This study develops a firm-level measure of AI use in Singapore based on data from online job postings. The measure is then linked to administrative firm-level data to enable analyses on the characteristics of AI-using firms and the impact of firms' AI use on their performance and employment to be studied.

The study's key findings are as follows. First, AI use is not a stand-alone leap for firms. Instead, it tends to build on the prior efforts of firms to adopt foundational and complementary digital technologies.

Second, firms in digital- and data-intensive sectors/clusters (i.e., information & communications, electronics, professional services and finance & insurance) are more likely to use AI. Larger firms are also more likely to use AI, even after accounting for sector and age.

Third, first-time AI use by firms is associated with firm-level increases in total employment and revenue, and these gains continue to rise as AI capabilities deepen. This could reflect the potential scale and/or innovation effects of AI (e.g., AI reducing costs and/or enables the creation of new products, thus allowing firms to expand output). At the same time, the increase in firm-level employment suggests that any worker separations that may occur at the firm are outweighed by new hiring. It may also be the case that AI tends to automate specific tasks rather than entire jobs, thus allowing workers to focus on the remaining and/or new complementary tasks.

On the other hand, firms do not see a statistically significant increase in their productivity and profit within four years of first AI adoption. This could be because the full benefits of AI may only materialise after complementary investments are made, similar to the experience of earlier transformative technologies such as the internet.

Deeper analysis on the employment effects show that they differ across worker types. Initial gains are found to be concentrated among local higher-earners and mid-career workers, as well as skilled foreign professionals. However, as firms deepen their AI capabilities, the local employment gains broaden across wage and age groups.

Fourth, heterogeneity analyses show that the impact of firms' AI use varies across sector and firm size. For example, firms in the finance & insurance, wholesale trade and information & communications sectors, as well as micro and medium firms, see larger gains in revenue on average.

These findings suggest three policy lessons to help firms and workers realise economic benefits from AI. First, it is important for firms to strengthen their foundational digital capabilities as this could aid in their AI adoption. Second, support for AI use should be differentiated by sector and firm size. This may entail identifying sector-specific AI use cases with larger returns, or the provision of support to smaller firms that may lack internal capabilities to effectively integrate AI. Third, workforce policy should focus on job transformation and worker training to help workers move toward AI-complementary tasks even as some tasks become automated.

As the study analyses firms' AI use up to 2024, the estimates should be seen as reflecting the early impact of AI diffusion, and would not capture the effects of more recent advances in AI capabilities (e.g., agentic AI) as well as broader enterprise adoption. Future studies could analyse the effects of the different AI use cases that firms are implementing using more recent data that better capture the advances in AI technology and new patterns of adoption.

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ANNEX

Annex A: Characteristics of AI-using firms

Term	AI use
Manufacturing - Electronics	0.149***
Manufacturing - Chemicals	-0.028
Manufacturing - Biomedical Manufacturing	0.020
Manufacturing - Precision Engineering	-0.014
Manufacturing - Transport Engineering	-0.010
Manufacturing - General Manufacturing	-0.040
Construction	-0.052
Utilities	-0.067
Other Goods Industries	0.023
Wholesale Trade	-0.005
Retail Trade	-0.016
Transportation & Storage	-0.041
Accommodation	-0.013
Food & Beverage Services	-0.067**
Information & Communications	0.221***
Finance & Insurance	0.061*
Real Estate	-0.019
Professional Services	0.062*
Administrative & Support Services	-0.036
Other Services - Education	0.000
Other Services - Health & Social Services	-0.049
Other Services - Arts, Entertainment & Recreation	-0.040
Other Services - Others	-0.057*
Age 6-10	0.039
Age 11-20	0.030
Age >20	0.010
Employment Size 11-50	0.050***
Employment Size 51-250	0.115***
Employment Size >250	0.393***
N	19,263

Statistical significance level: *** p<0.01, ** p<0.05, * p<0.1.

Annex B: Extensive-margin effects of AI use

Term	log (total emp.+1)	log (local emp.+1)	log (foreign emp.+1)	log (average local wages+1)	log (revenue+1)	asinh (profit)	asinh (vapw)
year of 1st AI use	0.043**	0.027	0.056***	0.010	0.076**	0.066	-0.137
1 year after	0.066**	0.044	0.077**	0.000	0.157***	0.175	0.138
2 years after	0.034	0.014	0.074	0.001	0.133*	0.047	0.066
3 years after	-0.010	-0.017	0.000	0.007	0.088	0.087	-0.126
4 years after	-0.136	-0.154	-0.096	-0.033	0.172	0.051	0.472
lag(digital using)	0.125***	0.095***	0.115***	0.002	0.009	0.035	0.237
lag(log(cumulative grant + 1))	0.028*	0.023	0.043***	0.015**	0.055***	0.043	0.348**
N	61,533	61,533	61,533	61,533	13,646	13,646	13,646

Term	log(locals earning <$3k +1)	log(locals earning $3k-$7k +1)	log(locals earning $7k-$10k +1)	log(locals earning >$10k +1)
year of 1st AI use	0.003	0.018	0.058**	0.014
1 year after	0.029	0.023	0.085**	0.037
2 years after	0.027	-0.007	0.047	0.040
3 years after	-0.018	-0.036	0.012	0.016
4 years after	-0.119	-0.152	0.023	-0.050
lag(digital using)	0.021	0.101***	0.093***	0.047**
lag(log(cumulative grant + 1))	0.000	0.048***	0.039***	0.021
N	61,533	61,533	61,533	61,533

Term	log(local emp. aged <24 +1)	log(locals aged 25-34 + 1)	log(locals aged 35-44 + 1)	log(locals aged 45-54 + 1)	log(locals aged 55-64 + 1)	log(locals aged >65 + 1)
year of 1st AI use	0.010	0.046**	0.064***	0.016	0.002	0.010
1 year after	0.007	0.072**	0.098***	0.027	0.003	0.032
2 years after	0.068	0.024	0.099*	0.015	0.012	0.019
3 years after	-0.040	-0.051	0.064	0.025	0.018	0.002
4 years after	-0.166	-0.187	-0.008	0.001	-0.091	-0.005
lag(digital using)	0.071***	0.144***	0.078***	0.093***	0.050**	0.024
lag(log(cumulative grant + 1))	0.006	0.049***	0.042***	-0.010	0.001	0.006
N	61,533	61,533	61,533	61,533	61,533	61,533

Term	log (EP holders+1)	log (S Pass holders+1)	log (Work permit holders+1)
year of 1st AI use	0.054***	0.013	0.025*
1 year after	0.115***	0.023	0.001
2 years after	0.108**	0.002	-0.002
3 years after	0.019	-0.052	0.012
4 years after	-0.076	-0.108	0.024
lag(digital using)	0.063***	0.044**	0.052***
lag(log(cumulative grant + 1))	0.045***	0.012	0.000
N	61,533	61,533	61,533

Statistical significance level: *** p<0.01, ** p<0.05, * p<0.1.

Annex C: Intensive-margin effects of AI use

Term	log (total emp.+1)	log (local emp.+1)	log (foreign emp.+1)	log (average local wages+1)	log (revenue+1)	asinh (profit)	asinh (vapw)
lag(log(cumulative max AI job postings + 1))	0.223***	0.232***	0.178***	0.021	0.244***	-0.110	-0.289
lag(digital using)	0.197***	0.175***	0.168***	0.052**	0.130**	0.131	0.166
lag(log(cumulative grant + 1))	0.031**	0.026*	0.052***	0.019**	0.036*	0.064	0.224
N	32,173	32,173	32,173	32,173	6,837	6,837	6,837

Term	log(locals earning <$3k +1)	log(locals earning $3k-$7k +1)	log(locals earning $7k-$10k +1)	log(locals earning >$10k +1)
lag(log(cumulative max AI job postings + 1))	0.118**	0.186***	0.137**	0.208***
lag(digital using)	0.089**	0.132***	0.130***	0.118***
lag(log(cumulative grant + 1))	-0.003	0.020	0.036**	0.013
N	32,173	32,173	32,173	32,173

Term	log(local emp. aged <24 +1)	log(locals aged 25-34 + 1)	log(locals aged 35-44 + 1)	log(locals aged 45-54 + 1)	log(locals aged 55-64 + 1)	log(locals aged >65 + 1)
lag(log(cumulative max AI job postings + 1))	0.011	0.264***	0.242***	0.196***	0.049	0.034
lag(digital using)	0.065	0.206***	0.117***	0.115***	0.100***	0.027
lag(log(cumulative grant + 1))	0.016	0.039***	0.032**	-0.015	0.024	0.006
N	32,173	32,173	32,173	32,173	32,173	32,173

Term	log (EP holders+1)	log (S Pass holders+1)	log (Work permit holders+1)
lag(log(cumulative max AI job postings + 1))	0.143***	0.133***	0.092
lag(digital using)	0.117***	0.062**	0.087***
lag(log(cumulative grant + 1))	0.049***	0.019*	0.004
N	32,173	32,173	32,173

Statistical significance level: *** p<0.01, ** p<0.05, * p<0.1.

Annex D: Impact of AI use by sector

Term	log (total emp.+1)	log (local emp.+1)	log (foreign emp.+1)	log (average local wages+1)	log (revenue+1)	asinh (profit)	asinh (vapw)
Manufacturing	-0.011	0.007	-0.053	-0.010	0.060	0.099	1.355
Construction	0.197***	0.054	0.277***	-0.088***	0.012	0.130	-2.071
Wholesale Trade	0.181**	0.128	0.382***	0.040	0.243**	0.262	0.250
Information & Communications	0.186***	0.199***	0.148***	0.034	0.227***	0.161***	0.713**
Finance & Insurance	0.075	0.082	0.007	0.206**	0.261**	0.731***	1.395
Professional Services	0.099**	0.098**	0.062	0.002	0.117**	-0.125	-0.394
Administrative & Support Services	0.122	0.129	0.175	0.016	0.016	0.090	0.335
lag(digital using)	0.125***	0.095***	0.115***	0.002	0.010	0.038	0.245
lag(log(cumulative grant + 1))	0.027*	0.022	0.043***	0.015**	0.055***	0.042	0.346**

Statistical significance level: *** p<0.01, ** p<0.05, * p<0.1. Sectors with low sample size (i.e., less than 30 AI-using firms) or results that are not statistically significant are not shown.

Annex E: Impact of AI use by revenue size

Term	log (total emp.+1)	log (local emp.+1)	log (foreign emp.+1)	log (average local wages+1)	log (revenue+1)	asinh (profit)	asinh (vapw)
Micro (<$1M)	0.006	-0.017	0.159	0.007	0.179**	0.142	0.854
Small ($10M-$100M)	0.130***	0.134**	0.091*	0.003	0.135*	0.088	0.272
Medium ($10M-$100M)	0.212***	0.202***	0.191***	0.074**	0.167***	0.136	0.235
lag(digital using)	0.142***	0.112**	0.154***	0.008	0.012	0.053	0.289
lag(log(cumulative grant + 1))	-0.038	-0.050	0.030*	0.007	0.054***	0.046	0.364**

Statistical significance level: *** p<0.01, ** p<0.05, * p<0.1. Results for large firms (revenue size >$100M) not shown due to low sample size (i.e., less than 30 AI-using firms).

FEATURE ARTICLE

ESTIMATING THE ECONOMIC IMPACT OF AIR CONNECTIVITY USING NETWORK ANALYSIS


HSBC

Feature Article

ESTIMATING THE ECONOMIC IMPACT OF AIR CONNECTIVITY USING NETWORK ANALYSIS

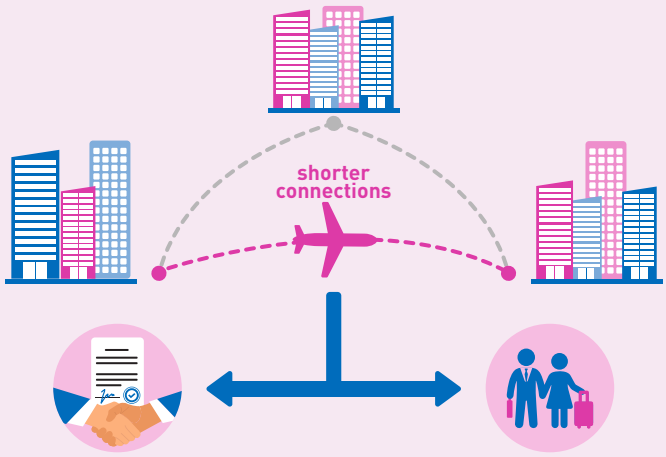
OVERVIEW

As a small and open island economy, Singapore relies on its strong aviation sector and international air connectivity to facilitate the movement of people and goods, support trade and the flow of essential supplies, and create good jobs for Singaporeans. Our air connectivity brings the world to Singapore and also allows Singaporeans to venture beyond our shores. Overall, Singapore's strategic location and connectivity reinforce Changi's position as a key air hub linking the region with the wider global economy.

FINDINGS

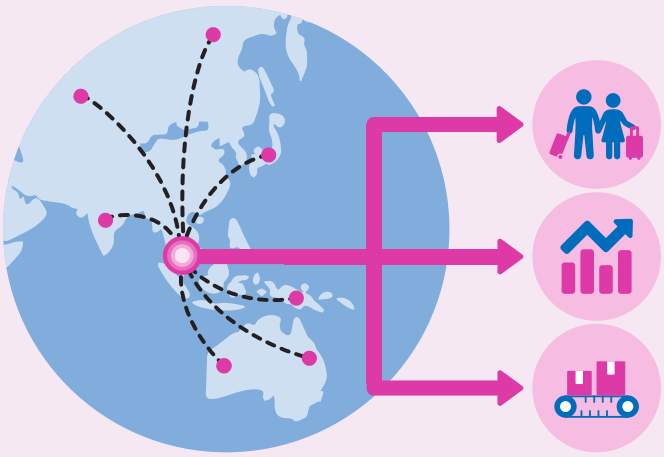
Finding 1:

Shorter and more convenient flight connections between cities are associated with higher foreign direct investment (FDI), direct investment abroad (DIA) and air passenger flows. These relationships are stronger for cities that are geographically closer together, possibly because such cities are more likely to have established regional production networks, trade and investment relationships, and travel links.



Finding 2:

Cities that lie along more efficient routes between other cities tend to have higher GDP. This may reflect the benefits of serving as an air hub, as facilitating a larger share of passenger and cargo flows results in greater economic activity to support these flows. The larger volume of flows may also generate agglomeration effects and economies of scale, such as enabling airlines to sustain more frequent flights due to transfer demand.



POLICY TAKEAWAY

Air connectivity generates significant economic benefits by improving access to overseas markets and strengthening a city's position as an air hub. The findings highlight the importance of considering network effects when assessing new air links, as the economic value of a connection extends beyond direct traffic flows and improves connectivity across the wider network. Our simulations suggest that strengthening links with less well-connected and growing regions yield significant economic gains.

EXECUTIVE SUMMARY

- Singapore's air connectivity is a strategic economic asset that undergirds its role as a global hub. With Changi Airport targeting 200 city links by the mid-2030s, this study seeks to understand how enhanced air connectivity could lead to economic gains and also provide a broad assessment of the cities and regions that Singapore could establish new links with to deliver the greatest economic gains to Singapore.

- To conduct the study, we combine flight schedules, city-level GDP and foreign investment data for over 2,000 cities from 2014 to 2024. We then apply network analysis on the dataset to estimate the economic impact of improving air connectivity.

- We find that shorter travel times arising from more direct flight routes are associated with stronger economic flows (i.e., foreign direct investment (FDI), direct investment abroad (DIA) and air passenger arrivals). Specifically, a 1-unit reduction in GDP-weighted flight distance experienced by a city is associated with higher FDI inflows of US$192 to US$490 and DIA outflows of US$100 to US$1,250 over five years, as well as an increase in 0.003 to 0.008 air passengers per annum, for the city, depending on the geodesic distance between the city and the source city.

- We also find that cities that are better connected within the global air transport network (i.e. with higher betweenness centrality) tend to achieve stronger GDP, reflecting gains from facilitating air passenger transfers and improved efficiency arising from network and scale economies. Specifically, an analysis on the global aviation network found that a 1 percentage-point increase in betweenness centrality of a city is associated with a 0.22 per cent increase in its GDP, while a smaller but statistically significant increase in GDP of 0.084 per cent is estimated for cities with GDP levels similar to Singapore's.

- Our simulations specific to Singapore suggest that the largest economic gains would come from stronger air links with developing and emerging regions, including Latin America, Africa and Central Asia.

- Our findings support continued investment in Singapore's air hub and access to future growth markets, while recognising that route development will also depend on aircraft availability and capability, airline strategies, and the availability of air traffic rights in air service agreements.

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 or the Government of Singapore.[1]

INTRODUCTION

As an open economy with a small domestic market, Singapore's economic growth depends heavily on its connections with the rest of the world. By enabling the efficient movement of people and goods between Singapore and overseas markets, our air connectivity supports trade, investment, tourism and other economic activities. Singapore's strong air connectivity to cities across various regions also enables it to serve as a key transfer hub that efficiently connects other city pairs through Singapore, thereby generating additional passenger and cargo flows for Singapore. Taken together, these benefits make air connectivity a key economic asset for Singapore.

Over the years, the Government and industry partners have taken steps to strengthen Singapore as an air hub and improve its connectivity. In 2025, Changi Airport (henceforth "Changi") served around 70.0 million passengers, an increase of 3.4 per cent from the 67.7 million in 2024. Almost 2.1 million tonnes of air cargo were handled by the airport in the same year, up 4.5 per cent from 2024. As at January 2026, Changi is connected to over 170 cities in 50 countries and territories worldwide.

1 *We would like to thank Ms Yong Yik Wei, Dr Andy Feng, Dr Tan Di Song, Dr Tan Yi Jin, and MOT and CAAS colleagues for their useful suggestions and comments. All remaining errors belong to the authors.*

Changi aims to grow its number of city links to more than 200 by the mid-2030s when Terminal 5 becomes operational.[2] Given Changi's role as a key enabler of the Singapore economy, important questions to address include the extent to which improved air connectivity will benefit the Singapore economy and where the new air links should be established in order to reap the largest economic gains for Singapore.

Broadly, industry and academic studies provide evidence that improved connectivity leads to economic gains for countries and cities. For example, studies by the International Air Transport Association (IATA) report that a 10 per cent increase in air connectivity led to a 0.07 per cent increase in labour productivity (Smyth and Pearce, 2007), and a 1.1 per cent increase in long-run GDP among EU countries (IATA, 2006). In the economic literature, Campante and Yanagizawa-Drott (2018) found that long-distance non-stop flights led to significant increases in business linkages and capital flows between cities. Overall, they estimated that a one standard deviation increase in air connectivity would lead to a 0.8 per cent growth in the cities' GDP on average.

In this study, we similarly seek to improve our understanding of how air connectivity generates economic benefits for cities by first developing centrality-based[3] measures of air connectivity that account for the broader structure of the global aviation network. Using a city-level panel dataset, we then use these measures to examine how improvements in air connectivity have contributed to economic outcomes such as foreign direct investment (FDI), direct investment abroad (DIA) and air passenger arrivals, and hence GDP of the cities. Finally, we outline how these findings may be used in simulations to identify cities and regions where new direct air links could generate significant economic benefits for Singapore.

CONNECTIVITY / CENTRALITY MEASURES AND DATA

Before describing the data, we first describe the conceptual framework used to understand how economic gains could accrue from enhanced air connectivity via the establishment of direct air links, and the relevance of centrality measures in quantifying the extent of such gains, using Singapore as an example.

In assessing the economic gains from direct air links, it is important to account for network effects, as a new connection does not just link two cities but will also have an impact on the global aviation network, which could lead to additional benefits for the cities. Taking into account network effects, there could be two main channels of impact when new air links are established: improved market access and enhanced air hub status. For example, when Singapore establishes a direct air link with a previously-unconnected city, it could:

- **Channel 1: Improve market access for Singapore**. This occurs as the new link shortens (i) the direct flight distance between Singapore and the newly-linked city, and also (ii) the effective flight distance to other cities that are not directly linked to Singapore but are now better connected to Singapore via this newly-linked city (i.e., indirect link). The overall improvement in Singapore's flight distance to the newly-connected city and other cities increases Singapore's attractiveness as a destination for business and tourism, which leads to increased FDI and tourist expenditure, respectively. It also improves Singapore's access to overseas markets, thus facilitating DIA.

- **Channel 2: Reinforce Singapore's role as an air transfer hub.** This occurs as the new link may lead to changes in the global aviation network such that other city pairs in the network may now benefit from a reduction in their total flight distance and travel time by routing through Singapore as a new stopover option. The resulting increase in passenger transfers and cargo transshipments through Singapore will benefit the Singapore economy, including the services and logistics sectors. Additionally, increased demand for flights through Changi allows Singapore to enjoy economies of scale, such as increased flight frequencies and lower input costs.

2 *Source: The Business Times (https://www.businesstimes.com.sg/singapore/changi-airport-banks-apac-aviation-boom-strong-partnerships-growth)*
3 *Centrality is a concept from network analysis that describes the importance of a node within a network based on its connections with other nodes. Central nodes generally have larger contributions to the overall connectivity of the network, hence capturing greater network activity and having more influence on network dynamics.*

In the literature, there are two centrality measures commonly used in network analysis that map closely to the two channels described above:

- **Closeness centrality, which measures how efficiently one city can reach all other cities in the global air network, is our theoretical measure of market access (i.e., Channel 1).** The intuition is that a new direct flight between a city pair will not just increase the efficiency of travel between the pair, but will also have an indirect impact on the flight distance to other unlinked cities if the new link facilitates shorter routes than previously available.

- **Betweenness centrality, which measures the frequency at which a city is situated on a shortest path between other cities within the network, proxies for the city's status as an air hub (i.e., Channel 2).** The intuition is that a city that is frequently on the shortest path will have a higher likelihood of passengers and cargo choosing flight routes via the city to improve travel efficiency. The introduction of a new direct flight between a city pair may increase the frequency at which the cities are situated on a shortest path within the network.

To construct the above centrality measures and quantify the economic impact of improved air connectivity, we put together an analytic dataset from three separate data sources: flight schedules data covering scheduled air routes and number of air passengers at the route level from a third party data provider, the Global Human Settlement Layer dataset containing city-level GDP (available in 5-year intervals) and geographic coordinates, as well as Orbis foreign investment data detailing the date, investment amount, project status and source and destination cities at the project level.[4] The merged dataset covers over 2,000 cities for a few selected years within the period of 2014 to 2024.

EMPIRICAL METHODOLOGY

First, we construct the two centrality measures as follows:

- **Closeness centrality.** We compute an equivalent measure based on the flight distance between cities in the global aviation network. Specifically, we compute the shortest flight distance $\rho_t(i, j)$ between cities i and j in year t, with a penalty term of 2,700 km for each intermediate stop on the route, to account for the additional time needed for stopovers.[5]

- **Betweenness centrality.** We use the distance measure $\rho_t(i, j)$ above to identify whether a city lies on the shortest path between every other city pair in the global aviation network, with the paths weighted by the GDPs of the cities at the endpoints of the path, to compute our measure of betweenness centrality.

Second, following other network studies in the literature (e.g., Bramoullé et al. (2020)), we model the degree of influence a source node has on another node[6] in the network as the product of:

- The size of the connection between the two nodes, which we measure using the distance measure $\rho_t(i, j)$; and
- The strength of the source node, which we proxy using the GDP of the source city, $GDP_{i,t}$.

4 We include only projects where the source and destination cities are in two different countries, and retain only projects that are confirmed (i.e., projects that are rumoured or announced are excluded).

5 This is equivalent to the distance covered by approximately three hours of flight time, which we estimated from dividing passengers' willingness to pay to avoid a stopover by the valuation of air travel time provided in Ennen et al. (2019).

6 In this study, our transmission channels are economic flows, and our nodes are the cities where the international airports are located.

Third, to assess the impact of improved market access, we exploit changes in $\rho_t(i,j)\cdot GDP_{i,t}$ (which captures changes in closeness centrality)[7] over time that can be attributed to changes in $\rho_t(i,j)$ by fixing the GDP of the source city at the base year, and estimate the following two-way fixed effects regression at the city pair level:

$$Y_{i\to j,t} = \beta \cdot \rho_t(i,j) \cdot GDP_{i,t_0} + CityPair_{i,j} + Year_t + \varepsilon_{i\to j,t}$$

where

- $Y_{i\to j,t}$ is the economic flow from source city i to destination city j in year t for air passenger arrivals, and across year t to $t+4$ for FDI flows.[8] It also represents the economic flow from destination city j to source city i across year t to $t+4$ for DIA flows;
- GDP_{i,t_0} is the GDP of source city i in base year t_0; and
- $CityPair_{i,j}$ and $Year_t$ are city pair and year fixed effects respectively. The city pair fixed effects account for time-invariant properties of city pairs such as the geodesic distance between cities, while the year fixed effects account for global economic trends that affect all city pairs.

We also run the regression separately for two subsamples to account for possible heterogeneity in impact based on the geodesic distance between the cities, arising from factors such as differences in traveller profiles and availability of other transport modes. Specifically, we segment city pairs based on whether they are more or less than 7,500 kilometres (km) apart.[9]

Fourth, to study the impact of enhancements to a city's air hub status, we use the betweenness centralities computed to estimate the impact of changes in a city's betweenness centrality over time on its GDP using the following two-way fixed effects regression at the city level:

$$\ln GDP_{i,t} = \beta\, Betweenness_{i,t} + \varsigma \ln GDP_{i,t-5} + City_i + Year_t + \varepsilon_{i,t}$$

where

- $Betweenness_{i,t}$ is the betweenness centrality of city i in year t;
- $GDP_{i,t}$ is the GDP of city i in year t; and
- $City_i$ and $Year_t$ are city and year fixed effects respectively. The city fixed effects account for time-invariant city-level variables such as geographic location, while the year fixed effects account for global economic trends that affect all cities.

The coefficient of interest β represents the relationship between betweenness centrality and GDP. The inclusion of city and year fixed effects allows us to control for city-specific characteristics that do not change over time, as well as macroeconomic trends that are common to all cities. We also include lagged GDP (five years prior) to account for pre-existing GDP trends.

Finally, we use our findings from the analyses above to simulate the economic impact to Singapore from the introduction of new direct air links between Singapore and currently-unconnected cities. The simulations will allow us to identify cities and regions that currently have low air connectivity to Singapore, and if connected to, can strengthen Singapore's connectivity and generate significant economic benefits. We carry out the simulations in two steps:

- Step 1: We compute the changes in flight distance (ρ) for all city pairs in the global aviation network, as well as Singapore's betweenness centrality, if a direct air link is introduced between Singapore and a currently-unconnected city. The computation is carried out separately for every city with an international airport that Singapore is currently not connected to.

7 *Specifically, our regressor appears in the denominator of the weighted closeness centrality* $\frac{\sum_{i\neq j} GDP_i}{\sum_{i\neq j}\rho_t(i,j)\cdot GDP_i}$ *. The closeness centrality can therefore be viewed as a measure of the ability of a node to interact with the rest of the network.*

8 *FDI and DIA flows are aggregated across five years to smooth out volatile changes.*

9 *The cutoff of 7,500km is chosen as it is approximately the median distance between cities, across all city pairs in our sample.*

- Step 2: For each of these cities, we then simulate the economic impact to Singapore of introducing a direct air link between Singapore and that city arising from the overall reduction in flight distance for Singapore (i.e., reduction in distance between Singapore and the city connected to, as well as between Singapore and all other unconnected cities) and improvement in Singapore's air hub status (as measured by betweenness centrality). We do so by multiplying the overall reduction in flight distance and improvement in betweenness centrality for Singapore derived in Step 1 with (i) the historical relationships between flight distance and economic flows (FDI, DIA and air passenger arrivals), as well as the relationship between these flows and GDP;[10] and (ii) the historical relationship between betweenness centrality and GDP, respectively.

RESULTS AND DISCUSSION

Channel 1: Improved Market Access

Our analysis shows that improvements in market access arising from enhanced air connectivity (i.e., reductions in flight distance) are associated with statistically significant increases in cross-border investment flows (i.e., FDI and DIA) as well as air passenger arrivals, and the effects are stronger for city pairs that are geographically closer [Exhibits 1 and 2].

Specifically, we find that a 1-unit reduction in GDP-weighted flight distance, expressed as the product of the source city's GDP (in billion USD) in the base year and the flight distance measure ρ (in km), is associated with higher FDI inflows of US$490 and DIA outflows of US$1,250 over five years, as well as an additional 0.008 air passenger arrivals per annum, for the destination city, if the source city is less than 7,500 km away from the destination city by geodesic distance. As for source cities that are at least 7,500 km away, the impact is estimated to be an increase of US$192 and US$100 in FDI inflows and DIA outflows respectively over five years, as well as an additional 0.003 air passenger arrivals per annum, for the destination city.

The stronger investment response for geographically closer cities could be because these cities are more likely to be linked through regional production networks and existing trade and investment relationships, supported by regional integration initiatives and trade agreements. Improved air connectivity may reinforce these established linkages and generate a stronger increase in investment flows. Similarly, the stronger air passenger arrivals response for geographically closer cities may reflect the greater sensitivity of travel demand for short-distance travel to improvements in journey time and increased convenience, or regional tourism being seen as discretionary travel and hence having a more elastic demand.

The increase in FDI and DIA from enhanced air connectivity in turn translates to higher GDP by adding to capital formation and productive capacity in recipient economies, and enabling investing firms to expand their operations and enter new markets (Borensztein et al., 1998).

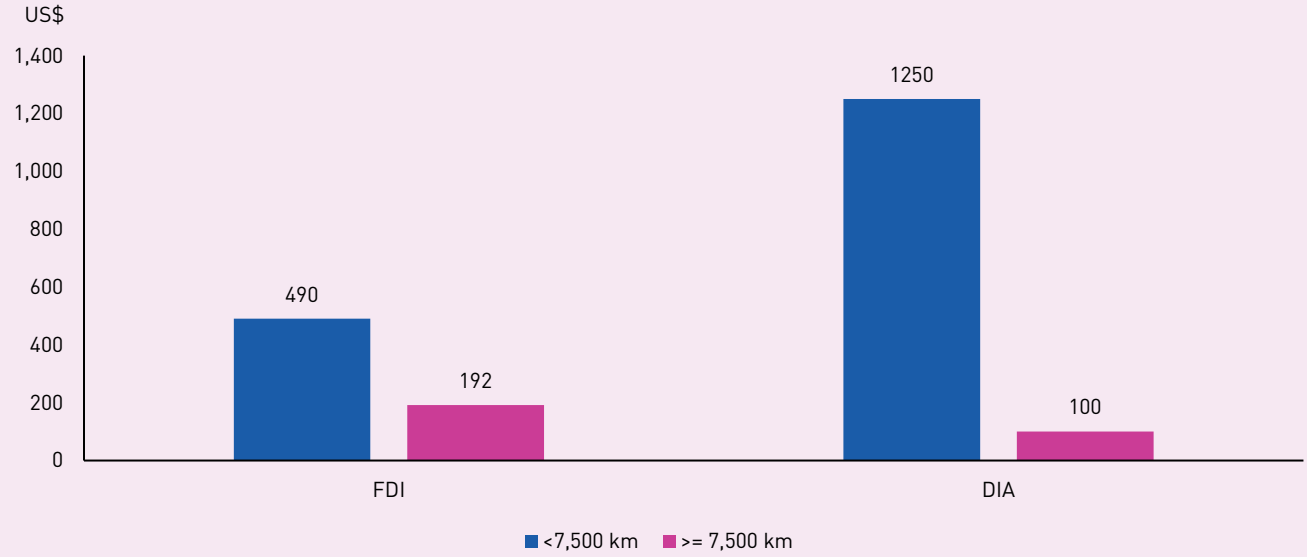
To put our technical estimates in context, eliminating a stopover along a flight connection (which results in time savings of three hours on average, or equivalent to shortening a flight by 2,700 km) to an economy of the same size as Singapore that is within 7,500 km of Singapore is estimated to lead to increases in FDI and DIA flows of approximately S$200 million (or 0.083 per cent of the historical average annual increase in FDI) and S$520 million (or 0.050 per cent of the historical average annual increase in DIA)[11] per year respectively, for Singapore. It will also likely increase air passenger arrivals to Singapore by 3,100 per annum (or 0.0089 per cent of our annual air passenger arrivals).

10 The elasticities used to convert FDI and DIA flows into GDP are based on estimates in the literature (e.g., Borensztein et al. (1998), Vu (2025)) and other studies. As for the increase in air passenger arrivals, we convert them into expected tourism value-added (VA), using historical tourist expenditure data and VA multipliers generated from DOS' Input-Output tables.

11 These are computed as the average annual increase in FDI and DIA stocks over the period of 2019 and 2024.

Based on elasticities from the literature, the increases in FDI and DIA are estimated to directly contribute S$160 million and S$65 million in value-added (VA) per annum respectively to the Singapore economy (or around 0.021 and 0.0085 per cent of Singapore's GDP respectively). Beyond these direct contributions, FDI flows may also generate broader economic benefits to the rest of the economy. For instance, a MTI study found that EDB-supported firms generated positive spillovers to other firms in Singapore, including higher VA, productivity, employment and wages.[12] Similarly, increased air passenger arrivals can support Singapore's air transport industry[13] and facilitate greater visitor spending in Singapore, thus benefitting other tourism-related sectors in the economy such as the accommodation, food & beverage and retail trade sectors.[14]

Exhibit 1: Impact of a 1-unit decrease in GDP-weighted flight distance on investment flows over 5 years



Source: Authors' estimates

Exhibit 2: Impact of a 1-unit decrease in GDP-weighted flight distance on air passenger arrivals per annum

Source: Authors' estimates

12 *Tan et al. (2025) reported positive spillover effects of EDB-supported firms on the VA and productivity of other firms that were driven mainly by the labour market channel. Technology space spillovers also contributed positively to local employment and wages by facilitating improvements in firms' production and organisational processes.*

13 *The air transport segment accounts for close to 10 per cent of the nominal VA of the transportation & storage sector in 2024, and includes Singapore-based airlines that provide air passenger and air cargo services, as well as firms that support the operations of airlines at the airport (Ngoh, 2025).*

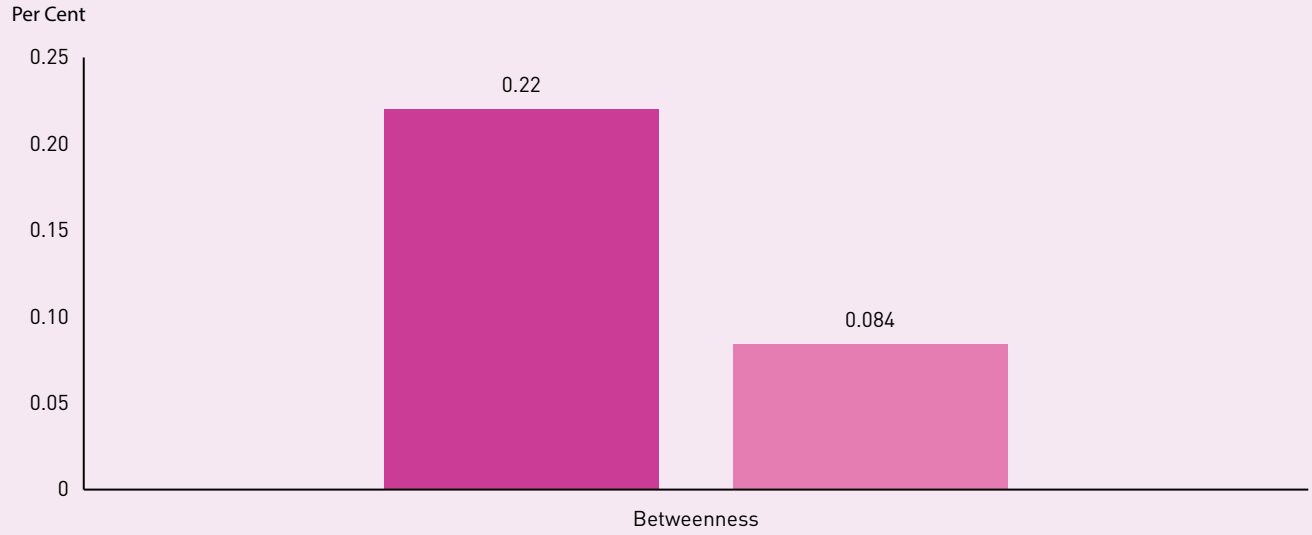
14 *Tourism contributes to the VA of several sectors, including accommodation, arts, entertainment & recreation, food & beverage services, retail trade, and transportation & storage. In 2024, tourism was estimated to account for 6.0 per cent of Singapore's services exports (Ngoh and Abdul, 2025).*

Channel 2: Enhanced Air Hub Status

Our analysis shows that a 1 percentage-point (pp) increase in betweenness centrality is historically associated with a 0.22 per cent increase in GDP [Exhibit 3]. Even among cities with GDP comparable to Singapore's[15] and would already be more connected globally, the same 1 pp increase in betweenness centrality is still associated with a 0.084 per cent increase in GDP.

Improvements in betweenness centrality contribute to GDP growth as the strengthening of a city's position as an air hub allows the city to benefit from the increased flow of passengers and cargo through its airport. Having a large volume of flows also facilitates agglomeration and economies of scale (e.g., airlines can maintain a higher flight frequency due to transfer demand), which further boost GDP.

Exhibit 3: Impact of a 1-pp increase in betweenness centrality on GDP



Source: Authors' estimates

Simulations of New Air Links for Singapore

Lastly, we conduct simulations on the existing global aviation network to identify cities and regions with which Singapore could potentially establish new direct air links with to best increase our closeness and betweenness centralities, and hence GDP.

As Singapore is already well-connected with most advanced economies, we find largest improvements to our centrality scores if there are new non-stop flights to developing and emerging regions, such as Latin America, Africa and Central Asia. These new air links will benefit our economy by facilitating access to new markets for investment and trade, particularly if we anticipate that these markets will enjoy sustained economic growth in the years ahead. Our simulations also identify selected cities in North America and Europe where introducing new direct flights could generate significant economic gains.

Concomitantly, the new direct flights will enhance Singapore's air hub status. By improving connectivity from these regions to Southeast Asia and Oceania via Singapore, Singapore could attract more passenger and cargo flows to route through Singapore.

While our analysis identifies the new air links with significant economic potential, we caveat that the feasibility of establishing these links will also depend on a range of operational, commercial and regulatory considerations. These include the availability of suitable aircraft (e.g., range and payload) to serve the route economically, airlines' assessments of the commercial viability of operating the route (e.g., potential yields, presence of competition, contribution to airline's network), and the availability of the relevant traffic rights.

15 We define comparable cities to be those whose GDP is at least one-tenth of Singapore's GDP.

CONCLUSION

In summary, this study finds that improvements to Singapore's air connectivity can generate economic benefits by improving market access and strengthening Singapore's air hub status. The findings highlight the importance of considering network effects when assessing new air links, as the economic value of a connection extends beyond direct traffic flows and improves connectivity across the wider network. Our simulations suggest that stronger links with less well-connected and growing regions yield significant economic gains.

More broadly, the study highlights how network analysis can deepen our understanding of the economic gains associated with air connectivity, including the gains arising from Singapore's position as a global air hub. As a small and highly open economy, Singapore's continued ability to connect with and be a connector between different markets will remain important for our economic resilience, competitiveness and long-term growth.

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