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ECONOMIC IMPACT OF GOOGLE'S APAC NETWORK INFRASTRUCTURE

FOCUS ON SINGAPORE

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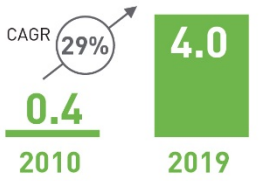
Economic impact of Google's network infrastructure in Singapore

DATA TRAFFIC IN SINGAPORE IS GROWING STRONGLY, DRIVEN IN PART BY THE POPULARITY OF GOOGLE'S SERVICES

Singapore data traffic growth 2010–2019 (EB)



12% Google services' share of APAC internet traffic

GOOGLE INVESTED OVER USD2 BILLION IN NETWORK INFRASTRUCTURE ACROSS APAC, WHICH SUPPORTS THE INTERNET IN SINGAPORE

>$2bn

Google's APAC network infrastructure investment

Singapore investments

- **2** submarine cables (SJC, Indigo)
- **2** private facilities and **5** IXPs with Google PoPs
- **~75%** of bandwidth purchased from telcos
- GGC nodes deployed across the city

GOOGLE'S INFRASTRUCTURE INVESTMENT HELPS SINGAPORE REALISE STRONG ECONOMIC BENEFITS FROM INCREASED INTERNET USAGE

Last 10 years (2010-2019)	Next 5 years (2020-2024)
8 600 Jobs	**9 300** Jobs
$9bn in GDP	**$9bn** in GDP

1 All currency in USD, in real 2019 terms

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THESE INVESTMENTS IMPROVE THE CONNECTIVITY ECOSYSTEM WHICH BENEFITS CONSUMERS AND BUSINESSES

2024

1.9 Exabytes internet traffic

82Tbit/s in additional capacity

6ms reduction in end-user latency

4.8x faster download speeds vs. rest of APAC

79% lower IP transit prices vs. rest of APAC

3 new use cases supported

- Video Conference
- Commerce and Transactions
- Cloud Services

SINGAPORE CLOUD SPEND IS EXPECTED TO GROW STRONGLY DRIVING ADDITIONAL ECONOMIC BENEFITS

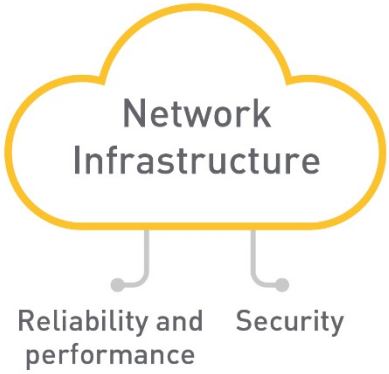
Singapore cloud spend (USD bn)
2018–2023

Benefits of cloud adoption

- Supports digital transformation agenda
- Additional economic impact from 2019-2023

43 000 Jobs **$31bn** in GDP

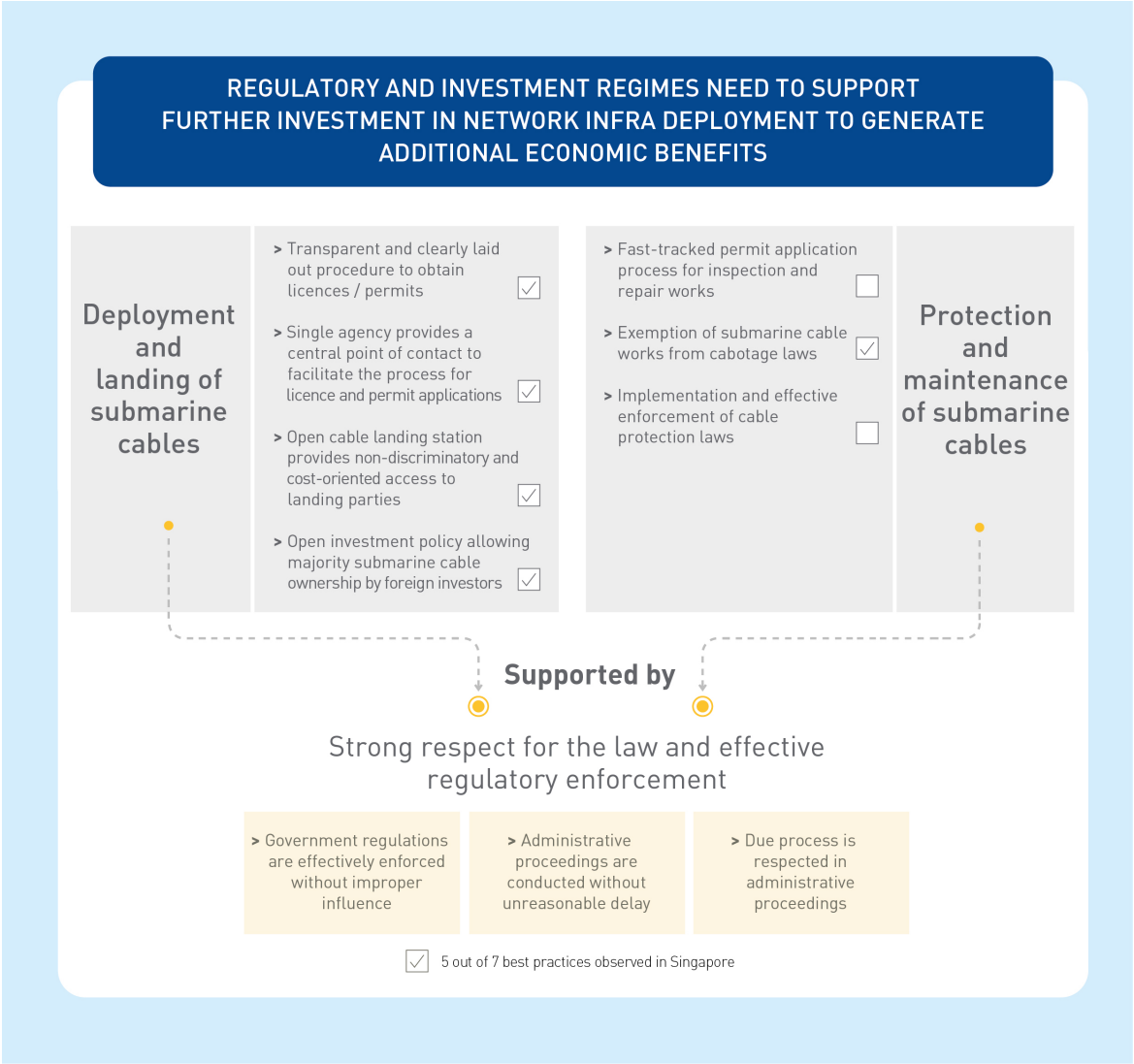
NETWORK INFRASTRUCTURE IS IMPORTANT FOR CLOUD – IT IMPROVES:



Case Study: Ninja Van

As a 24/7 business, Ninja Van needs to stay connected with its customers at all times. Ninja Van handles high load events efficiently and improves data-driven decision making with GCP.

"[GCP] processes data in the scale of hundreds of gigabytes to speed up analytics... Delivers network performance 10 times faster between data centers."


REGULATORY AND INVESTMENT REGIMES NEED TO SUPPORT FURTHER INVESTMENT IN NETWORK INFRA DEPLOYMENT TO GENERATE ADDITIONAL ECONOMIC BENEFITS
Deployment and landing of submarine cables
> Transparent and clearly laid out procedure to obtain licences / permits
> Single agency provides a central point of contact to facilitate the process for licence and permit applications
> Open cable landing station provides non-discriminatory and cost-oriented access to landing parties
> Open investment policy allowing majority submarine cable ownership by foreign investors
> Fast-tracked permit application process for inspection and repair works
> Exemption of submarine cable works from cabotage laws
> Implementation and effective enforcement of cable protection laws
Protection and maintenance of submarine cables
Supported by
Strong respect for the law and effective regulatory enforcement
> Government regulations are effectively enforced without improper influence
> Administrative proceedings are conducted without unreasonable delay
> Due process is respected in administrative proceedings
5 out of 7 best practices observed in Singapore

Singapore has one of the world's most developed telecom landscapes. As of 2019, 88% of its population was connected to the internet. Internet traffic generated across both fixed and mobile networks has been growing strongly at around 29% annually from 2010 to 2019, reaching 4EB in total in 2019.

There are three main telecoms service providers in Singapore, in addition to a smaller new-entrant mobile operator (TPG) and many retail service providers and MVNOs:

- **Singtel**, the incumbent and largest telecoms operator in Singapore
- **StarHub**, the second-largest operator under ST Telemedia
- **M1**, owned by Keppel Corporation.

Singapore's fixed and mobile networks provide extensive coverage: close to 100% of households[2] have access to fibre broadband and 99% of the population is within range of 4G mobile coverage.[3]

Singapore is also one of the main submarine cable hubs in APAC, and is connected to 23 international submarine cable systems that, as of 2019, offered a total of 857Tbit/s in potential capacity.[4]

1 Google's network infrastructure investments contributed to higher internet usage in Singapore, equivalent to 20% of internet traffic in 2019

Google's investments in network infrastructure not only improve service performance and reliability of its content and services, they also improve the overall performance and cost-effectiveness of internet infrastructure in Singapore. Investments in submarine cables bring new supply, improve the diversity of links and also support the expansion of Google's edge infrastructure in Singapore. The connectivity improvements include lower latency, faster end-user speeds, lower cost of international connectivity and stimulation of new use cases. These effects translate into more internet traffic generated by both consumers and businesses in Singapore.

Google is an investor in two submarine cable systems that land in Singapore, namely:

- **SJC**, a Pan-Asia cable which launched in 2013 and connects Singapore, Japan, China, Hong Kong, the Philippines, Brunei and Thailand
- **Indigo**, which went live in 2019 and connects Australia, Singapore and Indonesia.

These cables bring a total of 82Tbit/s in potential capacity to Singapore. Google also purchases additional capacity on other international links provided by telecoms carriers, and this purchased bandwidth accounts for close to 75% of Google's network capacity in Singapore.[5]

2 FTTx coverage and capex worldwide: forecast and analysis 2019-2025, Analysys Mason Research

3 Analysys Mason Research

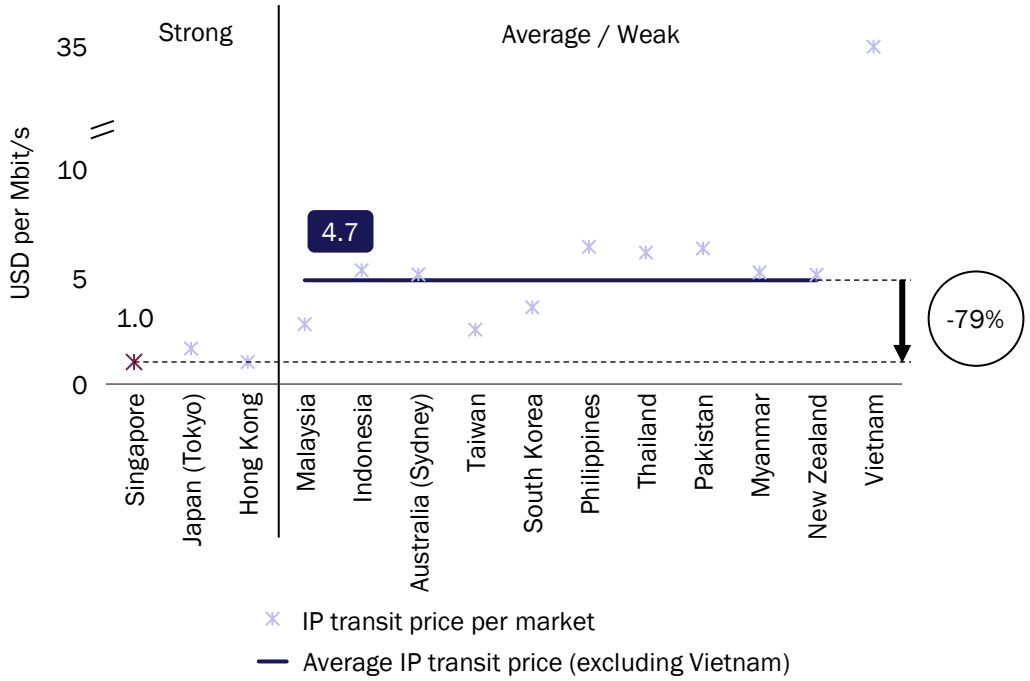
4 Refers to the estimated theoretical maximum capacity that a cable could handle with current technology

5 Google data received in Feb 2020

Besides bringing additional bandwidth into Singapore, Google's investments in submarine cables also improve route diversity. Our modelling also suggests that Google's network investments are correlated to lower end-user latency: in Singapore, this could be linked to a 6ms reduction in end-user latency in Singapore by 2019.

Google's investments have also contributed to the decline in the cost of international bandwidth: IP transit prices in Singapore are amongst the lowest in the region, at around 79% lower than less well-connected economies as shown in Figure 1 below.

Figure 1: IP transit prices[6] across APAC [Source: TeleGeography, Analysys Mason, 2019]



Apart from investments in international capacity, Google has also invested in edge infrastructure and deployed PoPs in two private peering facilities and cross-connected to IXPs at five locations as shown in Figure 2 below. GGC nodes are also deployed in operator networks across Singapore.

Name of facility / fabric	Type	Location
BBIX Singapore	Public	Singapore
Equinix Singapore	Public	Singapore
MegaIX	Public	Singapore
SGIXPeering LAN	Public	Singapore

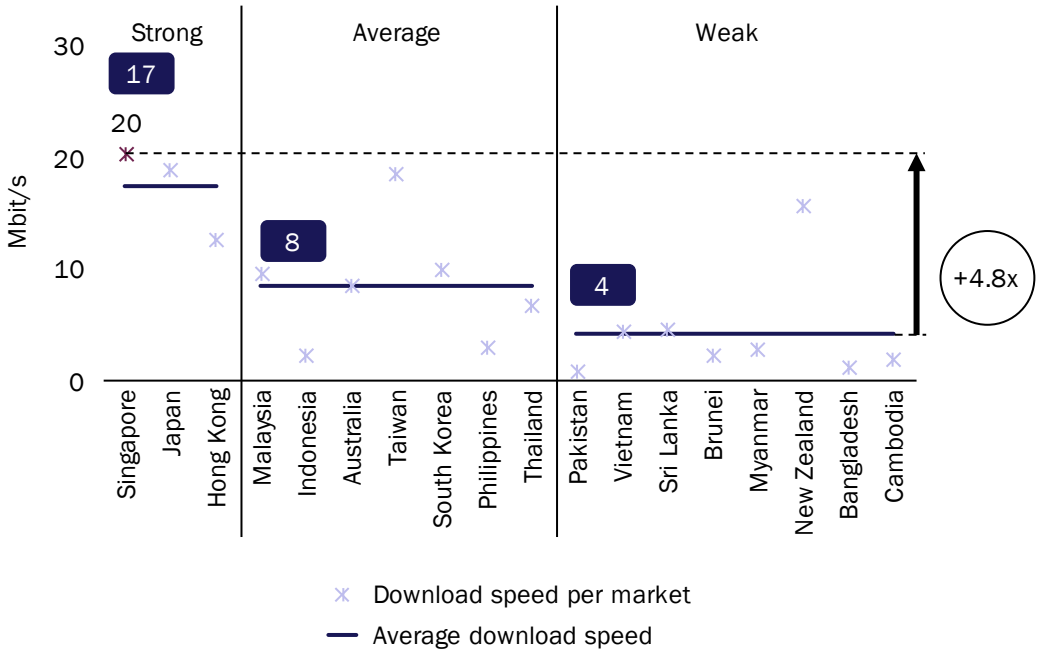
Figure 2: List of Google peering facilities in Singapore [Source: Google, PeeringDB, 2020]

6 Refers to USD per Mbit/s of IP transit prices in 2019 based on the committed data rate of 10Gbit/s from TeleGeography; calculation is based on averaging the weighted median prices by cities and quarters (up to Q3 2019) to derive 2019 prices; IP transit price data for 10Gbit/s is referenced, as it provides the highest number of available data points (14 APAC economies with submarine cables)

SOX	Public	Singapore
Equinix (SG3)	Private	Singapore
Global Switch	Private	Singapore

These investments in edge infrastructure and PoPs bring popular Google content closer to end users in Singapore, which contributes to faster download speeds;[7] in 2019, the average download speeds in the country were up to 4.8× that of less well-connected economies, as shown below in Figure 3.

Figure 3: Download speed comparison [Source: M-lab, 2019]



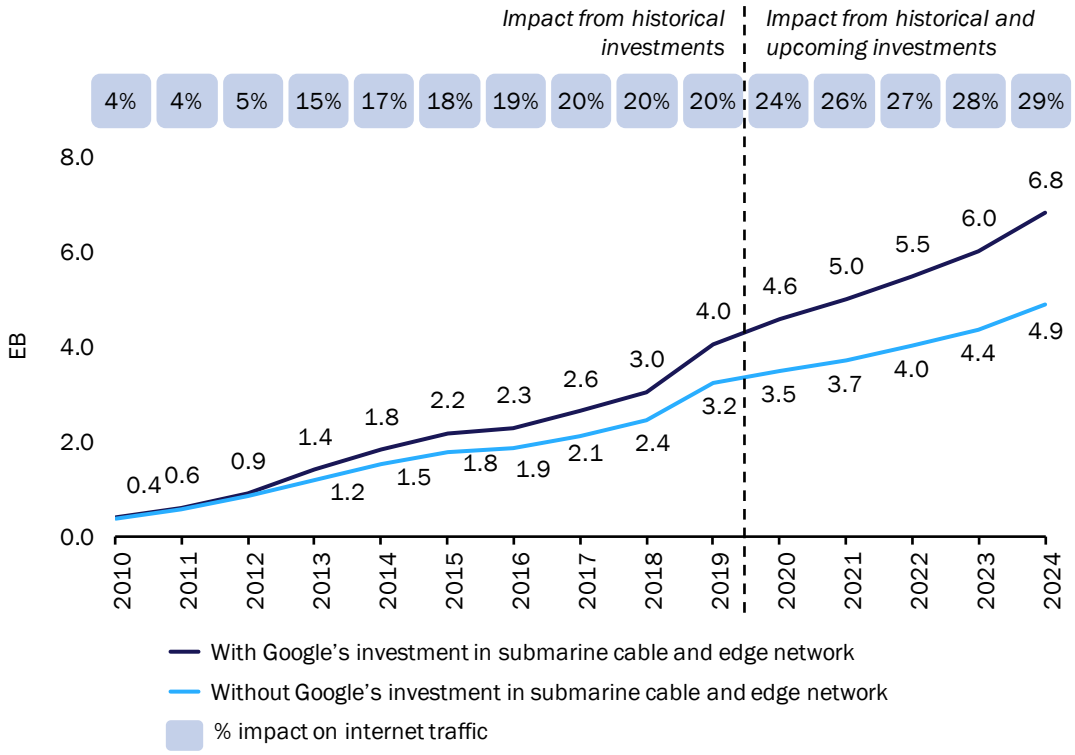
Improvements in latency and internet speed increase ISPs' ability to deliver innovative services such as cloud services, video conferencing and gaming. Low latency is also critical for transactional services, including e-commerce.

The end result of these improvements is greater demand for the internet in Singapore: based on Analysys Mason's modelling, we estimate that internet traffic in Singapore would have been 20% lower in 2019 had Google not made investments in network infrastructure, and the impact is expected to increase to 29% of internet traffic by 2024, as seen below in Figure 4.[8]

7 Google traffic is a significant contributor to network traffic in APAC – approximately 12% of total uplink and downlink network traffic

8 This takes into account the effect of the entire submarine cable system(s) that Google participates in. As explained in Annex A of the full report, the fact that Google was an investor in these systems appears to have a statistically significant effect on their impact on the geographies they serve, including Singapore.

Figure 4: Impact of Google's investments in edge network infrastructure on internet traffic served by Google's services in Singapore [Source: Analysys Mason, 2020]



2 The positive impact of Google's network infrastructure investment benefits the internet ecosystem in Singapore, supporting 9 000 jobs and led to USD1 billion in additional GDP in 2019 alone

The increase in internet use has a positive impact on economic activity across various sectors, leading to benefits for consumers and businesses. We estimate that the increase in internet usage contributed USD9 billion in GDP impact (in real terms[9]) in Singapore from 2010 to 2019; in 2019, we estimate that GDP would have been 0.37% lower in the scenario where Google had not made investments in network infrastructure.

Google's continued network investments from 2020 onwards are expected to spur higher internet traffic usage. The historical and continued investments are expected to contribute an additional USD9 billion in GDP impact from 2020 to 2024, of which USD1.9 billion would be in 2024 alone (see Figure 5 below). This GDP impact represents the base case of Analysys Mason's modelling estimates and could range between USD2 billion and USD16 billion from 2020 to 2024 (see Figure 6 below).

9 GDP figures are in constant USD using 2019 as the base year and using a fixed exchange rate to USD in 2019; GDP statistics in USD are sourced from the World Bank and Euromonitor

Figure 5: Increase in real GDP attributable to Google's network infrastructure investments in Singapore [Source: Analysys Mason, 2020]

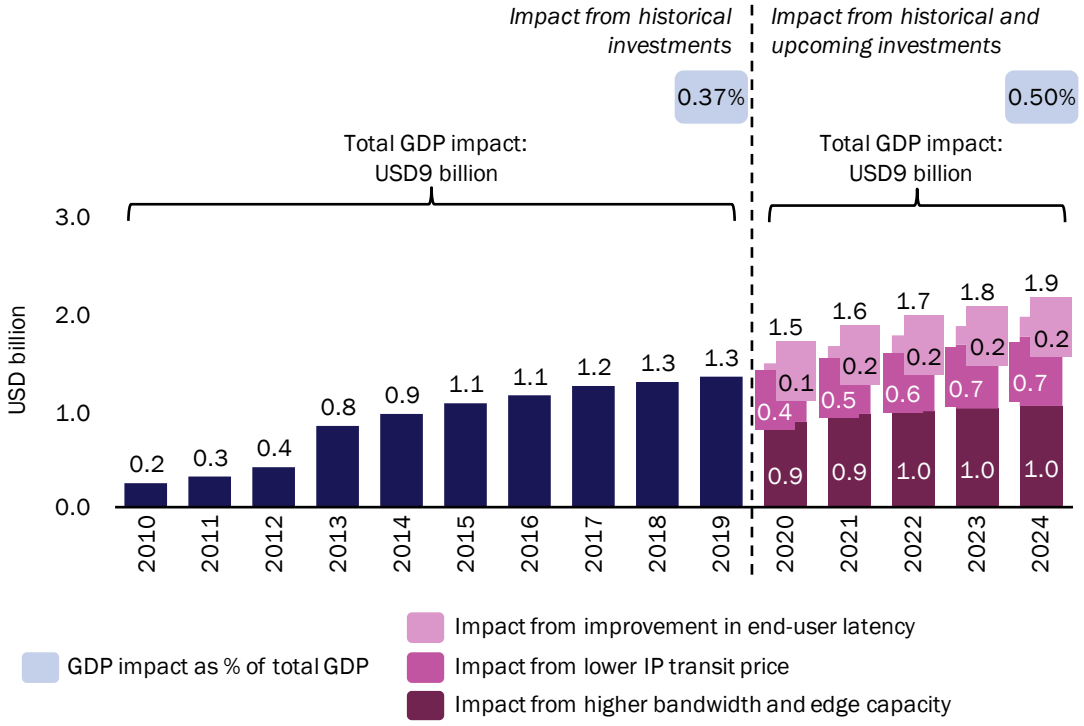


Figure 6: Increase in real GDP from 2020 to 2024 attributable to Google's network infrastructure investments in Singapore by modelling scenarios and connectivity components [Source: Analysys Mason, 2020]

Drivers of data traffic impacting GDP	Conservative[10]	Base case[11]	Aggressive[12]
Bandwidth and edge impact + IP transit price + Latency impact	5	9	16
Bandwidth and edge impact + IP transit price impact	5	8	14
Bandwidth and edge impact only	2	5	10

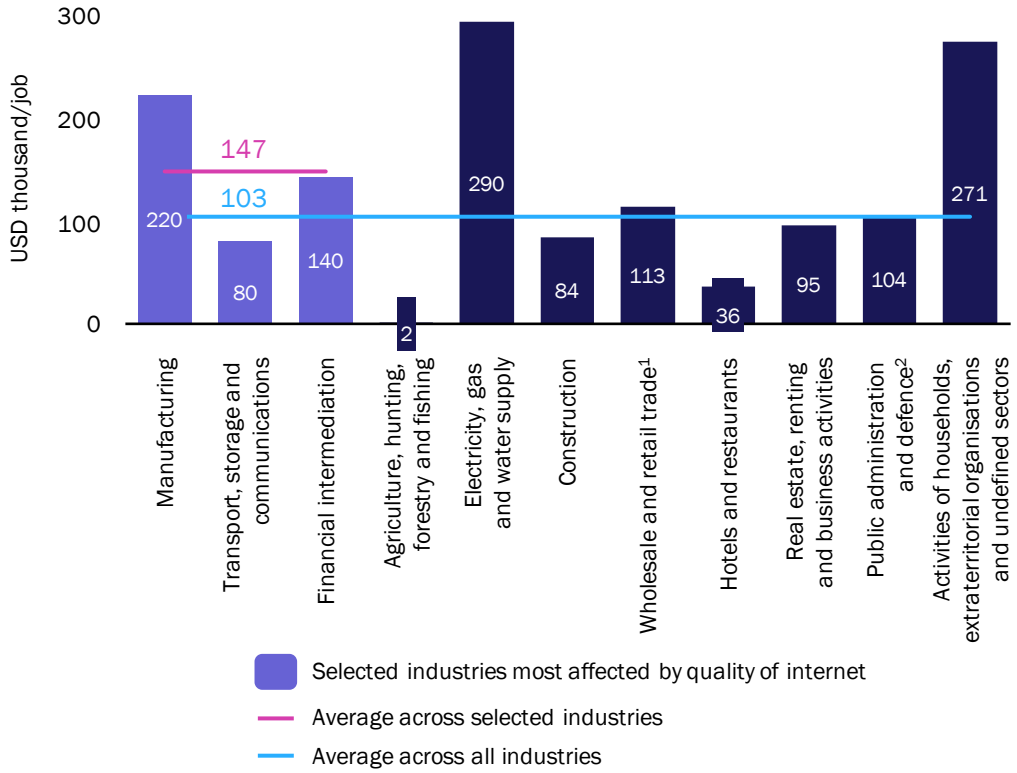
The economic benefits arising from Google's network infrastructure investments translate into jobs: direct jobs in the construction and telecoms sector and indirect jobs driven by the improvement of broadband connectivity across the broader economy, particularly in industries such as IT, financial services and manufacturing. Based on an assessment of gross value added (GVA) across industries in Singapore, we estimate that, in 2019, the average GVA per job was USD147 000 in industries most affected by the quality of the internet (see Figure 7 below).

10 The conservative modelling scenario refers to the use of coefficients (within the 95% confidence interval) in the supply and demand side equations to provide the lowest GDP impact. Specifically, the *highest* coefficient values are used in the supply side equation for latency and both latency and IP transit price variables in the demand side equation for mobile data usage; the *lowest* coefficient values are used in the supply side equation for internet bandwidth and internet bandwidth variable in the demand side equation for mobile data usage

11 The base case modelling scenario refers to the use of mid-point coefficients (within the 95% confidence interval) in the supply side equations (coefficients for submarine cable count and Google submarine cable percentage variables) and demand side equation (coefficients for internet bandwidth); Latency and IP transit price variables in the demand side equation are kept at the highest coefficient values which provides the lowest GDP impact

12 The aggressive modelling scenario refers to the use of coefficients (within the 95% confidence interval) in the supply and demand side equations to provide the highest GDP impact while keeping latency and IP transit variables unadjusted (see above base case modelling scenario). Specifically, the lowest coefficient values are used in the supply side equation for latency; the highest coefficients are used for the supply side equation for internet bandwidth and the internet bandwidth variable in the demand side equation for mobile data usage

Figure 7: 2019 GVA per job by industry in Singapore [Source: Analysys Mason, national statistics authority via Euromonitor, 2020]

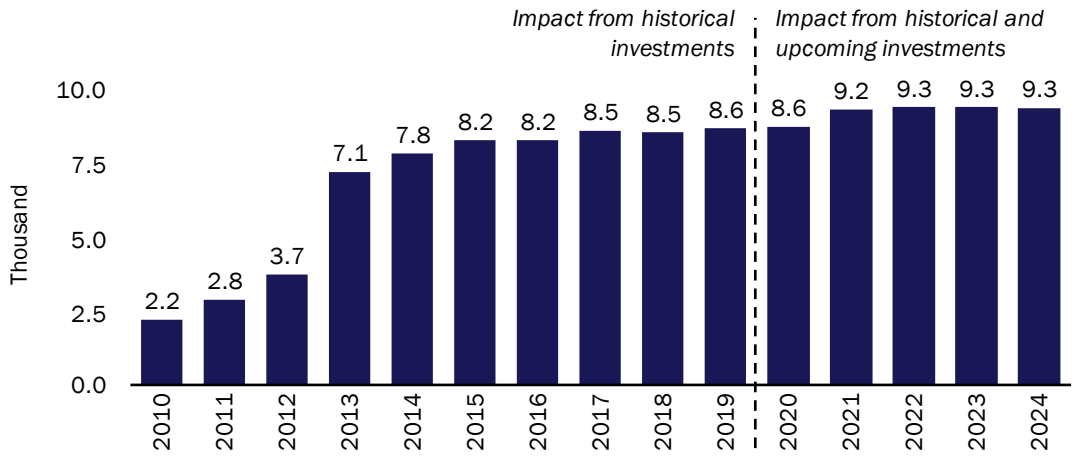


[1] Includes repair of motor vehicles, motorcycles, personal and household goods

[2] Includes compulsory social security

Based on this assessment, we estimate that Google's network investments and their impact on GDP translated to around 8600 jobs created by 2019, growing to around 9300 jobs by 2024 (see Figure 8 below).

Figure 8: Impact of Google's network investments on job creation in Singapore [Source: Analysys Mason, 2020]



3 Investments in network infrastructure contribute to the reliability and security of the cloud, driving further positive economic impacts in a segment that is expanding at 20% annually

According to BCG's "Ascent to the Cloud" report, Singapore has one of the most advanced public cloud markets in APAC. The country's public cloud spend is growing at 20% annually, from USD1.5 billion in 2018 to an expected USD3.6 billion in 2023. The increase in cloud spend is expected to have a cumulative GDP impact of USD31 billion between 2019 and 2023 and support 43 000 jobs in 2023.[13]

Google is an important player among cloud service providers in the world. At the end of 2019, GCP had been deployed in seven cloud regions in APAC, one of which is in Singapore. The GCP region in Singapore was launched in 2017 with two zones and was the first Google cloud region in South-East Asia. A third zone has been launched in 2018 which further improves the availability and reliability of cloud services to customers.[14]

Google's network infrastructure investments provide route diversity, connecting cloud regions in Singapore to other regions through different paths and enable low service latency, high levels of availability and increased resilience to cable cuts. The improved reliability, resilience and security of the Cloud service is important to Google Cloud customers in Singapore as shown in the case study below.

13 The studies underlying the cloud market forecasts were conducted before the onset of the COVID-19 pandemic and thus did not include the effects on the economy arising from COVID-19. We have left these forecasts unchanged, although the forecasts used for the main economic impact assessment in this report reflect updated forecasts as of June 2020. The size of the cloud services market may actually increase faster than anticipated as a result of COVID-19

14 Google Cloud Blog; see: https://cloud.google.com/blog/products/gcp/gcp-opens-a-third-zone-in-the-singapore-region

Case study: Ninja Van deployed GCP solutions to scale up its delivery service operations

Ninja Van was founded in 2014 and began its operations in Singapore and now has a last-mile logistics network covering six countries in Southeast Asia (Singapore, Malaysia, Philippines, Indonesia, Thailand and Vietnam).

As a 24/7 business, Ninja Van needs to stay connected with its customers at all times. Furthermore, with a majority of their customers being online shoppers, the company experiences unplanned surges in demand during online sales events making it hard to predict resource needs. Being a customer of GCP, Ninja Van is able to handle high load events efficiently with Google Kubernetes Engine and improves data-driven decision making with Cloud Dataproc.

> "[GCP] processes data in the scale of hundreds of gigabytes to speed up analytics [and] delivers network performance 10 times faster between data centres."
>
> **Ninja Van**

Besides improving the performance of cloud services, Google's network investments also serve as the underlying infrastructure layer delivering cloud traffic. Carrying cloud traffic on Google's own network reduces the security footprint, making it less likely that GCP customers' traffic will be attacked, intercepted, or manipulated by malicious actors.

4 Singapore's regulatory regime is conducive to the deployment and landing of submarine cables

Singapore has a transparent and efficient process for landing submarine cables. IMDA provides the required information to cable owners and helps to facilitate permit applications with other government agencies. Access to cable landing stations are based on cost-oriented pricing and on non-discriminatory terms, and there are also no equity limits on foreign investments in network infrastructure. These factors have enabled Singapore to become a leading submarine cable hub in the region.

Singapore is also a jurisdiction with strong regulatory enforcement principles. It scores well on the Rule of Law index, with a regulatory enforcement factor score of 0.87, which is the highest score amongst APAC countries.[15] This boosts investors' confidence, particularly in the context of capital-intensive investments such as the deployment of submarine cables.

15 World Justice Project – "Rule of Law Index 2020", see https://worldjusticeproject.org/our-work/research-and-data/wjp-rule-law-index-2020

There are best practice processes in other economies that could be applicable to Singapore, particularly regarding the protection and maintenance of submarine cables. Cable cuts on key routes can have a significant impact on the quality of the internet in the region and it is in the interest of governments to allow for speedy repair works to be conducted. An 'approval in principle' approach, such as that implemented in Taiwan, could speed up the permitting process, reducing the mean time to commence repair on cable faults. We also note that the seas around Singapore are busy and full of maritime activity. Singapore could consider introducing cable protection zones where possible, which would reduce the likelihood of cable damage due to human activity.