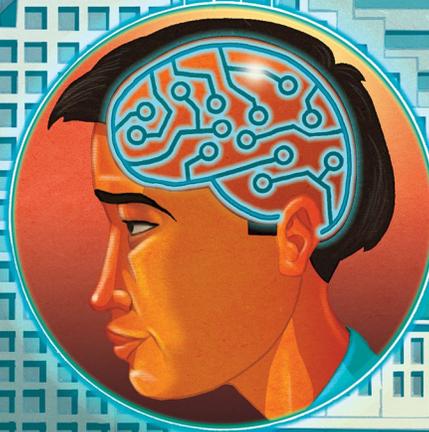


A Cloud for Doing Good:

A Technology Revolution
for All in ASEAN



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Foreword

We live in an age when technology is profoundly transforming every aspect of our lives, faster than at any other point in history. At the heart of what some call the “Fourth Industrial Revolution” is a singular innovation: cloud computing, or, just the cloud. The cloud enables the collection, storage, transfer, and analysis of data at unprecedented scale, speed, and depth over the internet. Housed in giant data centers around the world, the cloud enables individuals and organizations with connectivity and devices to have unprecedented, massive computing power in their hands. Indeed, rapid technological innovation is delivering advances in manufacturing, healthcare, education, government services, online employment, and other areas.

The ASEAN region, home to 620 million people, is one of the most economically dynamic regions in the world. The McKinsey Global Institute estimates that broader deployment of cloud technology could potentially generate up to US\$625 billion in annual economic impact by 2030. With over 600 million people or roughly 9% of the global population residing in ASEAN countries, McKinsey Global Institute predicts that the region will rank as the fourth-largest economy in the world by 2050.¹

But the news is not all good for the ASEAN region. In fact, the other side of ASEAN’s economic growth story is the fact that tremendous disparities in income, wealth, and opportunities still persist. Extreme poverty fell by more than 30% between 1990 and 2010, but the percentage of people living below the national poverty line still stands above 25% in the Philippines² and Myanmar³ and 10% in Vietnam⁴. 93 million workers, or 30% of the region’s workforce, live on less than US\$2 a day⁵ and, as of 2011, the adult and youth illiterate population in East Asia and the Pacific numbered 93 million, the third largest globally.⁶

1 McKinsey Global Institute. Southeast Asia at the crossroads: Three paths to prosperity. https://www.canback.com/files/2014_MK_MGI%20SE%20Asia_Executive%20summary.pdf (accessed 19 September 2017).

2 <http://povertydata.worldbank.org/poverty/country/PHL> (accessed 19 September 2017).

3 <https://www.adb.org/countries/myanmar/poverty> (accessed 19 September 2017).

4 <http://povertydata.worldbank.org/poverty/country/VNM> (accessed 19 September 2017).

5 Hartley, Kris. “Commentary: Inequality looms beneath the shiny façade of Southeast Asia’s growth” <http://www.channelnewsasia.com/news/asiapacific/commentary-inequality-loom-beneath-the-shiny-facade-of-8743726> (accessed 19 September 2017).

6 UNESCO Institute for Statistics. Adult and youth literacy: National, regional and global trends, 1985-2015. http://uis.unesco.org/sites/default/files/documents/adult-and-youth-literacy-national-regional-and-global-trends-1985-2015-en_0.pdf (accessed 19 September 2017).

ASEAN needs to ensure that its future transcends mere growth and moves to shared growth or shared prosperity. It is a tragedy when the potential of millions of youth, for example, is wasted for lack of access to education or lack of skills that lead to employability. The cloud that ASEAN needs is a “Cloud for Good”—technology that gives the marginalized access to education, banks the unbanked, improves government services, promotes skills for employment and entrepreneurship, helps generate new knowledge and insights to improve life, and unleashes the potential of people and organizations.

The Lee Kuan Yew School of Public Policy aims to transform the world through good governance and leadership excellence. Microsoft aims to empower every person and every organization on the planet to achieve more. With our overlapping missions, we have produced this report to highlight how ASEAN countries are taking advantage of cloud computing innovations now, and what more their leaders could do to help their people and countries truly thrive in the age of the Fourth Industrial Revolution. We hope that this report will stimulate discussion and actions that will contribute to sustained and shared prosperity in ASEAN for years to come.

– Dr. Astrid S. Tuminez and Prof. Eduardo Araral

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Executive Summary

I. Overview

Cloud computing is computing on the internet. Compared to conventional computing, cloud computing offers many benefits. It offers considerable savings because it requires no expensive capital investments for servers, maintenance, and replacements. It offers unlimited computing power and flexibility that allows users to scale up or down depending on computing needs. Users pay only for what they use and therefore it democratizes access to technology. It protects users from loss of data through more robust disaster recovery and ensures automatic software and security updates. It allows for greater collaboration with work teams and better control of documents, and gives flexibility to employees to work from anywhere.

Indeed, cloud computing is a technology whose time has come, especially for the Association of Southeast Asian Nations (ASEAN). It offers many practical benefits for countries in the region—for central governments and cities, businesses, especially small and medium enterprises (SMEs), manufacturing, banks and financial services firms, health and education institutions, and social enterprise organizations. Cloud computing can be harnessed for a more efficient and integrated public sector, especially for national governments and cities delivering front-line services. It allows various government agencies to work together with a whole-of-government approach instead of in the typical government silos. Large-scale, national social protection programs by the Philippines, Vietnam and Indonesia—for example, cash transfer programs—can be made more efficient and targeted through a biometric identification system similar to the Aadhaar card in India. Such large-scale biometric ID systems can be made more cost effective using cloud computing solutions. Metropolitan cities of ASEAN—Manila, Jakarta, Bandung, Bangkok, Ho Chi Minh, and Singapore—stand to benefit from cloud computing. Examples such as the Jakarta Smart City program¹ or Tel Aviv’s smart city transformation show that cloud solutions can improve city services and citizen participation in government decisions that affect their lives.² In Mexico, the tax country’s tax system administration (SAT) has leveraged the cloud to facilitate and increase tax filings and returns.³

Secondary cities and rural areas also stand to benefit from cloud computing. In Andhra Pradesh, India, farmers have increased their crop yields 30% by leveraging the cloud and using big data analytics to sow their crops at just the right time.⁴ In Myanmar, where over 70% of adults lack access to formal banking services, cloud technology has allowed financial services firms like Temenos to bring financial services to the most remote areas.⁵

1 <http://www.thejakartapost.com/news/2014/12/16/jakarta-launches-smart-city-program.html> (accessed 7 September 2017).

2 <https://enterprise.microsoft.com/en-us/customer-story/industries/citynext/tel-aviv-engages-citizens-innovative-digital-services/> and <https://www.timesofisrael.com/tel-aviv-aims-to-become-beta-site-for-smart-city-tech/> (accessed 6 September 2017).

3 <http://www.infotechlead.com/cloud/mexico-selects-microsoft-azure-cloud-annual-tax-returns-process-23503> (accessed 6 September 2017).

4 <http://timesofindia.indiatimes.com/city/hyderabad/ICRISAT-Microsoft-develop-sowing-app-for-Andhra-farmers/articleshow/52674122.cms> (accessed 6 September 2017).

5 <https://blogs.microsoft.com/transform/feature/theres-a-bank-branch-in-your-neighborhood-no-matter-how-remote-it-is/> (accessed 7 September 2017) See also <https://www.mmtimes.com/business/technology/17254-new-telenor-app-captures-cloud-technology.html> (accessed 8 September 2017).

SMEs make up 95% of all businesses in ASEAN, generate 23% to 58% of Gross Domestic Product (GDP), employ 57% to 91% of the labor force, and contribute 10% to 30% of exports. Cloud computing can help make these enterprises more competitive as they can free up capital investments for servers, software, and mainframes. With the flexibility offered by cloud computing, SMEs need not worry about significant, upfront capital costs as they seek to expand to new markets domestically and in the region. Small and medium-sized financial services firms, which require huge investments in information technology (IT), can become more competitive because they can be more productive through automation. They do not have to invest in expensive capital costs as they pay only for what they use.

Manufacturing is the main driver of growth in Vietnam, Thailand, Malaysia, Singapore, and Indonesia. Cloud-based, open Internet of Things operating systems can reduce manufacturing costs, improve production quality and productivity, provide flexibility and efficiency, shorten the response times to customer requests and customer demands, and open up new and innovative business opportunities. By shifting to cloud computing, manufacturing firms in ASEAN can remain competitive compared to their peers in China and the West. The Philippines is the world's top destination for business process outsourcing and will remain in the top ten in the coming years. The industry generates 9% of GDP and employs 1.4 million relatively well-paid workers. The industry very much depends on the English language competency of its young population as well as on the reliability and cost of its broadband infrastructure, which remains the most expensive in the region. Improvements in cloud computing efficiency therefore will help keep the industry competitive.

Cloud computing can help solve the huge problem of financial inclusion in ASEAN, where 438 million people remain unbanked. ASEAN can learn from Kenya, where two thirds of its adult population has access to mobile banking and a quarter of its Gross National Product (GNP) is transacted through mobile banking. ASEAN can also learn from India's efforts to provide bank accounts for a billion citizens through its Aadhaar biometric identification system.

Moreover, the Philippines, Indonesia, Cambodia, Vietnam, Thailand, and Myanmar receive considerable remittances from their migrant workers. In 2016, some US\$63 billion have been remitted to these countries, about half of which went to the Philippines. Cloud computing can help reduce the cost of remittances as local banks adopt digital payment systems using cloud-based solutions. Myanmar will particularly benefit by shifting from a largely cash-based economy to mobile banking solutions.

One of the major beneficiaries of cloud computing in ASEAN is healthcare services. Cloud computing can lead to cost reduction in IT and more connected healthcare, and allow for data analytics, tele-medicine in rural areas, diagnostic support, disaster recovery as a service, and backup as a service. Several healthcare trends in ASEAN are emerging—driven by a rising middle class—which in turn have important implications for cloud computing. These trends include healthcare consumerism, health financing and regulatory reforms, and the vertical and horizontal integration of healthcare services. We are also more likely to see the digitization of medical records, increasing focus on preventive healthcare and

the rise of new models of health care delivery such as tele-medicine. In Singapore, for example, RingMD has created a private, secure service, powered by the cloud, to let users consult a global network of doctors and wellness experts anytime, anywhere.

In turn, these trends have important implications for cloud computing. There will be demand to replace or augment traditional healthcare mechanisms with digital options. Consequently, we will see more investments in technologies that accelerate the digitization of the healthcare industry. There will also be a demand to employ new business models for lower cost, better efficiency and higher effectiveness. All of these changes would depend on cloud computing.

It is clear that cloud computing offers considerable benefits for governments and businesses in ASEAN. For these benefits to be realized, there is a need for a more concerted effort—within and among ASEAN member countries—to address the barriers that impede the widespread adoption of cloud computing in the region. These barriers include a lack of awareness about the technology, data localization requirements, the cost and quality of broadband infrastructure, privacy and cybersecurity concerns, and the lack of common cloud standards across countries. In addition, government and cloud service providers should comply with international standards such as ISO 22301 for business continuity management, ISO/IEC 27001 for information security management, and ISO/IEC 27018 for data privacy in the cloud.

Philippines

The Philippines has recently adopted a cloud first policy for the public sector. It has made good progress in the last five years in terms of improving readiness for cloud computing, but overall, it lags behind other ASEAN countries. For instance, the Philippines has the most expensive broadband connectivity, the slowest speed, and the most profitable telcos in the region. A good part of the reason for this is the country's duopoly telco market structure compared to more competitive broadband markets in ASEAN. This market structure is the result of archaic laws such as the Commonwealth Act No. 146 (Public Service Act), Republic Act 7925 (Public Telecommunications Policy Act), Republic Act 3846 (Radio Control Law), and Article XII, Section 11 of the 1987 Constitution. New laws and regulations are also needed to unbundle the broadband market into three segments to allow for more competition among content / applications providers, network providers, and service providers. Likewise, regulations have to be enforced to make internet peering mandatory among service providers and to establish an internet peering facility and exchange point to allow new players to connect to the backbone.

The adoption of data privacy regulations has raised concerns about rigid and onerous regulations. These concerns could be addressed by adopting data classification protocols like those of the United Kingdom (UK) and Australia, and also by leveraging industry, regional, and international certifications on data privacy and data security to make it easier for users to avail of cloud computing while remaining compliant to the necessary laws, regulations, and standards. The government should also serve as a catalyst for the

development, awareness raising and rollout of best practices in cybersecurity. An inter-agency cybersecurity network is needed to coordinate policies and initiatives in various parts of the government. Furthermore, there is a need to streamline and harmonize broadband-related permits, fees, and processes as well as harmonize cloud standards in the public and private sectors. In addition, the Departments of Information and Communications Technology (DICT), Transportation, and Public Works and Highways, and the National Grid Corporation, should jointly undertake a Memorandum of Understanding to allow the use of their infrastructure assets for broadband fiber rollout. Finally, the government should include the development of broadband infrastructure as a flagship project under its ambitious infrastructure program. Internet connectivity and physical connectivity should be recognized as complements to one another.

Vietnam

Vietnam has made impressive strides in embracing the ICT revolution to promote economic growth and development. From a country with an impoverished telecommunications system in the 1990s, Vietnam has emerged as a leading player among developing Asian economies on ICT infrastructure development and adoption. However, Vietnam is still struggling to leverage ICT-related advantages into decisive strengths for promoting economic growth and competitiveness. One of the critical problems hindering Vietnam in this endeavor is its lack of an explicit “cloud-first strategy” that would enable companies and governments to accelerate digital transformation through public, private, and hybrid cloud services.

This case study provides important policy insights for promoting cloud computing adoption in Vietnam. Among the top priorities for the government are continuing ICT infrastructure upgrades, demonstrating leadership in user adoption, providing financial incentives, raising awareness among businesses and governments about the benefits of cloud computing, and strategizing and monitoring the progress of cloud adoption. At the same time, the government should also work closely with all stakeholders to effectively address major obstacles to cloud computing adoption, including the high rate of software piracy and concerns about security and privacy.

To accomplish this, the government should define ICT as a major strategic driver of development, proactively leveraging it to boost productivity growth and build smart-technologies-enabled prosperity; establish a committee to strategize the promotion of ICT and cloud deployment; foster competition among ICT service providers by liberalizing markets and reducing barriers to entry; engage leading global technology companies to participate in the country’s digital ecosystem; and develop a bigger technologically literate human capital base to improve the quality of the labor pool and the sophistication of cloud computing customers.

Myanmar

Myanmar's recent transformational political reform has paved the way for the country not only to integrate into the international community but also to vigorously accelerate economic development. Myanmar has made rapid progress on basic telecommunication infrastructure and ICT adoption. The number of mobile phones per 100 inhabitants rose from 1.1 in 2010 to 7.1 in 2013 and 75.8 in 2015. However, the country still lags behind most Asian nations on more advanced measures of ICT penetration and digital transformation. For example, broadband penetration (number of subscribers per 100 inhabitants) in 2015 was well below 0.1% for Myanmar, compared to 8.2% for Vietnam.

Given the enormous potential benefits offered by the ICT revolution, Myanmar's government should develop a leapfrog strategy to advance directly from digital backwardness to cloud computing, avoiding a costly and unnecessary interim investment in legacy technologies such as physical servers. This requires a government commitment to emerging digital technologies, especially cloud computing services. Upgrading ICT infrastructure, promoting ICT adoption, and raising awareness of cloud computing services are utmost priorities for fostering a digital revolution within Myanmar.

To accomplish this, the government should define ICT as a major strategic driver of development, proactively leveraging it to fight poverty, productive inefficiency, and technological backwardness; establish a whole-of-government committee to strategize the promotion of ICT and cloud deployment; foster competition among ICT service providers by liberalizing markets and reducing barriers to entry; engage leading global technology companies to participate in the country's digital ecosystem; and develop a broader, technologically literate human capital base to improve the quality of the labor pool and the sophistication of cloud computing customers.

Singapore

Cloud computing adoption in Singapore has accelerated in tandem with the explosion of data and the need to organize it. Singapore is a lead adopter of cloud computing due to five key drivers: (1) Public demand for and satisfaction with e-government services; (2) Focus on whole-of-government policies and practices; (3) Restructuring of technology agencies to integrate strategy and implementation; (4) Building the Smart Nation Platform; and (5) Purpose-driven cloud applications, especially in healthcare.

The country takes a purpose-driven approach to cloud computing, investing in leading edge infrastructure to enable important Smart Nation applications that benefit individuals, organizations, and society. Cloud computing powers the Smart Nation Platform (SNP), a central engine that ingests and aggregates data to support whole-of-government operations and service delivery. The SNP supports many laudable applications including a cashless society, preventive health analytics, and economic "now-casting"—a dynamic sensing of the city-state's economic pulse.

Further progress is still needed on the technological, regulatory, and talent fronts. Technologically, Singapore should embrace cloud analytics and explore “fog computing”—an emerging technology that enables on-site data sense-making before transmission to the cloud. The country should promote regulatory sandboxes to experiment with policies that proactively manage novel technologies and business models that may radically change society. Finally, and critically, Singapore is relentlessly positioning itself as a talent super hub to attract up-and-coming digital firms and emerging global talent, and should do more to grow local talent through solution-based learning and proactive training to address the skills gap. Singapore should continue to establish unconventional partnerships to co-innovate on challenges like the skills gap, such as the partnership led by the Lee Kuan Yew School of Public Policy with the government, private sector, and unions.

Cloud Computing in the Philippines

Eduardo Araral

I. Introduction

Cloud computing—computing on the internet—offers many benefits over conventional computing solutions. It is cost effective because it frees up capital investment in expensive servers, maintenance, and replacements. With its subscription-based model, you pay only for what you use. It is flexible, allowing users to scale up or down depending on their computing needs. It protects users from loss of data through more robust disaster recovery and ensures automatic software and security updates. It allows for greater collaboration with work teams and better control of documents, and gives flexibility to employees to work from anywhere.

These features of cloud computing will lead to a more efficient and integrated public sector, improved access to financial services especially for the unbanked population, more efficient and integrated health service delivery, enhanced social security administration, more efficient implementation of conditional cash transfers, more competitive business process outsourcing, improved delivery of education services in remote regions, more jobs for online Filipino professionals, and increased competitiveness of SMEs, among others. Cloud computing therefore can help improve governance and sustain the growth momentum of the Philippine economy in the same way as the government's infrastructure build-up, but at a much lower cost.

The Philippines has made good progress in the last five years in terms of improving readiness for cloud computing, but overall, it lags behind other ASEAN countries. For instance, the Philippines has the most expensive broadband connectivity, the slowest speed and the most profitable telcos in the region. A good part of the reason for this is the country's duopoly telco market structure compared to more competitive broadband markets in ASEAN. This market structure is the result of archaic laws such as the Commonwealth Act No. 146 (Public Service Act), Republic Act 7925 (Public Telecommunications Policy Act), Republic Act 3846 (Radio Control Law) and Article XII, Section 11 of the 1987 Constitution. New laws and regulations are also needed to 1) unbundle the broadband market into three segments to allow for more competition among content / applications providers, network providers, and service providers; 2) make internet peering mandatory among service providers and establish an internet peering facility and exchange point to allow new players to connect to the backbone; and 3) streamline and harmonize broadband-related permits, fees and processes as well as harmonize cloud standards in the public and private sectors. In addition, the Departments of Information and Communications Technology (DICT), Transportation, and Public Works and Highways, and the National Grid Corporation, should jointly undertake a Memorandum of Understanding to allow the use of their infrastructure assets for broadband fiber rollout.

The next part of the report provides an assessment of the state of cloud readiness in the Philippines. The third section outlines a set of recommendations to address bottlenecks. The fourth and fifth sections examine the implications of cloud computing for financial and healthcare services, respectively. The sixth section concludes.

II. State of Cloud Computing

Good progress but still lagging in ASEAN

From 2011-2016, the Philippines has made good progress in terms of cloud readiness compared to other ASEAN countries. Overall, it still lags behind in terms of broadband cost, quality and cybersecurity. Cloud computing in the Philippines and ASEAN can be assessed using the Cloud Readiness Index.¹ The Index comprises ten indicators of readiness: 1) international connectivity; 2) broadband quality; 3) power grid and green policy; 4) data center risk; 5) cybersecurity; 6) privacy; 7) government regulatory environment and usage; 8) intellectual property protection; 9) business sophistication; and 10) freedom of information.

Table 1 provides an overview of cloud readiness in the Philippines. It shows overall improvement between 2012 and 2016. The table indicates that the Philippines has made the most progress in terms of privacy, broadband quality and intellectual property protection. There has been little progress in terms of the government regulatory environment and the use of cloud computing by government agencies, and protection of data centers from natural calamities.

Table 1: Cloud Readiness Index of the Philippines, 2012 and 2016

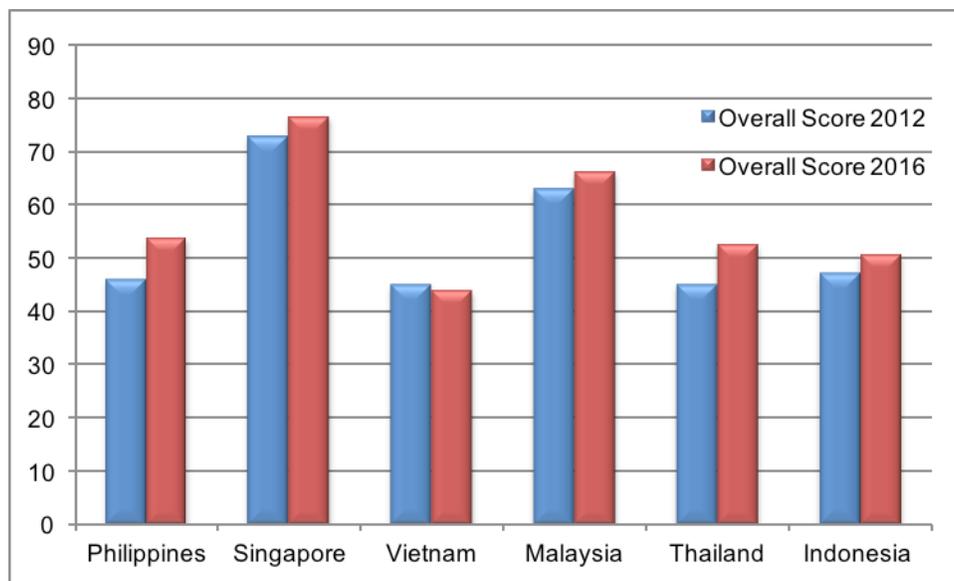
	2012	2016	Change
Overall Score	46.0	53.8	7.8
International Connectivity	4.6	3.3	-1.3
Broadband Quality	2.3	5.5	3.2
Power Grid	5.8	6.0	0.2
Data Center Risk	3.6	3.5	-0.1
Data sovereignty (2012)/ Cybersecurity (2016)	4.3	3.5	-0.8
Privacy	2.5	7.5	5.0
Government Regulatory Environment and Usage	5.5	5.5	0.0
Intellectual Property Protection	4.0	5.6	1.6
Business Sophistication	5.9	6.1	0.2
Freedom of Information	7.5	7.3	-0.2

Source: Asia Cloud Computing Association, Cloud Readiness Index, 2012 and 2016

¹ The Index is compiled by the Asia Cloud Computing Association, an industry association comprising the major cloud providers such as Amazon, Microsoft, Cisco, Salesforce, PLDT, SMART, etc. More information about the methodology and data sources for the index is available at: www.asiacloudcomputing.org/17-news/306-2016-cloud-readiness-index (accessed 20 September 2017).

Figure 1 compares the Cloud Readiness Index among ASEAN countries in 2012 and 2016. It shows that the Philippines registered the most improvement, with the overall score rising from 46 out of 100 in 2012 to 53.8 in 2016, an improvement of 7.8 points. This is followed by Thailand (7.7), Malaysia (3.3), Singapore (3.9), and Indonesia (3.5). Vietnam has deteriorated since 2012. The reason for this is that the Philippines is starting from rather low scores in 2012 compared with other countries; however, despite its marked improvement, the Philippines (53.8) still lags significantly behind front-runners Malaysia (66.3) and Singapore (76.7). The rest of the section provides a more detailed assessment of the state of cloud readiness in the Philippines compared to ASEAN.

Figure 1: Overall Cloud Readiness Index in ASEAN, 2012 and 2016

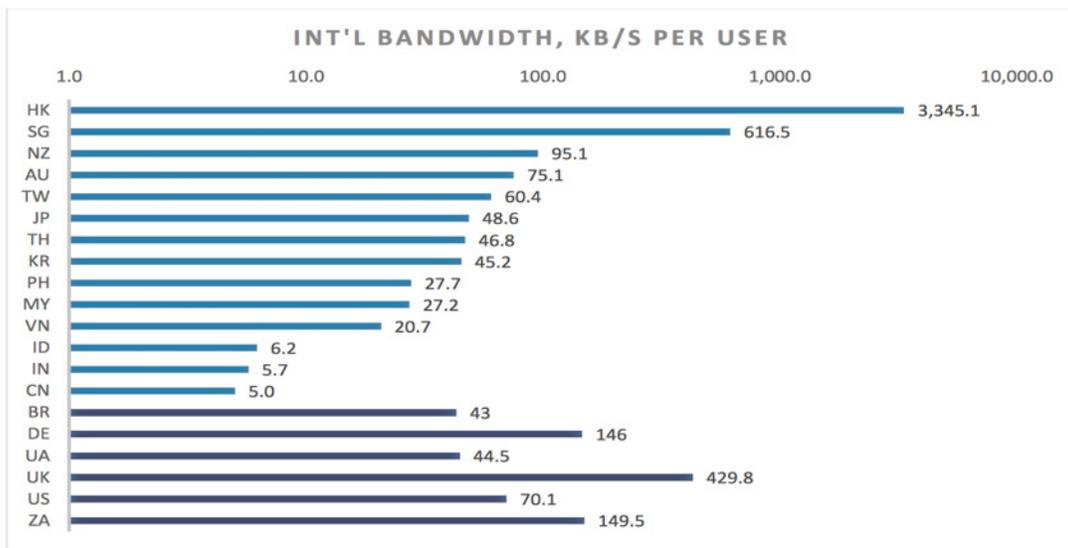


Source of raw data: Asia Cloud Computing Association, Cloud Readiness Index, 2012 and 2016

International connectivity

International connectivity is measured in terms of kilobit / sec / user for submarine cables within Asia and outside of Asia (US, Europe). Figure 2 shows that the Philippines has relatively good international connectivity compared to ASEAN countries. As of 2016, the Philippines had 27.7 kb/s/user, about the same as Malaysia and ahead of Vietnam (20.7) and Indonesia (6.2). In contrast, Thailand has 46 and Singapore has 616, or 22 times than the Philippines, mainly because of its very small population.

Figure 2: International connectivity, Philippines vs. ASEAN, 2016



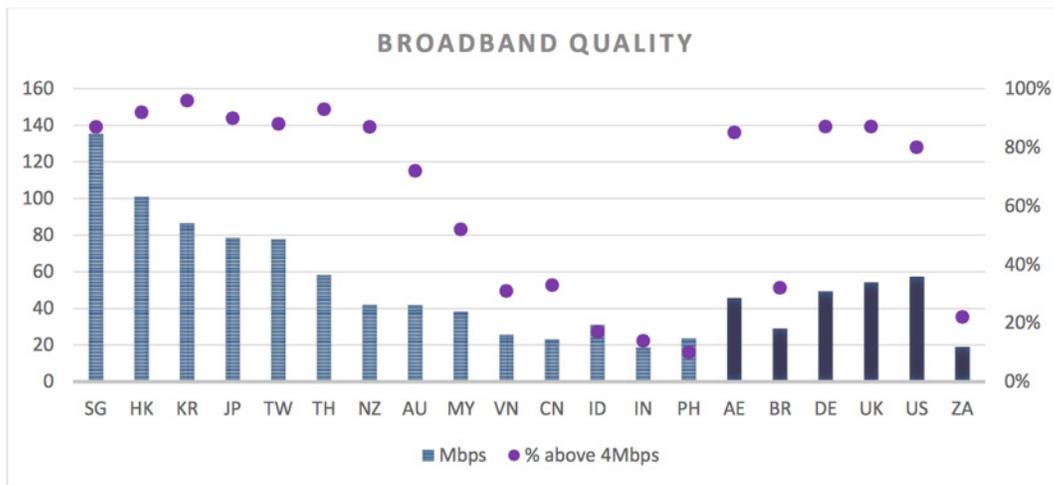
NZ (New Zealand), HK (Hong Kong), TW (Taiwan), JP (Japan), AU (Australia), SG (Singapore), KR (South Korea), PH (Philippines), TH (Thailand), ID (Indonesia), MY (Malaysia), VN (Vietnam)

Source: Asia Cloud Computing Association, 2016.

Poor broadband quality, high cost and poor access

Figure 3 shows that the Philippines has the worst broadband quality in ASEAN in both Mbps and % above 4 Mbps. The Philippines on average had an average peak connection speed of 23 Mbps, and only 10% of connections are above 4 Mbps. Thailand’s average peak connection speed is approximately 60 Mbps (three times the Philippines) and more than 90% of its connections are above 4 Mbps (nine times better than the Philippines).

Figure 3: Broadband quality, Philippines vs. ASEAN (Mbps and % connection above 4 Mbps)



NZ (New Zealand), HK (Hong Kong), TW (Taiwan), JP (Japan), AU (Australia), SG (Singapore), KR (South Korea), PH (Philippines), TH (Thailand), ID (Indonesia), MY (Malaysia), VN (Vietnam)

Source: Akamai 3Q 2015. Reported by the Asia Cloud Computing Association, Cloud Readiness Index (2016)

In terms of access, the Philippines lags behind its peers in ASEAN in fixed telephone subscriptions, fixed and mobile broadband subscriptions and households with computers. Table 2 compares digital access among ASEAN countries. The main reason for the poor quality and access to broadband in the Philippines is the current duopoly market structure of telecom service providers in the country (Table 3). In contrast, the average number of telcos across other ASEAN countries (Singapore, Malaysia, Thailand, Vietnam, Indonesia) is five. As a result of this duopoly, the Philippines’ broadband costs (fixed and mobile) are the highest in the region at 6.74% of Gross National Income, compared to Singapore (0.31%), Vietnam (3.52%), Malaysia (1.32%), Indonesia (1.36%) and Thailand (1.21%). In addition, the average broadband peak speed in the Philippines, at 4.3 Mbps, is the slowest in the region.

Table 2: Digital access, Philippines vs. ASEAN

	Philippines	Vietnam	Singapore	Thailand	Indonesia	Malaysia
Fixed Telephone subscriptions per 100 population	3.2	10	36	9	12	15
Mobile cellular subscriptions per 100 inhabitants	104	130	155	138	121	145
Fixed broadband subscriptions per 100 inhabitants	2.6	5.6	25.7	7.4	1.3	8.2
Mobile broadband subscriptions per 100 inhabitants	20.3	18.8	135	52	31	12.5
Households with computer (%)	18.7	19	86	29	15	65
Households w home internet (%)	23	17	86	23	5.7	64

Source: International Telecommunications Union (2013)

Table 3: Affordability, performance and market structure, Philippines vs. ASEAN

	Affordability of fixed broadband ¹	Affordability of mobile broadband ²	Broadband speed ³	Internet penetration rates (%) ⁴	# of TelCo operators (government investment?)	Average TelCo Earnings Before Interest, Taxes, Depreciation (%) ⁵
Philippines	\$15.73	6.74%	4.3	43.5%	2 (No)	41.5% (PLDT/Globe)
Singapore	\$2.39	0.31%	17.2	82.5%	3 (Yes)	29.6% (SingTel)
Vietnam	\$1.84	3.52%	5.1	52%	6 (Yes)	N/A
Malaysia	\$4.80	1.32%	6.8	68.6%	8 (Yes)	37.4% (Axiata)
Indonesia	\$21.51	1.36%	5.9	20.4%	5 (Yes)	51.9% (Telkom)
Thailand	\$5.26	1.21%	13.7	42.7%	5 (Yes)	N/A

1 Price of Fixed Broadband in \$PPP per Mbps, 2015 (Source: Telegeography: <https://www.telegeography.com/> for \$PPP and Akamai as of 4Q2015 for average internet speed)

2 Cost of mobile broadband (1GB) as % of GNI per capita (2014): International Telecommunications Union: <http://www.itu.int/en/Pages/default.aspx>

3 Average speed (Mbps) as reported by Akamai as of 2Q 2016: <https://www.akamai.com/us/en/our-thinking/state-of-the-internet-report/>

4 Statistica.com: <https://www.statista.com/statistics/281668/internet-penetration-in-southeast-asian-countries/>

5 Earnings before interest, taxes, depreciation, amortization (EBITDA), 2014

Source: Telegeography: <https://www.telegeography.com/>

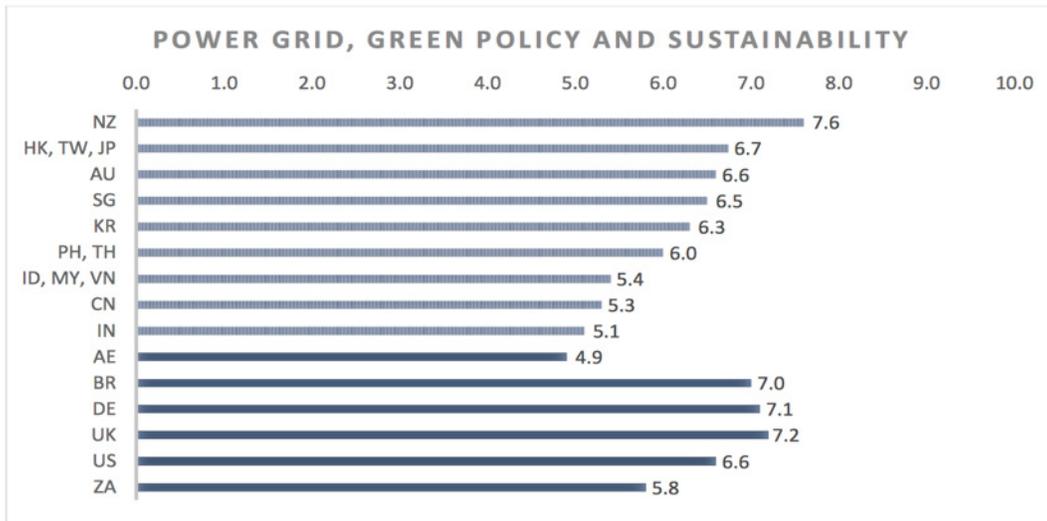
Good use of renewable energy but most expensive in ASEAN

This indicator reflects “the long-term ability of a country to supply cloud computing services” (CRI, 2016). It includes the reliability of the country’s power grid and the country’s “green policies” on renewable energy. Scores were taken from the Global Energy Architecture Performance Index 2015 and normalized to a ten-point scale as reported by CRI (2016).

The Philippines has a particularly good score in terms of the use of renewable energy—25% of its consumption comes from geothermal and hydro-power resources and other renewables (Figure 4). In recent years, there has been an increase in the use of solar power but this is not yet on a large industrial scale.

However, the electricity cost in the Philippines is still one of the most expensive in the region, which poses constraints on the growth of cloud computing. There are several reasons for this high electricity cost. First, electricity rates in the Philippines are subject to multiple taxes, royalties and fees, unlike counterparts in the region. Second, the total generation capacity in the Philippines is low at 0.44 tons of oil equivalent (toe) per person per year, as compared with Indonesia (0.87), Thailand (1.89), and Malaysia (2.78).

Figure 4: Power grid reliability, Philippines vs. ASEAN, 2016



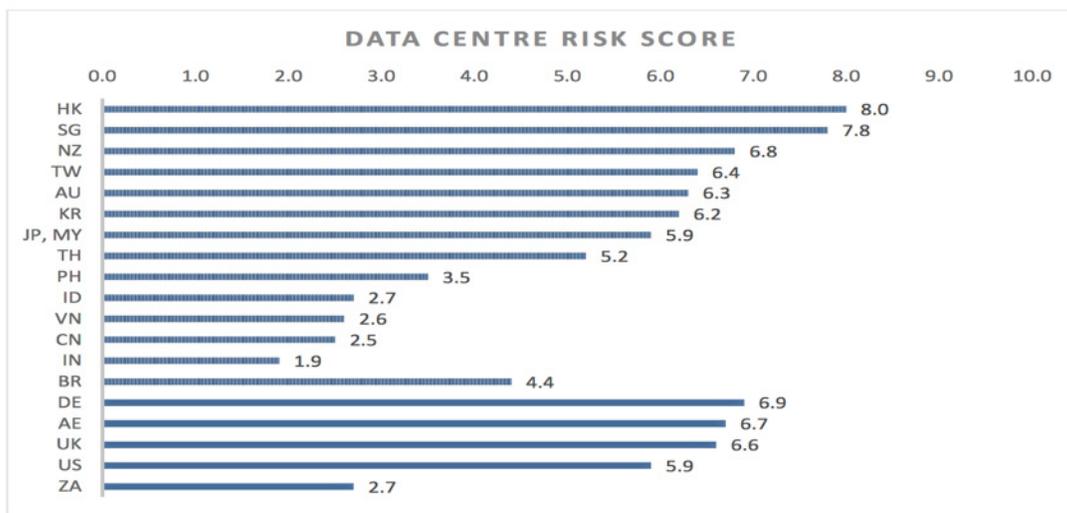
NZ (New Zealand), HK (Hong Kong), TW (Taiwan), JP (Japan), AU (Australia), SG (Singapore), KR (South Korea), PH (Philippines), TH (Thailand), ID (Indonesia), MY (Malaysia), VN (Vietnam)

Source: Global Energy Architecture Performance Index, as reported in Asia Cloud Computing Association, Cloud Readiness Index (2016)

High data center risk

This indicator assesses the risks to investments in data centers. The risks include high corporate tax rates, labor costs, inflation, water availability, and vulnerability to natural disasters. The Philippines scored 3.5 out of 10 as measured by Cushman and Wakefield. The Philippines lags behind Singapore (7.8), Malaysia (5.9), and Thailand (5.2) but is ahead of Indonesia (2.7) and Vietnam (2.6) (Figure 5). The relatively low scores are due to high corporate taxes (the corporate tax rate in the Philippines is the highest in ASEAN) and the country's vulnerability to natural disasters (super typhoons and earthquakes). Water availability (to cool down the data centers) is another major constraint, as the major users of data centers (Metro Manila and Metro Cebu) are themselves water-scarce regions.

Figure 5: Data center risk score, Philippines vs. ASEAN Countries, 2016



NZ (New Zealand), HK (Hong Kong), TW (Taiwan), JP (Japan), AU (Australia), SG (Singapore), KR (South Korea), PH (Philippines), TH (Thailand), ID (Indonesia), MY (Malaysia), VN (Vietnam)

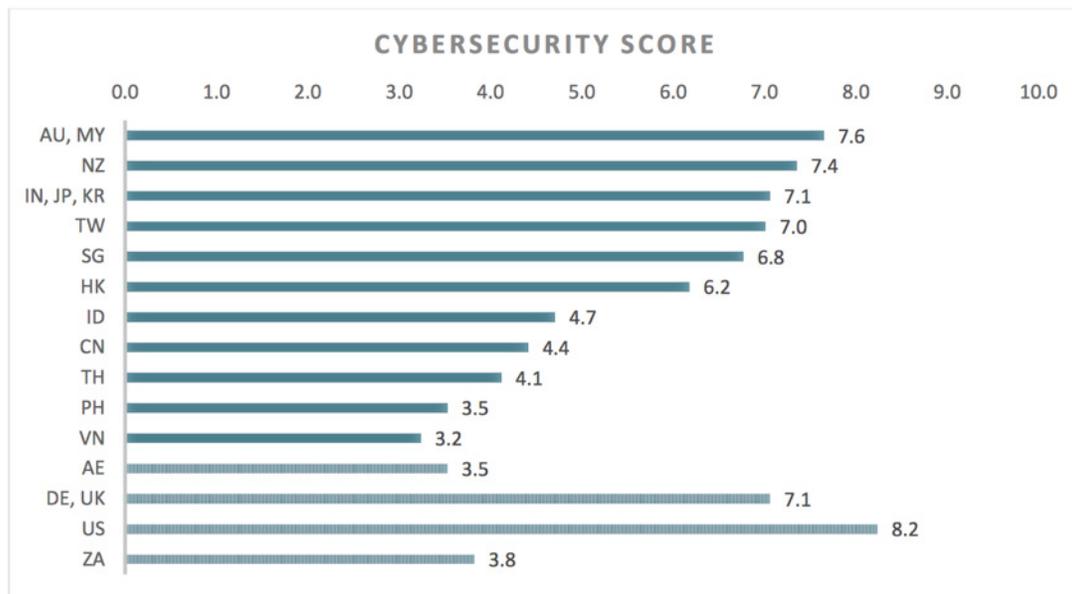
Source: Asia Cloud Computing Association, Cloud Readiness Index (2016)

Generally weak cybersecurity

Cybersecurity is another key barrier to the adoption of cloud computing in the Philippines. Cybersecurity encompasses variables such as “cybercrime and data protection; technical standards, frameworks and initiatives for infrastructure, ICT use and education; and overarching organizational structures for national ICT and cybersecurity strategies, R&D, technical committees and capacity building on information security, network monitoring and encryption; as well as enhancing cooperation across borders” (CRI, 2016).

Despite the passage of the Cybercrime Act of 2012 and the Electronic Commerce Act of 2000, the Philippines remains among the weakest in ASEAN in terms of cybersecurity, scoring 3.5/10 versus 4.1 for Thailand, 4.7 for Indonesia, 6.8 for Singapore, and 7.6 for Malaysia (Figure 6). The Philippines is particularly weak in terms of the following: 1) the lack of international cooperation to combat cybersecurity (it is the only country in ASEAN with no or very little international cooperation efforts); 2) the lack of overarching national organizational structures for cybersecurity; and 3) low capacity building on information security across different government agencies.

Figure 6: Cybersecurity, Philippines vs. ASEAN, 2016



NZ (New Zealand), HK (Hong Kong), TW (Taiwan), JP (Japan), AU (Australia), SG (Singapore), KR (South Korea), PH (Philippines), TH (Thailand), ID (Indonesia), MY (Malaysia), VN (Vietnam)

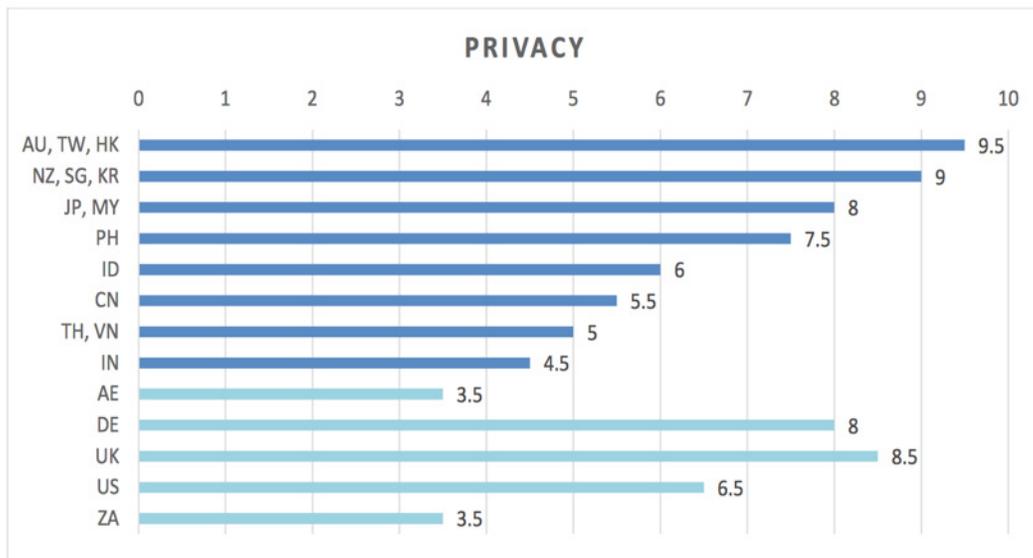
Source: Asia Cloud Computing Association, Cloud Readiness Index (2016)

Comparable to best practices in data privacy

The development of cloud computing depends on the reliable and secure flow of information across service providers, borders, and networks. Data privacy readiness is measured in terms of the Business Software Alliance’s (BSA) Global Cloud Computing Scorecard 2013 “Data Privacy” parameter.

Among the 10 indicators of cloud readiness, the Philippines fares well on data privacy, performing in the same league as the top countries (Figure 7). The Personal Data Protection Act of 2012 covers data privacy laws. The Act provides “strong institutional safeguards for privacy online, with laws regulating the collection and use of personal information, a compulsory data breach notification law, and a national agency for enforcement of privacy laws” (CRI, 2016). In addition, CRI reports that “Filipino data controllers and cross border data transfers are free from registration requirements, limiting government surveillance and ensuring anonymity.”

Figure 7: Cloud privacy, Philippines vs. ASEAN, 2016



NZ (New Zealand), HK (Hong Kong), TW (Taiwan), JP (Japan), AU (Australia), SG (Singapore), KR (South Korea), PH (Philippines), TH (Thailand), ID (Indonesia), MY (Malaysia), VN (Vietnam)

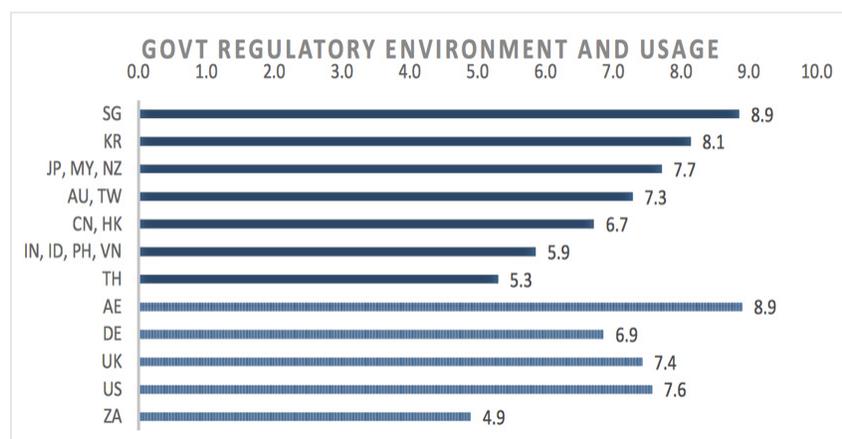
Source: Asia Cloud Computing Association, Cloud Readiness Index (2016)

Improved regulatory environment but poor government usage

Countries with significant cloud uptake have significant government support and usage of cloud computing, according to the 2016 CRI report. This has been the case with leaders such as Singapore, South Korea, Japan, Malaysia, and New Zealand. Cloud development and uptake in the Philippines therefore would depend largely on government support and technology usage—both at the national and city level. The building blocks for this usage are slowly being laid down, albeit in a belated manner compared to its neighbors. In 2016, the Philippines created the Department of Information and Communications Technology (DICT), formulated the Draft National Broadband Plan (2017), and issued cloud first policy guidelines covering all government agencies, among other developments. Laws for data privacy, intellectual property protection, and cyber security are already in place, making the regulatory environment conducive. Indeed, the policy environment in the Philippines is at approximately the same level as Indonesia and Vietnam and better than Thailand (Figure 8).

At the same time, there are still many policy and regulatory barriers to the adoption of broadband throughout the country and consequently to the rollout of cloud computing. These issues are discussed extensively in the section on policy and legal reforms. However, despite an improving policy environment, uptake by government agencies in the Philippines remains slow due to legacy issues and a lack of understanding by senior government officials. A more top down and decisive leadership would be needed to compel various government agencies to adopt cloud computing in their departments, for example, a Presidential Executive Order. At the same time, there is also a need to get the buy in of city mayors. The leadership of the League of Cities of the Philippines would have to be persuaded on the business case for cloud computing.

Figure 8: Government regulatory environment and usage, 2016



NZ (New Zealand), HK (Hong Kong), TW (Taiwan), JP (Japan), AU (Australia), SG (Singapore), KR (South Korea), PH (Philippines), TH (Thailand), ID (Indonesia), MY (Malaysia), VN (Vietnam)

Source: Asia Cloud Computing Association, Cloud Readiness Index (2016)

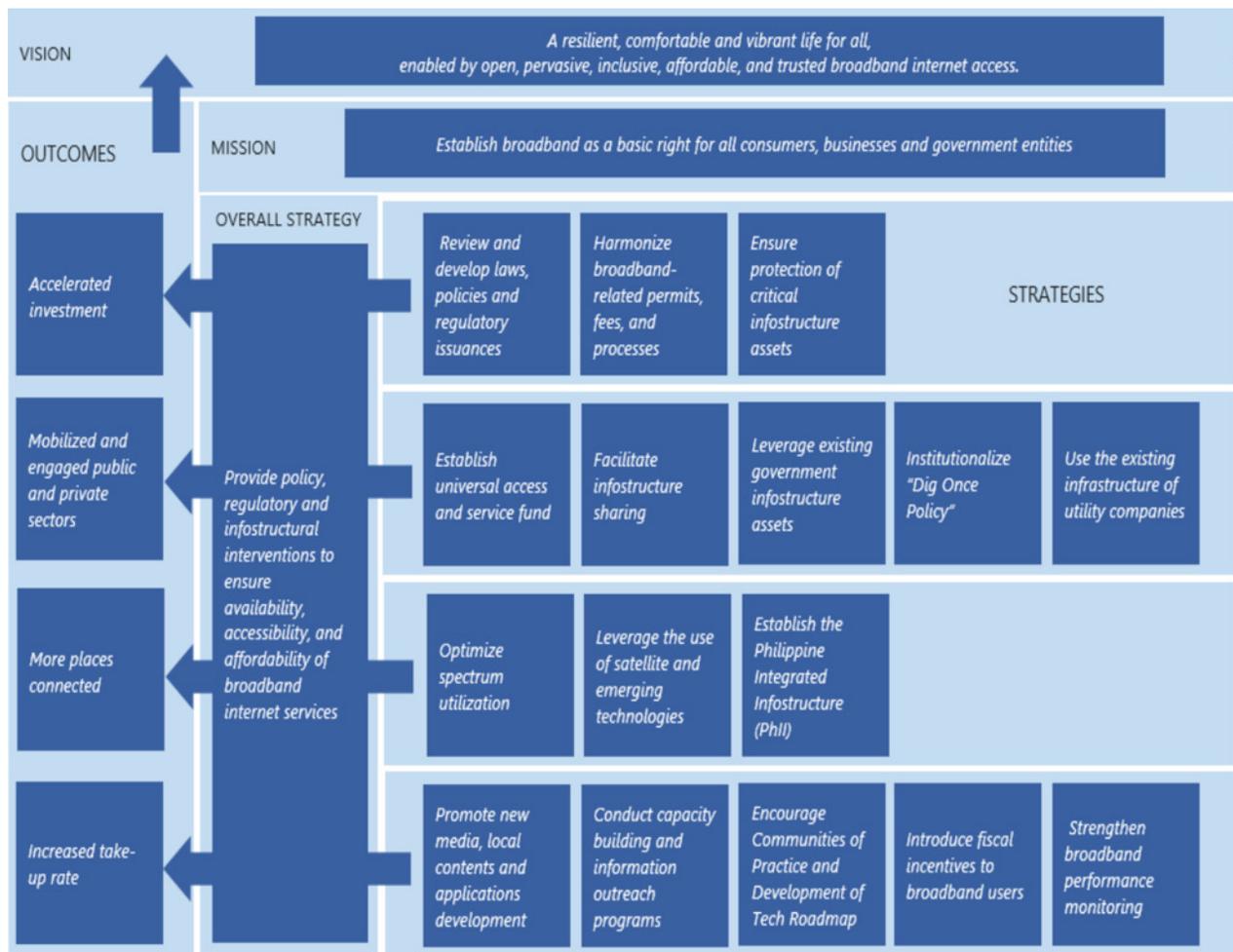
III. What Needs to be Done?

The Philippines has made good progress since 2012 in terms of improving cloud readiness, but overall it lags behind its peers in ASEAN. To catch up, it has to address several major weaknesses and exploit its strengths and opportunities. The major weaknesses include poor broadband quality, access and cost; international connectivity; cybersecurity; poor government usage of cloud computing; low technical capabilities; and high data center risks.

A major stumbling block to the Philippines' readiness in embracing cloud computing is the poor state of its broadband quality, access and cost. The Philippines has the second lowest fixed broadband subscription rate in the region, at 2.6 broadband subscriptions per 100 residents compared to 5.6 in Vietnam, 25.7 in Singapore, 7.4 in Thailand and 12.5 in Malaysia. In terms of mobile broadband subscriptions, the Philippines has 20.3 subscriptions per 100 inhabitants, Vietnam 18.8, Singapore 135, Thailand 52 and Indonesia 31 (Table 2). The Philippines also has the most expensive broadband costs (both fixed and mobile) in the region. The cost of fixed broadband in the Philippines, PPP\$15.73 per Mbps, is 8.5 times that of Vietnam, 6.5 times that of Singapore, and 3 times that of Thailand and Malaysia. The relative cost of mobile broadband is even worse. At 6.7% of gross national income, it is 20 times more expensive than Singapore, 2 times more expensive than Vietnam and 5 times more expensive than Malaysia, Indonesia and Thailand. Not surprisingly, the Philippines has the most profitable telcos, with average earnings before interest, tax, depreciation and amortization (EBITDA) margins of 48% compared to 29% in Singapore and 40% in Malaysia (Table 3).

The government is aware of these problems, and in March 2017 issued a comprehensive National Broadband Plan (NBP) that outlines a vision, mission, specific strategies and outcomes for improved broadband connectivity (Figure 9).

Figure 9: National Broadband Plan of the Philippines, 2017



Source: Draft National Broadband Plan of the Philippines (March 2017)

The following section provides recommendations for improvements in cloud computing, drawing mainly from the recommendations outlined in the NBP. It includes a roadmap for the promotion of cloud computing in the Philippines.

Revise outdated laws

One major reason for the relatively poor performance of the Philippines compared to its peers is the outdated and archaic set of legislations that hamper innovation in the ICT sector.² For example, Philippine laws still regulate the internet as a public utility in the same way as a telephone service that requires a franchise. Simply put, current laws have stifled technological innovations and need to be revised.

- Commonwealth Act No. 146 (Public Service Act). To make it more responsive to current needs, policymakers should revise the penal provision of this act and exempt telecommunications and value-added services from the public utilities stipulated in this act. This may ease ownership restrictions required by the Philippine Constitution and remove the need for securing a legislative franchise before putting up a network.
- Republic Act 7925 (Public Telecommunications Policy Act). Among other things, the government should consider the following amendments/revisions: (1) Strengthen roles of DICT and NTC in upholding competition by redefining the market structure set by this act; (2) Make this act responsive to technology advancements, i.e. shifting from a telephone to internet paradigm; and (3) Set specific clauses to ensure the protection of consumer rights.
- Republic Act 3846 (Radio Control Law). Policymakers should review the need for a congressional franchise to operate a telecoms / ICT network.
- Article XII, Section 11 of the 1987 Constitution. Policymakers should consider the review / amendment of this provision to accelerate investment in telecoms/ICT.
- Guidelines on the Procurement of Orbital Slots and Frequency Registration of Philippine Satellites. The government should update these guidelines in adherence to the radio regulations set by the ITU Radiocommunication Bureau, including administrative fees and orbital slot coordination procedures.

² This section was quoted verbatim in the Draft National Broadband Plan (2017).

Adopt new laws and guidelines

In addition to revising archaic legislations, there is also a need to introduce new ones to facilitate nationwide adoption of broadband infrastructure and cloud computing.

Market segmentation. To ensure more competition and improve services, the government should restructure the broadband market into three segments: 1) content / applications providers, (2) network providers, and (3) service providers. Although the Philippines earlier had several network providers, today the broadband market is controlled by only two telco operators. In contrast, the small city-state of Singapore has 3 operators, while Vietnam has 6, Malaysia 8, Indonesia 5, and Thailand 5 (Table 3). In all of these countries, the government plays an active role as investor, operator and regulator. The situation in the Philippines is the complete opposite, with the government taking a laissez faire approach.

Segmentation will reduce barriers to entry and allow more competition. In this manner, new market players will be given a chance to compete with the incumbents. The government should include guidelines in this framework such as setting price bulletins and creating a repository of available infrastructure, to ensure fair, non-discriminatory access, and transparency in these facilities.

Peering. One major reason why internet service in the Philippines is one of the slowest in the region is the absence of an internet peering facility. Internet traffic is still routed outside of the country, making it very slow. Internet peering must be mandatory among service providers. There is also a need to establish an internet peering facility and internet exchange point to allow new players to connect to the backbone.

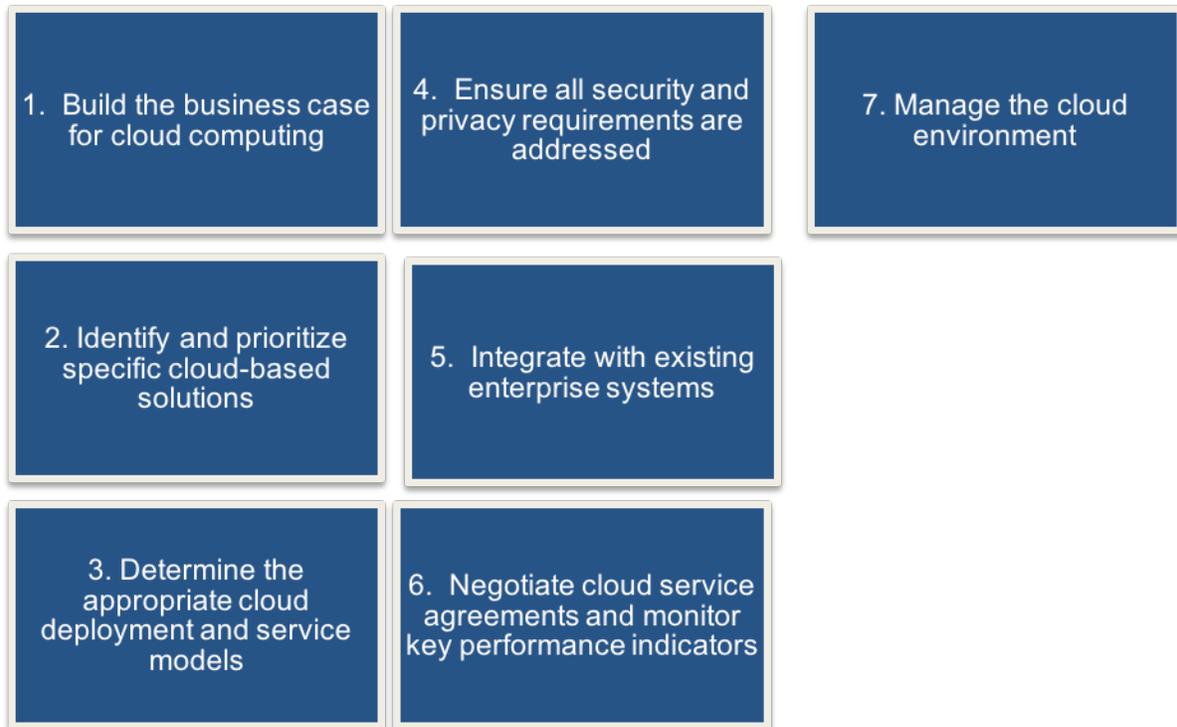
Harmonization and simplification. The Philippines needs guidelines to streamline and harmonize broadband-related permits, fees, and processes as well as to harmonize cloud standards in the public and private sectors. There is also a need to simplify the process of constructing cell sites, which currently requires six months, 16 steps, and 7 national and local government permits.

Use government infrastructure assets. One of the major barriers to entry in the broadband business is the prohibitively high cost of civil works for fiber rollout. To address this problem, it is recommended that the Departments of Information and Communications Technology, Transport, and Public Works and Highways, and the National Grid Corporation, jointly undertake a Memorandum of Understanding to allow the use of their infrastructure assets for broadband fiber rollout. The terms of use could be in the form of long-term leasehold, public-private partnerships (PPPs) or memorandums of agreement (MOAs). This could provide an additional source of revenue to these agencies while simultaneously promoting broadband adoption.

Adopt a roadmap for cloud computing

To promote the use of cloud computing in the Philippines, DICT, along with government and private sector stakeholders, should adopt a roadmap for cloud computing. Figure 10 illustrates the elements of the roadmap.

Figure 10: Roadmap for promoting cloud computing in the Philippines



Source: Adapted from Cloud Standards Customer Council (2017), available at <http://www.cloud-council.org/deliverables/migrating-applications-to-public-cloud-services-roadmap-for-success.htm>

Step 1. Make a business case for government cloud computing

To increase demand for cloud computing, the government has to lead the way and make a strong business case for cloud computing. Cloud computing offers many benefits compared to current modes of computing—in terms of greater budget control, lower spending on legacy infrastructure, improved efficiency, better online citizen services, better collaboration among government agencies, more responsive service delivery, and improved operational continuity and business recovery. DICT should work closely with the Department of Budget and Management (DBM), which is pushing for a law on the rationalization and streamlining of the government. DBM should champion cloud computing as a tool to improve efficiency and responsiveness in the Philippine bureaucracy.

Greater budget control. Cloud computing is scaleable, meaning that you only “pay for what you use.” In addition, greater transparency in the pricing structure of cloud computing (as compared with conventional computing) means that government agencies would have more control over their budgets. This helps prevent overinvestment and underutilization of computing services.

Decreased spending on legacy infrastructure. Cloud computing enables government agencies to significantly reduce their spending on IT. There is no need for agencies to maintain their own hardware and software. Security upgrades are managed by the cloud service provider, hence there is less need for in-house IT personnel.

Greater efficiency and responsiveness. Cloud computing helps to achieve a “whole of government approach” to governance. This is made possible by allowing government agencies and ministries to easily share computing resources and data. This will result in greater efficiency and responsiveness in delivering public online services.

Operational continuity and business recovery. In times of crisis, data retrieval and business recovery are faster, easier and more cost effective with the use of cloud computing, because data storage, management and backups are centralized with the cloud service provider.

Faster deployment of services. In cloud computing, government agencies are able to test and deploy online services much faster than is possible when they are required to acquire and operate their own computing facilities. The government agency can focus more on service delivery and worry less about its computing facilities.

Step 2: Identify and prioritize the rollout of cloud-enabled services

In early 2017, DICT announced a cloud first policy and issued a set of guidelines to all government agencies to facilitate its adoption. It will take time, however, before government agencies actually shift to the use of cloud computing. The first reason for this is that government agencies face high switching costs from their current software, systems, and infrastructure. Switching to cloud computing raises concerns about business continuity and disruption. A second reason is that many senior government leaders are not aware of the costs and benefits of using cloud computing in their departments. A third reason is the lack of skilled cloud computing talent in the public sector because of better pay in the private sector.

One strategy to address these issues is to prioritize and focus the rollout of cloud-enabled services. For example, the first priority is to deploy cloud computing services to significantly improve the delivery of public services on a national scale. The goal is to ensure seamless, last mile connectivity to citizens. Priority projects should include the permit and licensing system, the Real Property Tax System, the e-Payment System, the eService System and the national ID system. In addition, the national flagship program of conditional cash transfer (4Ps) under the Department of Social Welfare and Development should migrate to the cloud to enhance its efficiency. Likewise, the Department of Education should consider the use of ICT and cloud computing solutions in its portfolio of services.

A second priority would be to focus on the administrative systems in national and local government agencies—from emails to storage and integration of networks, among others. DICT should propose that the DBM, which is spearheading the streamlining of the bureaucracy, require the use of cloud computing as a major solution to improve efficiency in the public sector.

Step 3: Determine the appropriate cloud deployment model

Given the very limited government capacity to roll out these complex projects, DICT can consider the possibility of implementing these projects via a PPP model, including the use of unsolicited bids and Swiss challenge. All these projects are viable candidates for PPP given their revenue stream.

Step 4: Ensure security and privacy

The risks from cloud computing depend on the deployment model, the nature of the cloud user (e.g., whether the user is a consumer, an SME or a multinational enterprise) and how critical the activity is that will be carried out in the cloud.

DICT as a regulatory agency should adopt a dynamic and risk-based approach to cloud security. This is the appropriate approach given that in an open networked environment, threats and vulnerabilities are dynamic and always evolving. The four principles of

cloud risk management are as follows: 1) risk assessment; 2) security management; 3) security design and implementation; and 4) risk reassessment. Furthermore, there is a need to deal with the challenges of online fraud and cybercrime that will arise as individuals, governments, and businesses increase the use of cloud computing.

In the area of privacy, DICT has to deal with the question of whose laws apply to the data stored in the cloud, who can access this data, and under which circumstances the processing of data in the cloud amounts to a cross-border transfer. It is recommended that ASEAN start a conversation on this question as part of a broader conversation on how the region can collectively benefit from the Fourth Industrial Revolution and the use of cloud computing across borders.

Step 6: Manage contractual issues in cloud services

Several contractual issues arise in the adoption of cloud services in the Philippines, including fixed terms of contract, legal jargon, the scope of legal coverage, agreements on service levels, the threshold for disclosure of data to third parties, the preservation of data at the end of a contract, and the legal system under which the contract is offered. As an industry, cloud service providers need to agree on a code of conduct governing these contractual issues. DICT can help facilitate this code of conduct in view of its mandate as a regulatory body.

For example, standard cloud service contracts between service providers, SMEs, and consumers are typically non-negotiable and offer “take-it-or-leave-it” terms. The details of the contract terms may not be well understood by new users with limited legal expertise, or the terms may not provide the expected legal coverage for providers. This results in risk and uncertainty for both providers and users that could inhibit the growth of cloud computing.

Contracts should clearly spell out service level agreements, for example in the event of outages, and provide concrete remedies if outages occur. Industry codes of conduct also need to be developed in relation to the threshold for disclosure to third parties, the preservation of data at the end of a contract and the legal system under which the contract is offered. Service providers should also improve delivery methods (such as videos) for standard, non-negotiable contracts in addition to written contracts.

Step 7: Manage the evolving cloud environment

The cloud environment is dynamic and constantly evolving, thus DICT should provide guidelines for managing the issues inherent therein. These include standardization, trade and competition implications, and tax implications. In addressing the emerging business model of cloud computing, governments should consider sandbox regulation.

Standardization. One of the major challenges to the development of cloud computing in the Philippines and in ASEAN more generally is the lack of appropriate standards (for example, the contractual issues discussed in step 6). There is also the possibility of vendor lock-in due to the use of non-inter-operable solutions. As a regulator, DICT should require vendors to fully disclose the presence of lock-in provisions in contracts with buyers.

DICT should encourage and support the continued development of open inter-operable standards for business support, provisioning, and configuration. All public procurement for cloud services should use open standards to ensure the inter-operability of platforms and software. ASEAN ICT leaders might want to start a discussion on ASEAN-wide standards for cloud computing in consultation with cloud service providers.

Trade and competition implications. It may still be too early to evaluate the trade and competition implications of cloud computing for the Philippines and ASEAN. However, DICT and the Philippine Competition Commission (PCC) should keep in mind the possibility that anti-competitive practices might result from market domination by a few companies in the future. PCC should keep an eye on potential violation of anti-trust laws related to cloud services and keep in mind that the growth of cloud computing depends on the efficient flow of data across jurisdictions.

Tax implications. Policymakers will need to consider the tax implications associated with more companies moving to the cloud, including companies with less experience in cross-border transactions and accounting. These tax implications are foreseen as being mainly related to record keeping requirements and possible evasion of taxes.

Sandbox regulation. Cloud computing is a relatively new, evolving, and dynamic business model. Regulatory agencies should be cautious in adopting overly restrictive regulations that could slow down the development and adoption of cloud computing. Instead, governments should take a sandbox approach to regulation, i.e., allow for experimentation, learning, adaptation, and risk-based regulation.

This requires that regulatory agencies adopt a neg-reg (negotiated regulations) approach to regulation. Compared to the traditional top-down, government-knows-all approach, neg-reg requires consultation, negotiation, and compromise with various stakeholders.

IV. Implications for Financial Services

Cloud computing can help solve one of the major problems in financial services in the Philippines—financial inclusion. In its latest available survey, the Bangko Sentral ng Pilipinas (BSP) reported that among the 43% of Filipino adults who claimed to have some savings, only 33% put their savings in a bank.³ This means that 86% of Filipino adults are unbanked. The World Bank’s Financial Development Index found similarly dismal results for other key indicators of financial inclusion, such as the low proportion of individual borrowing from formal financial institutions compared to other Southeast Asian countries. Access to financial services is still limited in parts of the country. Of the country’s 1,634 cities and municipalities, 24% still do not have any banking presence and 12% do not even have access to non-bank providers of financial services such as credit cooperatives, pawnshops, or remittance agents.

Low levels of digital banking penetration exacerbate the problem of financial inclusion. The adoption rate of digital banking among bank customers in the Philippines is only around 12%—well below the average of 28% in comparable Asian markets.⁴ Additionally, smartphones are rarely used for banking transactions, even among smartphone owners who have already made online purchases. The lack of financial inclusion, combined with low levels of digitalization, suggest that for many Filipinos, financial transactions continue to be inconvenient and costly in terms of time and effort. This has deeply negative consequences for the country’s economic development.

For example, without ready access to formal sources of borrowing to smooth out cash flows or to invest, low-income households or small businesses will likely resort to informal channels that charge higher interest rates on short-term loans. This makes it more difficult for low-income households to break out of poverty or for small businesses to accumulate capital and grow. The distance from access points to financial services has been found to deter poor households from consistently saving. In addition, there is solid evidence that informal finance is limited in its ability to foster faster business growth.⁵ It cannot substitute for a well-developed formal financial sector that reaches most economic actors.

Developing the formal financial sector in ways that widen financial inclusion will require a multi-pronged solution, of which increased deployment of cloud computing and other emerging technologies could be an important component. The BSP is already taking the right steps to institutionalize financial inclusion as a policy priority.⁶ The 2015 National Strategy for Financial Inclusion is forward-thinking in listing the use of technology and other innovations to improve financial inclusion as a specific objective.⁷ Cloud computing could support the government’s financial inclusion strategy in a major way: by lowering the upfront cost of using cutting-edge and powerful computing resources and services, for

3 <http://www.bsp.gov.ph/downloads/Publications/FIDashboard.pdf> (accessed 20 September 2017)

4 http://www.mckinsey.com/~/media/McKinsey%20Offices/Malaysia/PDFs/Digital_Banking_in_Asia_What_do_consumers_really_want.ashx (accessed 20 September 2017)

5 https://openknowledge.worldbank.org/bitstream/handle/10986/4485/wber_22_3_383.pdf?sequence=1 (accessed 20 September 2017)

6 <http://www.bsp.gov.ph/publications/media.asp?id=4087> (accessed 20 September 2017)

7 <http://www.bsp.gov.ph/downloads/Publications/2015/PhilippinesNSFIBooklet.pdf>

both large and small, traditional and alternative financial service incumbents and entrants. Lower IT costs could impact financial inclusion directly from the supply side—by lowering the delivery costs of financial services—and indirectly from the demand side—through improved macroeconomic fundamentals.

Economic simulation studies point to overall positive effects of increased cloud computing adoption on GDP growth, public sector deficit, firm creation, and employment rates.⁸ For economies with modest growth, the additional contribution of cloud adoption to GDP growth could range from 5% to 10% per annum, accompanied by an estimated five new jobs created per each job lost in the traditional IT sector in the medium and long-term.⁹ Even under the most pessimistic assumptions, cloud adoption appears to modestly reduce the ratio of the public sector deficit to total GDP.¹⁰

Cloud computing is characterized by elastic and on-demand access to computing hardware, storage, and applications. It allows firms to rent and pay-as-you-go for IT resources that would otherwise require large upfront investments. It effectively transforms capital expenditures into operating expenditures. Budget benchmarking surveys generally find that banking and financial service firms tend to spend between 7 - 8% of their total revenues on IT, the highest of any industry.¹¹ About one third of this spending is devoted to investment in IT for improving business processes, products, and services. These numbers suggest that the financial investment needed for IT could present a significant barrier to entry in financial services, especially for firms engaged in transaction banking that are heavily reliant on IT. Cloud computing minimizes this entry barrier by transforming fixed IT costs into variable costs. When accompanied by supportive legal frameworks, cloud computing can potentially open the playing field to innovative and alternative financial service start-ups who can deploy digital technology to reach underserved segments of the market. Cloud is simply a more cost-effective way to store and manage data, especially for smaller financial service providers. Results from economic simulation studies point to an overall positive effect on economic growth.

Organizations on the cloud have the advantage of being able to easily scale up and down their use of IT resources without significant overhead costs. Such flexibility gives organizations of any size an added competitive advantage, since they can nimbly respond to changing market conditions and develop new products and services faster. This flexibility also supports more efficient provision of digital services that will ultimately make financial transactions less costly for both businesses and consumers.

The Philippine government is cognizant of the advantages of cloud computing technologies and is already putting in place general and sector-specific regulatory guidance. The Data Privacy Act of 2012 and its implementing rules spell out the requirements for the lawful

8 Etro, F. (2011). The economics of cloud computing. *IUP Journal of Managerial Economics*, 9(2), 7-22.
http://econpapers.repec.org/article/icficfjme/v_3a09_3ay_3a2011_3ai_3a2_3ap_3a7-22.htm (accessed 20 September 2017)

9 Ibid.

10 Ibid.

11 https://www.dbresearch.com/PROD/DBR_INTERNET_ENPROD/PROD000000000299039.pdf (accessed 20 September 2017)

processing of personal data, providing much-needed clarity to facilitate the compliance of both cloud providers and cloud customers.¹² Broadly, the Philippine privacy law allows for the processing of personal data provided such processing adheres to the principles of transparency, legitimate purpose and proportionality. It also lays out the rights of data subjects, needed security measures, reporting requirements, and penalties for non-compliance. For the financial sector, BSP has released a 2013 circular permitting the use of cloud computing technologies for bank and non-bank financial institutions under their supervision.

As it currently stands, BSP rules require pre-approval for the use of public cloud services for non-core applications (e.g. customer analytics and customer relationship management) and prescribes private clouds for core applications (e.g. banking, treasury, reconciliation, and collections). Cloud security has increased significantly since the release of the circular, shifting the benefit-risk ratio in favour of cloud versus traditional IT infrastructures. Hence, the time is ripe to re-examine the rules for cloud deployment in the financial sector in keeping with technological realities. BSP recognizes this necessity and is working on a regulatory update in collaboration with stakeholders. Given these regulatory developments, financial service providers can more confidently explore cloud computing technologies for various business applications, beginning with more easily migrated, non-core applications, while piloting potential uses of public cloud services for core applications.

The Philippine financial sector has shown capacity for innovation. In 2001, it was the first country in the world to launch mobile money, done through a partnership between a leading mobile network operator and a major bank.¹³ Since then, mobile money has transformed the country's financial services and demonstrably increased financial inclusion. Electronic money transactions now total close to PhP 500 billion per year and are growing annually at a rate of 4%.¹⁴ At present, telecommunication providers continue to lead the innovation in this space, with recent ventures transitioning away from SIM-based platforms towards over-the-top (OTT) mobile payment applications. Soon, cloud-powered financial players will gain the agility to innovate their services, move quickly into new markets, and along the way bring more people into the formal financial sector.

12 <https://privacy.gov.ph/implementing-rules-regulations-data-privacy-act-2012/#3> (accessed 20 September 2017)

13 <https://www.gsma.com/mobilefordevelopment/programme/mobile-money/mobile-money-philippines-market-conditions-drive-innovation-smart-money-gcash-philippines-becoming-mobile-money-innovation-hub> (accessed 20 September 2017)

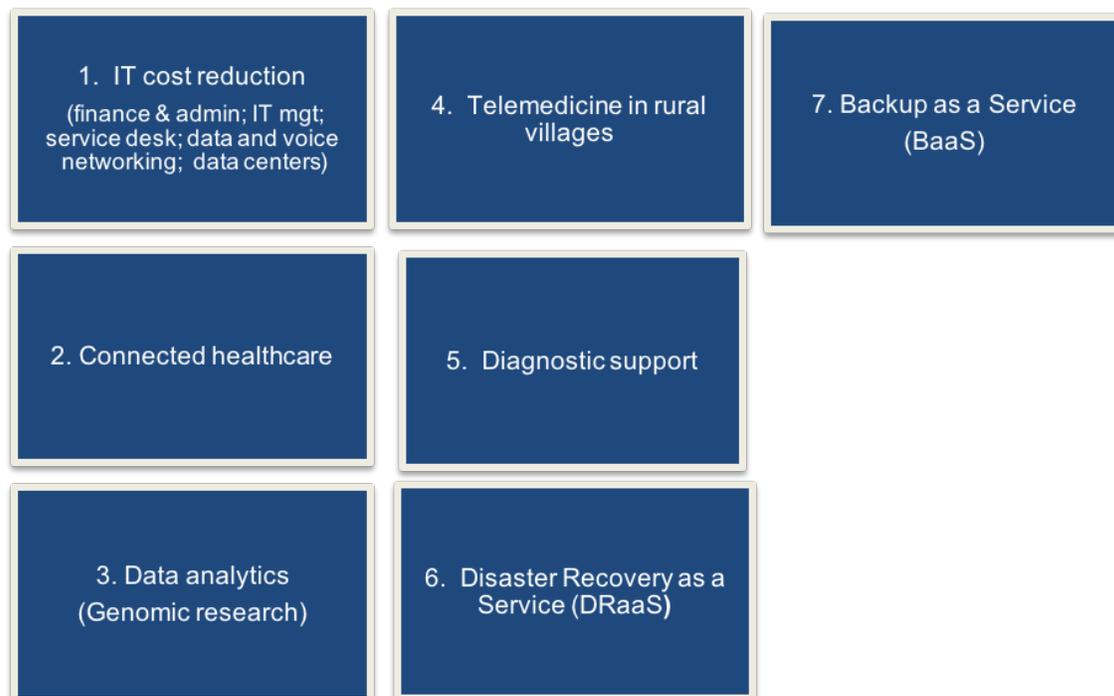
14 http://www.bsp.gov.ph/downloads/Publications/2016/FIDashboard_4Q2016.pdf (accessed 20 September 2017)

V. Implications for Healthcare Services

Cloud computing has considerable implications for the future of healthcare services in the Philippines. Figure 11 provides an overview of the potential uses of cloud computing in healthcare services in the Philippines and in ASEAN. These include IT cost reduction, connected healthcare, data analytics, telemedicine in rural areas, diagnostic support, disaster recovery as a service, and backup as a service. In practice, cloud-enabled solutions are currently used in electronic health records management, telemedicine (clinical assistance), medical coding and billing, and radiology services.

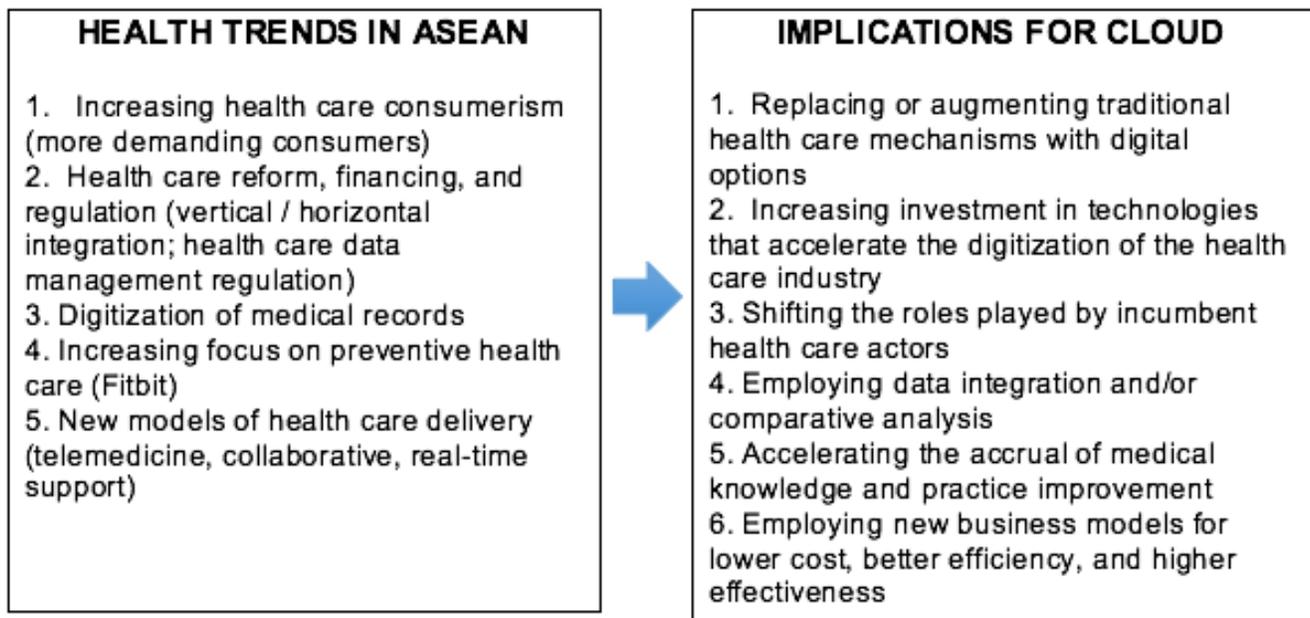
For example, some public hospitals use cloud solutions for their electronic health records (MaryJohnston Hospital in Manila began using cloud solutions in 2011). Seven other hospitals in Metro Manila are now using telemedicine. Healthcare information management in the Philippines employs about 87,000 workers, mainly for medical coding and billing. The field generates US\$3 billion (PhP136.9 billion) in annual revenues, and is growing at 30% annually. In the next few years, the industry will need another 30,000 medical encoders as the US shifts from using 9-digit codes to 10-digit codes. A more promising and permanent growth segment in the healthcare industry is in clinical assistance, in which US-registered nurses provide telemedicine. Companies are now investing in US certification for Filipino nurses based in the Philippines.

Figure 11: Potential uses of cloud computing in health care



In addition to these international developments, the extent to which these uses of cloud computing in healthcare are realized depends on how domestic healthcare trends evolve in the coming years (Figure 12). Table 4 provides a stylized checklist of healthcare trends in ASEAN, with progress in each of the areas indicated by a greater number of ticks. For example, Singapore shows significant development in all of the indicated healthcare trends, while Myanmar lags behind in most areas. In the Philippines, the healthcare industry is undergoing rapid consolidation—from Health Management Organizations to the chain of hospitals owned by conglomerates. The economy is forecast to grow 6.7% in the near term, accompanied by growth in the middle class. This growth is driven by three fundamentals—the US\$25 billion in annual remittances from Filipinos working abroad, the US\$24 billion annual earnings from business process outsourcing, and now the massive infrastructure spending by the government that will hit 7% of GDP in 2020. All of these developments will ensure that the Philippine economy will grow at a high and rapid rate in the coming years as other economies in the region slow down. This trend augurs well for the growth of a consumption and investment-driven large economy and consequently for growth in the use of cloud computing solutions in the healthcare sector.

Figure 12: Health care trends in ASEAN and their implications for cloud computing



Source: Adapted from Cloud Standards Customer Council, *Impact of Cloud Computing on Healthcare* (2017), available at <http://www.cloud-council.org/deliverables/CSCC-Impact-of-Cloud-Computing-on-Healthcare.pdf>

Table 4: Stylized healthcare trends in selected ASEAN countries

	Singapore	Philippines	Vietnam	Myanmar
1. Health care consumerism	✓✓✓	✓✓✓	✓✓	✓
2. Health care reform, financing and regulation	✓✓✓	✓✓✓	✓✓✓	✓✓
3. Digitization	✓✓✓	✓✓	✓✓	
4. Preventive medicine	✓✓✓	✓✓	✓	
5. New models of health care delivery	✓✓	✓✓	✓✓	

VI. Conclusion

Cloud computing offers significant benefits to improve governance and sustain the growth momentum of the Philippines in the same way as the government's infrastructure build-up, but at a much lower cost. The country has made good progress in the last five years but still significantly lags behind its peers in ASEAN. A major bottleneck is the cost, quality, and access of broadband connectivity. Fixing these problems requires amending archaic laws such as the Commonwealth Act No. 146 (Public Service Act), the Republic Act 7925 (Public Telecommunications Policy Act), and the Republic Act 3846 (Radio Control Law). New regulations are also needed to unbundle the broadband market; require mandatory peering and establish internet exchange points; streamline and harmonize broadband-related permits, fees and processes; and harmonize cloud standards in the public and private sectors. Finally, the Departments of Information and Communications Technology, Transportation, and Public Works and Highways, and the National Grid Corporation, should jointly undertake a Memorandum of Understanding to allow the use of their infrastructure assets for broadband fiber rollout.

Cloud Computing in Vietnam

Khuong Minh Vu and Kris Hartley

I. Introduction

As a rapidly developing country, Vietnam is an instructive case in how emerging economies can leverage ICT for development. Vietnam's market reforms and integration into the global economy have coincided with the rise of ICT, which has been applied to productivity enhancement, innovative capacity, and market expansion. The first wave of market reforms made measurable impacts on economic growth from the late 1980s, and a decade later ICT integration began to boost Vietnam's firm-level competitiveness after the government further developed ICT infrastructure, improving the quality and reach of internet access. As such, ICT heralds a second wave of economic transformation that is allowing Vietnam to maintain high growth rates well into the 21st century.

Vietnam's economic reforms were launched in 1986 after more than a decade of stagnant economic growth since the country's 1975 reunification. Under central planning and socialist ideologies, the country's annual economic growth averaged 1.4% between 1976 and 1986. In 1986, Vietnam was among the lowest-income nations and most economically isolated, while inflation reached 455%. Over three decades of reforms, Vietnam grew at an average rate of 6.7% per year and has profoundly transformed itself into one of the leading Asian countries for global integration, business environment improvement, and support of the ICT revolution.¹

Although Vietnam has made impressive strides in ICT infrastructure development and adoption, the country is still struggling to leverage its basic ICT-related advantages into decisive strengths for promoting economic growth and competitiveness. One of the critical problems hindering Vietnam in this endeavor is its lack of a "cloud-first strategy." Cloud computing enables firms and governments to embrace digital transformation through instant access to world-class ICT services without making costly up-front investments.

This case examines the dynamics of ICT development in Vietnam, with a special focus on cloud computing, an emerging ICT application that is defining the vigor and pace of digital transformation in countries around the world. The case explores the key factors underlying Vietnam's readiness for cloud computing and makes policy recommendations for promoting the adoption of cloud computing in Vietnam.

1 For example, in 2016 Vietnam performed well above Indonesia and the Philippines on openness (measured by the trade-to-GDP ratio), total manufactured exports, the attractiveness of business environment (measured by the World Bank's ease of doing business index), broadband penetration, and the average speed of internet connectivity.

II. ICT development in Vietnam

ICT development has progressed rapidly in Vietnam, as seen through a variety of key ICT development indicators including penetration rates, internet speed, affordability, and internet traffic volume. As shown in Table 1, Vietnam started from lower or equal levels of penetration compared to its Asian peers in 2000, and has made major strides on ICT development. It surpassed most ASEAN peers on mobile phones, internet usage, and fixed broadband in 2010, and has sustained this performance since.²

Table 1: ICT Penetration (number of subscribers per 100 inhabitants)

Country Name	2000	2005	2010	2015
Total mobile phone (2G+3G+4G)				
ASEAN				
Vietnam	1.0	11.3	125.3	130.6
Indonesia	1.8	20.9	87.8	132.3
Malaysia	21.9	75.6	119.7	143.9
Philippines	8.3	40.5	89.0	115.8
Singapore	70.1	97.5	145.4	146.5
Thailand	4.9	46.5	108.0	152.7
China-India				
China	6.7	29.8	63.2	92.2
India	0.3	8.0	62.4	78.1
Internet usage				
ASEAN				
Vietnam	0.3	12.7	30.7	52.7
Indonesia	0.9	3.6	10.9	22.0
Malaysia	21.4	48.6	56.3	71.1
Philippines	2.0	5.4	25.0	40.7
Singapore	36.0	61.0	71.0	82.1
Thailand	3.7	15.0	22.4	39.3
China-India				
China	1.8	8.5	34.3	50.3
India	0.5	2.4	7.5	26.0
Fixed broadband				
ASEAN				
Vietnam	0.0	0.2	4.1	8.1
Indonesia	0.0	0.0	0.9	1.1
Malaysia	0.0	1.9	7.4	10.0
Philippines	0.0	0.1	1.9	4.8
Singapore	1.8	14.6	26.4	26.4
Thailand	0.0	0.8	4.9	9.2
China-India				
China	0.0	2.8	9.3	19.8
India	0.0	0.1	0.9	1.3

Source: World Development Indicators database

² With the rapid adoption of smart phones since 2000, the total mobile phone penetration indicator has become less relevant as a measure of mobile phone adoption because 2G mobile phone users usually have multiple subscriptions, while 3G and 4G mobile phone users usually have only one subscription. As a result, countries with more developed mobile systems (such as Singapore) may have lower total mobile penetration than less developed ones (such as Cambodia) (See Vu, K. 2017, "ICT Diffusion and Production in ASEAN Countries: Patterns, Performance, and Policy Directions", Telecommunications Policy, forthcoming, 2017).

Vietnam's ICT development has been driven by vigorous investment in upgrading ICT infrastructure and fostering competition in ICT services provision. These policy efforts have produced particularly impressive results in internet speed and ICT affordability. On internet connection speed, Vietnam ranks well above most Asian peers (Table 2). Moreover, Vietnam's high performance on this metric was driven by rapid improvement rather than initial favorable conditions. The country improved in this metric by 89% between 2016 and 2017, far exceeding the improvement rate observed for its Asian peers.

Table 2: Internet connection speed, Vietnam vs. Asian peers

Global Rank	Country	Average connection speed (Mbps)	Year-over-year change
7	Singapore	20.3	23%
21	Thailand	16.0	49%
58	Vietnam	9.5	89%
62	Malaysia	8.9	40%
68	Sri Lanka	8.5	58%
74	China	7.6	78%
77	Indonesia	7.2	59%
89	India	6.5	87%
100	Philippines	5.5	57%

Data source: Akamai Q1 2017 Report. The report includes 149 countries qualifying for this metric.

On the affordability index for ICT use, Vietnam ranked third in the global ranking of 139 countries in 2016 (Table 3). The country's strong performance on ICT affordability is driven by low tariffs (PP\$) for fixed broadband subscriptions and robust competition among ICT service providers. Vietnam's first place ranking in the sub-ranking for affordability of broadband subscriptions is a positive sign on one crucial indicator of readiness for cloud computing adoption.

Table 3: Affordability of ICT use, Vietnam vs. Asian peers

Country	Overall Affordability		Global rank by affordability sub-index		
	Index value	Global rank	Mobile phone use	Broadband subscription	Competition
Vietnam	6.8	3	42	1	1
India	6.6	8	5	36	1
Indonesia	5.9	38	52	46	87
Cambodia	5.9	43	65	56	1
China	5.5	63	6	68	118
Thailand	5.5	64	16	89	97
Singapore	5.3	72	51	99	1
Lao PDR	5.0	82	25	88	126
Malaysia	4.7	91	46	110	1
Philippines	4.1	107	110	104	1
Myanmar	3.0	122	24	127	135

Data source: Global Information Technology Report 2016, World Economic Forum, 2016. The report rank 139 countries in its 2016 edition.

III. Cloud Computing Adoption in Vietnam

Although Vietnam has made remarkable progress on ICT infrastructure development and ICT usage, the country still lags in digital transformation and is far below its potential in reaping the benefits of the ICT revolution. One obstacle is the lack of a “cloud-first strategy” that supports efforts to promote the adoption of cloud computing across organizations and sectors (the benefits and global dynamics of cloud adoption are presented in Appendix I).

The Cloud Readiness Index (CRI), compiled by the Asia Cloud Computing Association (ACCA) for Asia-Pacific countries, ranked Vietnam ranked last in both 2016 and 2015 (Table 4). A country’s CRI is based on readiness on 10 pillars: (1) international connectivity; (2) broadband quality; (3) power grid, green policy, and sustainability; (4) data center risk; (5) cybersecurity; (6) privacy; (7) government regulatory environment and usage; (8) intellectual property protection; (9) business sophistication; and (10) freedom of information. As shown in Table 4, Vietnam’s performance on international connectivity exceeds that of the region’s three largest countries (Indonesia, India, and China). Nevertheless, Vietnam’s scores are below the world average (5.0) on four indicators: freedom of information (2.4), data centre risk (2.6), international connectivity (3.0), and cybersecurity (3.2). Vietnam’s score is well below all countries in the Asia-Pacific region on two indicators: cybersecurity and business sophistication.

Vietnam’s lagging cloud computing readiness indicates that the country is at a critical juncture for embracing new smart technologies that can help Vietnam fully reap the benefits of investment in ICT infrastructure and rapid diffusion of basic ICT applications. Vietnam has opportunities to promote cloud computing adoption. Among ASEAN countries, Vietnam is the fastest-growing economy in terms of cloud computing spending, an indication of the growing appetite for adoption in all sectors. Vietnam’s spending on cloud computing grew 64.4% between 2010 and 2016, followed by the Philippines (62.3%) and Indonesia (56.5%). However, Vietnam still lags its peers in per capita cloud computing spending: US\$1.70 per year in 2016 was more than 100 times lower than Singapore, 6.5 times lower than Malaysia, and 2.4 times lower than Thailand (Table 2, Appendix I).

Vietnam must undertake a robust accounting of obstacles and opportunities in order to promote cloud computing adoption. This includes a crucial role played by the government. Section IV presents selected results from a recent survey of Vietnamese firms and important policy insights.

Table 4: Cloud Readiness Index 2016

Rank, Country	CRI#01 International Connectivity	CRI#02 Broadband Quality	CRI#03 Power Grid, Green Policy, and Sustainability	CRI#04 Data Center Risk	CRI#05 Cybersecurity	CRI#06 Privacy	CRI#07 Government Regulatory Environment and Usage	CRI#08 Intellectual Property Protection	CRI#09 Business Sophistication	CRI#10 Freedom of Information	TOTAL CRI 2016 SCORE	Rank Change
#1 Hong Kong	8.1	9.1	6.7	8.0	6.2	9.5	7.2	8.6	7.4	7.2	78.1	+4
#2 Singapore	6.4	9.4	6.5	7.8	6.8	9.0	8.6	8.9	7.3	6.0	76.7	+2
#3 New Zealand	4.6	8.2	7.6	6.8	7.4	9.0	8.1	8.7	6.9	7.2	74.4	-1
#4 Australia	4.3	8.0	6.6	6.3	7.6	9.5	7.4	8.3	6.7	8.3	73.2	-1
#5 Japan	3.9	8.9	6.7	5.9	7.1	8.0	7.8	8.7	8.3	7.8	73.0	-4
#6 Taiwan	4.1	8.8	6.7	6.4	7.0	9.5	6.7	7.4	7.1	7.2	71.1	+1
#7 South Korea	3.8	9.0	6.3	6.2	7.1	9.0	7.0	6.0	6.9	6.7	68.0	-1
#8 Malaysia	3.3	7.6	5.4	5.9	7.6	8.0	7.4	7.7	7.6	5.8	66.3	-
#9 Philippines	3.3	5.5	6.0	3.5	3.5	7.5	5.5	5.6	6.1	7.3	53.8	+1
#10 Thailand	3.8	8.6	6.0	5.2	4.1	5.0	5.1	4.6	6.3	3.8	52.6	-1
#11 Indonesia	1.8	6.3	5.4	2.7	4.7	6.0	5.6	6.1	6.1	5.8	50.6	+1
#12 India	1.7	5.6	5.1	1.9	7.1	4.5	5.5	6.0	6.0	5.8	49.1	+1
#13 China	1.6	6.6	5.3	2.5	4.4	5.5	6.2	5.7	6.1	1.3	45.4	-2
#14 Vietnam	3.0	6.7	5.4	2.6	3.2	5.0	5.4	5.1	5.1	2.4	44.0	-

Source: Asia Cloud Computing Association (2016)

IV. Insights from the Survey of Businesses

Survey results

This case study's empirical study is based on the results of surveys of 368 private firm respondents familiar with cloud computing concepts. The surveys were conducted by the Lee Kuan Yew School of Public Policy in collaboration with various agencies and universities in Vietnam, and most of the surveyed firms are based in Ho Chi Minh City and Hanoi. The survey used a Likert scale to measure perceptions about readiness for ICT applications, the perceived benefits of cloud adoption, and the perceived obstacles to cloud adoption. The survey also measured firm perceptions about government priorities for encouraging adoption, based on the percentages of respondents placing each option among the top five priorities. The following section describes the results from each of these survey items in detail.

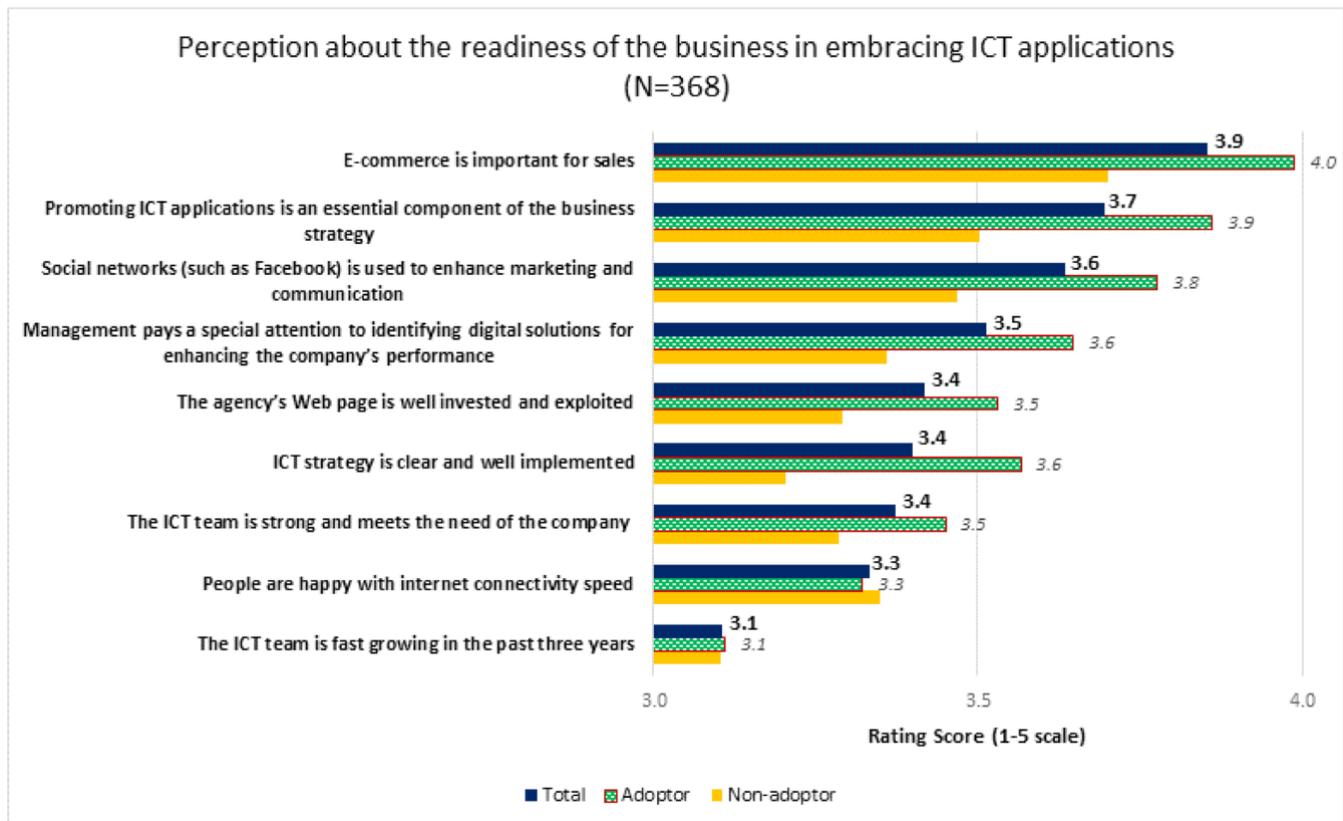
Table 5: Survey respondent characteristics

		Organization size (employees)			
Cloud adopter	Distribution	<50	51-100	101-500	>500
Yes	56%	57%	39%	73%	65%
Not yet	44%	43%	61%	27%	35%

Readiness for ICT applications

The highest-rated factors signaling readiness for adoption are the importance of e-commerce for sales, the use of ICT applications in business strategy, the use of social networks for marketing and communication, and the application of digital solutions to enhance operational performance. Survey scores for each of these factors are consistently higher for adopters than for non-adopters, evidence of the effectiveness of cloud computing as a business solution. Further, the perceptions of both adopters and non-adopters about the benefits of cloud adoption are significantly positive. The growth of a firm’s IT team, happiness with internet speed, and IT team strength are less important in signaling readiness to embrace ICT applications.

Figure 1: Factors signaling readiness for ICT adoption

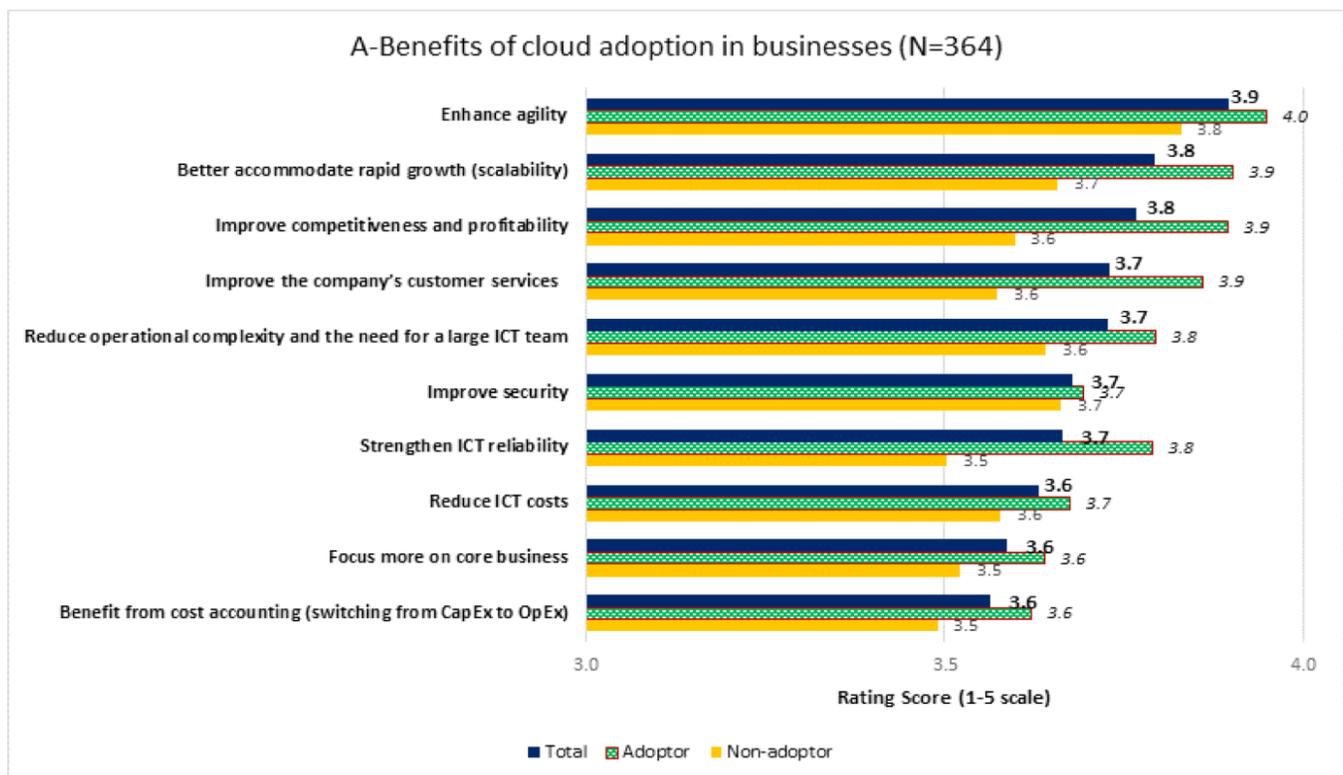


Notes: Responses were measured using a 1-5 Likert scale: 5=Strongly agree; 4=Agree; 3=Neutral; 2=Disagree; 1= Strongly disagree.

Perceived benefits of cloud adoption

Similar trends are evident in the survey’s measurement of perceptions of cloud computing benefits (Figure 2). Respondents indicated the top benefits as improvements in agility, scalability, competitiveness and profitability, and customer services. An example of benefits is Viet A Bank’s adoption of cloud computing (see Appendix A2), in which the bank experienced improvements in processing capacity, customer satisfaction, and IT cost savings. In the survey, the positive perception was shared by both adopters and non-adopters, but the assessment by adopters is stronger. This implies that use experience strengthens the positive perceptions of cloud computing. The weakest benefits included the transition of IT from a capital expenditure to an operating expenditure, the ability of businesses to focus on their core operations, and a reduction in overall IT costs. It is notable that the gap between adopters and non-adopters on the perception of improved security is narrower than that for any other measure. This may imply that awareness of the ability of cloud computing to improve security is broad across the entire population of businesses.

Figure 2: Perceptions about benefits of cloud computing

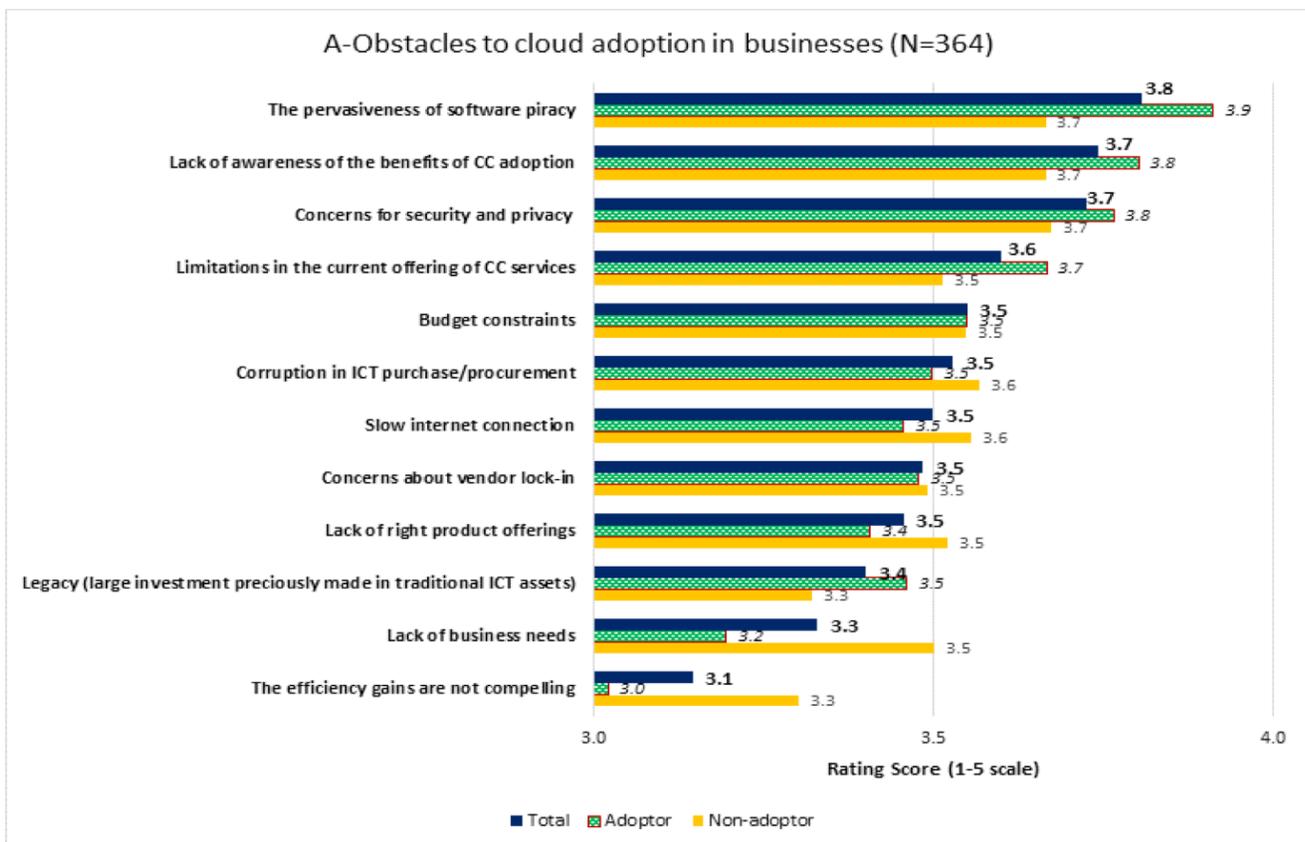


Notes: Responses were measured using a 1-5 Likert scale: 5=Strongly agree; 4=Agree; 3=Neutral; 2=Disagree; 1= Strongly disagree.

Perceived obstacles to cloud computing adoption

Software piracy is reported as the greatest obstacle to cloud computing, followed by lack of awareness about benefits, concerns about security and privacy, limitations in product offerings, and budget constraints (Figure 3). The least important obstacles to adoption are unconvincing efficiency gains, lack of business needs, and investment already made in ICT assets. The gap between adopters and non-adopters is largest for the efficiency gains measure; it appears that the user experience makes adopters far more likely to look favorably on the efficiency gains of cloud computing, implying that cloud computing offers such gains.

Figure 3: Perceptions about obstacles to cloud computing adoption



Notes: Responses were measured using a 1-5 Likert scale: 5=Strongly agree; 4=Agree; 3=Neutral; 2=Disagree; 1= Strongly disagree.

Detailed description of obstacles to cloud computing

In both national surveys and global indices, Vietnam is not considered to be adequately prepared for large-scale cloud computing adoption. This section outlines the top four obstacles identified in Figure 3: piracy, lack of awareness of cloud computing's benefits, data security, and limited service offerings.

Software piracy. The first obstacle to cloud computing adoption is software piracy. With the more widespread adoption of ICT and business management applications, growth in usage is outpacing awareness of vulnerabilities. Many firms have been targeted by malware, computer viruses, and other forms of hacking, compromising data and reducing investor confidence. Much of the hacking vulnerability comes from the use of pirated software, which can lack piracy controls and updates, or can itself contain malicious viruses, worms, and spyware. Given the high cost of software licenses, many users take chances with lower-cost pirated versions, reducing the use of licensed software or the desire of companies to contract for cloud services. SMEs are particularly vulnerable, as many lack the capital base or resources to purchase officially licensed software. Recent efforts by the government have targeted software piracy but piracy continues to be a problem. The use of cloud services can help prevent such compromises, as cloud computing offers international standards for safety and security that are not found in pirated software. Vietnam's SMEs are particularly vulnerable to piracy, but cloud computing can help improve security by providing users with licensed and updated versions of software. SMEs elsewhere have been particularly strong adopters of cloud computing: Intuit reports that around 37% of American SMEs have fully adopted cloud computing and 18% have adopted hybrid firms; by 2020 the full adoption rate is expected to increase to 78%.³

Lack of awareness about benefits. The second obstacle is a lack of awareness of the benefits of ICT and cloud computing. Failing to realize benefits like those outlined in this study makes cloud computing little more than an added cost and a new level of operating complexity. Firms may naively see the potentially positive disruption of inefficient business practices as a threat to continuity and not worth the effort. Lack of awareness results in part from inadequate information campaigns. Governments, industry associations, and cloud service providers must thus utilize effective communications channels to reach skeptical non-users; such channels include industry memos, policy circulars, press releases, and broader media campaigns. These materials must be supported by scientific evidence and credible case examples. As cloud computing is studied longitudinally among early-adopter firms and in countries where the industry is more developed, the evidence of benefits should become clearer. On a related note, as a cultural factor many Vietnamese business owners prefer ownership over renting, and the concept of owning physical assets (in this

³ <https://www.forbes.com/sites/louiscolumbus/2015/05/04/roundup-of-small-medium-business-cloud-computing-forecasts-and-market-estimates-2015/#40beb5af32b0> (accessed 30 August 2017)

case, hardware) is deeply entrenched in some industries. Companies must be convinced that the benefits of cloud computing adoption outweigh the opportunity costs (e.g. balance sheet strength) of not owning physical assets. Finally, the issue of price weighs heavily on the concept of benefits. The price of cloud services in Vietnam is comparable to international rates. However, by Vietnamese standards the price is still high and exceeds the costs expected by some businesses and government agencies. As a result, many businesses have purchased only virtual private servers (VPSs) instead of cloud servers, an option that is cheaper but offers far less security.

Security and privacy. A third obstacle is security, which can be compromised for a variety of reasons including unsecured infrastructure, poor data management practices, and a lack of awareness or care among firms. Vietnam has recently become known as a prolific distributor of spam and malware. According to the 2014 Global Security Index⁴—a measure of legal frameworks, technical standards, education, and organizational structures related to the management of cybersecurity—Vietnam ranked last among all countries studied, behind regional peers Philippines, Thailand, Malaysia, and Indonesia. Vietnam’s Law on Information Security, passed in 2015, addresses various issues related to cybersecurity, including warfare, conflicts, and other violations. Security of data is a concern, not only for firms’ proprietary information but also for the vast amounts of sensitive customer data. Data breaches can severely compromise a firm’s brand image, and at a broader scale can harm the reputation of an entire industry within a country. Robust security protection measures must not be left to market preferences; many firms do not appreciate the severity of the problem and lack digital controls and management protocols to respond effectively to breaches.

Demand for increased security must come not only from government and cloud service providers but from firms themselves; educating managers on the necessity of cybersecurity is a key element in building support for such initiatives from the ground up. Absent such standards and expectations, the market for cloud computing risks becoming like the markets for unregulated goods: inconsistent or poor product quality across suppliers, opaque pricing and service systems, and a general deterioration in consumer confidence. Despite these issues, there is evidence that concerns about security are easing. In a Microsoft study of almost 300 CIOs from the Asia-Pacific region, only 35% strongly believed that the potential of cloud computing in the public sector would be limited by security problems.⁵ Proper data classification would simplify data security management and lessen the concerns, but many companies do not classify data effectively. Much of what companies and government protect as private data can be shared publicly, liberating resources to better manage the most sensitive data.

4 International Telecommunications Union (ITU) and ABI Research, Global Cybersecurity Index 2014, <http://www.itu.int/en/ITU-D/Cybersecurity/Pages/GCI.aspx> (accessed 6 September 2017).

5 www.eiuperspectives.economist.com/sites/default/files/EIU_Microsoft_DigitisingGov_briefing_paper_Jan2016.pdf (accessed 30 August 2017).

Limited service offerings. The fourth and final obstacle is limited service offerings, as cloud services work to adapt to the needs of firms. While many business functions focus on customer services and can be improved through the efficiency gains offered by cloud computing, other aspects of business operations raise particular needs in the cloud computing arena. The protection of data is one such area, as firms must manage both internal and external customer information. Cloud service providers must be able to ensure world-class standards of data protection, particularly for the transmission of information across borders, as cybersecurity standards in one country may be inconsistent with those in another. Similar concerns arise when sensitive data, once stored in-house in filing cabinets or on-site physical servers, is now stored in distant locations. Indeed, ACCA has argued that cloud computing adoption has been stymied by some regulatory requirements that local content and local personal data be stored on local servers. Generating trust and faith in both the quality and management of cloud service technologies by providers is crucial for developing a robust market. Another serious obstacle to adoption is restrictions on online-based information flows. According to Freedom House's Freedom on the Net report for 2014, Vietnam ranks ahead of only China in the region for information and data access and cross-border information flows.⁶ This is one example of how a deeper institutional reform, going beyond technical aspects, is needed to further invigorate the cloud computing market. Liberalizing content distribution will allow companies to operate with a fuller understanding of market conditions, and help them leverage the advantages of cloud computing. Finally, educating firms about their consumer rights, establishing and publicizing related codes of conduct, and ensuring that legal venues are available to resolve contract disputes are paramount to generating confidence within the emerging market for cloud services.

Priorities for stimulating cloud adoption and policy actions

The Vietnamese government has played a leading role in the country's technological transformation. Vietnam lagged its peers in ICT development until the mid-2000s, and was ranked next to last among 75 countries by the Global Information Technology Report in 2002. The report cited Vietnam's weaknesses in network use and access, e-government, and e-business. More recently, the government's vision for ICT-based economic growth and nationwide connectivity, strategic implementation, and resource commitments have been instrumental in raising Vietnam's ICT profile among its peers.

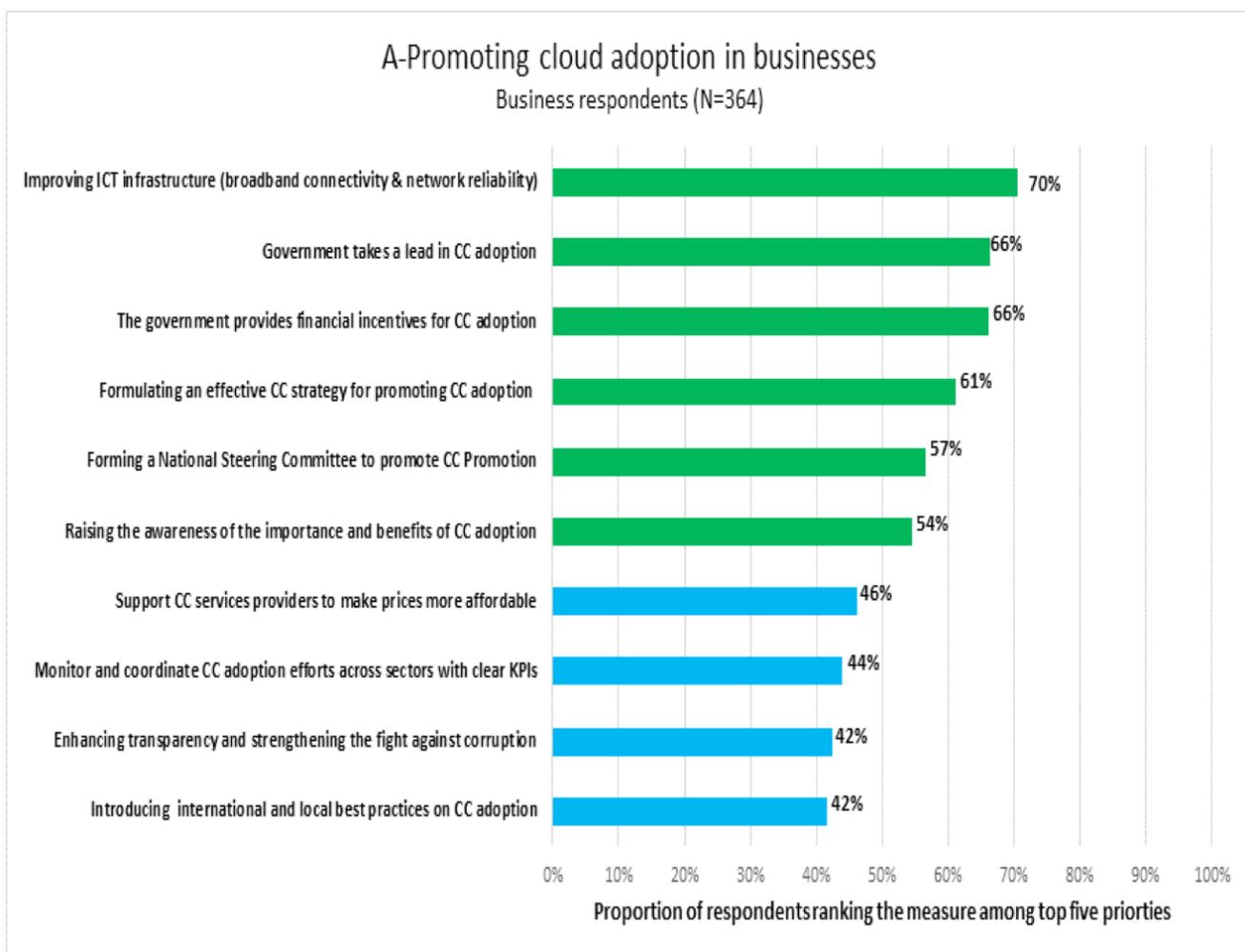
Governments rarely have the chance to be out in front of emerging technologies; often, the private sector moves much more quickly on account of profit potential, innovative appetites, and expertise. However, Vietnam's government has the opportunity to be an integral partner in developing the country's cloud computing industry by addressing the country's inherent weaknesses and providing a strategic vision for how cloud computing can enhance firm competitiveness and national economic growth. If Vietnam wants to

⁶ Freedom House, Freedom on the Net 2014, <https://freedomhouse.org/report/freedom-net/freedom-net-2014#VnKMPvI96M8> (accessed 6 September 2017).

provide the conditions for the cloud computing industry to thrive, it must ensure a stable institutional setting and help firms fully realize the benefits of adoption.

Survey respondents indicated the highest priorities were improvement of the ICT infrastructure (broadband connectivity and network reliability) and the government taking a leading role as a user, followed by financial support / incentives and the formulation of an effective strategy for promoting adoption (Figure 4). These findings underscore the importance of raising awareness, reducing the cost of the transition to cloud services, and enhancing the effectiveness of facilitation and coordination.

Figure 4: Priorities for government intervention



Priorities to improve the environment for cloud computing in Vietnam

The remainder of this section describes the top four priorities identified by respondents to improve the environment for cloud computing in Vietnam: infrastructure improvement, government taking the lead in adoption, the provision of financial incentives, and the formulation of an effective cloud computing promotion strategy.

Infrastructure improvement. Infrastructure improvement is crucial. Establishing a national information network is a crucial step in achieving infrastructure sophistication. The Prime Minister's decision No. 149/QD-TTg approved a master plan on ICT infrastructure development through 2020, which aims to (1) develop a nation-wide modern broadband infrastructure to enable secure, high-speed, and high-capacity network-wide services, and (2) provide broadband services with good quality at reasonable rates, in accordance with market mechanisms. Vietnam's recent rollout of the "Public Telco Service" aims to improve infrastructure access for rural and underserved communities between 2015 and 2020. With improved connectivity, cloud computing will be able to reach more remote areas, where the marginal benefits of technology investment could be sizable. Such a network also expands the market area of companies capable of reaching customers through e-commerce platforms. A well-connected and ubiquitous network can also reduce the cost of connection and participation, further improving the cost / benefit calculus and inducing more companies to participate. Tighter and more consistent communications connections across Vietnam can benefit all industries, enhance competition by providing greater reach for individual firms, and reduce the costs of serving a geographically disparate market.

Government leading in adoption. Second, government must take the lead in adoption. This involves committing to a vision for cloud computing adoption that receives priority consideration across agencies and government functional areas, not only in economic development but also in dimensions of social development including education, healthcare, and services. One example is Hue Family Medicine Center, which adopted cloud-related technologies for patient record-keeping and for facilitating communication between patients and doctors (see Appendix A1). Progress in government services can be realized through more efficient systems, including advanced data collection, management, and analysis that are enabled by the use of cloud technologies. The successful application of cloud computing to the many current challenges of governance in Vietnam, if clearly documented and publicized, can give private users the confidence to commit to cloud services. If the government does not lead in adopting cloud computing, government efforts to promote adoption within the private sector may prove to be unconvincing.

Financial incentives. Third, the government must provide financial incentives for adoption. The majority of businesses in Vietnam are small and lack the resources to purchase licensed software or to enter into cloud service contracts. If these firms have an avenue to utilize cloud computing and realize the efficiency gains it offers, the resulting financial benefits may convince firms to appropriate more resources for the purchase of cloud

services. The government has numerous tools to intervene in lessening the financial hardship to firms adopting cloud computing, including tax credits and deductions for related costs, direct subsidies for trial contracts, and the facilitation of collective service buyer groups to take advantage of volume discounts. Indirect financial interventions can also encourage adoption. For example, facilitating the development of industrial estates (e.g. Saigon High-Tech Park) or urban technology clusters and smart cities (e.g. Danang) with a significant cloud computing component will help attract foreign investment and generate the agglomeration and spillover effects that lead to collaboration, innovation, and entrepreneurial activity. This would improve the market for cloud computing and broaden the service offerings demanded. With increased competition, prices may fall.

Promotion strategy. Finally, it is crucial to have an effective strategy to encourage cloud computing adoption. The government must take a broad sectoral view of cloud computing penetration, facilitating adoption among firms across industry types and sizes. Currently, the financial, banking, real estate, marketing, and advertising industries appear to make most prominent use of cloud computing, as competitive advantage is often built in the industry on the speed of transactions and immediate access to information. However, the benefits of cloud computing extend to other industries that have shown a slower rate of adoption than finance, including business services (legal, etc.), tourism and hospitality, education, healthcare, manufacturing/production, and insurance. In each of these industries, the ability to connect more quickly and meaningfully with clients, in addition to the operational efficiency gains that are standard across all industries, should drive increased demand for cloud services, enterprise resource planning (ERP), customer relationship management (CRM) software, and logistics management systems. As such, the government must recognize the potential of cloud computing for these industries and devise campaigns to raise awareness and respond to any industry-specific bottlenecks.

A broad sectoral view also includes non-profits and the public sector. A more aggressive adoption of cloud computing by government agencies will not only send a signal to the private sector but also serve as a means for achieving efficiency gains and improving governance through service provision centered, where appropriate, on citizens-as-customers. A cloud computing ministerial conference can convene to establish a coordinated agenda on confronting shared challenges and advocating for resource commitments at the central level. This institutional reform can contribute to the balanced integration of cloud computing into strategic directives across agencies, leading to a more comprehensive approach for industry development and thereby more interest from consumers. The government's formation of a National Steering Committee on ICT (NSCICT), with membership including the leaders of 12 ministries, provides a useful example of how a cloud computing-specific conference can be arranged.

V. Conclusion

Vietnam has made impressive gains in fostering ICT diffusion and the country now sits at a critical juncture in digitally enabled economic transformation. Establishing a robust cloud computing ecosystem is imperative for Vietnam to leverage an already relatively high rate of ICT modernization. Improved productivity, efficiency, and competitiveness are all possible through the adoption of this rapidly advancing technology. In conceptualizing the Vietnam case's lessons for ICT governance and cloud computing adoption policy, the "SMART" framework (strategy, monitoring, accountability, rethinking, and trust) provides a useful guide.

First, *strategy* should be a seminal consideration for governments in guiding their efforts to integrate technologies with the highest economic and social impact, and in focusing their resource commitments to develop a robust and competitive cloud computing market. Vietnam's government should adopt a strategic approach that emphasizes effective collaboration among the key players in the cloud services market: consumers, providers, and government. Such collaboration would include assistance on the major restructuring needed to transition to cloud technology, ensure compliance with existing and new regulations, strengthen cybersecurity, put in place measures to ensure resilience and redundancy for important systems, and provide more robust IP protection. The concerns of firms identified in the survey can guide these strategic priorities towards the greatest bottlenecks for progress. Such strategic priorities include a balance of hard and soft infrastructure, workforce training and development, clear and consistent enforcement of regulations, commitment to innovation, and openness to new ideas.

Second, *monitoring* ICT adoption and its impact on the economy and society is crucial for raising awareness of benefits and generating support for additional policies to advance cloud computing. A suite of key performance indicators (KPIs) should guide efforts to collect data on a yearly basis through surveys of firms and users and government records on investments, expenditures, and other indicators of adoption. The results, where appropriate for public viewing, can be circulated through an open-access platform itself based on cloud technology. After several years of data, meaningful research can be conducted by the academic and non-profit sectors to understand lessons and develop best practices to help guide policy and assist the next generation of rapid-adopter economies.

Third, *accountability* systems based on transparency and collaboration must be used to build the credibility of policy efforts. With strengthened regulatory frameworks in place, the government must prioritize fair and consistent enforcement. The development of the cloud computing industry is contingent upon the technology's ability to be integrated into existing economic and social systems without compromising them or monopolizing opportunities for certain parties. The government must therefore ensure that the potential benefits of ICT are equally available across sectors, geographies, and population sub-groups. Firms, non-governmental organizations (NGOs), and citizens have an important role to play in this process, as they must hold government accountable for such measures.

Fourth, *rethinking* is crucial for the government and private sector to avoid becoming comfortable with or dependent on legacy technologies. Understanding global trends and best practices in the rapidly evolving cloud computing environment—and embracing them for economic development—is an important supplement to the types of infrastructure and regulatory initiatives already underway. Rethinking also involves keeping track of developments in and needs of domestic society, and recognizing how technologies can help address them. This requires an open-mindedness and flexibility, seeing technology not as a destination but as a moving target that constantly evolves and generates new opportunities. In application, rethinking can be actualized through policy experiments. One example is the use of test-beds: zones, defined by either geography or industry, where new regulations and policies are implemented for the sake of observation. Another example is innovation incubators, clusters of firms in similar industries and communities of practice that function in physical proximity and encourage information exchange, collaboration, and experimentation. Like test-beds, activities within incubators can be observed for reference in future policymaking. Test-beds can also be developed as demonstration facilities at expos and events, and as “centers of excellence” within organizations (e.g. universities) to exhibit applications of cutting-edge developments. Test-beds can also be implemented through organizational decentralization that gives individual units the autonomy to experiment. Finally, the government must seriously re-think its approach to ICT hardware procurement, in particular the opportunities for corruption it provides. If agencies move towards rental agreements with cloud services providers, opportunities for under-the-table kick-backs are reduced.

Finally, *trust* is the crucial element for developing a robust cloud computing industry. For emerging technologies such as cloud computing, domestic firms may be wary of the risks of adoption; public policies and service providers must include safeguards against predatory behavior, cybercrime, data compromises, and other threats to business security and continuity. From the policy side, building trust necessitates specific regulations that are robustly enforced, to ensure the proper and transparent functioning of markets and the lawful behavior of both domestic and foreign service providers. Improved infrastructure and hardware also builds trust, as system quality and resilience (minimization of interruptions) ensures business continuity. Finally, promotion of transparency and rule of law, and the elimination of corruption from public bodies having control over ICT, can build trust among the private sector and civil society.

In addition to the government intervention priorities revealed in the survey, the government must also pay close attention to education and training, developing a robust human capital base to advance cloud computing. This can be achieved by integrating cloud computing into IT curricula at secondary and tertiary institutions, by providing scholarships for students who want to study cloud computing for careers in industry or research, and by establishing continuing education programs to allow working professionals and managers to build cloud computing skills. Further, building capacity in Vietnam’s universities for programs devoted to cloud computing and other Fourth Industrial Revolution technologies will help position Vietnam to be competitive in the long run, and will build capacity for related Vietnam-based research. Until Vietnam’s universities and other institutions are able to

develop globally competitive programs in cloud computing, provision should be made for people wanting to study outside the country and bring new skills back. A number of ASEAN countries provide government sponsorships for promising students to study at the best universities in the United States, the United Kingdom, and Australia. Providing similar opportunities for students wanting to study cloud computing is a way to boost skill levels for the long-term.

Cultivating a fertile ecosystem for the adoption of cloud computing will require a collaborative effort between the government, private sector, and civil society. Leveraging domestic resources for infrastructure development, in combination with attracting foreign investment, is crucial for increasing capacity in a way that keeps pace with quickening adoption. Public-private partnership models have been successful in ICT development in the more developed markets, and can be a useful way to achieve this transformation, if they are managed in accordance with the principles of transparency, accountability, and good faith. Furthermore, international firms can be partners in the development of soft infrastructure. For example, technology companies such as Microsoft have outreach programs that assist governments in implementing technology for social benefit in the fields of education, health, poverty alleviation, and citizen empowerment. Such efforts, supplemented by aid and assistance from international organizations and NGOs, will help technology realize its greatest potential. As this case demonstrates, leveraging ICT for development is a complicated process that exposes weaknesses in policy and market systems. An honest accounting of these weaknesses and a sincere commitment to correcting them are essential before meaningful progress can be made in developing Vietnam's cloud computing market.

Appendix A1: Hue Family Medicine Center

Founded in 2016, the Hue Family Medicine Center (HFMC) is a useful case study in the adoption of cloud computing technology. Planned to serve 15,000 patients per year, HFMC has pioneered the use of the Bacsi24x7 application as a method of electronically managing patient records. Data is stored on Microsoft Cloud and transformed into a manageable format through Microsoft's intelligent language conversion model (LUIS). Technology through Microsoft's Bot Framework gives HFMC access to advanced medical knowledge, and builds its capacity for more sophisticated diagnostics. This helps doctors determine effective treatment regimens. In particular, Bacsi24x7 is a repository for the history, symptoms, and complaints of patients, and is linked with the hospital's systems for maintaining electronic medical records. Patients communicate with medical staff through other messaging applications such as Skype. This modernization of record-keeping is expected to reduce patient waiting times, improve the quality of treatment, streamline operational processes, and reduce costs.

Appendix A2: Cloud transition at Viet A Bank (VAB)

Established in 2003, Viet A Bank (VAB) is one of Vietnam's youngest major banks, with total assets of approximately US\$3 billion. Serving both households and businesses, VAB makes efforts to continuously improve products and service quality, including investments in electronic banking systems, to build its presence in Vietnam's financial markets. Before embarking on cloud deployment, VAB operated two data centers. The bank transitioned to cloud computing in early 2017 to embrace digital banking in its business strategy through the adoption of SMAC (social media, mobile, analytics, cloud). The total transition time, including moving and rehearsing, was three months. The last rehearsal included the full development of a backup data center and 15 days to fully transform the main center according to the cloud provider's infrastructure.

The key features of the cloud transition process provide several useful illustrations of cloud transitions. First, the board of directors passed a resolution to deploy cloud computing, approving its total estimated cost and plans for the transition. Second, upper management was made directly responsible for approving expenditures and implementation plans. Third, the company's CTO was made responsible for technology strategies, scenarios, and plans for re-engineering applications and network models. Fourth, the CIO / CTO served as key coordinators of the transition process. Fifth, KPIs were established, including downtime, operational efficiency, reduced monthly costs, and reduced manpower. These were established in association with the introduction of two centers operating in parallel with the cloud computing model. The deployment process was monitored closely by the management team on a daily basis. The estimated cost was less than US\$100,000 for deployment and approximately US\$50,000 - 60,000 for cloud service in the first year.

The initial results were generally positive. Regarding business performance, processing capacity increased by 40% and customer satisfaction increased by 30%. IT cost savings were 40%. Additionally, the number of IT staff dropped by 12 people, from 72 to 60, with several moving to other departments. Employee motivation improved substantially—increases

were reported in sense of pride and self-confidence. Furthermore, on an industry-wide basis, VAB became the first bank to exceed requirements of the State Bank on service quality and cyber-security.

The lessons from this case are relevant to other businesses deploying cloud applications. First, the IT strategy must be clearly elaborated and efforts made to acquire new ideas and technology. Companies need to monitor digital trends among peer companies and globally to remain current on trends and competitive with the service and product quality of competitors. Second, defining the concept of digitization is indispensable to develop a comprehensive digital model. In order to include all necessary stages, a model can be an appropriate guide. SMAC, as mentioned above, is one example. Building a presence in modern communications requires companies to embrace numerous venues and technologies, and having a strategic guide for how to prioritize these is crucial in environments of rapid technological advancement and budgetary constraints. Finally, the quality of the transition can determine success or failure. Not only is it important to have the right technologies for the most appropriate purposes, but companies must maintain business continuity and service quality amidst transitions. If short-cuts for design and implementation are taken to reduce the impact on current business operations, there is a risk that the investment in technology will not realize its full effect. Transitions must be planned with various departments, in both time and resource allocation, to ensure smooth rollout and minimization of re-design and corrective actions.

Cloud Computing in Singapore

Reuben Ng

I. Introduction

The world now generates more data every two days than it did from the dawn of early civilization through the year 2003 combined, and data rates continue to grow at approximately 40% per year. Against this background, the amount of data has outstripped common warehousing and analytics tools. To move forward, organizations—both public and private—need new capabilities, especially cloud computing, to differentiate their products and services.

Every major study hails the potential of cloud computing and analytics. Gartner found that enterprise spending on cloud computing grew faster than overall IT spending and predicted the technology will grow by over 100%.¹ Synergy Research Group concluded that in 2016, cloud computing dominated many components within the ICT market, pushing cloud revenue growth above 25% year-on-year. A cloud-enabled business model survey found that 62% of Chief Information Officers and Chief Data Officers consider cloud computing as the top priority for ICT.² Bessemer Venture Partners reported that the cloud computing market revenue grew 35.8% annually from 2008-2014, and 22.8% annually from 2014 to 2018, culminating in projected revenues of US\$127 billion (Figure 1). A 2010 survey found that 23% of Singapore companies adopted cloud technology. More recently, IDC forecast that the cloud computing market in Singapore will grow to US\$1 billion by the end of 2017.³

There are three features of cloud computing. First, cloud computing provides services on demand, and these resources are scalable over multiple data centers. Second, these services are easily accessible and location independent, meaning that a user can access the suite of services worldwide through internet browsers. Third, service quality is guaranteed for bandwidth and memory capacity.

These features give rise to three benefits. First, cloud computing provides a more palatable cost structure. It requires no upfront hardware cost compared with traditional data warehouses with high capital investments. The use of cloud computing is recorded as operating expenses and costs are significantly lower. Second, business risk is reduced as it is outsourced to providers who are better equipped to manage these risks. Third, organizations who are starting their digital journey can leverage on the latest computing technology to leapfrog their capabilities rather than undertake a traditional step-wise build up.

1 PRWEB (2012). Garner predicts cloud computing spending to increase by 100 percent in 2016. Available at <http://www.prweb.com/releases/2012/7/prweb9711167.htm> (accessed 20 September 2017)

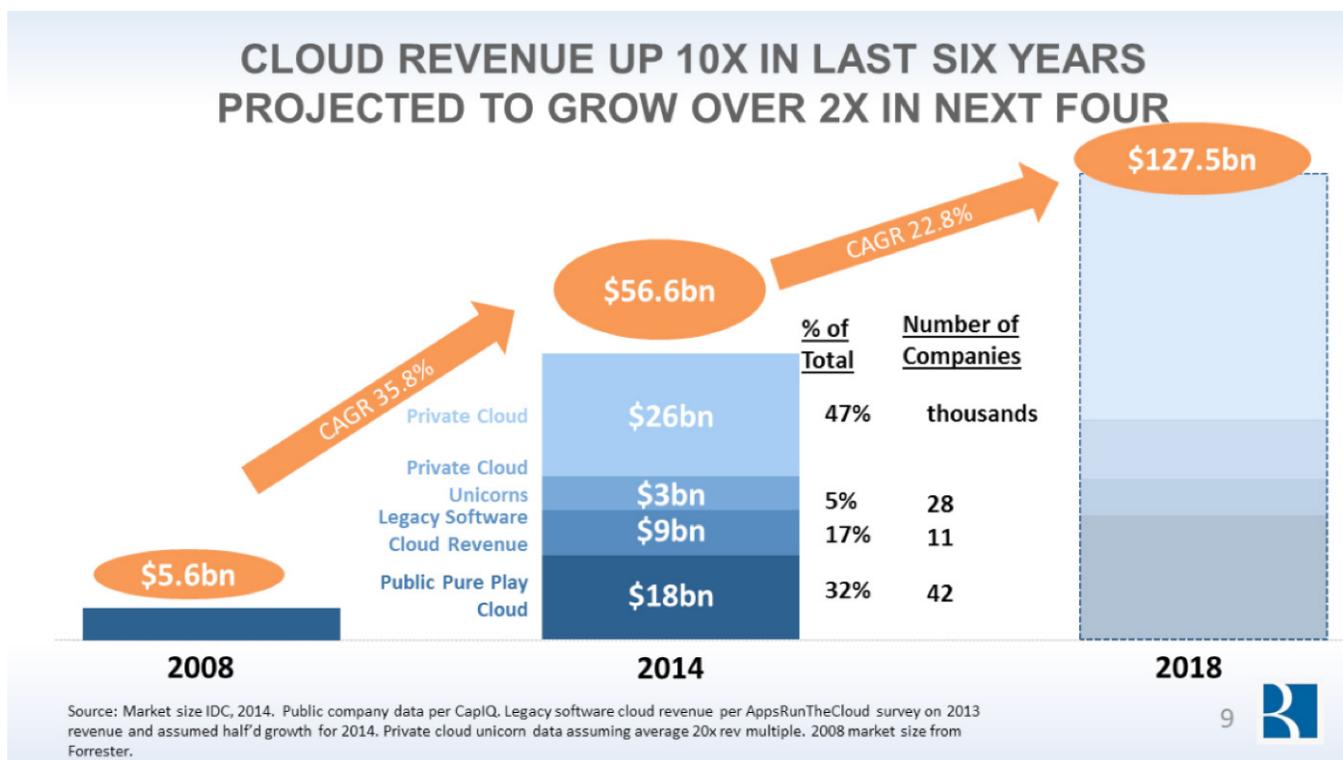
2 Berman, S., Kesterson-Townes, K., Marshall, A., & Srivatbsa, R. (2011). The power of cloud: driving business model innovation. IBM Institute for Business Value. Available at <http://www.ibm.com/cloud-computing/us/en/assets/power-of-cloud-for-bus-model-innovation.pdf> (accessed 20 September 2017)

3 Lim, Patrick John (2015). Cloud computing set to become integral part of Smart Nation shift. Channel NewsAsia. Available at <http://www.channelnewsasia.com/news/business/cloud-computing-set-to-become-integral-part-of-smart-nation-shif-8224156> (accessed 20 September 2017)

In Singapore, cloud computing is positioned as a crucial enabler in Singapore’s Smart Nation plan—the national effort to put Singapore at the forefront of technological innovation and implementation. Prime Minister Lee Hsien Loong has taken a personal interest in launching the vision in 2014, and in 2017, he devoted a significant part of his National Day Rally Speech, an important annual address, to provide an update on the nation’s initiatives and aspirations.

The case study will first outline the key drivers for Singapore’s adoption of cloud computing. It will then analyze the cybersecurity considerations in cloud computing adoption and will conclude with recommendations.

Figure 1: Incredible growth of cloud computing market revenue over a decade, 2008-2018



Source: Bessemer Venture Partners (2015), State of the Cloud 2015. Available at <https://www.bvp.com/blog/state-cloud-2015>.

II. Five Key Drivers of Singapore's Cloud Computing Adoption

1. Public demand for and satisfaction with e-government services

Singapore has done well in ICT infrastructure development as evidenced by the extraordinarily high mobile subscription penetration rate of 155.6%, and the high internet penetration rate of 135.1% in 2013. In addition, 73% of Singapore's population uses the internet and is exposed to the information deluge on the worldwide web. The statistic is comparable to average internet use of above 70% in developed countries. Alongside this growth, fixed telephone line usage has plunged to 36.4%, and wired broadband subscriptions to 25.7%. These numbers underscore the high levels of connectivity and mobility of residents in Singapore.

Figure 2: Singapore tops the ranks for e-government implementation, 2013

No	Final Ranking	Score
1	Singapore	94.00
2	Finland	93.18
3	USA	93.12
4	Korea	92.29
5	UK	88.76
6	Japan	88.30
7	Sweden	87.80
8	Denmark	83.52
9	Taiwan	83.52
10	Netherlands	82.54
11	Australia	82.10
12	Canada	81.78
13	Switzerland	81.33
14	Germany	80.08
15	Italy	79.11

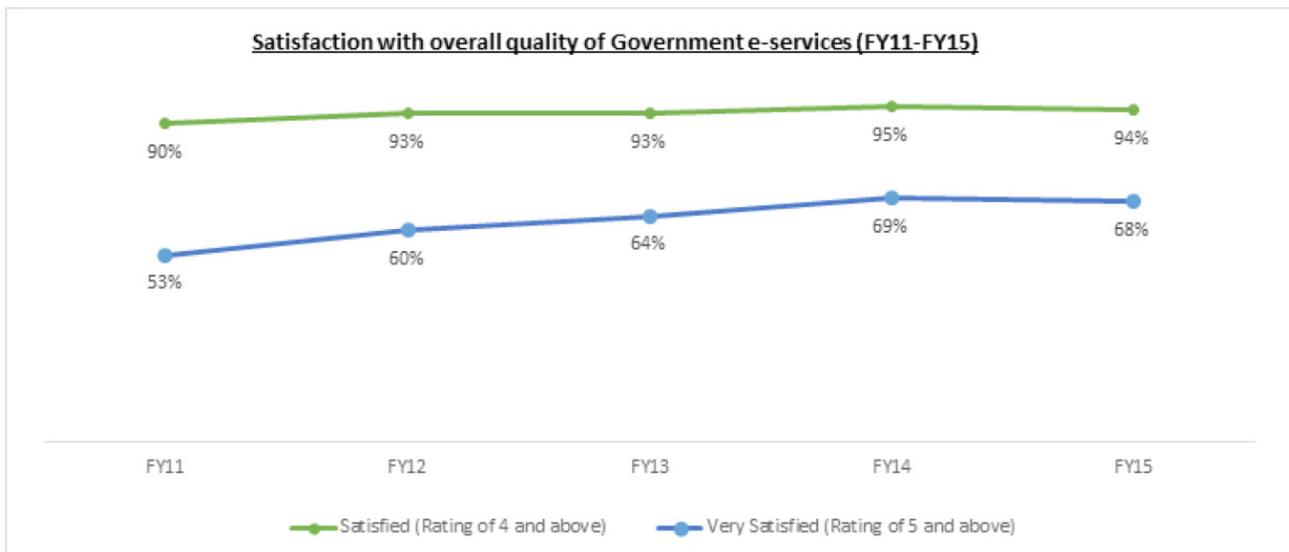
Source: Hashemi, Monfareedi and Masdari (2013), p. 1242⁴

4 Hashemi, S., Monfareedi, K. and Masdari, M. (2013). Using cloud computing for e-government: challenges and benefits. *International Journal of Computer, Electrical, Automation, Control and Information Engineering*, 7(9): 1240-1247.

On the public front, through e-government initiatives, Singapore has migrated many processes that previously required face-to-face interactions to self-help channels, and has adopted paperless transactions. As a result, Singapore has been ranked highly in e-government implementation, and in 2013 ranked first in e-government implementation worldwide, ahead of Finland and the United States. The country's initiatives have resonated with the citizenry and Singapore garnered positive feedback from 2011 to 2015 from both businesses and individuals, according to 2016 surveys from the Singapore Government Technology Agency (GovTech).

On the government-to-business front, a survey of more than 1,500 representatives from multiple industry sectors indicated that 99% of businesses visited government websites and more than 90% were satisfied with the quality of information provided and the ease of completing transactions online.

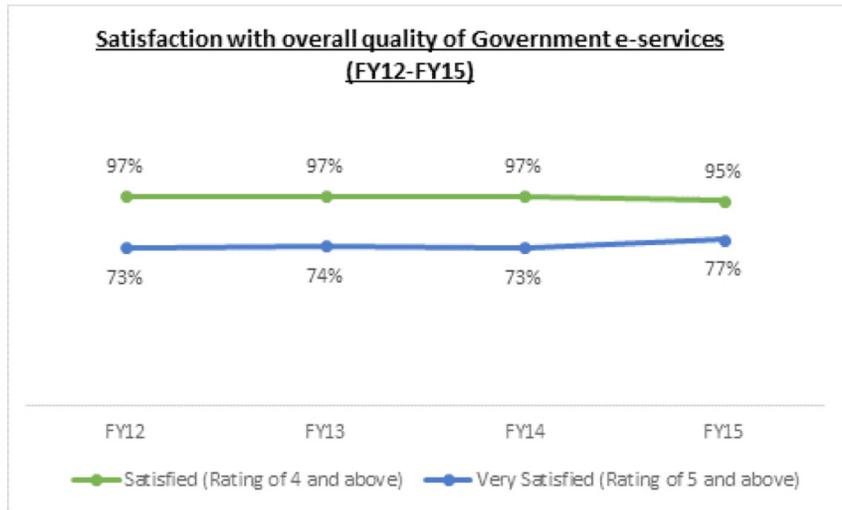
Figure 3: Business users' satisfaction with overall quality of government e-services, 2011-2015



Source: GovTech, e-Government Perception Survey on Businesses (2016), available at <https://www.tech.gov.sg/About-Us/Facts-and-figures/Survey-Reports/Government-to-Business-Surveys/2016-For-2015>

For individuals, 80% visited government websites in the past 12 months and more than 90% expressed satisfaction with the ease of locating and comprehending the information provided.

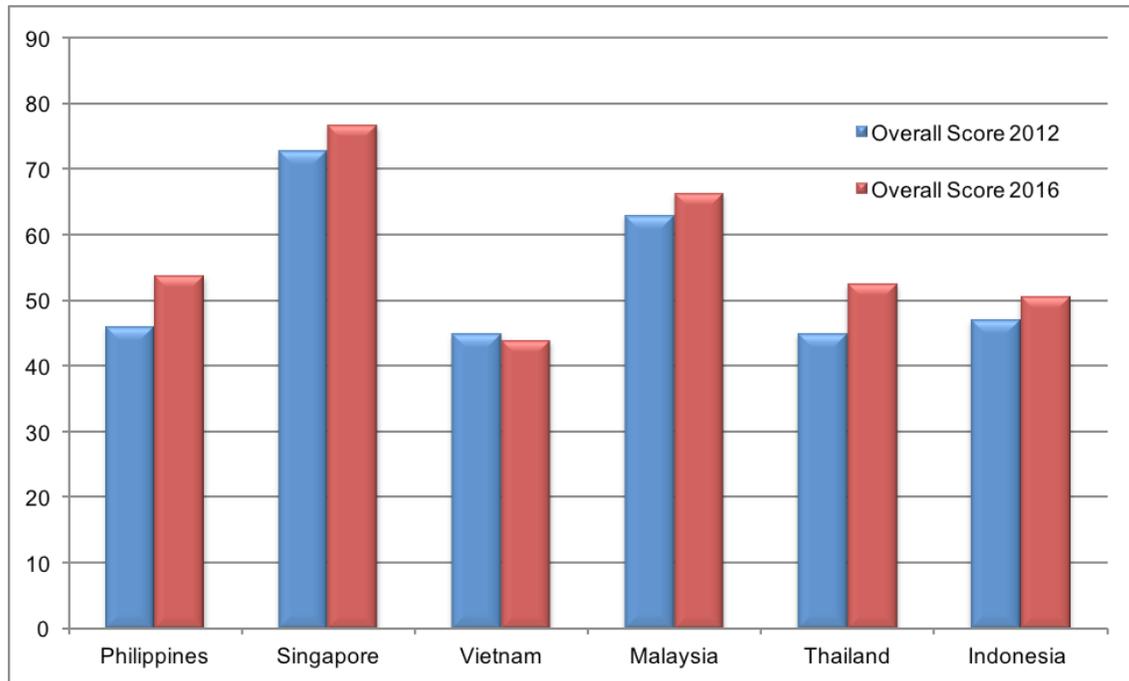
Figure 4: Citizens' satisfaction with overall quality of government e-services, 2012-2015



Source: GovTech, e-Government Customer Perception Survey (2016), available at <https://www.tech.gov.sg/About-Us/Facts-and-figures/Survey-Reports/Government-to-Public-Surveys/2016-For-2015>

Given the appetite for e-services and platforms in Singapore and the extraordinary ability of the government to provide them, it is hardly surprising that the country ranks highly on cloud readiness—a collection of variables that measure the propensity for cloud adoption. Singapore ranked ahead of ASEAN peers in 2012 and 2016.

Figure 5: Overall Cloud Readiness Index in ASEAN, 2012 and 2016



Source: Asia Cloud Computing Association, 2012 and 2016

The Asia Cloud Computing Association’s (ACCA) Cloud Readiness Index ranks countries in Asia Pacific and Oceania on 10 indicators related to cloud computing. In the 2016 ranking, Singapore emerged second behind Hong Kong and ahead of New Zealand (#3), Australia (#4) and Japan (#5) among 14 countries. Singapore scored well in broadband quality, data privacy, government regulation, and intellectual property protection, but less well in cybersecurity and freedom of information.

Figure 6: Cloud Readiness Index 2016

Rank, Country	CRI#01 International Connectivity	CRI#02 Broadband Quality	CRI#03 Power Grid, Green Policy, and Sustainability	CRI#04 Data Centre Risk	CRI#05 Cybersecurity	CRI#06 Privacy	CRI#07 Government Regulatory Environment and Usage	CRI#08 Intellectual Property Protection	CRI#09 Business Sophistication	CRI#10 Freedom of Information	TOTAL CRI 2016 SCORE	Rank Change
#1 Hong Kong	8.1	9.1	6.7	8.0	6.2	9.5	7.2	8.6	7.4	7.2	78.1	+4
#2 Singapore	6.4	9.4	6.5	7.8	6.8	9.0	8.6	8.9	7.3	6.0	76.7	+2
#3 New Zealand	4.6	8.2	7.6	6.8	7.4	9.0	8.1	8.7	6.9	7.2	74.4	-1
#4 Australia	4.3	8.0	6.6	6.3	7.6	9.5	7.4	8.3	6.7	8.3	73.2	-1
#5 Japan	3.9	8.9	6.7	5.9	7.1	8.0	7.8	8.7	8.3	7.8	73.0	-4
#6 Taiwan	4.1	8.8	6.7	6.4	7.0	9.5	6.7	7.4	7.1	7.2	71.1	+1
#7 South Korea	3.8	9.0	6.3	6.2	7.1	9.0	7.0	6.0	6.9	6.7	68.0	-1
#8 Malaysia	3.3	7.6	5.4	5.9	7.6	8.0	7.4	7.7	7.6	5.8	66.3	-
#9 Philippines	3.3	5.5	6.0	3.5	3.5	7.5	5.5	5.6	6.1	7.3	53.8	+1
#10 Thailand	3.8	8.6	6.0	5.2	4.1	5.0	5.1	4.6	6.3	3.8	52.6	-1
#11 Indonesia	1.8	6.3	5.4	2.7	4.7	6.0	5.6	6.1	6.1	5.8	50.6	+1
#12 India	1.7	5.6	5.1	1.9	7.1	4.5	5.5	6.0	6.0	5.8	49.1	+1
#13 China	1.6	6.6	5.3	2.5	4.4	5.5	6.2	5.7	6.1	1.3	45.4	-2
#14 Vietnam	3.0	6.7	5.4	2.6	3.2	5.0	5.4	5.1	5.1	2.4	44.0	-

Source: Asia Cloud Computing Association (2016). More information about the methodology and data sources for the index is available at: www.asiacloudcomputing.org/17-news/306-2016-cloud-readiness-index

2. Focus on whole-of-government policies and practices

The Singapore public service is moving towards a whole-of-government approach to policymaking and operations, which is providing a key driver for whole-of-government cloud adoption. This approach reflects the reality that many contemporary issues cannot be siloed. For example, ageing is not only a health issue, it is also related to transport, environment, and social and family issues. In order to create opportunities for silos to “talk” to each other, the government has organized forums for top leaders within different sectors to discuss and craft policies. For example, the social forum brings together senior leaders from all the social agencies to build consensus for social policies. This is also a great platform to commission important analytics projects that require data from multiple agencies, which is typically an arduous process. When these projects are debated and benefits are delineated among senior leaders across agencies, agencies are more willing to share data that contribute to a common good. Such initiatives provide use cases for whole-of-government cloud adoption.

In addition to building platforms to talk between silos, the Prime Minister’s Office started an important team of “bridge builders”, a.k.a. The Strategy Group, to shepherd and coax whole-of-government policy and practice. The Strategy Group staffs the sectoral forums and has pioneered the data science commissioning platform to nudge line agencies towards a more whole-of-government approach to policy, practice, and data sharing. At a tactical level, Singapore formed a Municipal Services Office (MSO) whose app is likened to a one-stop shop for public feedback. The app is managed across government to ensure a coordinated response. Such centralizations at the strategic and tactical levels are key drivers for cloud computing adoption in the public service.

3. Restructuring technology agencies to integrate strategy and implementation

To enable whole-of-government innovation and implementation, technology-related agencies are also being restructured. Telco and media regulation have been brought under one agency—the Info-communications Media Development Authority of Singapore (IMDA). Formed from a merger of the Infocomm Development Authority of Singapore (IDA) and the Media Development Authority of Singapore (MDA), IMDA will focus on leveraging new technologies for better regulation and application to improve lives.

In May 2017, the Prime Minister’s Office launched the Smart Nation and Digital Government Group and assigned a permanent secretary to lead this group. This new group brings together strategy and implementation capabilities. The strategic capabilities are integrated from the teams formerly in the PMO, Ministry of Finance, and Ministry of Communication and Information. These teams will be responsible for policy and strategy which will be implemented by GovTech consisting of deep capabilities in data science and software development.

Other developments include bringing together cybersecurity capabilities through the 2015 formation of the Cyber Security Agency (CSA) to implement the National Cybersecurity Masterplan 2018. On the local front, the MSO was established in 2015 to coordinate whole-of-government responses to municipal services that were previously managed by different agencies. These major restructuring exercises are both expensive and expansive but necessary to integrate strategy and implementation.

4. Building the Smart Nation Platform

A key catalyst of cloud computing is the Smart Nation Platform (SNP) involving a nationwide communications and sensor infrastructure. This platform will enable centralized data aggregation and sharing, as well as provide new capabilities to derive refined insights from cross-referencing a vast array of government datasets. Datasets can also be shared with the community and industry for co-creation and self-enablement. The SNP will be a key enabler for Singapore to remain on the cutting edge of government operations and service delivery.

The SNP will connect sensors through the deployment of Aggregation Gateway Boxes (AG Boxes) throughout Singapore. Approximately 2,000 AG Boxes could be deployed at major roadside locations and 10,000 AG Boxes deployed at residential estates. AG Boxes provide connectivity to street lights and wireless mesh networks to ensure that wireless sensors can be easily plugged in to the network. As AG Boxes are not licensable telecommunication services, the government will own and operate them. Private operators could share the remaining space in each AG Box.

The network will carry sensitive data from sensors, and the government's ownership of relevant portions of the SNP will assure that the critical components within the network are treated with the highest security and trust. Specifically, the IMDA will own the infrastructure. In doing so, they are not welded to any one contractor and can leverage on different vendors to meet changing demands. Private companies will operate licensed services such as the transmission of data and will handle a majority of maintenance.

Essentially, the SNP is projected to carry a significant amount of government sensor data. Hence, an integrated platform for data collation, sharing, and analytics will ensure more coherent insights and swifter deployment of government services. The cloud computing backbone is the Smart Nation Operating System (SN-OS) that pulls together all sensor and other data types for sense-making. The SN-OS consists of three platforms: sensor management, data exchange and sense-making.

Through the SN-OS, public sector entities will be able to access cross-agency sensor data to analyze and decrease duplicity of data collection. An analytics layer will facilitate the merging of different datasets (e.g., sensor and admin) to inform policy positions and research. Underlying the cloud infrastructure is a data governance framework with proper access restrictions and trails to ensure that only the right officers can access the data.

In sum, the SNP is an ambitious example of a comprehensive and massive cloud computing platform that sets the foundation for whole-of-government policymaking.

5. Purpose-driven cloud applications in healthcare

Healthcare transformation

Within the healthcare space, cloud computing is applied at scale to healthcare transformation. Signalling the government's commitment to transformation, the Ministry of Health (MOH) recently appointed outgoing National University of Singapore President and former MOH Director of Medical Services, Professor Tan Chorh Chuan, to direct the inaugural Healthcare Transformation Office.

Setting up this important national function will accelerate the use of cloud computing, especially in population health analytics and tele-medicine. In 2017, the Singapore government announced that the public healthcare sector was being restructured into three clusters, with each cluster consisting of entities in the continuum of care (e.g., acute hospital, community hospital, and primary care). Each cluster is responsible not only for acute care through large tertiary hospitals but also for population health within a specific geographic area. This involves disease prevention, treatment of acute conditions, chronic disease management, and long-term care.

Each cluster utilizes their own cloud which is linked to the common registry, a large private cloud known as the National Electronic Health Records (NEHR). This national database contains demographics and subvention and financial data that can be used to stratify the population according to risk for various health conditions. New data sources from other government agencies—including social and family relationships, and birth and death data—are explored to further enrich the registry. In addition, the registry is enriched by longitudinal and multi-disciplinary data around each individual's health.

Such a cloud platform yields invaluable insights on the ageing population that will support primary prevention efforts to better manage the size of population with chronic diseases. At the national level, predictive modelling is used to stratify the population and predict the propensity of groups to develop pre-identified medical conditions such as diabetes and cancer.

Tele-medicine

Another application of cloud computing is in tele-medicine. The aim of tele-health is to shift from institution-based care towards home and community care, augmenting healthcare resources (e.g. allied health professionals, mental health psychiatrists, etc.) in the system. Essentially such technologies represent a shift from a doctor-centric model to a team-based model to manage the shortage of doctors and promote holistic care.

There are four domains to tele-health applications:

- Tele-monitoring to support vital collection and remote care between patient and provider
- Tele-treatment and tele-rehabilitation to administer treatment to patients remotely
- Tele-collaboration to facilitate remote collaboration between providers
- Tele-support to provide non-clinical care support to patients

Tele-health applications bring cost-effective supervised rehabilitation to homebound elderly patients who face functional, medical, and social challenges to attending outpatient rehabilitation centers. By exploiting currently available technologies to develop user-friendly, cost-effective, improvement-adaptive rehabilitation devices specially designed for home and remote use, homebound elderly patients may no longer need to struggle to outpatient rehabilitation centers to access rehabilitation equipment. Further applications include cost-effective, two-way, real-time, simultaneous-audio-video, minimal-lag, high resolution and preferably wireless, secure video-conferencing technology, and rigorous therapy protocols to enable the multidisciplinary rehabilitation team to assess, monitor, and prescribe rehabilitation to homebound elderly patients remotely. Such video-conferencing technology will also help patients to seek advice and guidance from all members of the multidisciplinary rehabilitation team.

Tele-rehabilitation will save time and expense because members of the multidisciplinary rehabilitation team will not need to travel to homebound elderly homes. It will improve communication between healthcare teams and patients and reduce inconvenience to patients and their families. The development of user-friendly, cost-effective, professionally useful physiological and functional monitoring devices to measure rehabilitation progress and tolerance, and capture the information electronically such that it can be transmitted in real time or later, will enable the multidisciplinary team to monitor and prescribe progressively challenging rehabilitation exercises appropriately. Another expected positive outcome would be greater adherence to rehabilitation resulting from increased patient involvement, real-time and delayed biofeedback from monitoring devices, and motivation from regular face-to-face encouragement by the multidisciplinary rehabilitation team via video-conferencing.

With cloud computing enabled tele-monitoring, care-givers can remotely track elderly citizens or immobile individuals living alone through home / wearable sensors to detect and respond early to unusual extended periods of non-movement or potential falls. Consumers can utilize tele-health services from their home / community for greater access to health education and to obtain timely proper care that was previously confined to specialized healthcare settings. Through tele-collaboration or tele-support, care-givers can coordinate

the holistic care of high priority patients across clinical, social, and community care settings, integrating referrals and phone-based disease education and lifestyle coaching.

Two possible applications for cloud computing enabled tele-medicine include stroke rehabilitation and a commercial application linking patients to doctors.

Although stroke patients are recommended for rehabilitation after their discharge from an inpatient rehabilitation unit, less than a quarter of the patients attend the therapy sessions. To maximize functional recovery, there is a need to increase adherence to post-discharge rehabilitation.

One possible solution is to bring rehabilitation to the home of the disabled stroke survivor. Home rehabilitation is when a therapist comes to the stroke survivor's home to provide supervised rehabilitation, rather than requiring a disabled stroke survivor to maneuver handicapped-unfriendly environments to reach an outpatient rehabilitation center. While home rehabilitation is a straightforward solution, it is expensive—four to five times more expensive than therapy at an outpatient rehabilitation center (\$150 - 200 per hour vs. \$40 per hour). The increased cost is due to the time the therapist spends traveling to the patient's home to provide supervised rehabilitation; home therapists can only see 2 - 3 patients a day whereas center-based therapists can see 10 - 15 patients a day.

A more cost-effective solution is to use technology to supervise rehabilitation remotely so that patients can remain in their homes but communicate in real-time with their therapists who are sited in their office. Tele-rehabilitation is the use of home-tele-health technologies to provide distance support, rehabilitation services, and information exchange between people with disabilities and their clinical providers. It is a novel approach that potentially addresses the problem with access to post-acute rehabilitation care for stroke survivors. Tele-rehabilitation is convenient for patients and families, fosters closer patient-healthcare team communication, and encourages rehabilitation within the patient's natural environment, which is more realistic and practical. Moreover, with therapists not needing to travel between patients' homes and their office, time and transportation costs are saved. In a study by Sanford and colleagues, a multi-factorial, individualized, home-based tele-rehabilitation intervention improved self-efficacy in mobility-impaired adults to the same degree as supervised rehabilitation with physiotherapists and occupational therapists at outpatient rehabilitation centers.⁵

The IMDA is rolling out the infrastructure for nationwide ultra-high-speed broadband access of 1Gbps and more, known as the Next Generation Nationwide Broadband Network, to all physical addresses including homes, schools, government buildings, businesses, and hospitals. IMDA is also exploring the Heterogenous Network (HetNet), an enabling infrastructure for Internet of Things (IoT) devices to be connected. Such infrastructure will support the implementation of a nationwide tele-rehabilitation program for patients.

5 Sanford, J.A. et al. (2006). The effects of in-home rehabilitation on task self-efficacy in mobility-impaired adults: A randomized clinical trial. *Journal of the American Geriatric Society*, 54: 1641-8.

Another application for cloud computing in tele-medicine is a commercial app to link patients and doctors that has been developed by a Singapore-based company, RingMD, which now manages 1.5 million patients in more than 50 countries. The firm aims to provide healthcare to under-served populations by accessing the best doctors through tele-consultations. This is predicated on high mobile phone penetration rates in both developed and developing countries that enable consultations through mobile phones and devices.

Users enroll on the RingMD platform and consultations are conducted through a video link on mobile devices. Individuals can also wear devices that transmit their vital signs to doctors in real time. Conditions that do not require physical checks can be remotely diagnosed and treated. Through analyzing copious amounts of data, global and local insights can be provided to patients, doctors, and caregivers.

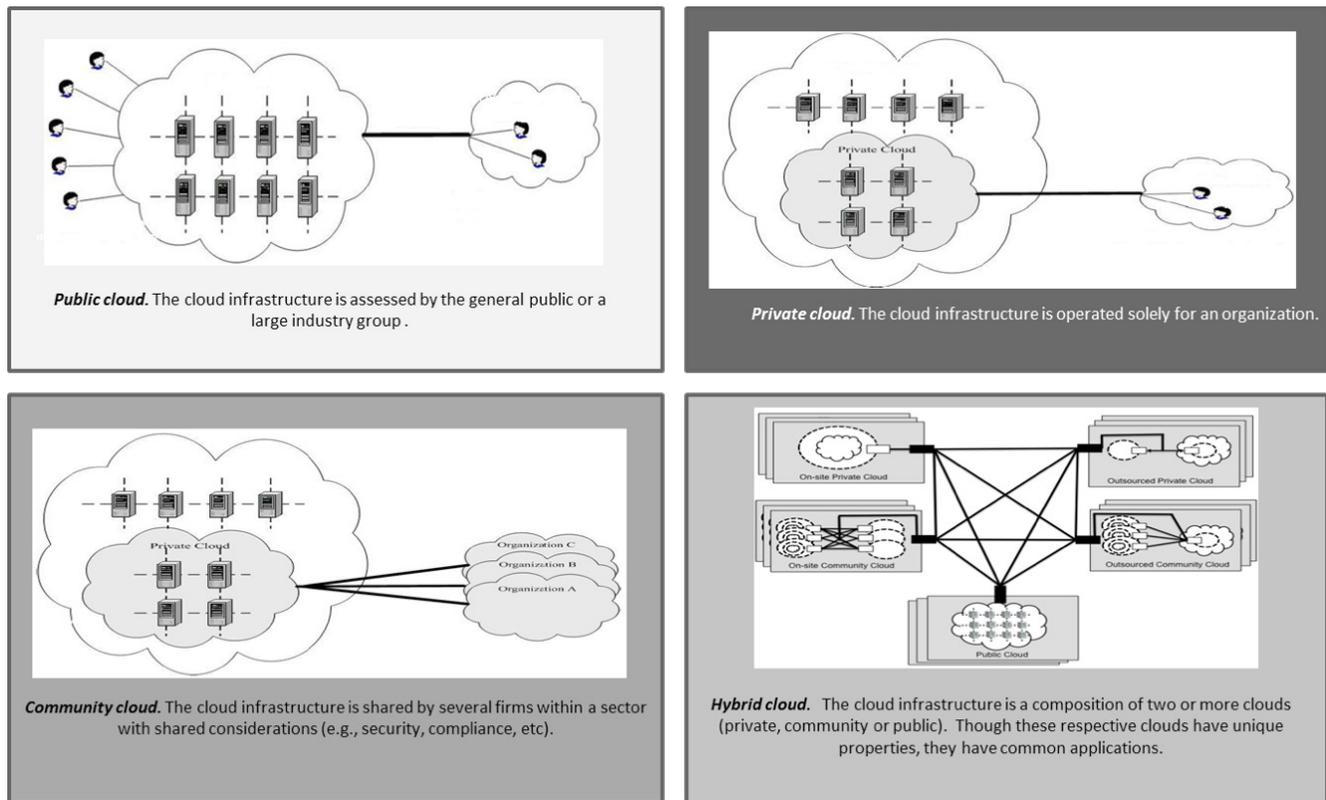
In sum, the key driver for cloud computing in Singapore is purpose-driven, especially in healthcare through healthcare transformation and tele-medicine. With the formation of a new healthcare transformation office driving population health analytics and a bustling commercial health sector, the adoption of cloud computing is projected to accelerate.

III. Cybersecurity and Cultural Considerations in Singapore's Cloud Adoption

There are four models of cloud adoption as shown in Figure 7. The public cloud, as the name suggests, is accessed by the general public. An example is the government sharing portal data.gov.sg, where government datasets are shared for co-creation and public consumption. A community cloud serves a particular sector and is best exemplified by the Singapore Ministry of Education's iCONnect system, an e-mail and collaboration platform for the teaching profession. Both the public and community clouds are within the medium assurance zones where computing resources are shared with different cloud users at decreased cost. A hybrid cloud is composed of two or more clouds, and is currently being explored as a model for data sharing within and beyond government.

A private cloud is used for most government agencies. Known as the Central G-Cloud, it meets high assurance needs of providing a dedicated computing resource within government. Most web service exchange and gateways leverage the G-Cloud. The predominant use of a private cloud is driven, among other reasons, by cybersecurity concerns and a prevention-focused cultural tendency.

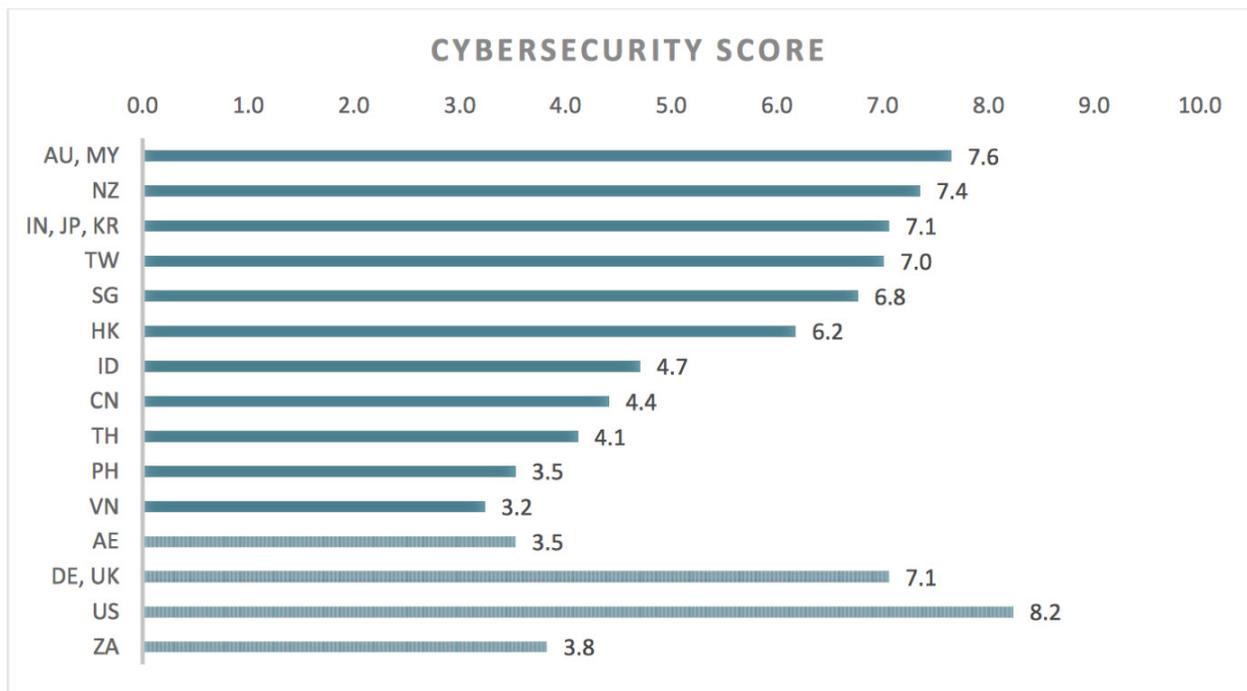
Figure 7: Four models of cloud adoption



Source: Adapted from Ernst & Young (2014), *Building Trust in the Cloud*. Available at [http://www.ey.com/Publication/vwLUAssets/EY_-_Building_trust_in_the_cloud/\\$FILE/EY-grc-building-trust-in-the-cloud.pdf](http://www.ey.com/Publication/vwLUAssets/EY_-_Building_trust_in_the_cloud/$FILE/EY-grc-building-trust-in-the-cloud.pdf)

Cross-cultural experts who categorize national cultures have often described Singapore as “tight”, characterised by strong social norms and low patience for deviant behavior. In a study of 33 countries, Singapore emerged in the top quartile of tightness scores.⁶ In another study, Singapore was categorized as a prevention-focused society, where civil servants are detail oriented and place great emphasis on the absence of negative outcomes, perpetuating a state of vigilance where individuals are careful not to make mistakes.⁷ The opposite is that of a promotion-focused society, where the focus is on nurturance and the presence of positive outcomes.⁸ These empirical studies on culture provide an indication of the mindset of the government in employing a private cloud.

Figure 8: Cybersecurity, Singapore vs. ASEAN, 2016



NZ (New Zealand), HK (Hong Kong), TW (Taiwan), JP (Japan), AU (Australia), SG (Singapore), KR (South Korea), PH (Philippines), TH (Thailand), ID (Indonesia), MY (Malaysia), VN (Vietnam)

Source: Asia Cloud Computing Association, Cloud Readiness Index (2016)

6 Gelfand, M. et al. (2011). Differences between tight and loose cultures: A 33-nation study. *Science*, 332: 1100-1104.
 7 Han, J., & Ling, J. (2016). Emotional appeal in recruitment advertising and applicant attraction: Unpacking national cultural differences. *Journal of Organizational Behavior*, 37(8): 1202-1223.
 8 Higgins, E. T. (1997). Beyond pleasure and pain. *American Psychologist*, 52(12), 1280-1300. See also Higgins, E.T. et al. (2001). Achievement orientations from subjective histories of success: Promotion pride versus prevention pride. *European Journal of Social Psychology*, 31: 3-23.

More importantly, a private cloud attempts to mitigate cybersecurity risks. As seen in Figure 8, Singapore's cybersecurity prowess is not as strong compared with Australia, South Korea, and India, according to the Cloud Readiness Index 2016. In the new world of data explosions, information security is of paramount consideration. There is intense competition between cryptographers attempting to protect data and hackers attempting to steal it. When the latter happens, public trust is undermined. With Singapore's push to build the world's first Smart Nation, an unprecedented number of devices are being connected to the internet, escalating the risk of expansive disruptions in cyberspace that potentially disrupt defense, public transport and stock markets.

Exacerbated by the IoT, the accessibility and decreasing cost of hacking tools have brought about increased risks, enabling lone wolves and terrorists to wreck cyber havoc. Over 5% of American organizations lost more than of US\$1 million in 2013 to cyber-crime. More staggering, managing the fallout from hacks costs the world about US\$445 billion per year.⁹ Further, the obscure origins of cybercrime make it difficult to differentiate between state and non-state actors. The challenges that cyber-enabled threats bring for Singapore will be non-trivial.

Against this background, Singapore has embarked on a coordinated approach to deal with cyber-enabled threats at the government level. Cybersecurity is transiting from prevention to response and recovery, with a 'not if, but when' mindset. Infrastructure development and policy planning also take into account resilience and incident-response capabilities. This is exceptionally paramount in critical information infrastructure (CII) sectors such as banking, transport, health, energy, and telecommunications.

Taken together, the increasing barrage and sophistication of cyber-attacks (which are not publicly disclosed), a prevention-focused mindset, and the imperative to protect against more damaging cyber-attacks have pushed the government to adopt a private G-Cloud. Though the costs are significantly higher, the Singapore government has probably calculated that the benefits outweigh the costs—or more specifically, that the potential cost of not implementing a private G-Cloud outweighs the actual cost of doing so.

9 Bremmer, I. (2015). These 5 facts explain the threat of cyber warfare. Available at <http://time.com/3928086/these-5-facts-explain-the-threat-of-cyber-warfare/> (accessed 20 September 2017)

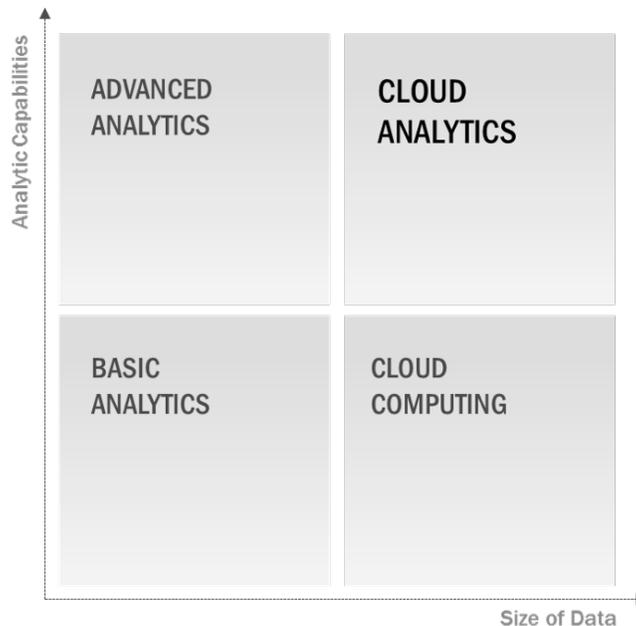
IV. Recommendations for Singapore

Despite Singapore’s advances in cloud computing, it can make advancements in three areas: technology, regulation, and partnerships. Technologically, Singapore should embrace cloud analytics and explore “fog computing”—an emerging technology that enables on-site data sense-making before transmission to the cloud. It should promote regulatory sandboxes to experiment with policies that proactively manage novel technologies and business models that may radically change society. Lastly, the country should seek out unconventional partnerships, beyond the PPP model, to co-innovate on initiatives to address perennial issues like the skills gap.

Accelerate cloud analytics and explore fog computing

On the technological front, the current phase for cloud computing is management and organization with real-time data that are high in volume, velocity and variety. The next phase will be the ability to make sense of the endless streams of data and provide on-demand analytics. While there are fore-runners in the cloud management space, few have been distinguished as market leaders in cloud analytics. Singapore can attract up-and-coming firms in cloud analytics and invite them to advance their research and operations in Singapore.

Figure 9: Cloud analytics is a key capability given that data volume and the need for sense-making is increasing exponentially



Source: Adapted from Booz Allen (2012), *Cloud Analytics Playbook*. Available at <https://www.slideshare.net/BoozAllen/1111212-cloud-playbook-digital>

Fog computing is another technological advancement to explore. Singapore's Smart Nation drive has led to many IOT nodes that ingest data but are unable to perform analytics. Cloud servers are too far away to analyze data and respond real-time when required. By 2020, IDC projects that 10% of the world's data will be produced by these devices at the edge.¹⁰ Fog computing is an edge layer with analytics and artificial intelligence (AI) capabilities. The advantages are analytics-on-site and the transmission of only relevant data to cloud servers, driving down costs.

Create regulatory sandboxes for policy experimentation

On the regulatory front, the speed of technological advancements has resulted in changes in business models and societal behavior that are too rapid for policy and regulations to manage. Often, policies and regulations react rather than proactively manage emerging changes, and may hinder the flourishing of new technology. The Monetary Authority of Singapore (MAS), the nation's central bank, innovatively created regulatory sandboxes—spaces for policy experimentation—as a means to co-innovate on policies and practices for the explosive FinTech sector. In the sandbox, regulations are relaxed to allow the experimentation of promising FinTech products. If the outcomes are successful, both the service and policy innovations can be scaled up and implemented. Such incubation practices can be applied beyond the financial sector for policy innovations in the health, social, and transport sectors.

Establish unconventional partnerships to co-innovate on challenges like the skills gap

The main assets of technology companies are intangible—data models, codes, and business models—enabling them to scale at significantly lower cost. For example, it will cost less for Grab or Uber to enroll a driver than for taxi companies to add another vehicle to their fleet. Traditional companies amass assets and procure hardware while new tech companies procure talent through acquisitions.

The centrality of intangible assets drives tech companies to gravitate toward talent. This will likely lead to ultra-hubs where talent and tech companies cross-nurture in a virtuous cycle. As a result, tech companies may have either little qualms to relocate for talent or greater inertia to leave an existing ultra-hub since talent is readily available. Against this background, traditional levers like tax incentives, impeccable governance, and market hinterlands may be less likely to attract the tech companies of tomorrow.

With the gravitation of tech jobs towards certain talent ultra-hubs, there is an urgent need for Singapore to develop a base with deep and transferable skills. It is difficult to predict what skills will be needed in the future, and even more challenging to train a critical mass on these skills to meet future demand. Institutions need lead time to design new training courses that respond to market demands. By the time these courses are designed and

¹⁰ Thurai, A. and Devine, M. Cloud computing moves to the edge in 2016. Available at <http://data-informed.com/cloud-computing-moves-edge-2016/> (accessed 20 September 2017)

students enrolled, the demand may have shifted.

Attempting to tackle the skills gap in Singapore, the Lee Kuan Yew School of Public Policy at the National University of Singapore signed a Memorandum of Understanding with government agencies (SkillsFuture Singapore at the Ministry of Education), technology firms (Microsoft and LinkedIn), and the National Trade Union Congress. This MOU seeks to mine public and public-sector data to understand the supply and demand of skills within different occupations. Such insights will empower individuals to skill up appropriately, and provide information for training institutions on the types of courses to offer to meet future demand, and for the government on programs to meet sectoral demand.

This MOU represents an unprecedented multilateral partnership between different parties with unique resources to contribute towards addressing a sticky problem such as the skills gap. Such a partnership across ASEAN could be leveraged to engender a collaborative approach to address a host of labor and social issues that accompany the Fourth Industrial Revolution.

Cloud computing adoption in Singapore has accelerated in tandem with the explosion of data and the need to organize it. Singapore is a lead adopter of cloud computing due to five key drivers: (1) Public demand for and satisfaction with e-government services; (2) A focus on whole-of-government policies and practices; (3) A restructuring of technology agencies to integrate strategy and implementation; (4) The development of the Smart Nation Platform; and (5) The use of purpose-driven cloud applications, especially in healthcare.

The case study elaborates Singapore's cybersecurity considerations in cloud adoption, and makes the following recommendations. Technologically, Singapore should embrace cloud analytics, and explore "fog computing"—an emerging technology that enables on-site data sense-making before transmission to the cloud. The country should promote regulatory sandboxes to experiment with policies that proactively manage novel technologies and business models that may radically change society. And on the collaboration front, it should establish unconventional partnerships to co-innovate on challenges like the skills gap, such as the unprecedented partnership led by the Lee Kuan Yew School of Public Policy with the government, private sector, and unions.

V. Conclusion

This study, one of the first on cloud computing in Singapore, identified five key drivers: (1) Public demand for and satisfaction with e-government services; (2) A focus on whole-of-government policies and practices; (3) A restructuring of technology agencies to integrate strategy and implementation; (4) The development of the Smart Nation Platform; and (5) The use of purpose-driven cloud applications, especially in healthcare. These key drivers could serve as learning points and considerations for other nations embarking on their cloud journey. While Singapore's pragmatism has powered the nation forward, this pragmatism must be increasingly coupled with experimentation agility, especially in regulation and policy. Only then can Singapore stay ahead in the global race to be a cloud computing hub and a technology catalyst for ASEAN.

Cloud Computing in Myanmar

Khuong Minh Vu, Theta Aye, and Kris Hartley

I. Introduction

Within less than a decade, Myanmar has emerged from political and economic isolation to become a democratic country rapidly opening to the world. As a technological latecomer undergoing accelerated modernization, Myanmar has an opportunity to shape its development by embracing the Information and Communications Technology (ICT) revolution.

ICT development in Myanmar has shown remarkable progress. As shown in Table 1, Myanmar's mobile phone penetration rate surged from 0.3 in 2005 to 1.1 in 2010, 7.1 in 2012, and 75.7 in 2015. Myanmar was ranked among the world's fastest-growing countries in mobile subscription base in recent years.¹ Myanmar has also surpassed Cambodia and Laos on internet penetration, reaching an internet penetration rate of 21% in 2015, comparable to that of Indonesia. However, for broadband, a better indicator of ICT development, Myanmar's growth has just barely registered. Its penetration rate in 2015 was 0.06%, notably below its Asian peers and only a modest improvement from 0.04% in 2010.

While ICT penetration data suggest that Myanmar has the potential to leapfrog its peers in embracing the ICT revolution, to succeed in this endeavor the country needs deep leadership commitment, vigorous rethinking and learning, and robust coordination.

Cloud computing involves accessing content and computing applications via the internet that are stored on external servers rather than on physical servers and hard drives. Third party providers manage and secure these storage spaces. Cloud computing allows firms and government agencies to access world-class computing services without making expensive upfront investments. The adoption of cloud computing can help Myanmar leverage its latecomer advantage by allowing it to skip directly to technological modernization and avoid the typical interim-stage investment in legacy technologies such as physical servers.

This case study examines the dynamics of cloud computing in Myanmar through the lens of governance, deriving lessons and recommendations from the country's brief but instructive experience in promoting ICT development, especially cloud computing adoption. The aim is to provide a thorough understanding of policy challenges and opportunities in the context of a rapidly developing country that is also a late adopter of emerging technology. The findings are expected to be applicable not only to Myanmar but also to similarly situated countries around the world.

1 <http://www.exportfinland.fi/documents/10304/23be4b6e-ee00-4ac7-9ecc-262beaa70ffe> (accessed 3 September 2017)

Table 1: ICT penetration (number of subscribers per 100 inhabitants), 2000-2005

Country Name	2000	2005	2010	2012	2015
<i>Mobile cellular subscriptions</i>					
Myanmar	0.0	0.3	1.1	7.1	75.7
Cambodia	1.1	8.0	56.7	128.5	133.0
Lao PDR	0.2	11.4	62.6	64.7	53.1
Vietnam	1.0	11.3	125.3	145.0	130.6 ²
Indonesia	1.8	20.9	87.8	114.2	132.3
Philippines	8.3	40.5	89.0	105.5	115.8
<i>Internet subscriptions</i>					
Myanmar	0.0	0.1	0.3	1.4	21.8
Cambodia	0.0	0.3	1.3	4.9	19.0
Lao PDR	0.1	0.9	7.0	10.7	18.2
Vietnam	0.3	12.7	30.7	39.5	52.7
Indonesia	0.9	3.6	10.9	14.5	22.0
Philippines	2.0	5.4	25.0	36.2	40.7
<i>Fixed broadband subscriptions</i>					
Myanmar	0.0	0.0	0.04	0.04	0.06
Cambodia	0.0	0.0	0.2	0.2	0.5
Lao PDR	0.0	0.0	0.1	0.1	0.5
Vietnam	0.0	0.2	4.1	5.3	8.1
Indonesia	0.0	0.0	0.9	1.2	1.1
Philippines	0.0	0.1	1.9	2.2	4.8

Source: World Development Indicators database

2 Vietnam's total mobile phone penetration declined due to shifts from 2G to 3G and 4G (smart) mobile phones, which substantially reduced 2G subscription rates (Vu, K. 2017. "ICT Diffusion and Production in ASEAN Countries: Patterns, Performance, and Policy Directions", Telecommunications Policy, forthcoming, 2017).

II. ICT Development in Myanmar

Enabling conditions and ICT usage

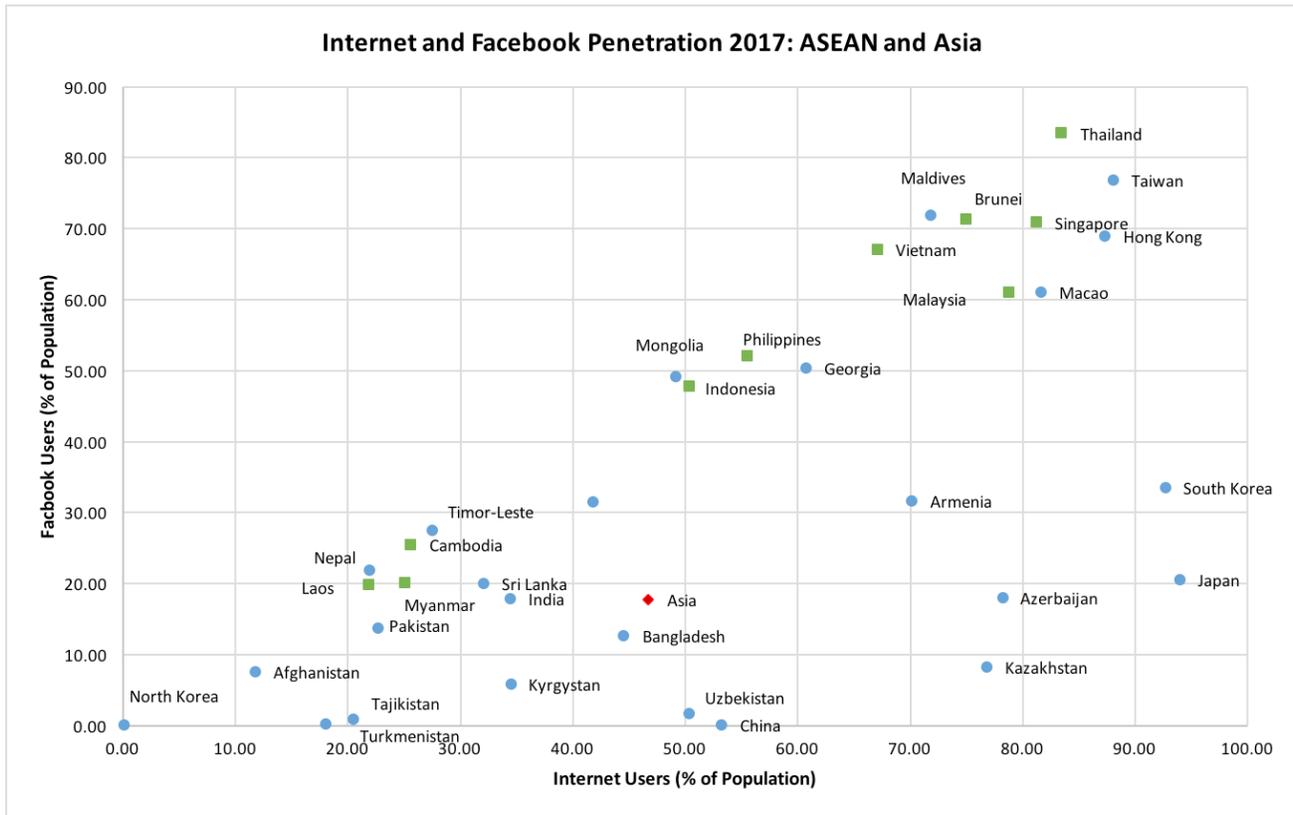
The Myanmar government moved to embrace the ICT revolution starting in the 1990s. The development of the Computer Science Development Law (CSD), along with the formation of the Myanmar Computer Development Council (MCDC) and Myanmar Computer Federation (MCF), helped the government institutionalize and coordinate ICT adoption within the country's broader development strategies.

2013 was a seminal year for Myanmar's development. In that year, operations for mobile networks were opened to foreign firms, liberalizing the rapidly expanding ICT industry and laying the foundation for investment in and improvement of Myanmar's technology capabilities. In the same year, specific national goals regarding ICT were outlined in the Framework for Social and Economic Reform. These included targets for technology penetration and access, sector liberalization and the promotion of competition, infrastructure upgrading, and ICT-related workforce skill development. As a result, Myanmar has entered a stage of rapid ICT penetration.

Myanmar has shown high growth rates in ICT adoption, especially in mobile phone penetration, as shown in Table 1, but continues to lag its ASEAN peers on many measures. For example, the country's adoption rates for internet and Facebook are around 20%, among the lowest in the region.³

3 80% of Myanmar's mobile phone users have a smart phone and 50% of them have installed Viber on their device ("Myanmar 33 million mobile users, smart usage 80%", Digital in Asia, January 9, 2017; available at <https://digitalinasia.com/2017/01/09/myanmar-33-million-mobile-users-smartphone-usage-80/> (accessed 28 August 2017).

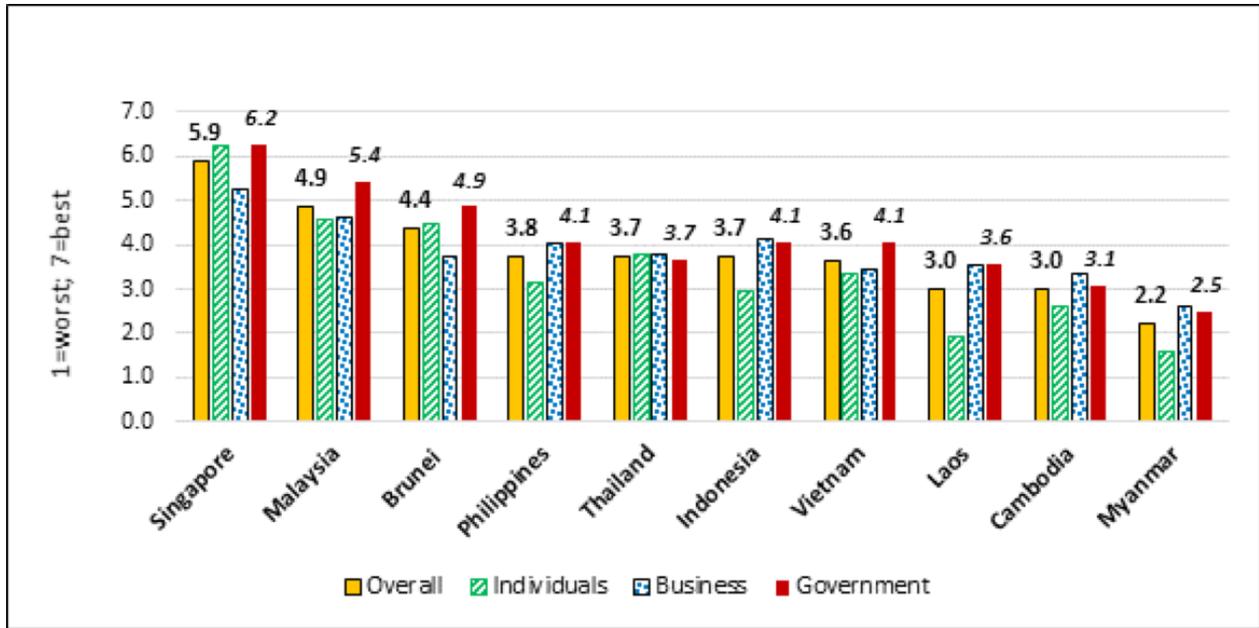
Figure 1: Internet and Facebook penetration, 2017



Source: Internet statistics: (1) The Asian Internet Statistics were updated for March 31, 2017.
 (2) Facebook subscriber data was updated for June 30, 2016.

Overall, Myanmar’s ICT usage is far behind its ASEAN peers and well below the mid-range value of 3.0 (Figure 2). It is important to note that for Myanmar, the government has not taken a lead in ICT adoption, as its usage index of 2.5 is lower than that for usage by businesses. In comparison, Vietnam’s government usage index is 4.1, well above the values for business and individual usage.

Figure 2: ICT usage index, 2015



Source: UN E-government Survey 2016

In practice, the adoption of technology by government requires training and facilities and an investment of both time and money, and implementation to date has been slow. However, the government continues to implement new e-government projects within ministries, and to serve as an interface across agencies and with citizens. Implementation of the e-governance master plan is expected to yield substantial progress in ICT infrastructure and adoption, improving efficiency in e-government, and narrowing the country’s digital divide.

III. Cloud Computing Development in Myanmar

Cloud computing adoption

To better understand cloud adoption in Myanmar, this study conducted a survey of 92 business leaders who are knowledgeable of ICT applications. The results show that the most common usage for cloud computing in Myanmar is software-as-a-service (SaaS) for web, email, and application hosting, while very few companies use Platform-as-a-service (PaaS).

Many SaaS end users, however, did not understand that Gmail, Office 365, Dropbox, and similar programs are considered cloud computing applications. Infrastructure-as-a-service (IaaS) customers are mostly large private enterprises and conglomerates in the media, entertainment, and financial services sectors. These users are often involved in new business formation and may also be transitioning from on-premises data storage facilities to cloud service or self-service enterprise solutions; these are used for accessing, monitoring, and managing remote data center infrastructures for computing, storage, and networking.

In addition to private sector clients, some government agencies have already adopted cloud computing. This has compelled these users to move beyond an IT-specific view of cloud computing and embrace business process re-engineering made possible by improved data management systems and other technologies. Rather than seeing cloud computing only as an IT initiative, some public sector users are considering fundamental changes in the way they conduct business to best leverage increasingly sophisticated storage, infrastructure, and application services. One example is the case of the Central Bank of Myanmar (CBM), which adopted cloud computing as a way to improve transaction efficiency and strengthen security. These steps were crucial for an institution that plays a significant role in facilitating Myanmar's economic growth, as digitization and automation enabled CBM to more easily scale up operations as demand grew.

CBM is also an example of facilitative collaboration for the expansion of cloud computing. The development of CBM's cloud computing systems was done through collaboration among Daiwa Institute of Research Ltd. (DIR) and Japanese firms Fujitsu Limited and KDDI Corporation. The project was initiated in 2012 with 150 terminals.⁴ It was the first of its kind in the country and is based on a model reflecting international standards. The breakdown of the tasks of each partner presents a model for how to mobilize the capabilities of individual firms to accelerate cloud computing rollout. This included designing and building

4 <https://blogs.wsj.com/japanrealtime/2012/12/26/myanmars-central-bank-heads-for-the-cloud/> (accessed 6 September 2017).

the system (for which DIR was responsible), providing hardware including terminals and security features (Fujitsu), and developing the local area network on which the system relies (KDDI). Efforts to expand this technology within Myanmar’s financial sector may eventually target not only private firms and government agencies but also trading platforms. IaaS based on cloud computing technologies also has the capacity to support the Yangon Stock Exchange (YSX) (opened in 2016) and Myanmar Securities Exchange Centre (MSEC).⁵

Cloud computing service providers

Myanmar lacks “home-grown” cloud computing service providers but domestic operators often engage in business partnerships with foreign ICT companies, typically through contractual arrangements for onshore technical support and for IaaS sales and marketing efforts.⁶ Companies offering cloud services through linkages with Asia-based vendors typically offer prices 20 - 25% less than those linked with US-based vendors. Data from interviews with cloud service providers indicate that inquiries about cloud computing services and potential adoption have increased in the past two years. Some interviewees estimate that within five years, the market for cloud-based IaaS could grow to 400 clients.

Obstacles to cloud computing adoption

Despite the many benefits of cloud computing, there are numerous obstacles that are a result of both the underdeveloped state of Myanmar’s private sector and the limited capacities of Myanmar as a developing country. The challenges include internet speed, ICT awareness, policy and regulatory standards, security, integration with public sector needs, and bargaining power. While many of these challenges appear to have simple solutions—additional investment, more regulation, or the accumulation of experience and wisdom—they must be approached with the caution and stakeholder involvement that characterize robust policymaking. Understanding these challenges in greater depth is an important early step.

First, advanced infrastructure technologies such as cloud computing require stable and reliable internet connectivity, which is not currently available in Myanmar. Inadequate network bandwidth and lack of access in remote areas are two challenges, and for firms operating in the Myanmar market physical servers are still more appropriate and prevalent than cloud-based servers. Comparable and recent data for Myanmar’s average internet speed is unavailable, and not included in Akamai’s internet speed reports.

Second, there is a lack of awareness about the benefits of ICT in general, and cloud computing in particular. Failure to understand these benefits makes both private and public organizations reticent to enter into service contracts, which may appear to be an

5 <http://www.fujitsu.com/global/about/resources/news/press-releases/2012/1225-01.html> (accessed 6 September 2017)

6 [https://www.datanyze.com/market-share/hosting/Myanmar%20\(Burma\)/amazon-aws-market-share](https://www.datanyze.com/market-share/hosting/Myanmar%20(Burma)/amazon-aws-market-share) (accessed 20 August 2017)

unnecessary cost or management burden. Furthermore, any potential reconfiguration of business systems and processes to accommodate a cloud-based operations model may seem overwhelming and not worth the effort. Educating professionals on the benefits of cloud computing, including gains in efficiency and cost savings, can help overcome this limitation. Such an effort could be spearheaded by the government or by a trade or industry association. As additional studies are conducted on cloud computing adoption in other developing countries, the evidence about benefits will become clearer and will need to be communicated effectively to public and private sector decision-makers.

Third, the absence of policy and regulatory standards for ICT may appear to elevate the riskiness of adopting cloud computing technologies. The presence of consistent institutional controls, overseen by the national government in an integrated and standardized way, is a crucial step in building confidence among adopters about the predictability and stability of cloud computing services, particularly in regard to service standards, IP protection, cybersecurity, and legal recourse for breached contracts. Related to these issues, growth in Myanmar's cloud computing market is hampered in part by the absence of a single government entity to oversee ICT markets and issues related to information access, competitive fairness, product quality, and legality. This is discussed later. Currently, multiple government agencies are digitizing data for reliability and efficiency, but are also developing individual agency-specific ICT and information management procedures and standards. This makes future integration more difficult and misses an opportunity to model a unitary ICT platform for the private sector. Furthermore, regarding individual issues such as data protection, building a nationwide platform for addressing concerns would help to develop Myanmar's brand among potential investors.

Fourth, security is a concern in terms of underdeveloped systems and prioritization among firms. Data protection is essential not only for customers but also for sensitive information within firms. The development of an industry standard for robust security protection measures should be driven by the priorities of business leaders, demands from customers, and the willingness of government to establish and enforce standards. Absent this push from stakeholders, the cloud computing services market in Myanmar may resemble the poorly regulated markets often seen for other products, characterized by widely variable service quality, below-standard goods, and a lack of confidence among consumers. These factors would further hinder the adoption of cloud computing.

Fifth, from the public sector perspective, the risks associated with cloud computing may be magnified by the increased need for reliability and security that defines standards for public data stewardship. Efficiency and cost savings are factors that drive cloud computing demand at the private sector level, which are also motivations for the public sector. However, the importance of data protection could be seen as a paramount concern for a government agency, and the uncertainties around cloud computing regarding reliability, privacy, and data governance could be restricting uptake in the public sector. An additional

issue is the flow of sensitive information across borders, which can expose governments to risk. In particular, data that were once stored on hard documents in filing centers or on privately owned on-site servers would now be stored on a distant server. This underscores the confidence that governments must have in the quality of oversight and the security measures offered by cloud computing providers.

IV. Stimulating Cloud Computing Adoption

Provider roles

As cloud computing service capacity increases in Myanmar, it is crucial that market demand grow in order to provide robust incentives for further supplier investment. Increased demand would also induce more suppliers—domestic and foreign—to enter the market, thereby increasing competition and stimulating innovation, efficiency, and competitive pricing. There are three steps that cloud computing service providers can take to strengthen demand: enhance value for both private and public sector clients, improve skill levels among local workers, and leverage the strength of local and national brands.

Enhance value for private and public sector clients

First, in the cost-focused private sector, return on investment is a key determinant in deciding whether to undertake investment in technology and other enterprise applications. In 2015, Kanbawza (KBZ) Group, one of Myanmar’s largest conglomerates, embarked on a digital transformation by adopting cloud computing, first for its banking division and later for other subsidiaries.⁷ Examples like this are evidence that the private sector is beginning to recognize the financial returns to investments in cloud computing. Return on investment can be measured by operational aspects (such as gains in efficiency, productivity, and security), and by marketing aspects (such as customer value creation, market access, and brand visibility). For the public sector, cost and security are important drivers, but these are balanced against administrative ideals such as transparency, accountability, and public service. ICT can be applied to a variety of public functions including tax collection, business permitting, and infrastructure management (e.g., through “smart cities” initiatives). Cloud computing can play a crucial role in such functions by streamlining information storage and access—crucial for an era in which intelligent monitoring applications are gathering vast amounts of “big” data. In serving the public sector’s unique needs, cloud service providers are able to segment the overall market and provide products (i.e., clouds) with differing features, including varying levels of security, mechanisms for collaboration and public information sharing, and system redundancies to ensure operational continuity.

⁷ <https://news.microsoft.com/apac/2015/09/21/myanmar-conglomerate-kanbawza-group-embarks-on-its-digital-transformation-journey-with-microsoft/> (accessed 1 September 2017).

Improve skill levels of local workers

Second, cloud service providers must improve internal capabilities in order to build markets. Instrumental to such capabilities is personnel resourcing and skill capacity. Domestic firms may not be able to compete with firms in other countries to attract high-skilled workers (especially neighboring China and India, both technology skill powerhouses). As such, it is crucial that Myanmar's workforce be developed more comprehensively. Cloud service providers must establish close working relationships with the country's universities and technical schools to nurture the next generation of skilled ICT employees. A recent joint study by KPMG and NUS's Institute of Systems Science (ISS) on ICT curriculum benchmarking found several challenges in Myanmar's educational capacity. These included under-staffed IT facilities, resource limitations, outdated curricula, and demanding degree programs lasting six years in some cases. Notably, female students constituted more than three quarters of IT program enrollment, although most did not expect to join the local ICT workforce upon graduation. Five target areas for strengthening the capacity of academic programs were proposed in the study: (1) building capacity and infrastructure, (2) empowering universities, (3) strengthening the focus on learners, (4) adopting more of an industry orientation, and (5) developing a robust credentialing system.⁸

The government and domestic firms should also continue to partner with international development organizations to improve training and education. For example, international development organization TAG focuses on building capacity in livelihoods and agriculture, health, and youth empowerment, while Myanmar Book Aid and Preservation Foundation provides support for building library capacity, developing information literacy curricula, and transforming community libraries into community centers.⁹ Projects such as these help develop a deeper understanding of technology that prepares students for productive careers and ensures that Myanmar has a competitive and productive labor force.

A stronger relationship between cloud service providers and educational institutions could include collaboration on curriculum development that suits the needs of domestic firms; work-study and apprenticeship programs that boost worker skills and firm capacity; and research programs in which both faculty and students seek to more deeply understand the challenges and opportunities of cloud computing. The transition to a more competitive economy, as enabled by cloud technologies, is therefore contingent not only on the efforts of private firms but on the public sector's response to firms' staffing needs and skill shortages. Recruiting employees from a local or national workforce, rather than competing on the international market for IT talent, would be more convenient and less costly for providers. The institutionalization of such collaborations should be built into Myanmar's longer-term strategies for education and workforce development.

8 <https://www.iss.nus.edu.sg/community/newsroom/news-detail/2016/05/18/digitising-myanmar-building-ict-capacity-for-growth> (accessed 2 September 2017).

9 <http://myanmarbookfoundation.org/about-us/> (accessed 1 September 2017).

Leverage the strength of local and national brands

Finally, domestic firms have an opportunity to build brand loyalty among local customers. In the early stages of adopting what some firms consider uncertain and experimental technology systems, trust is an important consideration when deciding which service provider to engage. This type of trust has been established within the rapidly growing individual and personal telecommunications services market in Myanmar, including among foreign operators Telenor (based in Norway) and Ooredoo (based in Qatar). With the entry of foreign firms and their rapid acquisition of market share, the idea that domestic firms have a commitment to Myanmar and to other local enterprises can be a strong basis for establishing brand loyalty in markets for additional products and services, including those offered at the firm level. These local firms have an opportunity to offer cloud services that are competitive in price and quality with what international providers offer, but also contextualized to the needs of Myanmar's firms. Another option is to partner with international providers, applying their vast resources and deep knowledge of leading-edge technologies with the local understanding, connections, and trust enjoyed by domestic firms. Some cloud services are already being offered through a collaboration between MPT and KDDI Myanmar, focusing on basic business applications for information storage and processing. Myanmar's other ICT firms have not shown similar initiative but must enter the market before existing providers develop a dominant market position.

Government roles

In a rapidly developing country such as Myanmar, the role of government is important in supporting digital transformation and the rollout of technology, as the private sector itself may be underdeveloped and lack the necessary capacity. Furthermore, government should assert its presence from the early stages of adoption in order to ensure that technologies such as cloud computing emerge in a stable institutional setting and provide the greatest benefits for private firms and for overall economic and social progress. This section describes six areas in which the government can stimulate demand for cloud computing.

Improve broadband infrastructure

First, government should focus on improving broadband infrastructure, including the development of a nationwide high-speed network that provides equal access and opportunity for enterprises in all parts of Myanmar. This is a challenge given that Myanmar's population is one of the most rural and least dense in Asia. Myanmar's membership in the Alliance for Affordable Internet, an international effort to improve internet affordability, and the development of a "Universal Service Strategy and Fund," are indications that the government understands the necessity of equalizing ICT access. However, such access is lagging. According to the Global Information Technology Report 2016, Myanmar is last in ASEAN for affordability, which is largely driven by the high cost of fixed broadband subscriptions and the lack of robust competition among ICT service providers (Table 2)

Table 2: Affordability of ICT use, 2016

Country	Overall Affordability		Global rank by affordability sub-index		
	Index value	Global rank	Mobile phone use	Broadband subscription	Competition
Vietnam	6.8	3	42	1	1
India	6.6	8	5	36	1
Indonesia	5.9	38	52	46	87
Cambodia	5.9	43	65	56	1
China	5.5	63	6	68	118
Thailand	5.5	64	16	89	97
Singapore	5.3	72	51	99	1
Lao PDR	5.0	82	25	88	126
Malaysia	4.7	91	46	110	1
Philippines	4.1	107	110	104	1
Myanmar	3.0	122	24	127	135

Source: *Global Information Technology Report 2016*, World Economic Forum, 2016. The report ranks 139 countries in its 2016 edition.

Improving the broadband infrastructure can be advanced in three ways. First is the capacity and reach of spectrum. Spectrum refers to air waves utilized historically by broadcast technologies (e.g., radio and television) but now increasingly occupied by mobile communications technologies (e.g., wireless data and internet). Efforts to improve spectrum access for mobile technologies include the expansion of coverage and capacity, and the granting or selling of licenses for particular uses—including those that are internet-supported. To accomplish this in an efficient and effective way, governments and regulators must understand technical issues such as the relationship among radio frequency levels, coverage distance, and data quality. Such efforts are often described as “releasing new spectrum,” and are the responsibility of the government as it is the only entity with sovereign regulatory power over spectrum use. Myanmar’s government has recently been active in the release of spectrum. In developing an effective spectrum policy that supports cloud computing adoption, liberating spectrum capacity effectively adds additional lanes to the information “superhighway,” improving not only the speed and reliability of service but also expanding coverage—the latter potentially serving the broader social and public good as well.

In addition to spectrum, which concerns radio frequencies, the extension of broadband access also entails investment in hard infrastructure and physical assets that strengthen Myanmar’s so-called “internet backbone.” Examples of such assets are centers for high-capacity networking, access points, facilities for exchange, transmission, and switching, and wire or (preferably) fiber-optic cable links. Facilities to manage cross-border bandwidth and data interchange (complemented by laws that liberalize international commerce)

can also be considered strategic infrastructure for Myanmar, particularly in the absence of ASEAN or region-wide governance frameworks for ICT and cloud computing. Finally, the promotion of competition in the wireless broadband arena may help induce further private sector investment in infrastructure, as customers demand faster and more reliable service. In a competitive environment, the incentive to remain efficient and innovative would be expected to prompt such investment, which also improves collective outcomes by adding capacity and enabling the wider adoption of bandwidth-intensive applications and technologies that improve firm productivity.

Facilitate the adoption of cloud computing

Second, government should target companies directly through a suite of measures designed to make cloud computing adoption attractive and convenient, and venture investment more efficient and viable. Four measures can accomplish this: awareness, training, public sector adoption, and fostering a competitive cloud services environment.

First, government should raise awareness about the benefits of cloud computing, as previously mentioned. This involves not only information campaigns disseminated through various media but also funding research that can provide empirical support for press and promotional publications.

Second, it is crucial to develop a technologically literate human capital base to improve the quality of the labor pool and the sophistication of cloud computing customers. The government should commit resources to strengthening training and education, not only in universities among engineers and computer scientists but also among technicians and maintenance staff needed to support additional and more complicated technologies. Furthermore, technology literacy should be an underlying theme among curricula across all fields, including business and the social sciences, to foster the development of a new generation of ICT-savvy corporate managers, entrepreneurs, and workers. Ongoing ICT training programs within the government should be initiated, and a certification system established that provides clear goals for individual skill attainment and labor market signaling by job seekers. Sharing experiences across agencies and functional groups with organizations is a key component to making this training knowledge applicable to practical ICT-related challenges faced by individuals in the workplace.

Over time, the cohort of workers trained in ICT and cloud computing will rise to the ranks of managers, directors, and other executive positions. It is expected that this new generation of leadership would have an understanding of the benefits of ICT and cloud computing, and help to champion related policies. Additionally, ICT has been recognized in Myanmar has an opportunity to adopt cloud computing to increase the effectiveness of education more broadly. For example, in Myanmar's National Education Strategic Plan 2016-2021, the third program component of the plan's strategy to strengthen coordination, management, and monitoring pledges "development of assessment-related information

and communication technology infrastructure to improve current work processes and the provision of examinations related services.”¹⁰ Such technologies not only improve the student experience through information access, but can also be used to improve the quality of education in remote areas, by connecting students in rural areas to resources and educational offerings provided in more developed areas of the country.

Third, government can send signals to the private sector about the value of cloud computing by itself taking a lead in its adoption. Myanmar’s e-government master plan outlines the application software to be adopted for shared use, including a national government portal, citizen ID management system, document management system, civil service identity management system, e-government call center, and human resource management system. Performance and management dashboards offer significant opportunities to improve governance efficiency and effectiveness, and cloud computing can support such technologies by improving data collection, storage, and analytical capacities. Certain ministries, such as Planning and Finance, and Transport and Communications, manage the types of initiatives that heavily rely on sophisticated data analytics. They are well situated to be leaders in the adoption of robust ICT systems and software, and in related innovations. There are signs that Myanmar’s government has begun to adopt cloud computing in certain measures, but the effort should ultimately be more comprehensive and government-wide. Support for research and development is also crucial. Myanmar cannot have a robust cloud computing-based economy without first having a thorough understanding of how this transformation will impact businesses and society. Such highly contextual research cannot be done by external parties alone; those with deep knowledge of Myanmar’s business environment must be trained, incentivized, and given the resources to thoroughly understand this transformation. The adoption of cloud computing in Myanmar can then ultimately serve as a valuable case study for other developing countries in Southeast Asia and worldwide in how best to undertake this digital transformation.

Fourth, the government must foster a competitive environment for service provision by liberalizing markets, improving reporting and transparency requirements, and reducing barriers to market entry. Progress in these areas, which will increase the number of market participants, involves a two-pronged approach. First, Myanmar must ensure that domestic service providers have the capacity and expertise to comply with international operating standards (e.g., data security) and to deliver a broad suite of cloud-related services. Domestic-side provider growth can come either from existing telecommunications firms expanding their product lines, or from start-ups. The government must also address workforce up-skilling, provide incentives to innovate and expand product lines, and strengthen regulation of the industry to ensure fair competitive practices.

Another aspect of fostering a competitive environment involves effectively engaging well-established global service providers, either as individual competitors in the domestic marketplace or as collaborators with domestic firms. Engaging leading global technology companies to participate in creating a vibrant and globally integrated digital ecosystem

10 http://resources.mmoe.myanmarexam.org/docs/nesp/NESP_SUMMARY_English.pdf (accessed 1 September 2017).

system in Myanmar is a crucial strategic step. The institutional learning associated with developing a cloud computing product line is significant, and Myanmar's users cannot wait for domestic firms to develop this expertise. Partnerships with global firms would help to increase capacity quickly and to leverage international best practices. If global firms compete directly in domestic markets, they are likely to dominate until local firms are able to match their service quality and operating stability. As cloud customers become more sophisticated and develop the knowledge to compare service offerings and negotiate effectively, the market will need to respond. Global firms are well positioned to capture market share in the early cloud adoption stage.

Strengthen legal frameworks for privacy, security and data protection

The third broad area in which the government can promote cloud computing adoption is by strengthening legal frameworks for privacy, security, and data protection, and by ensuring that these frameworks are flexible enough to accommodate rapid changes in technology and the global competitive landscape. Given the pace of the ICT revolution, and the speed with which some firms are adopting technologies such as cloud computing, existing legal frameworks may struggle to adapt in appropriate measure and timing. The inevitable result is a recurrent cycle of policy layering that resembles patchwork regulation, expanding and complicating regulatory codes, and adding to the burdens of compliance. The government must also streamline legal and regulatory barriers to adoption. This involves a comprehensive and integrated framework to oversee the rollout of ICT technologies and cloud computing by providing consistent and predictable oversight. A framework that is flexible and able to accommodate changes in technology and usage patterns, without adding regulatory complexity, is ideal in an environment of rapid transformation. Generating such a framework should be a collaborative effort involving the public and private sectors, and more specifically should be undertaken with the participation of agencies either directly or tangentially overseeing ICT-related activities.

The establishment of an autonomous agency solely dedicated to coordinating digital policy, communications regulation, and ICT promotion would be a practical start, facilitating a "whole-of-government" approach to developing and disseminating technologies. Such an agency could also prompt the creation of a national-level information officer post, a position with the power to marshal public resources and shape public and government support for ICT modernization. A politically autonomous body and position would help ensure consistency in vision and policy across political cycles. Currently, ICT and related responsibilities fall under the Ministry of Transport and Communications, formerly the Ministry of Communications and Information Technology. Recent reforms have included the establishment of separate regulatory agencies and operators, which represents a useful effort to separate policymaking and oversight. Regulatory independence is seen as a positive development for the maturation of Myanmar's ICT sector. Another effort that may be a catalyst for government-wide adoption of cloud computing is ensuring that the e-government master plan is updated for the current realities of the ICT market and achievable given the limitations to implementation outlined earlier in this case. If done on a government-wide basis, such an initiative would necessitate more shared infrastructure

across agencies and departments, justifying the development of a government-wide cloud that standardizes information, improves openness and collaboration, and harmonizes procedures for data management and access. Figure 3 outlines proposals regarding Myanmar's cloud infrastructure for e-government.

Figure 3: Myanmar government's initiative on cloud infrastructure

ID: Name of the Initiative	MCIT-2: Myanmar Cloud Infrastructure for e-Governance Applications
Description	Cloud Infrastructure set up for e-Governance Applications engaging the Cloud Services partner
Key Features	<ul style="list-style-type: none"> • Shared Storage, Network Infrastructure, Security and IT Operations and Management Components. • On Demand Compute Resources (Servers) for each ICT Application of the department. The cost to be borne (Capex and Opex) by individual departments depending on the quantum of compute resources • Cloud Management & Monitoring Software and Infrastructure • Cloud Security Solution • Virtualization Capability • The Capex for the shared components should be borne by MCIT. Opex should be accordingly across various departments. • Cloud Metering Solution
Expected Benefits	<ul style="list-style-type: none"> • Reduced Total Cost of Ownership: The pay per use model of pricing in cloud will ensure that upfront investments for various government departments can be minimized • Reduced Efforts in Managing ICT Infrastructure: cloud offerings are based on pre-packaged and standardized technology. This Will reduce technology heterogeneity and hence reduced efforts in managing ICT infrastructure. • Optimum Utilization of Infrastructure: Each department doesn't have to buy its own storage and other ICT infrastructure. These infrastructure components can be shared in an efficient manner. • Reduced Time Frame for deployment of ICT Applications of the departments. once the Cloud Infrastructure has been deployed • This will facilitate standardized service delivery and individual departments do have to build skills and capacity in developing ICT Infrastructure Management Skills. • The infrastructure can be scaled up quickly as and when the load increases

Source: ADB (2015). *Republic of the Union of Myanmar: Design of e-Governance Master Plan and Review of Information and Communication Technology Capacity in Academic Institutions*. Project Number: 47158.

Standardize cloud systems

Standardization is the fourth measure to promote cloud computing adoption, and involves four elements. First, standardization should extend to interoperability. At the early stages of ICT transformation, differing levels of adoption—as a function of firm-specific resource commitment and time—may lead to a fragmented operating landscape in which the ICT capabilities vary widely across firms, even those in the same sector. This not only limits opportunities for collaboration and sharing of best practices but also complicates consumer markets as customers must consider the varying technological capabilities of cloud providers. Standardization would facilitate the transfer of knowledge and technology among firms, helping cloud service providers market to a broader base while retaining the ability of providers and customers to design customized proprietary systems.

Second, virtualization formats and open platforms provide standardized opportunities for firms to streamline and improve operations. Virtualization refers to the development of a virtual, abstracted, simulated, or disaggregated version of a hardware platform like a server. This process can be applied, through the use of software, to networks, individual desktops, and applications, and enables more efficient control of systems through a central source. Virtualization can reduce costs associated with hosting physical assets, saving the time and effort of applying large hardware platforms to particular uses; it also enables tighter coordination among business functions. Open platforms provide the opportunity for users to tailor standardized software to their particular needs by accessing the underlying architecture and code of the programs. Such open platforms can promote innovation within firms and across industries, and enable best practices to be collectively disseminated.

Third, standards for web applications and services are important as a means of regulating the market and ensuring quality. There are many international examples of such standards on which Myanmar can base its own, and these standards are crucial at a stage when new providers are emerging and attempting to gain market share. Ensuring consistency and quality across a well-regulated marketplace is crucial to building consumer and investor confidence in Myanmar's domestic ICT and cloud computing industries.

Finally, standardizing security, identity management, privacy measures, and procedures for linked data is important for building consumer trust in the system. Current regulatory regimes related to these issues are relatively weak in Myanmar. As part of a comprehensive regulatory package, these elements should be institutionalized at an early stage. For sectors deemed particularly crucial to economic development, such as the finance industry, regulatory requirements can be adjusted to account for unique risk factors and the dominant presence of individual firms in certain markets. This type of risk management, long present in the private sector, would be appropriate for framing ICT and cloud computing policies.

Promote measuring and monitoring

The fifth measure for government to promote cloud computing adoption is through robust measurements. Myanmar's government should establish standard processes for transparency, reporting requirements about levels of cloud service consumption, and the means by which cloud computing progress is measured against firm-level and national goals. Measures are necessary for two reasons. First, understanding these dynamics will help the government be aware of which interventions are successful and the speed with which new initiatives generate desired effects. Second, robust measuring systems generate data that are useful for firm-level decision-making and for scholarly research. Data must be collected consistently across a representative sample of companies grouped by characteristics including size, industry, and market reach, among other factors. This data must be analyzed robustly through econometric methods, expressed in meaningful and accessible language for policymakers, and disseminated through effective channels. Furthermore, they must be made open to many user groups including businesses, analysts, and academics.

Provide direct incentives

Finally, the government should provide direct incentives for cloud computing adoption, including tax breaks and other financial inducements. The power of tax incentives to influence firm behavior is well documented across a variety of areas, including foreign direct investment, property investment, corporate social responsibility, philanthropy, and other activities that generate profits but also enhance value for the public good. For cloud computing, similar programs should be explored, reducing the financial risks to firms and stimulating an environment of technological experimentation and entrepreneurship. With further evidence of efficiency and productivity gains, as measured principally through return on investment, the industry should be able to sell itself effectively and direct incentives can then be retrenched or removed.

V. Conclusion

Cloud computing has the potential to be a transformative force in Myanmar's economic development. According to a report by the Myanmar Center for Responsible Business (MCRB 2015), by 2030, the ICT sector could boost Myanmar's economy by US\$6.4 billion and employ approximately 240,000 more people. These recent and rapidly developing trends are evidence that ICT can support structural transformation in Myanmar, with cloud computing playing a crucial role.

Despite these impressive projections, Myanmar is still far behind its Asian peers and well below its potential in promoting ICT diffusion and development. The country can make considerable progress in this endeavor by developing a clearer vision and a more effective strategy for embracing ICT for development, and fostering cloud computing adoption. The potentially high efficiency and productivity gains from such technologies make them particularly attractive for firms in developing countries trying to capture early market space in expanding industries and for governments striving to improve efficiency and service quality. Cloud computing is among the newest technologies to reach Myanmar, bringing not only transformative potential but also significant challenges.

Myanmar is at a crossroads in its development history. The potential of ICT to enhance productivity and profitability in the private sector and efficiency and service delivery in the public sector is transforming industries and accelerating social development. The governance challenge for developing countries is to manage rapidly emerging ICT such as cloud computing in a way that enhances the competitiveness of domestic businesses while also ensuring fair and equal access across geographic and income strata. The adoption of cloud computing represents a leapfrog strategy in which Myanmar is able to bypass costly investments in bridge and legacy technologies that are already out of date in developed economies and to embrace cutting-edge technology. Examples in other developing contexts are numerous, including the use of Microsoft-enabled cloud technologies in India to inform farmers about conditions related to weather, soil, and other factors.¹¹ Similar cloud-based mobile technologies have been used in Africa to connect farmers with markets and record public health conditions. These are some of the types of innovations that should be made possible in Myanmar by smart policy intervention.

As with most policy opportunities or challenges, steering ICT productively requires a calibrated mix of the basic ingredients of good governance: openness to new ideas, transparency in policy development and implementation, involvement of multiple stakeholders, and commitment to the values of public service. As such, this Myanmar case is illustrative of the valuable lesson that hardware is not enough for ICT development. Institutional, legal, and administrative elements must function in a way that promotes progress across the economy, society, and government. In conceptualizing Myanmar's

11 http://www.business-standard.com/article/companies/microsoft-icrisat-develop-new-sowing-app-for-farmers-using-ai-and-azure-cloud-116060900752_1.html (accessed 1 September 2017).

lessons for ICT governance, and in particular for cloud computing adoption policy, it is useful to apply the “SMART” framework: strategy, monitoring, accountability, rethinking, and trust.

First, strategy reflects the idea that governments should focus their efforts on technologies that have the highest economic and social impact, and should commit resources to fostering robust and competitive markets for these technologies. The concerns of firms identified by this case study can guide these strategic priorities towards areas with the greatest bottlenecks for progress. Such strategic priorities include, but are not limited to, a balance of hard and soft infrastructure, workforce training and development, clear and consistent enforcement of regulations, commitment to innovation, and openness to new ideas. Myanmar’s government should define ICT as a major strategic driver of development, proactively leveraging it to fight productive inefficiency and technological backwardness. An important early step is establishing a committee with a strong mandate to strategize the promotion of ICT development and cloud deployment.

Second, a robust system to monitor ICT adoption and its impact on the economy and society is crucial for helping raise awareness of ICT’s benefits and for generating political support for policies that advance new technologies. A suite of KPIs should guide efforts to collect data on a yearly basis through surveys of firms and users. The results can be circulated through an open-access platform which is itself based on cloud technology. After several years of data, meaningful research can be conducted by the academic and non-profit sectors to understand lessons and develop best practices to assist the next generation of rapid adopter economies.

Third, the credibility of ICT policy efforts must be supported by accountability systems based on transparency and collaboration. With strengthened regulatory frameworks in place, the government must take ownership of enforcement on a variety of market-related issues, including competitive practices and IP protection, among others. The development of the cloud computing industry is contingent upon the technology’s ability to be integrated into existing economic and social systems without compromising them or monopolizing opportunities for certain parties. The government’s role is to ensure that the potential benefits of ICT are available across sectors and population sub-groups. Firms, non-governmental organizations, and citizens must hold government accountable in this regard.

Fourth, rethinking implies that the government and private sector must not become comfortable with or dependent on current technologies, but must be willing to understand global trends and best practices in the rapidly evolving cloud computing environment—and embrace them for development promotion. Rethinking also involves keeping track of the developments in and needs of domestic society, and recognizing how technologies can help address these. In short, rethinking requires open-mindedness and flexibility, seeing technology not as a destination but as a moving target that is constantly improving and offering new opportunities. In application, rethinking can be actualized through policy experiments. One example is the use of test-beds: zones, defined by either geography or industry, where new regulations and policies are

temporarily or permanently implemented for the sake of observation. Another example is policy support for innovation incubators, clusters of firms in similar industries and communities of practice that function in physical proximity, encouraging information exchange, collaboration, and experimentation. Like test-beds, activities within incubators can be observed for reference in future policymaking.

Trust is the final element crucial for ICT and cloud computing governance. For emerging technologies such as cloud computing, domestic firms may perceive the risks of adoption to be high; as such, public policies and the service provider marketplace must offer a value proposition that includes safeguards against predatory behavior, cybercrime, data compromises, and other threats to business security and continuity. From the policy side, specific regulations that are robustly enforced are needed to ensure the proper and transparent functioning of markets and the lawful behavior of service providers, both domestic and foreign. In a leapfrog context such as Myanmar, where technology adoption can outpace the development of regulations, regional, international, and industry standards can be immediately used for guidance. Myanmar's government does not need to embark on the tedious and time-consuming process of reinventing standards. The benefit of including international cloud service providers in the domestic market is that these firms must comply with regional and international standards, forcing all providers to match their levels of data protection, security, and privacy in order to stay competitive. Improved infrastructure and hardware also builds trust, as system quality and resilience (minimization of interruptions) ensures business continuity. In a more general context, the promotion of transparency and rule of law, and the elimination of corruption from public bodies having control over ICT, can build trust among the private sector and civil society.

Building a fertile ecosystem for the adoption of cloud computing is a collaborative effort between the government, private sector, and civil society. Myanmar should leverage both domestic resources and foreign investment to ensure that infrastructure capacity growth keeps pace with adoption. Public-private partnership models have proven successful in ICT development throughout the world, and can be a valuable way to achieve this transformation if they are managed in accordance with the principles of transparency, accountability, and good faith. Furthermore, international firms are important partners in the development of soft infrastructure. For example, technology companies such as Microsoft have outreach programs that assist governments in implementing technology for social benefit, in the fields of education, health, poverty alleviation, and citizen empowerment. Such efforts, supplemented by aid and assistance from international organizations and NGOs, will help Myanmar realize its technological and developmental potential. More generally, a commitment to improving ICT governance and capturing the gains of emerging innovations can help Myanmar become a competitive force in ASEAN and the region.

Appendix I

Appendix 1: The Benefits of Cloud Adoption and its Global Dynamics

First introduced by Amazon in 2006, cloud computing services are transforming the way that firms operate, compete, and serve customers. Between 2015 and 2020, the total data center workload processed by cloud services is expected to rise from 75% to 92%, with cloud server growth expanding by 15% per year over the same period. Rapid adoption is expected as awareness increases about the numerous benefits of using cloud services, including lower computing costs, improved economies of scale in hardware and physical assets, and facilitation of business process reengineering. Furthermore, cloud computing customers are able to purchase service levels directly proportional to their needs at a given time, reducing the burden of maintaining excess capacity and allowing firms to respond to elastic markets and business cycles. Further incentives from a government perspective include macro-scale impacts from enhanced efficiency and competitiveness at the individual firm and industry-wide level. Firms must communicate these benefits to the wider business audience not only to be competitive, but also to establish a robust, competitive, and customer-responsive provider landscape.

The business model for cloud computing can be described as infrastructure-as-a-service (IaaS), in which the need to purchase and maintain hardware is eliminated, and the risks of physical asset ownership are borne by service providers. The portfolio of services offered in sophisticated cloud computing markets is broad and applies to multiple user needs; these include “off-the-shelf systems,” customized proprietary programs, and combinations thereof. Free from the burdens of purchasing and managing hardware, or maintaining IT departments, companies can focus more intensively on their core competencies and budget predictably for the levels of data service they anticipate. The demand in cloud computing among government users is driven by opportunities for efficiency and responsiveness gains in public service delivery. Examples include the digitization of business registration processes and the virtualization of tax collection, the latter made simpler by the types of e-file systems now common in more developed countries. According to Oliveira et al. (2014),¹ key factors influencing cloud computing adoption are top management support, firm size, and technology readiness. Frost and Sullivan (2011) identify several benefits of cloud computing adoption as value propositions. Table 1 summarizes the value propositions and capabilities of cloud computing in the public sector, comparing measures from Frost and Sullivan (2011) and Oliveira et al. (2014).

¹ Oliveira, T., Thomas, M. and Espadanal, M., 2014. Assessing the determinants of cloud computing adoption: *An analysis of the manufacturing and services sectors. Information & Management*, 51(5), pp.497-510.

Table 1: Value propositions for cloud computing in the public sector

Factor	Frost and Sullivan (value proposition)	Oliveira et al. (significance of effect on cloud adoption)
Reduction in IT spending	Justifies central pool of shared resources, consolidation	
Agility	Eliminates time-consuming approvals and purchase order processes	Compatibility (-)
Access to most updated technology	Places onus of software updates on service provider	Technology readiness (<0.01)
Elimination of procurement and maintenance	Places cost and risk of procurement, monitoring, and maintenance on providers	
Universal resource access	Internet-basis allows broad access and common platform	
Security	Increased spending by cloud hosts on data security would attract more usership	

Adapted from Frost and Sullivan (2011) and Oliveira et al. (2014)

Global Trends

Rapid global adoption of cloud computing has been facilitated by upgrades to digital infrastructure and broader awareness about the benefits of cloud computing. Table 2 shows country-level data on cloud computing expenditure (CCE). Two trends are clear. First, CCE has grown rapidly across the world, with a consistently high average annual growth rate (2010 to 2016) across all country groups: 42.5% worldwide and ranging from 29.4% (Latin America) to 49.6% (Africa and the Middle East). Second, CCE per capita varied significantly across countries in 2016, ranging from 1% of the US value for Egypt and India to over 200% for Australia, Sweden, and Canada. CCE per capita remains low for developing countries: less than 10% of the US value for seven of 11 countries in developing Asia, five of eight in Eastern Europe, and all seven Latin American countries.

Table 2: Cloud Computing Expenditure (CCE), 2016
(Countries in each group are sorted in decreasing order by CCE/capita)

Economy	Total cloud services		Cloud service expenditure/capita	
	\$US (Million)	2010-2016 Growth	\$US	US=100
Total World (45 economies)	99,936.3	42.5%	---	---
Industrialized Economies	81,466.5	42.4%	---	---
Canada	9,986.4	54.2%	275.2	294.0
Sweden	2,376.8	32.6%	241.3	257.8
Australia	5,409.7	34.7%	222.5	237.7
Germany	10,270.5	50.9%	127.3	136.0
France	7,538.8	39.1%	116.6	124.6
Israel	945.8	75.6%	115.5	123.4
United States	30,335.5	39.5%	93.6	100.0
Japan	10,811.1	51.6%	85.6	91.5
United Kingdom	3,791.9	32.2%	58.2	62.2
Developing Asia	11,516.9	47.0%	---	---
Singapore	1,043.0	46.8%	183.1	195.6
South Korea	4,720.2	40.0%	93.5	99.9
Hong Kong	826.7	45.4%	45.0	48.1
Malaysia	340.6	40.4%	11.1	11.9
Thailand	281.8	54.4%	4.1	4.4
Philippines	228.4	62.3%	2.2	2.4
China	2,383.8	73.9%	1.7	1.8
Vietnam	160.2	64.4%	1.7	1.8
Sri Lanka	28.1	81.0%	1.3	1.4
Indonesia	299.7	56.5%	1.2	1.3
India	1,204.4	45.1%	0.9	1.0
Eastern Europe	2,071.3	44.5%	---	---
Slovenia	98.9	47.0%	47.8	51.1
Czech Republic	144.0	33.3%	13.7	14.6
Romania	193.7	53.5%	10.0	10.7
Hungary	87.6	41.1%	8.9	9.5
Poland	314.3	36.3%	8.1	8.7
Russia	1,158.2	49.2%	8.1	8.7
Bulgaria	46.9	34.0%	6.6	7.1
Serbia	27.7	41.9%	3.9	4.2
Latin America	3,023.5	29.4%	---	---
Argentina	405.6	42.2%	9.2	9.8
Chile	139.2	39.5%	7.7	8.2
Brazil	1,506.5	22.6%	7.2	7.7
Peru	189.2	52.2%	6.0	6.4
Mexico	555.2	32.4%	4.4	4.7
Colombia	167.1	56.2%	3.4	3.6
Venezuela	60.7	68.0%	1.9	2.0
Africa & Middle East	1,858.1	49.6%	---	---
United Arab Emirates	351.4	50.9%	37.9	40.5
Qatar	42.4	51.5%	18.5	19.8
Saudi Arabia	554.7	60.5%	17.2	18.4
Bahrain	14.3	40.0%	10.3	11.0
Kuwait	40.4	42.6%	10.1	10.8
South Africa	314.4	36.8%	5.7	6.1
Turkey	436.2	50.1%	5.5	5.9
Oman	15.7	41.0%	3.4	3.6
Lebanon	12.6	58.3%	2.1	2.2
Egypt	76.0	60.8%	0.8	0.9

Data source: BMI

This report is part of an ongoing collaboration between LKYSPP and Microsoft.

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