Microeconomics of Competitiveness: Firms, Clusters and Economic Development

Costa Rica: Data Center Cluster
May 2016

Team
Céleste Clipp
Sarah Fetter
Maia McCarron
Katherine Suttor

Table of Contents

PART I: Introduction & Competitiveness Overview

Introduction: Data Center Cluster

This paper will explore the requisite elements of a robust data center cluster and whether there is a viable opportunity for one to develop in Costa Rica. The Data Center market is large and has been historically concentrated in the established markets of North America, Western Europe, and the Asia-Pacific region. The gap that once existed between established and emerging markets in terms of market size as well as technological access and sophistication has been disappearing as the industry as a whole shifts from in-house facilities towards colocation and outsourced space as well as from physical servers towards virtualized and software-defined architectures and cloud-enabled services.[1]

Costa Rica currently has seven data centers, which serve local and regional demand. In order for a data center cluster to develop, Costa Rica will need to position itself as a gateway and leading choice for global data centers to establish a regional presence – most likely in terms of a secondary, backup center rather than a primary location for global providers – as well as encourage both a stronger local and regional demand for services from startups and companies transitioning away from proprietary in-house facilities.

Costa Rica: Country Backdrop

Costa Rica is a small, Spanish-speaking central American country of 4.8 million citizens bordered by Nicaragua to the north and Panama to the south that enjoys coastal access to both the Pacific and Atlantic Oceans. Costa Rica is home to 5% of the world's known biodiversity and has a unique commitment to protect flora and fauna and as well as develop renewable energy

sources. Unfortunately, natural disasters present a substantial risk when considering where to develop infrastructure.

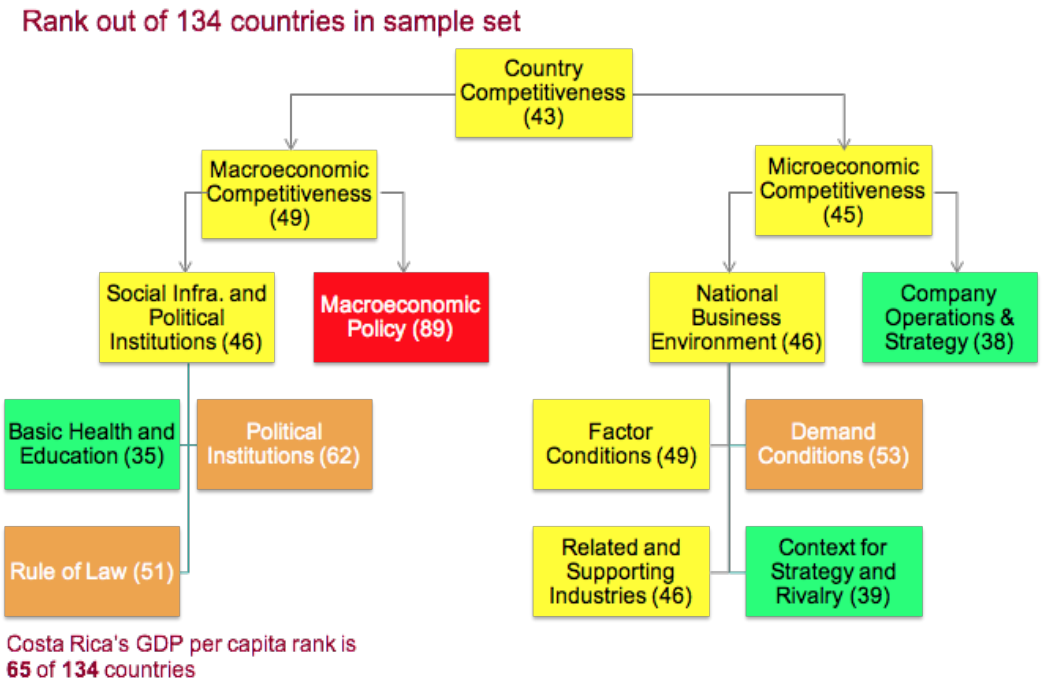
Macro-economically, Costa Rica has shifted from a labor-intensive, commodity agriculture to technology-based competition and is known for its political stability, independent court judicial system, and robust education and healthcare systems. The roots of many of the modern-day success stories can be drawn back to the 1948 Constitution, which abolished the national army as well as prohibited a presidential re-election to a 2nd term. A reduction in military spending has allowed the government to better concentrate resources on social development in health, education, housing and establish a political structure that pre-empted a sole focus on an imminent re-election. The results have been stellar: Costa Rica has become known as the *Switzerland of Latin America* thanks to its 50 plus years of peace and democracy, strong freedom of press, and low corruption; the education and health systems are among the best in the region.

Micro-economically, CR is strong in areas that have helped drive the IT cluster's success, including robust strategy, operational, and organizational practices, a high quality electrical supply, a strong innovation infrastructure, and an abundance of IT workers. However, weaknesses exist, including significant administrative burdens and a lack of access of loans or venture capital.

As seen in Exhibit 1, an assessment of Costa Rica's macroeconomic and microeconomic competitiveness in 2015 highlights energy sustainability and high education levels as clear strengths both within the Latin American region as well as globally, while energy costs and natural disaster risk – two variables that are critical in determining geographic placement of data

centers – emerge as key weaknesses and significant hurdles to the development of a data center cluster.

Exhibit 1: Costa Rica Competitiveness Summary, 2015[2]

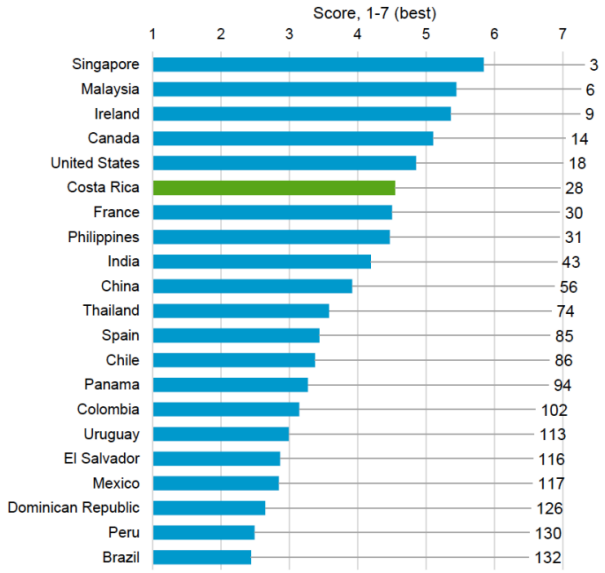


Macroeconomic Deep-Dive

Overall, Costa Rica ranks 49/134 in terms of macro-economic competitiveness primarily due to to its exceptionally strong basic health and education systems (35/134) and strong social infrastructure institutions (46/134). There is large room for improvement with respect to its macroeconomic policy (89/134) as well as rule of law (51/134) and political institutions.

Education. As mandated in the Constitution, Costa Rica dedicates at least 6% of GDP to its free, mandatory education system. According to the 2015 World Economic Forum Competitiveness Report and displayed in Exhibit 2, Costa Rica's education system ranks first in Latin America and 28th in the world above France, India, China and the Philippines, and enjoys a 95% literacy rate.

Exhibit 2: Quality of the Education System - World Ranking[3]

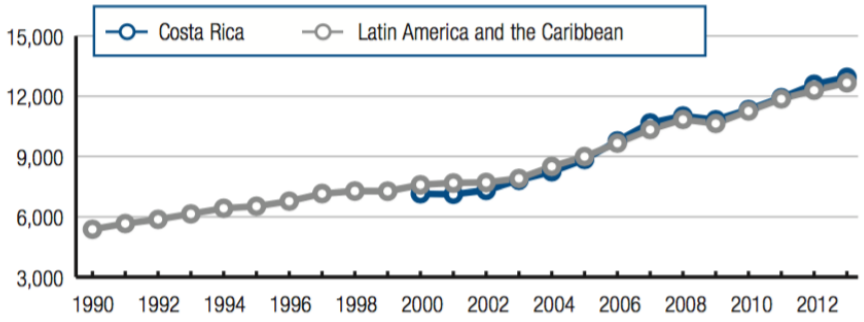


Technical high school graduates for the service sector are constantly increasing and based on data provided by CONARE, Universities' Registry Departments CINDE has reported the following CAGRs from 2009 - 2013: 8.2% for total university graduates, 13.6% for software and informatics graduates, and 5.3% for engineering programs graduates.[4]

Healthcare. Costa Rica has led Latin America in spend on healthcare by allocating 7% of GDP from 1990-1995. Such an investment has helped contribute to the robust life expectancy of 76.8 years which edges out the Latin American average of 68.5 years and even beats the industrial country average of 74.3 years.

Fiscal sustainability. While Costa Rica's GDP is in lockstep with the rest of Latin America and the Caribbean from 2000-2013 (Exhibit 3) and has high capacity for innovation (36/134), its low macroeconomic ranking (89/134), even relative to neighboring El Salvador (48/134) and Panama (39/134), are owing largely to its large government deficits (110/134) and inflation management (87/134). Strong social programs such as health care and education come at a cost.

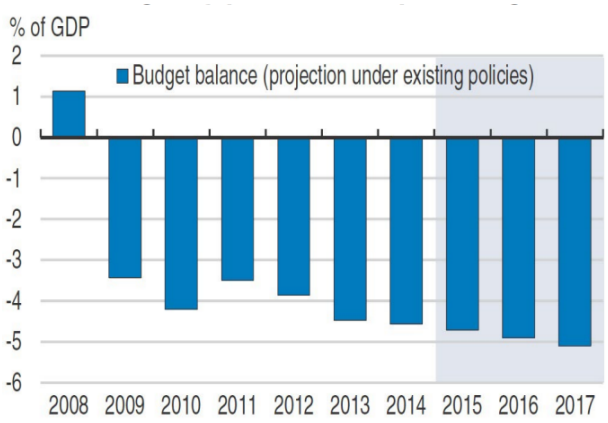
Exhibit 3: GDP (PPP) per capita (int'l $)[5]



According to the OECD Economic Survey on Costa Rica and detailed in the graph below, it is urgent to restore fiscal sustainability:

> *The public deficit and debt have risen since the start of the 2009 global crisis. Rating agencies have downgraded Costa Rica's debt to below-investment grade and its country risk spread has risen. To restore the fiscal balance it is urgent to raise more tax revenue and curb spending, notably the fast increasing public-sector wage bill by enhancing its transparency and predictability, and reinforcing central government control over public finances would strengthen public-finance management.*

Exhibit 4: Costa Rica's budget balance[6]



The OECD further out specific actions to restore fiscal sustainability and enhance monetary credibility, such as: eliminating tax exemptions that have no economic or social rationale, introducing a verifiable expenditure rule, strengthening the authority of the Ministry of Finance to control public-sector expenditure, introducing performance-based budgeting, delinking the President of the Central Bank from the political cycle to increase accountability,

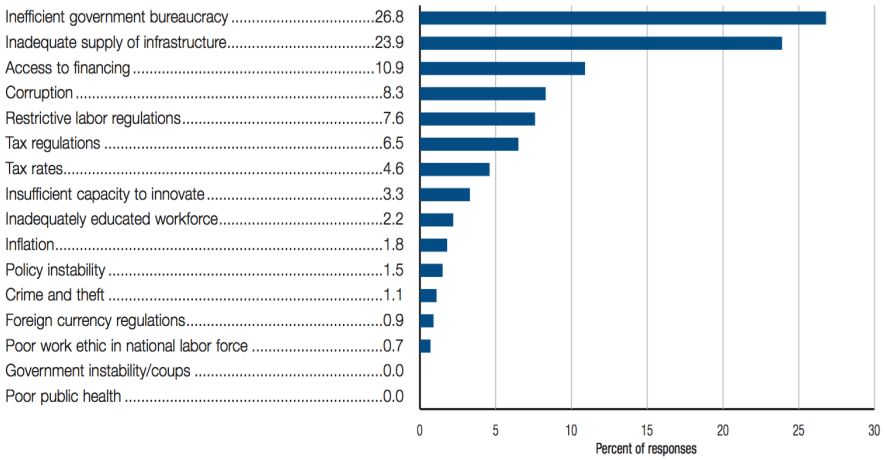
and introducing a deposit-insurance scheme for banks as well as a enforcing stricter adherence to the Basel III rules.

Rule of Law. In terms of rule of law, Costa Rica has very strong judicial independence (33/134) and control of corruption (36/134) but struggles with: business costs of crime/violence (92/134) and diversion of public funds (77/134) and awarding of public contracts (75/134). Otherwise, Costa Rica has enjoyed a reputation for integrity and independence. To diminish influence of a single congress, Supreme Court justices are elected every eight years while parliamentary elections are held every four. Furthermore, the OAS unit Inter-American Court of Human Rights has been located in San José since the court's founding in 1978 in recognition of the country's judicial excellence and respect for human rights.

Microeconomics Overview

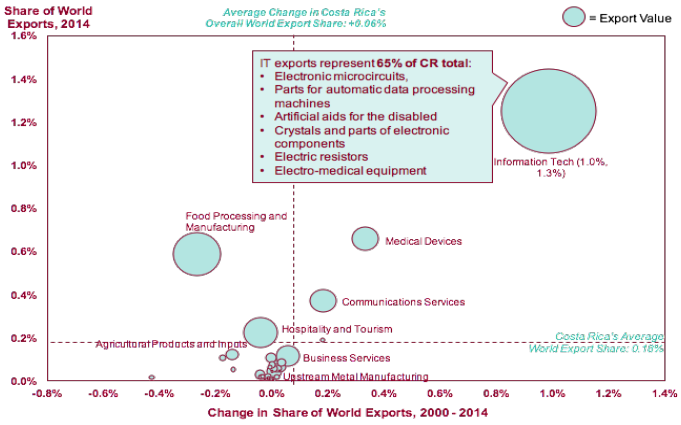
Costa Rica ranks 45/134 in terms of microeconomic competitiveness, strengths including its exceptional innovation infrastructure (32/134) and context for strategy and rivalry (39/134). There is room for improvement within factor conditions (49/134), particularly related to logistical infrastructure (82/134), administrative infrastructure (98/134), ease of access to loans (104/34), and venture capital availability (105/134). Furthermore, as seen in Exhibit 5, the World Economic Forum identifies inefficient government bureaucracy as the most problematic factor for doing business in Costa Rica.

Exhibit 5: Most Problematic Factors for Doing Business in Costa Rica[7]



Despite these challenges, Costa Rica has developed a very strong IT cluster, representing 1.0% of global exports by value, this growing by 1.3% from 2000 - 2014. Since winning Intel's microchip contract in 1996, this sector has grown dominant in the economy, now representing 65% of exports by value. Indeed, Costa Rica has developed a track record for attracting foreign direct investment from high technology corporations. According to the 2011 World Bank indicators, Costa Rica is the Latin America's #1 high-tech exporter and 4th highest tech exporter in the world. The Costa Rican Foreign Trade Ministry (COMEX) and the Costa Rican Investment Board (CINDE) details that FDI reached $1.5 billion plus in just the first nine months of 2011. In addition to microchip and software development, Costa Rica attracts investments in tourism, customer service, pharmaceuticals, and biotechnologies. The Financial Times publication FDI Intelligence named Costa Rica the "Best Country of the Future for Foreign Direct Investment in Central America and the Caribbean."[8]

Exhibit 6: Costa Rica's National Cluster Export Portfolio[9]



PART II: Data Center Cluster

Data Center Cluster Overview

Data centers are facilities used to house computer systems and associated components, such as telecommunications and storage systems. They generally include redundant or backup power supplies, redundant data communications connections, environmental controls (e.g., air conditioning, fire suppression) and various security devices.

Data centers are conventionally categorized according to their uptime (data availability) as a means of measuring their performance and return on investment. Data center infrastructure costs and operational complexities increase with Tier Level. Exhibit 7 summarizes the difference between data center tiers, ranging from 1 as the simplest and most commonly used for small businesses to 4 as the most robust and less prone to failures.

Exhibit 7: Data Center Tiers[10]

Tier	Description	Uptime
1	Non-redundant capacity components (single uplink and servers)	99.671%
2	Tier 1 + Redundant capacity components	99.741%
3	Tier 2 + Dual-powered equipment and multiple uplinks.	99.982%
4	Tier 3 + all components are fully fault-tolerant including uplinks, storage, chillers, HVAC systems, servers etc. Everything is dual-powered	99.995%

The increased digitalization of society has led to strong growth in data centers of 10% p.a. since 2010. More specifically, a larger percentage of services conducted online, greater private investment in computers and software, higher electric power prices and demand from data processing and hosting services (e.g. cloud computing) has driven growth.

Cluster Structure

There are two key types of data centers: enterprise data centers and colocation facilities.

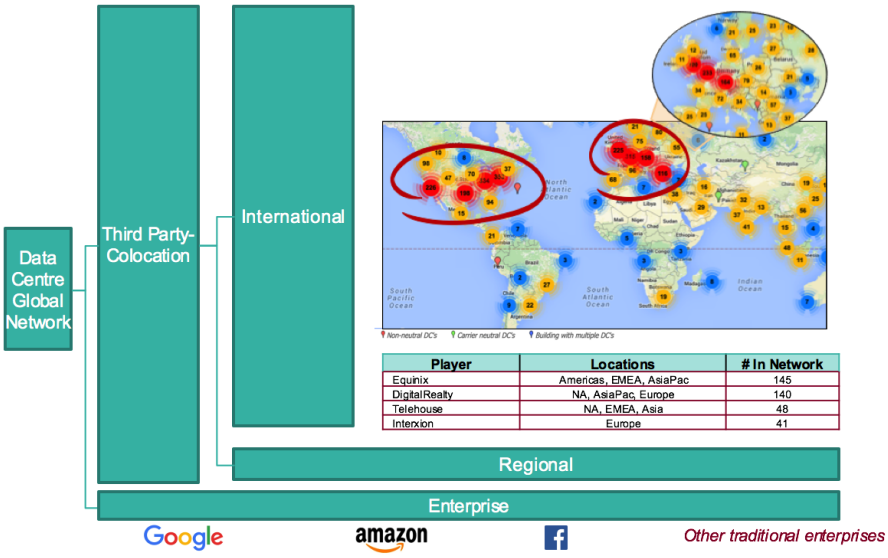
Enterprise data centers. Enterprise data centers are primarily IT-related companies that have the expertise and resources to manage in-house their data center needs. Such enterprises include large global tech companies such as Google, Facebook and Amazon, as well as smaller traditional companies. Many global Internet companies that in house their data centers, such as Facebook, had historically housed their centers domestically but have increasingly expanded their footprint globally with increasing demand, costs and attention towards data storage quality.

Colocation facilities. Colocation facilities include third party industry operators who own and operate data centers and primarily lease equipment space. Their customers can be from any industry and generally use the centers for off-site data storage to backup their data or to allow them to focus on other parts of their business without paying for these operations. A customer can either lease a space within the center in a retail agreement, or can lease the whole center under a wholesale agreement. Colocation facilities sometimes offer additional services such as power management, security and network neutrality. The space required to house data center machinery in colocation facilities may be owned, but in many cases it is rented.

Colocation players can be either international or regional in their coverage. Equinix is the largest international player with 145 centers, followed by Digital Realty with 140 (see

Exhibit 8). The data center industry has historically been strongest in Western Europe (i.e. UK, Germany) and the United States.

Exhibit 8: Data Centre Landscape[11]

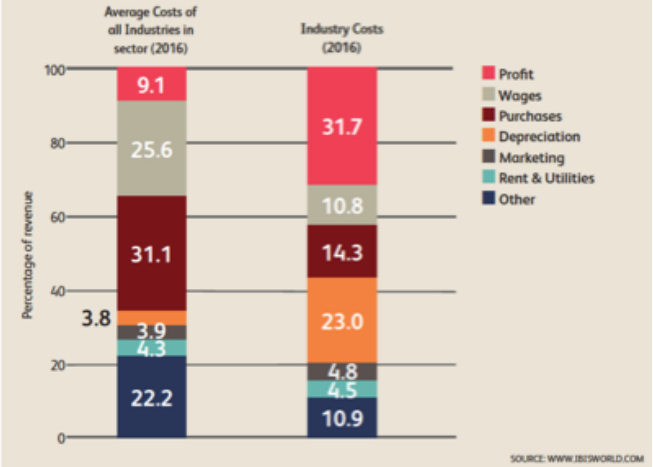


Player	Locations	# In Network
Equinix	Americas, EMEA, AsiaPac	145
DigitalRealty	NA, AsiaPac, Europe	140
Telehouse	NA, EMEA, Asia	48
Interxion	Europe	41

Key Cost Drivers

Colocation facilities require reliable power supply, using a large amount of power to keep equipment up and running on a daily basis (and in the case of an emergency) as well as cooling to keep equipment at the right temperature. Energy costs typically represent 50-60% of total operational expenditure.[12] Additionally, data centers require strong internet access, with operators connecting to fiber optic cable and multi-amperage power. Other capital investment includes up-front construction costs for the facility, as well as extensive cooling operations and energy-efficient systems. Other costs for the industry include wages, security, power management and connectivity-related costs. The industry requires skilled workers for installation and tech support services; however, increased technology efficiency has meant wages represent a small share of costs relative to other industries.

Exhibit 8: Illustrative Cost Structure From US Colocation Data Center Industry[13]



Key Trends

The environmental impact of data centers will become increasingly important when companies choose where to locate their data centers. Increasing energy costs make utility price negotiation, energy-efficient infrastructure and sustainable energy sources key determinants in where to locate data centers. This trend has and will continue to work in Costa Rica's favor, given its clean energy supply, but will put pressure on energy costs to compete with neighbors.

As enterprises and third-party providers hasten investments to keep up with expanding data traffic, the landscape is increasingly shifting towards larger-scale, purpose-built facilities with a focus on operational cost and efficiency. The market in general will continue to see consolidation to leverage economies of scale, and while data center numbers will continue to grow in the short run, over the longer term this growth will transition to greater unit capacity as technology improves.

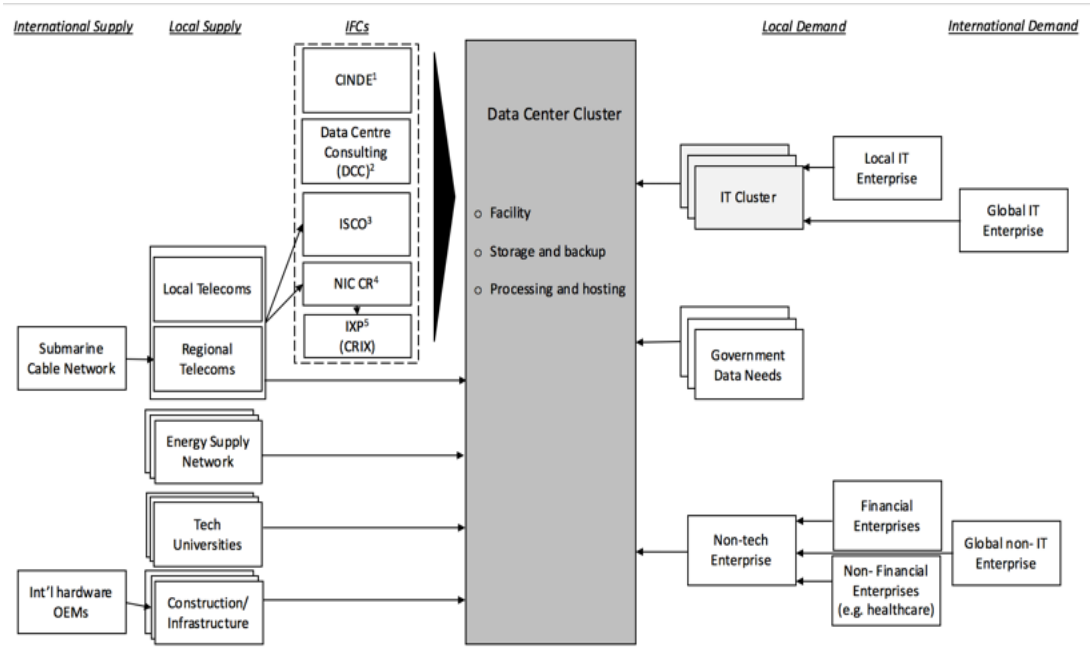
The importance of Data Center Cluster in Costa Rica. The cluster diagram below (Exhibit 9) illustrates how, on the demand side, a data center cluster in Costa Rica would play a key supporting role as part of the broader ecosystem, providing secure data storage at close proximity within the country to support the local IT cluster (Costa Rica's aforementioned largest

export industry), new start-ups in the country, as well as local non-tech enterprise customers (e.g., banks) and government. As Costa Rica continues to build the cluster, it aims to serve regional Latin American and even global customers as well. In the long term, a globally appealing, leading position in data storage further solidifies Costa Rica's shift towards a tech-heavy, knowledge-based economy.

Furthermore, on the supply side, a growing data center cluster drives business to supplier industries such as construction, energy, and equipment. The presence of a data center cluster also incentivizes and, in some cases, finances the continued investment in both local and international telecom infrastructure, the development of which provides positive externalities to the broader ecosystem, further fueling the industrial shift described above.

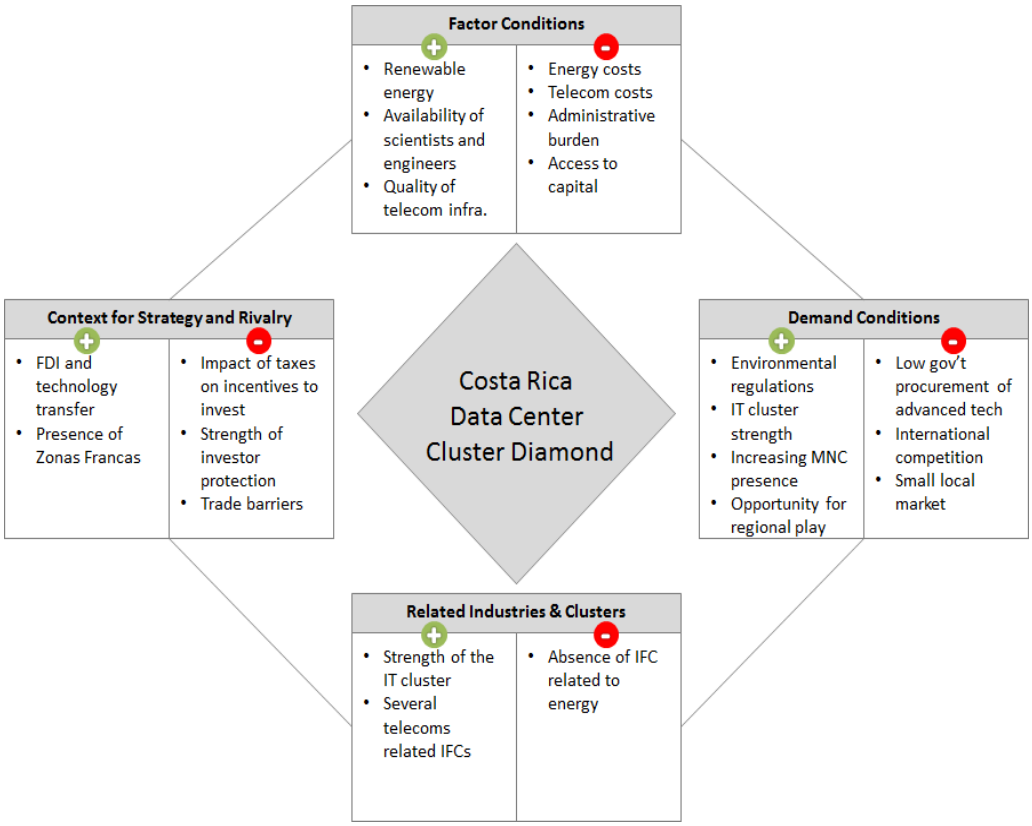
However, this cluster is not expected to generate much employment as a typical mid-sized co-location data center requires only a few dozen IT professionals.[14]

Exhibit 9: Data Center Cluster Map



The Potential for a Data Center Cluster in Costa Rica. Harvard Business School Professor Michael Porter's cluster analysis will be used to assess the potential to develop a competitive data center cluster in Costa Rica, the findings of which are summarized below.

Exhibit 10: Cluster Competitiveness Diamond Analysis



Factor Conditions

The most important factor conditions for data centers, including electricity, internet connectivity, administrative requirements, financial capital and human resources, will be the focus of our analysis of factor conditions below.

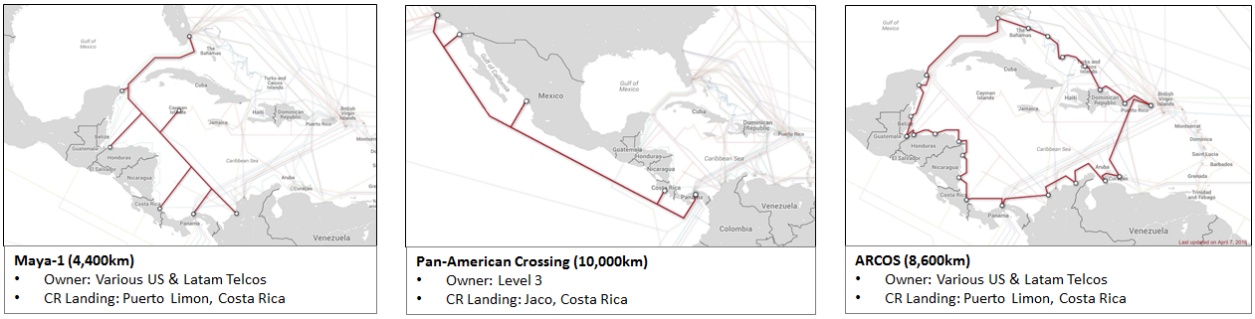
Electricity. Cost, reliability, and sustainability of the local energy supply is of the utmost importance to data center developers and operators, given that energy makes up well over 50% of ongoing operating cost for most data centers. At Facebook's data center in Northern Sweden,

for example, the company estimated that 65% of its ongoing operational cost would come from energy.[15] The cost of energy is driven by the design and efficiency of the data center itself, as well as the cost per kWh available from local energy providers, which stems both from the base cost per kWh and taxation rates. Data from Climatescope indicates that Costa Rica's industrial energy prices averaged $0.195 per kWh for commercial customers in 2014, and $0.153 per kWh for industrial customers.[16] While these prices represents a cost advantage over a few Central American neighbors, it appears to be a weakness as compared to many South American alternatives as well as the United States, whose industrial prices average just ~$0.07.[17] Costa Rica's relatively high energy prices are partially due to the fact that the energy supply relies very little on oil (which is currently at very low prices), but instead is made up of renewable sources such as solar, hydro, wind, and geothermal.[18] Additionally, unlike its neighbors, Costa Rica's energy sector remains state-run, which artificially lowers competition. According to one local Professor, while Costa Rica was once a leading innovator in the energy space, in particular through shifting to renewables, it has reportedly fallen behind from a cost and efficiency perspective as neighbors have privatized.[19]

Telecommunications. The majority of bandwidth arrives in Costa Rica via three fiber optic connections: the Pan-American Crossing landing in Jaco on the Pacific coast and the Maya-1 and ARCOS submarine cables landing at Puerto Limon on the Atlantic coast. These cables provide connectivity to Central American neighbors, as well as to US peering locations in Miami and San Francisco. Having multiple connections and at several locations provides redundancy, helping ensure uptime. However, neighboring Panama, leveraging its strategic asset the canal,

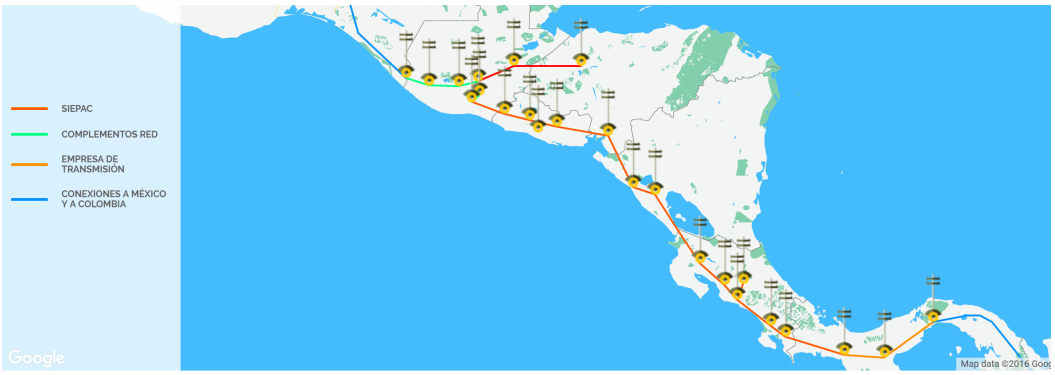
leads it to have more four submarine cables in addition to those connecting Costa Rica, providing connectivity from the Atlantic to the Pacific coasts of the Americas, as well as to South America.

Exhibit 11: Costa Rica Sea Cable Landings[20]



In speaking with Carlos Raul Gutierrez, the former Director of telecoms regulator SUTEL, price collusion has kept prices of international connectivity high on these cables. There is hope that once SIEPAC, an international terrestrial link connecting Colombia to Guatemala, is extended to connect to Mexico and thus the US (via Houston), this would help drive competition and bring prices down.

Exhibit 12: SIEPAC Terrestrial Broadband Link



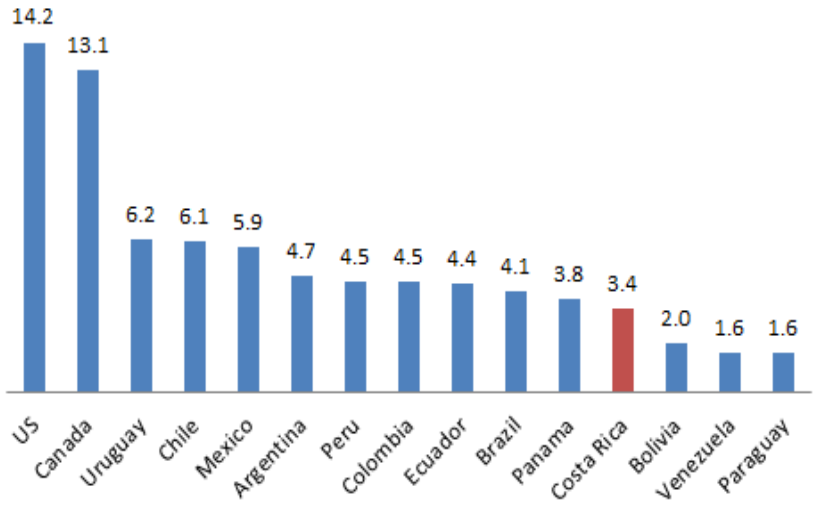
As San Jose is located in-land, national terrestrial fiber links then connect the submarine cables to the economic center where the network operation centers of the telecom operators are located. According to Fabian Segura, Broadband Representative for Costa Rica to the UN, the

prices on these long-haul links are quite high but coming down as competition increases in the country following telecom deregulation in 2011.[21]

The end-consumers of data centers also need a fiber optic link from their in-house servers to those of the data center provider, normally provided by a local ISP. According to IBM, the state of last mile infrastructure in Costa Rica is strong as compared to regional peers, having the highest broadband penetration in Central America. Furthermore, several operators, such as ICE-owned Kolbi and Cabletica, are deploying last mile fiber, increasing competition in this space.

While Costa Rica performs well as compared to most Central American peers in terms of broadband connectivity, when compared to other South or North American peers, or even Panama (see Exhibit 13 below) it still has room to improve.

Exhibit 13: Average Downlink Speed (Mbps) in Q4 2015[22]



Capital markets. Setting up a data center is very capital intensive, a typical data center having CAPEX of $200 per square foot, or $10M for a typical 50,000 square foot co-location facility.[23] As such, access to funding is important for driving growth in this sector. Historically Costa Rica has ranked very poorly in terms of capital markets, ranking 104 and 105 out of 134

for access to loans and access to venture capital funding, respectively on the Competitiveness Index. Weak investor protection (125/134), is likely one significant reason for the lack of development in capital markets.

However, in 2015 Costa Rica took significant strides in improving access to credit by adopting a new secured transactions law that establishes a functional secured transactions system and a modern, centralized, notice-based collateral registry. The law broadens the range of assets that can be used as collateral, allows a general description of assets granted as collateral and allows out-of-court enforcement of collateral.

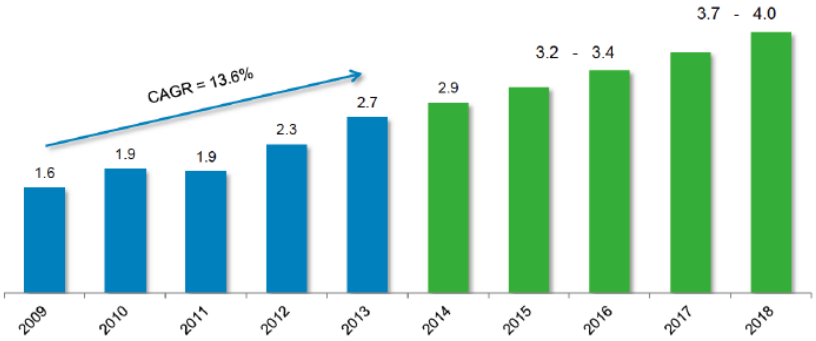
Administrative Burden. Another major hurdle for potential data center operators is the significant red-tape required, overall administrative infrastructure ranking 98 of 134 on the Competitiveness Index. Customs procedures, government regulation, and procedures/time to start a business all need significant improvement. A few relevant improvements include Costa Rica implementing an electronic system for filing corporate income tax in 2015 and launching an online platform to streamline building permits that integrates several agencies' approval processes.[24]

Availability of Scientists and Engineers. In Google's press release regarding locating a data center in Chile, it cited the quality of the local IT talent as being a driver in their decision.[25] This is despite data centers not being particularly human capital intensive. However, as data centers become increasingly complex due to value-added cloud and virtualization services, skilled talent could be more of a differentiator.

According to Gabriel Cambronero, CTO of Costa Rica Data Center Racklodge, Costa Rica has an abundance of technical talent thanks to quality of its education system and strength of its IT cluster.[26] It is by far the hub of talent in Central America, far outstripping even Panama,

and is ranking on par with Chile in the Competitiveness Index on this dimension. Furthermore, its labor-force has very strong English-proficiency, ranking #1 in Latin America on the TOEFL.

Exhibit 14: Costa Rica University Graduates in IT (000s)[27]



Demand Conditions

Global demand for data centers is projected to grow at 10% p.a., as large corporations increasingly outsource data management and adopt virtualization. Data storage has become increasingly commoditized, with large global players such as Amazon Web Services (AWS) seeking to drive costs down through the economies of scale achieved by consolidating facilities, locating these large centers in countries with low energy and bandwidth prices.

Unfortunately, as discussed above, Costa Rica is not globally competitive in terms of energy or bandwidth prices. Though attracting these mega-data centers may be challenging, there are other reasons why companies would choose to store data or host services nearby:

Lower latency. For both regional players as well as global companies with rising traffic in LATAM (e.g., Google, Facebook, Amazon), having commonly used content and services cached nearby improves speed, reducing latency. Amazon reports that for every 100ms of increased latency they lose 1% in sales,[28] meaning this has a huge impact for these major players.

Security and politics. From a security perspective, certain industries which control sensitive information (e.g. government, banking) have regulation that this data must be kept within the country.

Sustainability. Many large internet services companies have an environmental mandate as part of their CSR initiatives. Costa Rica in particular could be positioned as having greener energy vs countries such as the US and the UK. However, data center strongholds such as the Netherlands also have strong clean energy sources, so this is more a source of regional rather than global differentiation.

Cost. Latin America could offer a lower-cost construction and/or operating environment. However, the region cannot rely on just cheap labor as the main cost drivers for data centers are energy and broadband connectivity.

According to a DDC presentation, local demand for Data Center Services (cloud, storage, etc.) in Costa Rica comes primarily from the government sector, the financial sector, and the telecommunications companies. As the government currently scores very low (113/134) on the Competitiveness Index for adoption of advanced technology, there is likely unaddressed demand in this sector as it migrates its services online. As additionally detailed in a DDC presentation, there is a growing private market linked to multinational service companies located in free-zones such as HP, IBM, Emerson, Procter & Gamble, Amazon, etc. However, in speaking with numerous industry experts in Costa Rica, it is clear that while the Costa Rican market punches above its weight regionally in ICT and several local data center companies (e.g. CODISA, RackLodge) are expanding their facilities, its middle-income status and population of 4.8M (GDP of $49.6B in 2014, as tracked by the World Bank) creates too small a market to support a sizeable data center cluster based on local demand alone.

Should Costa Rica be able to position itself as the gateway to Latin America and/or hub for Central America, this would open up a much more sizeable opportunity. RackLodge, a data center provider with two data centers in Costa Rica and one in Miami, already has 70% of its demand coming from 22 countries globally, driven by the need to have a second (politically) stable location nearby its demand for redundancy purposes. Indeed, though Costa Rica is a regional haven for political stability, environmental stewardship and ICT cluster development, and has a telecoms infrastructure outpaced only by Panama, this may not be enough to attract demand if costs are not competitive. For instance, though (government-owned) ICE has a large Tier 3 data center near San Jose, it sits idle as prices are too high for the market to bear, the Costa Rican government not even opting to use its services.[29]

Context for Strategy and Rivalry

Local competition. Costa Rica currently has seven registered data centers, four of which have their own standalone facilities.

CODISA was built 10 years ago privately as the first Tier 3 data center in Costa Rica. It has since remained the biggest and most advanced data center.[30]

ICE is a state run internet provider with a data center that just meets Tier 3 standards. Its development was costly and in the five years since it opened the government is yet to use it for their data needs, with much of the facility underutilized[31]

RackLodge is part of a 3 network group (the third being in Miami). 70% of their customers come from 22 countries around the world. They serve casinos, code centers and banks. The group chose Costa Rica as a secondary location for backup and for the stability of the country with good infrastructure and good support resources. They are currently assessing potential locations in Costa Rica in which to build a Tier 4 center.[32]

There are currently no Tier 4 data centers in Costa Rica as demand has to-date been insufficient.

FDI and Trade. Costa Rica ranks very low (109/134) on the Competitiveness Index for its prevalence of trade barriers. With data centers potentially deriving significant portions of their revenues internationally, as well as sourcing equipment (e.g. servers) from international suppliers such as HP and Cisco, this could pose a barrier for cluster development.

Though typically these are targeted toward lightweight manufacturing, Zona Francas present a possible solution. Currently managed by PROCOMER, the government agency in charge of promoting Costa Rican exports abroad, the Zona Francas targeted towards the services sector provide the following fiscal incentives should a fixed assets investment of $150,000 within the Zona Franca or $2,000,000 outside the zone.[33]

Exhibit 15: Services Sector Fiscal Incentives in Costa Rica Zona Francas[34]

Fiscal Incentives	Period of Time	Tax
Income tax (statutory income tax = 30%)	8 years*	0%*
	4 years	15%
Remittances repatriation tax	No limit	0%
Local sales tax (13%)	No limit	0%
Import, export, excise taxes	No limit	0%

Supporting and Related Industries and Clusters

As was shown above in Exhibit 15, the data center cluster has a number of supporting industries on both the supply side (including IFCs) and demand side (such as the Costa Rican IT cluster).

IFCs. Since the mid-1990s, the Costa Rican government has implemented targeted FDI attraction policies, supported by the Costa Rica Investment Promotion Agency (CINDE), a private-public agency acting as a bridge between foreign multinationals and the government and offering post-investment services to foreign investors.[35] The World Bank ranked CINDE the #10 IPA (Investment Promotion Agency) in the world in 2009. Not only has CINDE played major

role in the winning of the $300M Intel microchip contract in 1996, which heralded a significant upgrade in the scope of FDI and the attraction of increasingly R&D intensive projects, but it has since worked together with other institutions such as the Inter-American Development Bank, venture capital funds and the INCAE Business School (#1 in Latin America) to continue increasing the technological sophistication of the cluster.[36] The sophistication of CINDE will be an important asset when getting Costa Rica on the "short-list" of potential data center locations of foreign customers.

The DCC is playing a key role in the promotion of a data center cluster in Costa Rica by hosting a series of data center summits, which attract 700+ attendees from Costa Rica, Colombia, Panamá, Dominican Republic. The sixth edition of this summit will take place in San José in August 2016.

IT Cluster. The IT cluster is dominant and growing in the Costa Rican economy. By the year 2012, Costa Rica hosted over one hundred multinational corporations specialized in business process outsourcing (BPO) and information technology outsourcing (ITO), as well as two hundred local firms, two research universities and two incubators, accounting for 10% of the Costa Rican labor force and 28% of national exports.[37] This cluster would not only provide an important supply of talent for the data center cluster, but also a source of local demand as these multinational and start-up firms increasingly employ cloud services and virtualization to manage their data storage and processing.

Though it ranks 16 of 134 on FDI and technology transfer on the Competitiveness Index and some local innovative firms have emerged, Costa Rica could still improve in its ability for nationally owned firms to establish fruitful linkages with foreign investors rather than be crowded out. A 2012 OECD study suggests MNCs tend to rely mostly on local suppliers for low

value-added services such as security, cleaning and packaging. With most data centers having low labor requirements and equipment being sourced from large international OEMs, it is unclear whether significant knowledge transfer would occur from a potential data center cluster.

Preliminary Evaluation: Costa Rica vs. US & Eight Regional Competitors. When co-location or enterprise companies consider potential locations for a new data center, they quickly narrow their screening process according to a number of key driving factors. As discussed above, we believe that Costa Rica would most often be considered against regional alternatives for those customers seeking a Latin American site. It is worth noting that, in a minority of cases where energy sustainability is the primary driver of location choice, Costa Rica may instead be compared globally against other clean energy havens such as Sweden, Finland, and Iceland. Therefore, our analysis compares Costa Rica vs. selected neighbors in Central America (Mexico, El Salvador, Nicaragua, and Panama), as well as South America (Brazil, Argentina, Chile, and Colombia), and the United States, is a historical data center hub.

The dimensions along which we compared this competitive set were derived from the Data Center Risk Index, a risk assessment and due diligence tool developed by Cushman & Wakefield (commercial real estate), hurleypalmerflatt (engineering consultants), and Source 8 (tech and security) as a quick weighted analysis of those elements most important to clients looking to build or invest in Data Centers.[38] This assessment does not, however, consider the important dimension of proximity to sufficient demand -- instead, it takes the simplifying assumption that the developer can locate anywhere. Furthermore, the Data Center Risk index has never been officially assessed for Latin American countries, simply due to the relatively smaller and emerging markets involved, as well as a lack of data available. Our analysis, therefore,

considers a Latin American competitive set along these same dimensions though with different data sources as available for this region.

In Exhibit 16, the box width corresponds directionally to the overall importance and weighting of each evaluation category in the Data Center Risk Index. Therefore, the most important drivers are seen to be (1) energy cost, including taxes (2) international bandwidth (3) and Ease of Doing Business, again, assuming there is sufficient demand to build. A poor environment along these key dimensions can easily take a country out of consideration for many developers, operators, or enterprises. Beyond these, it is important to consider (4) natural disaster risk (5) political stability (6) energy security (7) corporate tax and (8) sustainability.

Exhibit 16: Preliminary Competitive Evaluation of Costa Rica vs US and Regional Peers[39]

	Energy Cost	International Bandwidth	Ease of Doing Business	Natural Disaster Risk	Political Stability	Energy Security	Corporate Tax	Sustainability	Education	Labor Cost	Water Avail.	GDP per Capita	Inflation
United States	2	3	1	2	2	1	10	10	1	10	7	1	1
Costa Rica	7	2	5	10	1	7	4	1	2	7	6	7	7
Mexico	8	10	2	4	9	4	4	8	7	3	9	5	6
Panama	5	5	6	6	4	9	2	3	4	5	3	4	5
Nicaragua	10	9	10	8	7	10	4	7	8	2	5	10	9
El Salvador	9	8	7	9	8	8	4	5	10	1	10	9	1
Brazil	3	7	8	3	6	5	8	4	9	6	4	6	8
Chile	4	4	3	7	3	6	1	9	5	n/a	1	2	4
Argentina	1	6	9	1	5	2	9	6	3	4	8	3	10
Colombia	6	1	4	5	10	3	2	2	6	n/a	2	8	1

In conducting a high-level ranking of the competitive set along these dimensions, it becomes immediately evident that the overall region is not particularly strong along most dimensions, as illustrated by the abundance of red and yellow across the board. Latin America is perceived as higher risk along dimensions of bandwidth, ease of doing business, natural

disasters, and political stability, among others. Furthermore, while energy prices are often better than European options, most Latin American countries face energy costs well above the US.

As compared to the competitive set, Costa Rica appears to lag on two highly important dimensions -- energy prices, as discussed above, and natural disaster risk. Our rank of natural disaster risk was derived from the World Risk Index, a report by Alliance Development Works and the United Nations University Institute for Environment and Human Security, which systematically considers a country's exposure and susceptibility to natural hazards, as well as its coping and adaptive capacities to deal with such risk.[40] While Latin America is broadly seen as high risk, Costa Rica, El Salvador, and Guatemala are among the highest risk countries at the national level, with Costa Rica ranking #1 worldwide for urban natural disaster risk specifically.

Despite these limitations, the risk assessment in Exhibit 16 also reveals three core strengths for Costa Rica, as compared to regional competitors -- political stability, energy sustainability, and education. While these criteria are of lesser importance for most developers and operators as compared to energy cost and international bandwidth, for example, they give Costa Rica a tremendous boost as a regional competitor. For example, while Latin America overall still lacks the actual or perceived political stability of other global regions, Costa Rica is the most stable in the area. And, in technical education and energy sustainability, Costa Rica is truly world-class, gaining attention not just as a regional leader, but a global contender.

PART III: RECOMMENDATIONS / EVALUATIONS

This section of the paper will explore policy recommendations to increase the competitiveness of the cluster, including recommendations for national and regional governments, cluster participants, and other relevant stakeholders.

Factor Conditions	R1. Reduce Electricity Prices ➔ Privatize electricity sector to boost competition and drive down prices to keep pace with regional competitors and the US
	R2. Reduce Telecom Prices ➔ Improve SUTEL oversight of price collusion for the Maya-1 and ARCOS submarine cables ➔ Support finishing SIEPAC Guatemala - Mexico link
	R3. Improve Access to Capital ➔ Strengthen investor protections ➔ Create a telecoms infrastructure fund with project financing at attractive rates that can be accessed by data centers entrepreneurs
	R4. Reduce Administrative Burden ➔ Improve coordination between government agencies ➔ Increased adoption of e-Government to migrate procedures online
Demand Conditions	R6. Become the hub for Central American demand ➔ Increased government adoption of advanced technology to become a flagship customer for data centers ➔ Leverage CINDE's marketing prowess to ensure Costa Rica is on the short-list of data center locations for international customers
Context for Rivalry and Strategy	R7. Reduce trade barriers ➔ Reduce trade barriers for importing data center equipment and for exporting data center services ➔ Market the option of Zona Francas as an option for establishing Data Centers to potential investors
Supporting and Related Industries and Clusters	R8. Ensure coordination within the Data Center industry ➔ Leverage the knowledge and resources of DCC to ensure best chances of success and coordination across all stakeholders
	R9. Ensure cooperation with the IT cluster ➔ Include multinationals with in-house data centers in the data center cluster to improve technology transfer to local data center businesses

ENDNOTES

[1] DCD Intelligence
[2] Professor Michael E. Porter, International Cluster Competitiveness Project, Institute for Strategy and Competitiveness, Harvard Business School; Richard Bryden, Project Director.
[3] World Economic Forum. Executive Opinion Survey. The Global Competitiveness Report 2015-2016.
[4] CINDE based on data from Ministry of Public Education, CONARE, Universities' Registry Departments
[5] "The Global Competitiveness Report 2014–2015." Costa Rica Profile. World Economic Forum
[6] OECD Economic Survey on Costa Rica
[7] "The Global Competitiveness Report 2014–2015." Costa Rica Profile. World Economic Forum.
[8] Quirós, Fernando. "Hope for Cutting Red Tape in Costa Rica? -." The Tico Times. FDi Intelligence, 07 Sept. 2012. Web. 05 May 2016.
[9] "The Global Competitiveness Report 2014–2015." Costa Rica Profile. World Economic Forum.
[10] Gite, Vivek. "Explain: Tier 1 / Tier 2 / Tier 3 / Tier 4 Data Center" cyberciti.biz, January 29, 2011 http://www.cyberciti.biz/faq/data-center-standard-overview/, accessed April 2016
[11] Unknown author, "Data Center Map" datacentermap.com. http://www.datacentermap.com/, accessed April 2016
[12] Celeste Clipp, Hannah Larby, Fredrik Lind, Andreas Lundmark and Magnus Morin. "Digital Infrastructure and Economic Development". (June 2014). BCG Research, accessed June 2016
[13] Colocation Facilities in the US, IBISWorld, accessed April 2016
[14] "Quilicura, Chile – Data Centers – Google." Quilicura, Chile – Data Centers – Google. N.p., n.d. Web. 04 May 2016.
[15] Celeste Clipp, Hannah Larby, Fredrik Lind, Andreas Lundmark and Magnus Morin. "Digital Infrastructure and Economic Development". (June 2014). BCG Research, accessed June 2016.
[16] "The Clean Energy Country Competitiveness Index." Climatescope, 2014. (Raw data supporting report).
[17] Ascierto, Rhonda, and Andy Lawrence. "Will Energy Prices Power US Datacenter Growth or Short-circuit Energy Efficiency?" Will Energy Prices Power US Datacenter Growth or Short-circuit Energy Efficiency?451 Research, 27 Feb. 2013. Web. 05 May 2016.
[18] Mellino, Cole. "Costa Rica Powers 285 Days of 2015 With 100% Renewable Energy." EcoWatch. 24 Dec. 2015. Web. 05 Apr. 2016.
[19] Interview with Niels Ketelhohn, Professor of Strategy and Competitiveness at INCAE Business School in Nicaragua, March 29, 2016.
[20] "Submarine Cable Map." *Http://www.submarinecablemap.com/*. Telegraphy, n.d. Web. 05 May 2016.
[21] Segura, Fabian. Interview by authors. Boston, MA, April 7, 2016
[22] Akamai State of the Internet Report
[23] Sampera, Ernest. "Data Center Building vs. Outsourcing: What's Best For Your Business | Data Center Knowledge." Data Center Knowledge. N.p., 11 Feb. 2015. Web. 05 May 2016.
[24] World Bank Ease of Doing Business Report
[25] "Quilicura, Chile – Data Centers – Google." Quilicura, Chile – Data Centers – Google. N.p., n.d. Web. 04 May 2016.
[26] Cambronero, Gabriel. Interview by authors. Boston, MA, April 20, 2016

[27] CINDE based on data from CONARE & Universities' Registry Departments
[28] Eaton, Kit. "How One Second Could Cost Amazon $1.6 Billion In Sales." Fast Company. N.p., n.d. Web. 05 May 2016.
[29] Morales Acosta, Rosalia. Interview by authors. Boston, MA, April 8, 2016
[30] Morales Acosta, Rosalia. Interview by authors. Boston, MA, April 8, 2016
[31] Morales Acosta, Rosalia. Interview by authors. Boston, MA, April 8, 2016
[32] Cambronero, Gabriel. Interview by authors. Boston, MA, April 20, 2016
[33] DCC Presentation
[34] DCC Presentation
[35] The Innovation Policy Platform - World Bank
[36] Silicon Valleys of Latin America - European Business Review
[37] Silicon Valleys of Latin America - European Business Review
[38] Source 8, Hurleypalmerflatt, and Cushman & Wakefield. Data Centre Risk Index. Rep. N.p.: n.p., 2013. Print.
[39] Notes: Width of of box corresponds to importance/weighting of criteria (illustrative); number indicates relative ranking within 10 markets shown here; color indicates magnitude / relative performance globally (illustrative)
Sources: Climatescope, WEF, World Bank, WRI (World Risk Index / Trilemma Index), KPMG, New Global Competitiveness Index, ILO, IndexMundi / Food & Agriculture Assn. Evaluation adapted from Data Center Risk Index (C&W, Source8, hurleypalmerflatt).
[40] World Risk Report 2014." Alliance Development Works and the United Nations University Institute for Environment and Human Security. Web. 12 Apr. 2016.