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**Harnessing the Power of ICT and Innovation  
Case Study Singapore**

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**Summary:** The penetration and effects of ICT varies amongst countries. For small countries like Singapore the effects of ICT is especially prominent. This paper focuses on how Singapore exploited the benefits of ICT by analyzing first the evolution of ICT policies and the important role of the government in its development. Followed by the question how ICT has impacted the country. Looking at the impact of ICT both in the ICT sector as well as the penetration of ICT in households. The conclusions refer to additional actions that the government should focus on to further exploit the benefits of ICT in Singapore.

**Zusammenfassung:** Die Reichweite und Effekte durch IKT unterscheiden sich innerhalb verschiedener Länder. Für kleine Länder wie Singapur sind die Effekte, die sich durch IKT ergeben, besonders relevant. Diese Arbeit konzentriert sich auf die Vorteile, die sich durch die Nutzung von IKT für Singapur ergeben. Hierzu wird zuerst die Entwicklung der Strategien im Bereich IKT und die entscheidende Rolle der Regierung in ihrer Entwicklung analysiert. Im weiteren wird der Einfluss dieser Entwicklungen auf das gesamte Land dargestellt. Dieser Einfluss wird sowohl anhand des Sektors IKT, als auch mit Blick auf die IKT-Verfügbarkeit innerhalb aller Haushalte in Singapur erläutert. Eine Auswahl an notwendigen Schritten für die Regierung wird dargestellt, die sicherstellen sollen einen anhaltenden Nutzen und eine positive Entwicklung im Bereich IKT.



# **Harnessing the Power of ICT and Innovation**

## **Case Study Singapore**

Discussion Paper 203

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# **1. Introduction**

## **1.1 What is ICT?**

Since economist Solow included technical change as a factor for economic growth (Solow, 1957), there has been ever increasing emphasis on the importance of general purpose technologies (GPT), which is characterized by the pervasiveness (used as inputs by many downstream industries); technological dynamism (inherent potential for technical improvements) and innovation complementarities with other forms of advancement). Thus GPT should have positive feedbacks on the economy bringing about an overall productivity gain. With this definition, Information and Communication technology (ICT) can be seen as a GPT, as it is a driver for innovation, productivity and efficiency gains across industries; it also improves the social wellbeing of people by allowing information to be readily available.

The penetration and effects of ICT varies amongst countries. For small countries like Singapore the effects of ICT is especially prominent. Hence this paper shall focus on the way ICT has managed to transform Singapore, with a mere land size of 712.4 km<sup>2</sup> and a population of 5 million, into a country that is known for its highly competitive and efficient workforce amongst other things. It should be noted that there are many factors that have contributed to Singapore's success. However the focus of this paper shall be on the positive impact of ICT and how it has facilitated Singapore's competitiveness. This paper shall start with a brief introduction about Singapore. Followed by a run through of the evolution of the ICT policy and the important role the government plays in the development of ICT. Followed by an analysis of how ICT has impacted Singapore. In order to see the impacts of ICT, the paper will refer to Singapore's ICT producing sector, ICT penetration and the effects of using ICT, with reference to e-government as a case study. Lastly the paper shall discuss about the direct positive impact of ICT in Singapore, ending with an example of how innovation and ICT interact, thereby enabling Singapore to have competitive advantage over other countries.

## **1.2 About Singapore**

In the recent Global Competitiveness report 2011, which is based on the Global Competitiveness Index, developed for the World Economic Forum that gauges 12 pillars of competitiveness, providing a comprehensive picture of the competitiveness landscape in countries, Singapore was ranked 3rd after Switzerland and Sweden and 1st in Asia. Singapore was also ranked 1st both in the lack of corruption in the country and efficiency of the government. (WEF, 2009) A country with no natural resources, apart from human resources, Singapore had an annual growth rate of 14.5% in year 2010. There are certain key ingredients for the Singapore success story and that is a combination of Singapore's strategic location together with its visionary government.

Singapore is strategically located on major sea-lanes hence giving it economic importance in Southeast Asia (SEA). Due to its geographical location, Singapore is positioning itself as a hub with focus on being a service centre and logistics base in SEA (Yue, C. S., & Lim, J. J., 2003). The Hub strategy is based on the understanding that the key economic activities such as finance, shipping, air, transport, telecommunication and information converge in a few strategic locations around the world (Yue, C. S., & Lim, J. J., 2003). An example of a successful Hub strategy in Singapore is the financial sector. Ranked 2nd according to the global competitive report for its financial sophistication, as it provides a wide range of financial services (WEF, 2010).

In line with the hub strategy, the government has invested in both “upstream capacities” such as research and development (R&D), product design, application development and “downstream services” such as logistics, transportations, etc (WEF, 2009) together with ICT as an intermediate input. ICT acts as a multiplier for economic growth as it increases the flow of goods and services across countries by reducing both transportation and information cost as well as reducing barriers. Furthermore ICT creates and improves trade by connecting people and places previously isolated, thereby accelerating the generation of new ideas. Hence Singapore tries to secure the first-mover agglomerative advantage by laying the foundations with a pro business, pro foreign direct investment (FDI), export orientated and ICT focused economic policy framework. Thus securing Singapore’s position as a competitive nation.

## **2. ICT Policy**

### **2.1 ICT Plan timeline**

The national ICT plans started in early 80s which an aim to improve efficiency within the government sector through the computerization of the public sector. This first step planted the seed for greater development in ICT. In the early stage, information technologies are imported from multinational companies (MNC) thus drawing upon 2nd mover advantage by learning from the industrialized nations. The National IT plan developed in 1986 saw the beginning of the development of ICT especially in the private sector. Furthermore the education system was reworked to include more mathematical and technical aspect so as to prepare and expose the workforce to future ICT use. During this early stages, research and development (R&D) were still scares (Lim, 2003).

1992 to 1997 saw the beginning of the liberalization within the telecommunication sector. This resulted in the fall in the cost of ICT thus benefitting small medium enterprise (SMEs). Much of the IT2000 Plan aims at planning the infrastructure for ICT. An example would be Singapore ONE network, which is the setting up of broadband network. In addition to infrastructure the IT2000 plan also aims to improve the quality of life using ICT (Choo, 1995).

The next two phases of the ICT plans are Infocomm 21, which was formulated in 2000. The main aim of this plan is to develop Singapore into a global ICT capital, which is market-driven, private sector oriented and global in outlook. The most current plan in 2006 called the intelligence nation 2015 (iN2015). The strategy employed in this plan is to transform key economic sectors, government and society through more sophisticated and innovative use of ICT. The government also has the ambitious plan to develop a globally competitive ICT industry within Singapore (IDA, 2010).

Figure 1 below gives a summary of the ICT plans throughout the year. The table charts the evolution of ICT policies in Singapore. This timeline reflects the changes in the focus of the government, which reflects how the ICT policies adapt to the development and growth of the country as well as on an international scale.

**Figure 1: ICT Plan Timeline**

	IT Plan	Target Group	Strategic Goal
1980-1985	Civil Service Computerization	Public Sector: Government ministries, department	-Raise productivity -Improve Service -Develop IT manpower
1986-1991	National IT Plan	Public Sector: IT industry, Local companies	-Develop local IT industry -Promote Business use of IT -IT R&D
1992-2000	IT2000 Plan	Industry sectors, communities, Individuals	-Increase national competitiveness -Improve quality of life
2000-2005	Infocomm 21	Public and Private sectors: MNCs, Individuals	-Develop innovative ICT -Grow ICT sector -Increase ICT human capital
2006-2011	iN2015	All levels of Society	-Greater emphasis on innovative use of ICT - Strengthen ICT infrastructure. Eg: High-speed and trusted network -Develop Infocomm-savvy workforce

Source: National Computer Policy Management in Singapore and Own interpretation

## 2.2 Role of the government

The government can be seen as the master planner for ICT in Singapore. Starting early in the 1980s with the aim to improve efficiency to its current goals in transforming the ICT industry on a competitive level, it is evident that the government plays a massive role. The

government body implementing policies and regulatory framework that create a favorable environment for ICT in Singapore is the Infocomm Development Authority of Singapore (IDA). For a small city-state like Singapore, the role of the government is unique; with its top down approach on the implementation of ICT policies, it could be recognized as the main factor for the successful exploitation of the benefits of ICT. Furthermore, Bassanini and Stefano had found a correlation between regulation policies and the rate of penetration of new technologies, such as ICT. Based on the world economic forum's network readiness Index 2010- 2011, Singapore was ranked 2 in the world for network readiness. Of the 3 pillars used to measure network readiness, Singapore is ranked 1<sup>st</sup> in the sub categories; Political and regulatory environment, individual readiness and government readiness. Furthermore the biggest organization using ICT is the government itself. Based on the same report, government usage is also ranked 3<sup>rd</sup> in the world. E-government shall be further elaborated later in the paper.

Due to the dynamic nature of ICT, the government is aware that there are many dimensions to the ICT sector. Hence the policies adapted by the Singapore government incorporate additional factors that will compliment that usage of ICT such as integrating the use of ICT in the early stages of education. Similar to the nation wide ICT plans, the use of ICT in education also has its own master plan, which is inline with the national ICT master plan.

Furthermore the government is active in nurturing the ICT industry. Not only does the government encourage the creation of local ICT companies in Singapore, there are also multiple programs to assist local ICT companies to expand overseas, such as the Overseas Development Programme (ODP) and the Infocomm Local Industry Upgrading Programme (iLIUP). Since 2002, iLIUP has assisted to develop more than 560 new or enhanced products/solutions and gained more than \$198million revenue (IDA, 2010). In addition to these programs, the IDA has also set up a venture capital firm, called Infocomm Investment, managing more than US\$200million worth of fund, investing in IT startups both local and international.

In September 2011, Google has planned to boost Asian presence by building a data center worth an estimated of US\$120m in Singapore. Quoting Google, *"Singapore offers an ideal combination of reliable infrastructure, a skilled workforce and a commitment to transparent and business friendly regulations"* Hence these are some instances where the government has played a huge role in enhancing the competitiveness of the ICT sector in Singapore.

### 3. ICT in Singapore

#### 3.1 ICT Manufacturing Sector in Singapore

IDA has broadly defined ICT into 5 main segments, which are Hardware, Software, IT services, Telecommunication Services and content Services (IDA, 2009). Based on the most recent figures available, the infocomm industry revenue grew by 12% to reach \$70.39 billion in 2010 from \$62.74 billion in 2009. When we look at the structure of the Singapore economy, the increase in revenue has an impact on economic growth, as the manufacturing sector contributes to the highest amount of growth, which is evident when 22.2% of its real GDP comes from the manufacturing sector. From Table 1 below we are able to see the overall economic structure of the Singapore economy.

**Table 1: Overall Economy, 2010**

Structure of Economy	Nominal Value-Added (% Share)	Real Growth (%)
<b>TOTAL</b>	100.0	14.5
<b>Goods Producing Industries</b>	28.3	25.0
<b>Manufacturing</b>	22.2	29.7
<b>Construction</b>	4.5	6.1
<b>Utilities</b>	1.5	6.5
<b>Other Goods Industries</b>	0.0	-0.1
<b>Services Producing Industries</b>	67.6	10.5
<b>Wholesale &amp; Retail Trade</b>	16.5	15.1
<b>Transport &amp; Storage</b>	8.6	6.0
<b>Hotels &amp; Restaurants</b>	2.2	8.8
<b>Information &amp; Communications</b>	3.6	2.9
<b>Financial Services</b>	11.9	12.2
<b>Business Services</b>	14.0	5.9
<b>Other Services Industries</b>	10.7	14.3

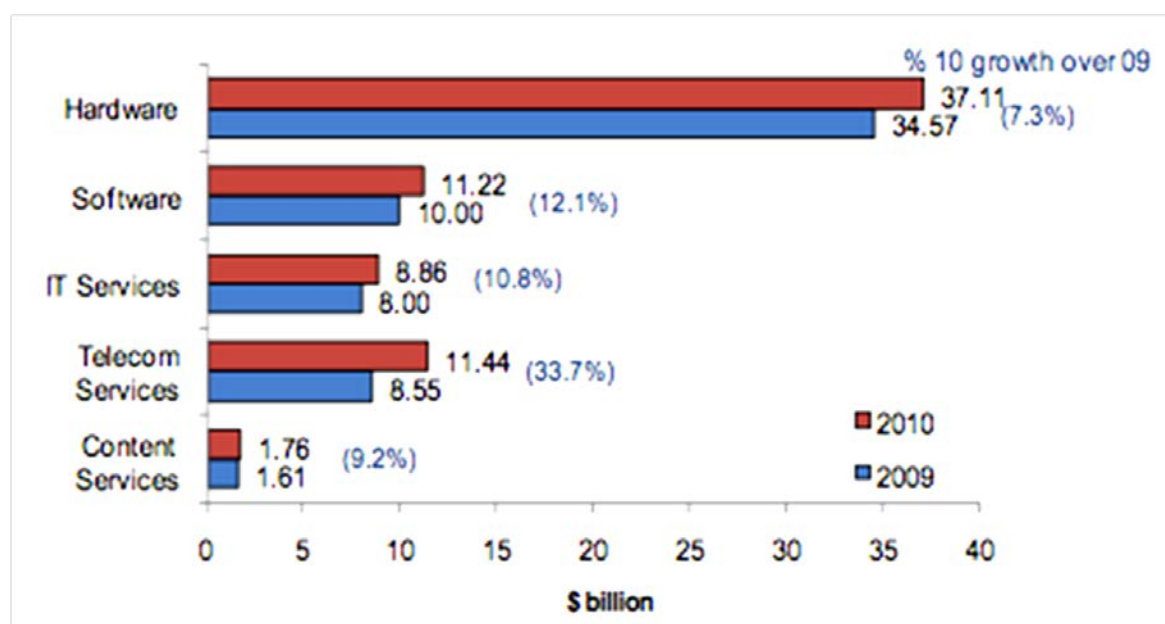
Source: Ministry of Trade and Industry

Based on the sectoral breakdown, which is then reflected in the Table 2 below, we are able to see that 31.4% of the manufactured goods are for electronics. The electronic sector consists of Semiconductor, Electronics components, Electronics Systems and Infocomm Products (EDB, 2011). The Hardware segment, which falls under electronic systems, remains the major contributor to the infocomm manufacturing industry revenue, with a share of 53% of the revenue and the Software and Telecom Services segment contributed 16% each to the revenue. The revenue by market segment is shown in Figure 2 below.

**Table 2: Manufacturing Sectoral Breakdown 2010**

MANUFACTURING	Nominal Value-Added (% Share)	Real Growth (%)
Manufacturing	100.0	29.7
Electronics	31.4	35.5
Chemicals	10.7	12.9
Biomedical Manufacturing	19.6	49.8
Precision Engineering	13.4	40.1
Transport Engineering	14.7	-4.6
General Manufacturing Industries	10.3	10.7

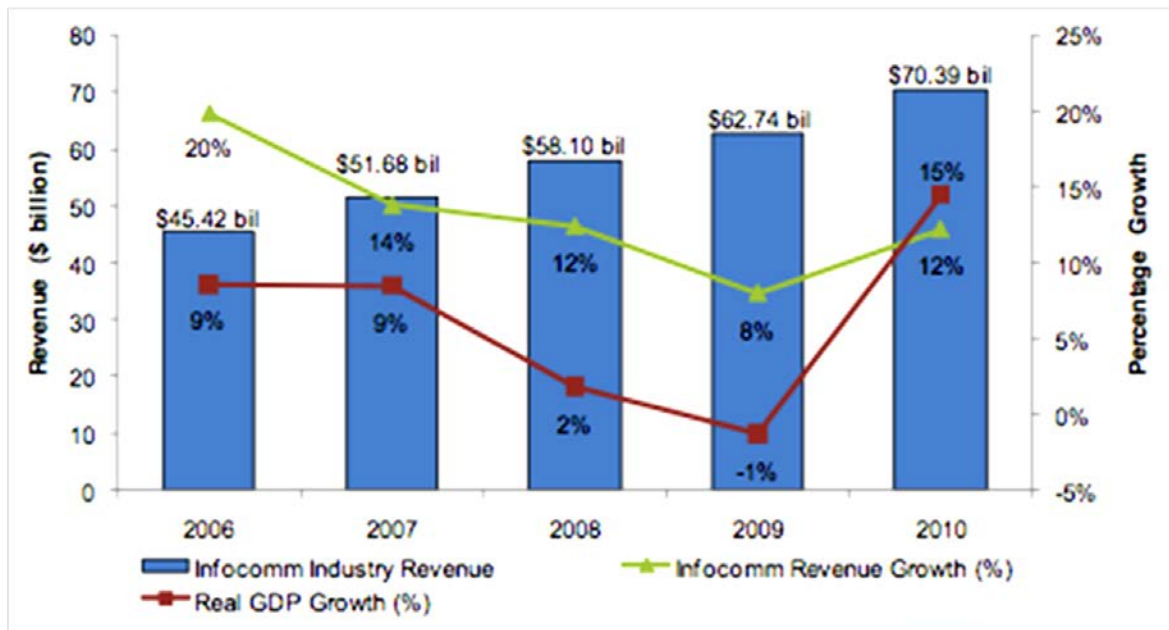
Source: Ministry of Trade and Industry

**Figure 2: Infocomm Industry revenue by market segment 2010 over 2009**

Source: IDA

Overall, the Infocomm manufacturing sector remains one of the engines of growth of the Singapore economy, which can be seen from the increasing revenue generated from the Infocomm industry in Figure 3 below.

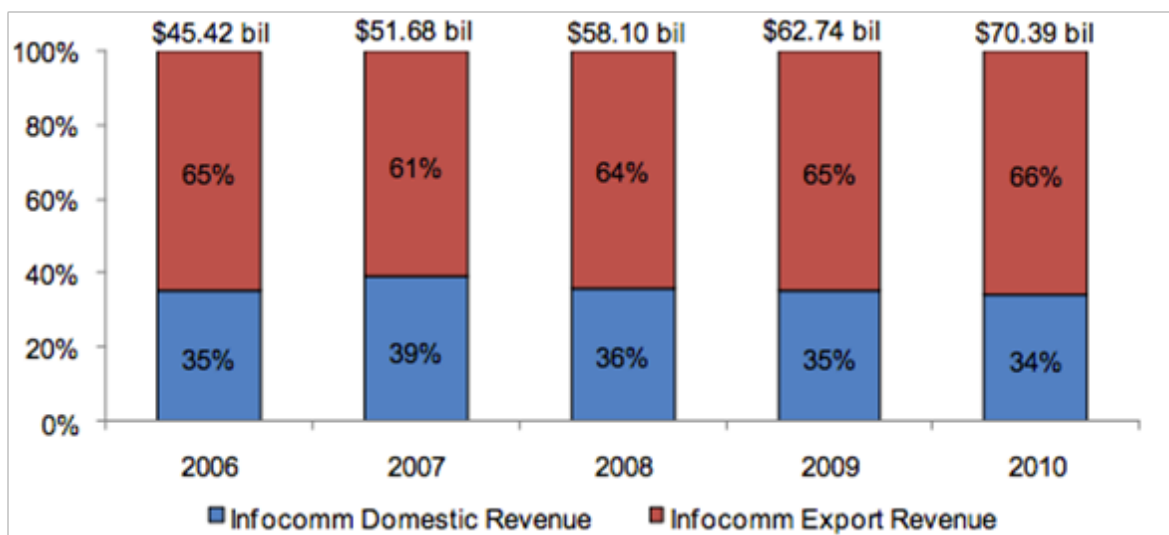
**Figure 3: Overall Infocomm Industry Revenue Growth 2006-2010**



Source: IDA

Much of the ICT hardware manufactured in Singapore are re-exported to the rest of the world and more than half of the export revenue was attributed to exports to the regions in Asia, with ASEAN as the top destination. Figure 4 below shows a comparison of the infocomm Domestic/export revenue Composition.

**Figure 4: Infocomm domestic/export revenue composition, 2006-2010 Annual**

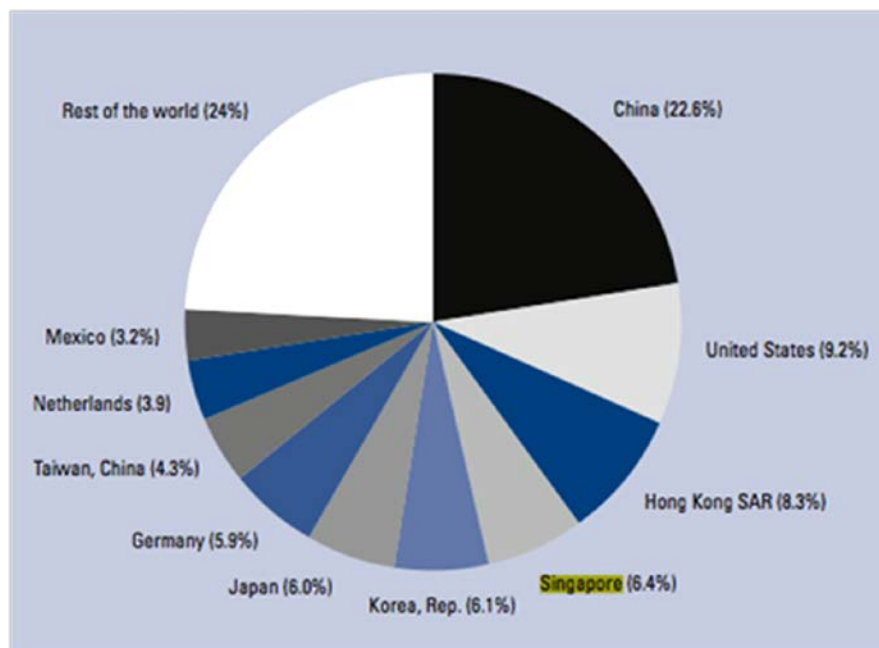


Source: IDA

On a global level, Singapore, albeit having less than 1% of the worlds GDP share, is a significant contributor to the export of ICT goods. With reference to figure 5 below, we are able to see that Singapore was one of the top exporters of ICT goods in 2008. The significance of Singapore as one of the top contributor of ICT goods, also highlights the

importance of ICT manufacturing on its economy, with an export valued at \$358.4 billion in 2010, which equates to being the world's top 13 exporter in terms of value.

**Figure 5: Global Exports of ICT goods by market share of top exporters, 2008**



Source: UNCTAD

## 3.2 ICT Penetration

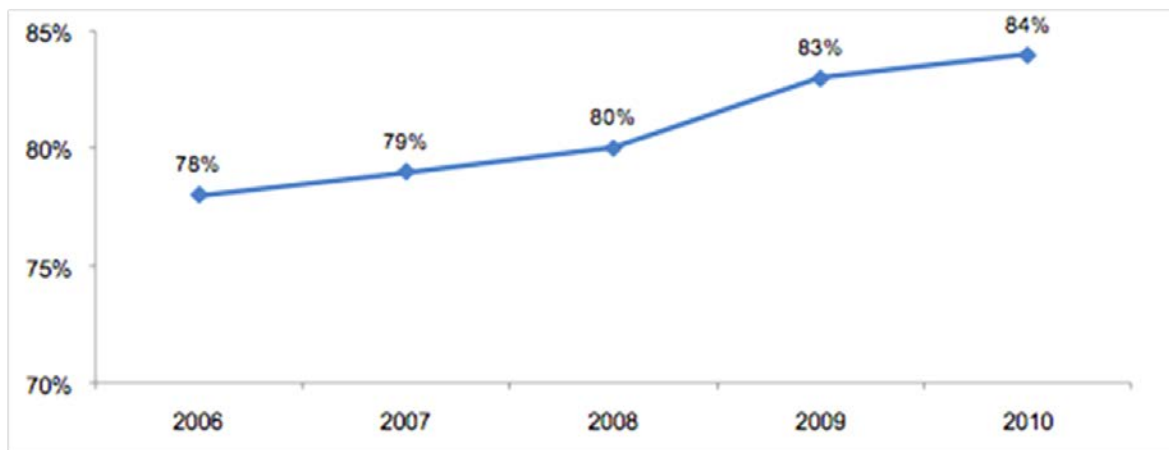
### 3.2.1 ICT at Home

There are indirect impacts of ICT on Singapore, which results in long run economic growth for Singapore, as there is a correlation between the use of ICT and positive macroeconomic growth (WEF, 2009). Based on OECD, to measure the economic impact of ICT, an indicator of ICT diffusion is the share of ICT in investment (OECD, 2003). Furthermore, ICT investment provides a higher contribution to GDP growth compared to non-ICT investment (MAS, 2009).

In the case of Singapore, laying the foundation of ICT remained the task of the government in the early stages. One such instance is the development of the National Infocomm Infrastructure (NII), which was a key initiative of the IT 2000 Masterplan, which aims to transform Singapore into an intelligent island, with the building of a high-speed nation wide broadband network (Choo, 1997). On a national level, household access to Broadband between 2006-2010 has been steadily increasing, as reflected in Figure 6 below.



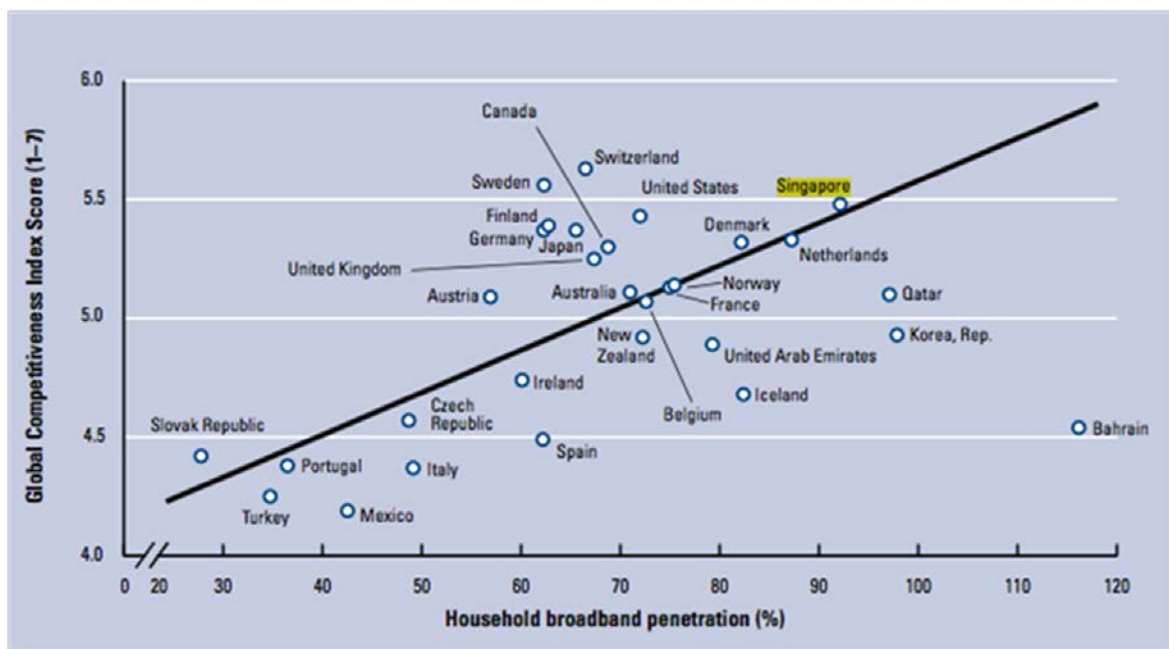
**Figure 6: Household Access to Broadband, 2006-2010 Annual**



Source: IDA's Annual Surveys

To further reiterate the correlation between Broadband penetration and competitiveness of Singapore, figure 7 below positions Singapore on the world map drawing the link between Broadband and competitiveness, where competitiveness is defined by the World Economic Forum as the set of institutions, policies, and factors that determine the level of productivity of a country. From the figure, we could also see that, while there are some outliers, such as Bahrain that has a very high household broadband penetration, it is not nearly as competitive as the other countries, nonetheless most of the countries along the 45degree axis reflects countries with a moderately high level of broadband penetration and are competitive at the same time such as Switzerland.

**Figure 7: Competitiveness vs. Broadband penetration, 2010**



Source: World Economic forum, 2010

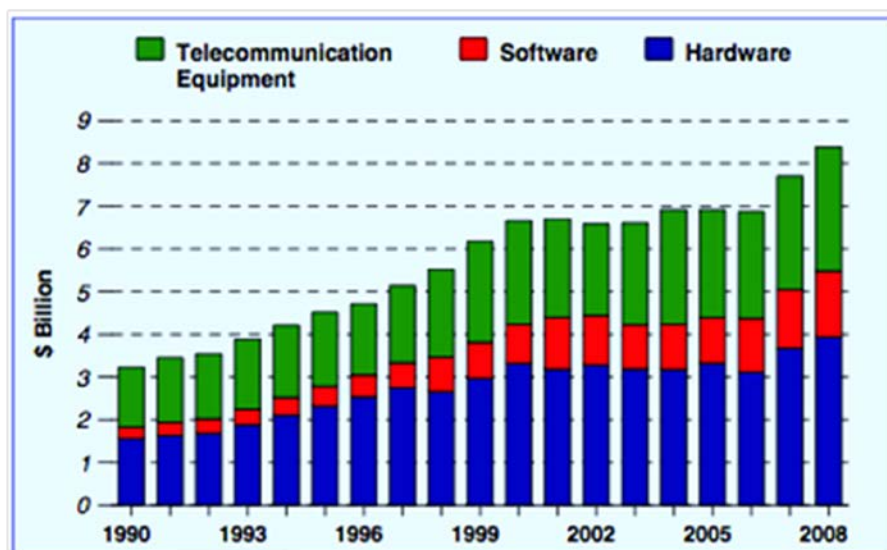
On a global level, Singapore was ranked 2<sup>nd</sup> of the Global Information Technology Report 2010-2011, after Sweden. The framework gauges for this report are based on the conduciveness of the national environment for ICT development and diffusion, including the broad business climate, regulatory aspects and human and hard infrastructure needed for ICT, followed by the degree of preparation for the interest in using ICT by individuals, business sector and the government and lastly the actual use of ICT in the society (Dutta & Mia, 2011).

### 3.2.2 ICT in the Private sector

According to the Monetary Authority of Singapore (MAS), ICT investment consists of three types of capital goods formation, which are computer hardware, computer software and telecommunication equipment (MAS, 2009). Investment in ICT directly impacts economic growth as it adds to the capital stock that is available for workers, thus raises labor productivity. The ICT-producing sector itself is also a source of growth, as explained above, with regards to the electronic manufacturing sector in Singapore as it is an important economic driver. In addition, the use of ICT enhances the total productivity factor by increasing the firms' efficiency by combining labor and capital inputs (MAS, 2009).

In Singapore, over the period of 1990-2008, overall ICT investment, on average increased by 5.5% per annum. Figure 8 below presents a breakdown by the type of ICT investments over the years. Hardware remains the highest form of ICT investment in Singapore. While the importance of software investment has been increasing since 1990.

**Figure 8: Types of ICT investment in Singapore**



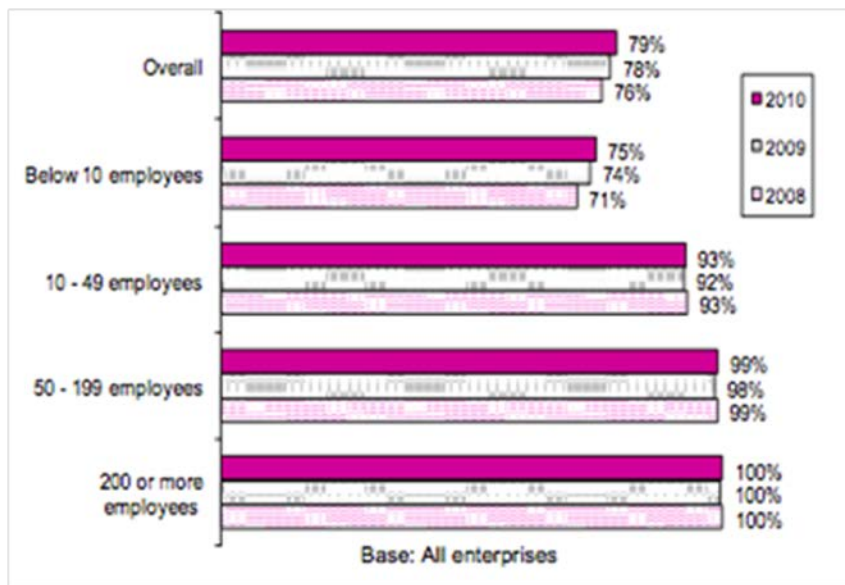
Source: EPG MAS Estimates

The use of ICT in business reflects the extent to which business have access to high speed internet and are part of the digital world of information. Faster download times allow business to be better connected, to work faster and more efficiently, thus reducing cost and

offering more or even better services online to their clients. By making business transactions more smooth and efficient, it lowers the cost of transactions and makes companies more competitive in the global arena (INSEAD, 2010).

In order to ensure that all levels of society are involved in the use of ICT, Infocomm@SME is a program by IDA that helps SMEs to adopt Infocomm for greater competitive and growth. SMEs as defined by the Singapore government are firms having a net fixed asset investment of less than \$15 million and fewer than 200 employees. In 2010, the proportion of enterprises that used computer and the Internet increased slightly from 79% and 77% respectively. While Broadband usage grew by 4% to reach 73%. Figure 9 reflects the computer usage by employment size.

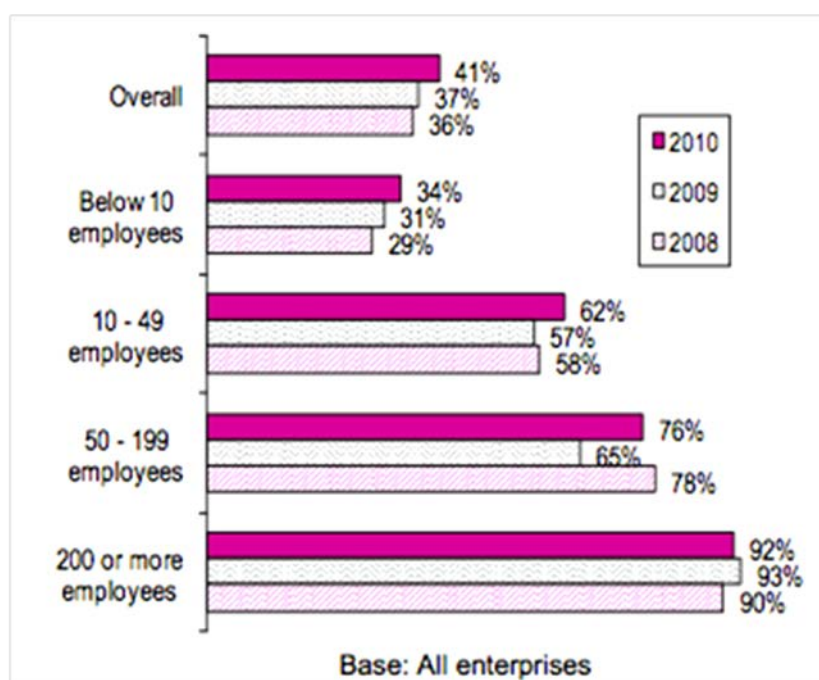
**Figure 9: Computer usage by employment size**



Source: IDA

Figure 10 below reflects the web presence by enterprise size. Web presence could be in the form of a website, home page or presence on another entity's website, blog sites or webpage listed at an online directory. From figure 10 below, it can be seen that while the year on year web presence of companies is increasing, there is still a lag in the adoption of ICT in smaller companies relative to the progress of larger companies in the integration of ICT.

**Figure 10: Web presence by employment size**



Source: IDA

### 3.2.3 Use of ICT case study: E-Government

Singapore's e-Government began with the Civil Service Computerization Program (CSCP) as part of the National Computerization Plan, in the early 80's. Since then, e-Government has evolved into a more interactive online platform where government interacts with both business and the citizens. The evolution of the E-Government master plan is always in line with the goals and aim of the national ICT master plan. A few of the initiative by the Government through out the years are, Mobile Government (mGov) which was launched in June 2011 to increase services to the public by jumping on the bandwagon of the mobile technology progress. Using the high mobile penetration rate in Singapore to offer feature-rich and innovative mobile services. Another initiate is the Singapore OnLine Portal (SGOL Portal) that unifies all government information and services electronically on four different segments, namely the Government segment, the citizens and Residents segment (or eCitizens), the business segment (or EnterpriseOne) and the Non-Residents Segment (IDA, 2011).

To measure the success of Singapore's e-Government, e-Government Perception Surveys on Business and the Public determines the level of receptivity, adoption and satisfaction. Surveying 1,629 businesses in 2009, an increasing number of business from 76% in 2008 to 80% in 2009 that had visited the EnterpriseOne website were satisfied with the overall quality of the website. Similarly, surveying 1,200 individuals, 66% of the respondents were satisfied with the quality of the Government electronic services and 93% would recommend Government electronic services to others. (IDA, 2011)

In addition to the satisfaction of the users in Singapore, the success of e-government framework has also been exported overseas. The Singapore Cooperation Enterprise, which exports the Singapore urbanization blueprint to developing countries, has given advices on e-government to Bhutan and Tanzania. Hence e-government can be seen as the biggest organization benefiting from the use of ICT and having the largest outreach to the public.

## **4. Positive Effects of ICT**

### **4.1 Contribution to Economic Growth**

One of the positive effects of ICT is economic growth. Using the simple Cobb-Douglas production function  $Y=ALaK^b$ , where Y is the total output, L is the labor input, K is the capital input and A is the total factor productivity. ICT investment is seen to increase total productivity (A) as well capital input (K) (Bassanini & Scarpetta, 2002). Jorgenson and Vu (2008) employed the Cobb- Douglas production function to project economic growth taking into account the contribution of ICT. Table 3 below is based on the figures from the paper. It shows Singapore's growth decomposition compared to the average of the world, three separate country groupings comprising the G7, industrialized non-G7 countries and developing Asia. From the table we are able to see that ICT as a capital input has a positive impact to GDP growth of Singapore and this impact remains above world indicators but lower than that of the industrialized countries (Vu, 2009). In terms of its share in GDP growth, the contribution of ICT has been relatively stable at about 13%.

**Table 3: Contribution of ICT Capital and Non-ICT Capital to GDP Growth**

		Singapore*	World	Industrialised Countries		Developing Asia
				G7	Non-G7	
% Point Contribution						
1990-99	GDP Growth	7.6	2.8	2.5	2.7	6.7
	Capital Input	4.5	1.5	1.5	1.3	2.9
	ICT	1.1	0.40	0.54	0.47	0.24
	Non-ICT	3.4	1.1	1.0	0.86	2.7
	Other Sources	3.1	1.3	0.95	1.4	3.8
2000-08	GDP Growth	4.9	3.9	2.0	2.7	7.3
	Capital Input	2.3	1.6	1.2	1.5	2.9
	ICT	0.70	0.43	0.45	0.47	0.46
	Non-ICT	1.6	1.2	0.72	1.1	2.5
	Other Sources	2.6	2.3	0.84	1.2	4.4
% Share						
1990-99	GDP Growth	100	100	100	100	100
	Capital Input	59	54	62	49	43
	ICT	14	14	22	18	3.6
	Non-ICT	44	40	40	32	40
	Other Sources	41	46	38	51	57
2000-08	GDP Growth	100	100	100	100	100
	Capital Input	46	41	58	57	40
	ICT	13	11	23	18	6.3
	Non-ICT	33	30	36	39	34
	Other Sources	54	59	42	43	60

Source: Jorgenson and Vu (2007) with updated data from MAS

Furthermore, ICT can also be seen as a contributor to the increase in labor productivity. With reference to table 4 below, we are able to see that ICT capital deepening has contributed to a 0.2% point increase in contribution between the years 2000-2009 and base on a percentage share of labor productivity growth, ICT capital deepening has a share of 19% during the same period. Hence the effects of ICT capital investment have multiple positive effects to all factor inputs.

**Table 4: Source of labor productivity growth**

	1990-99	2000-09
<b>% Point Contribution</b>		
<b>Labour Productivity Growth</b>	<b>3.4</b>	<b>1.1</b>
Capital Deepening	2.4	0.4
<i>ICT Capital</i>	0.8	0.2
<i>Non-ICT Capital</i>	1.6	0.2
Labour Quality	0.1	0.5
TFP	0.9	0.2
<b>% Share</b>		
<b>Labour Productivity Growth</b>	<b>100</b>	<b>100</b>
Capital Deepening	73	32
<i>ICT Capital</i>	25	19
<i>Non-ICT Capital</i>	48	14
Labour Quality	3.2	50
TFP	24	18

Source: Vu (2010)

## 4.2 Innovation

### 4.2.1 Innovation input

Quoting Schumpeter, “innovation in the form of creative destruction is *the* driving force not only of capitalism but of material progress in general.” In modern context “creative destruction” has become more vital with globalization and shorter product life cycle, there is a constant need to remain competitive. In order to do so, innovation is the key.

With the ground works of ICT in place, innovation turns these ICT tools into something valuable. Using sophisticated ICT infrastructure, in combination with innovation, Singapore is able to transform into a knowledge-based economy. With reference to the global competitiveness report 2010-2011, Singapore has moved into the innovation driven economy stage. As defined by the World economic forum, an innovation-driven economy is one where wages and standard of living increases only if business are able to compete with new unique products. Furthermore, companies must be producing new and different goods using the most sophisticated production and through innovation (WEF, 2010).

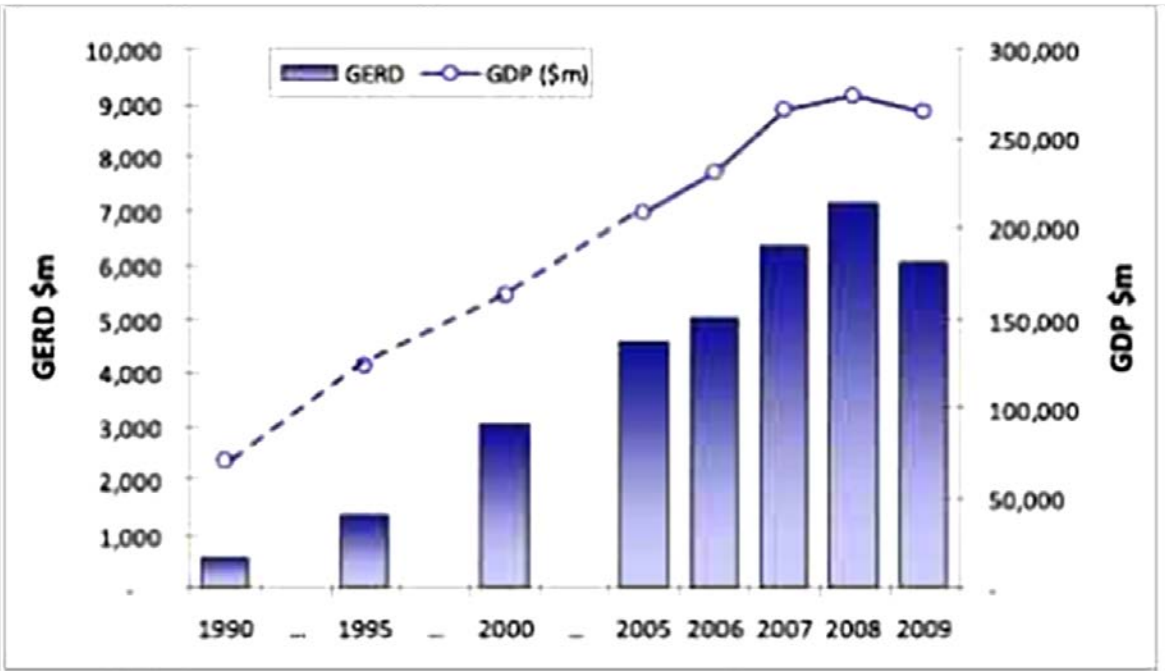
According to the Global Innovation index report (GII) 2009-2010, Singapore is ranked 7<sup>th</sup> after Denmark and Finland (INSEAD, 2010). Similar to the provision of ICT infrastructure and promotion of ICT usage, the government is also highly involved in fostering an environment that is conducive for the development of innovation. With reference to one of the assessments of Innovation in the GII report, Singapore is the leader in the Institutions segment. This segment consists of three sub pillars, which includes Political environment, Regulatory environment and conditions for business provided by public institutions. An



example of one of the institution is the National Science and Innovation Council, which oversee the National Research Foundation that invests heavily into the fields of digital media, science and environment technology as well as design and management.

An indicator of the government’s commitment and the resources available for innovation is the Research and Development (R&D) spending as a ratio to GDP. The R&D spending for 2010 and 2011 has remained constant at 2.25%. However, in 2010, the government reported their aim to grow the private sector R&D by increasing R&D spending to 3.5% of GDP in 5 years (Channelnewsasia, 2010). From figure 12 below, we are able to see the gross expenditure on R&D (GERD) and GDP growth from 1990-2009. The GERD has been consistently increasing apart for the year 2009, where the fall in GERD in 2009 is due to the economic slow down.

**Figure 11: Gross Expenditure on R&D and GDP Growth (1990-2009)**



Source: Agency for Science, Technology and Research

In addition to direct R&D investment, the government also supports enterprises to invest in innovation and productivity. An example is the ‘Productivity and Innovation Credit’ scheme, which offers “significant tax” deductions, for investments activities along the innovation value chain.

#### 4.2.2 Innovation Output

Innovation output could be measured with reference to the number of patent application, as patents reflect the actualization of an idea into something that could be valuable. From the figure 13 below, it reflects a break down of the number of patent applications filed in Singapore by local-based and foreign-based entities.



**Figure 12: Break Down of patent application by local-based and foreign-based Entities**

Year	No. of Applications by Local-Based Entities	No. of Applications by Foreign-Based Entities	Total
2010	892 (9%)	8,881 (91%)	9,773
2009	827 (9%)	7,909 (91%)	8,736
2008	808 (8%)	8,884 (92%)	9,692
2007	729 (7%)	9,226 (93%)	9,955
2006	626 (7%)	8,538 (93%)	9,164
2005	572 (7%)	8,033 (93%)	8,605
2004	641 (8%)	7,310 (92%)	7,951
2003	626 (8%)	7,282 (92%)	7,908
2002	624 (8%)	7,446 (92%)	8,070
2001	523 (6%)	7,610 (94%)	8,133
2000	516 (7%)	7,204 (93%)	7,720

Source: Intellectual Property Office of Singapore

From the figure above we could see the effects of innovation based on the number of patent applications. Patent applications have been increasing throughout the years and while the number of local based companies applying for patents have been increasing slowly. The proportion is pale in comparison to the patent application by the foreign-based companies.

Nonetheless, the capacity for innovation remains relatively high based on global standards. With reference to the Global Competitive report Singapore is ranked 17 on the capacity for innovation behind United Kingdom and Luxembourg. Based on Innovation and Sophistication factors, Singapore is also ranked 9 based on innovation on the same report (WEF, 2010).

#### **4.2.3 ICT and Innovation: Green Economy**

There have been many instances where ICT and innovation come together in Singapore to increase productivity and growth. An example is the use of ICT and innovation to transform Singapore into a green economy. In collaboration between government agencies, industry associations, ICT companies and service providers, a new global green data centre standard could be created (Kaye, 2011). A global green data is a storage, management and data dissemination system, which maximize energy efficiency and minimize environmental impact. Also government agencies such as Singapore's National Environment Agency (NEA) have partnered with Hewlett Packard to design a new set of energy efficiency benchmarks (Kaye, 2011).

## **5. Conclusion**

In conclusion, Singapore's focus on ICT has helped propelled the country into an innovation driven economy. The Singapore government has been the main driving force in transforming the ICT sector into a competitive industry known for its world-class service standards. With the growth of both local and foreign ICT firms in Singapore the government has taken into account the long-term needs of sustaining a competitive ICT industry. Also the focus on education and introducing the use of ICT as early as during primary school will continuously enhance the capabilities of the workforce. Thus it is vital that everyone is on the same page of the ICT progress in order to exploit the benefits of ICT. While the formation of new ICT related sectors are accelerating, it is important not to forget about the existing companies. More attention is needed to assist SMEs to follow up with the advancement of technology and to keep up with the changes. Furthermore with the establishment of a sophisticated ICT network, the progression towards a more innovative society will then be a natural progress. Therefore, ICT is without a doubt a key factor for Singapore's continuous growth.

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