The Impact of ICT Development on the Digitizing Economy of Taiwan

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ABSTRACT

It is clear that within the APEC economies there are patterns of industrial specialization and national idiosyncrasies, and that the development and influences of ICT are multi-dimensional. In an attempt to shed light on industrial-related policies, this study focuses on macro- and economic-oriented aspects as a means of evaluating the impacts of ICT. In embarking upon this project, our intention is to quantify the differences in ICT development for the APEC economies. In our efforts to reveal the effects of the ICT revolution on these economies, we employ an empirical study, involving principal component and growth accounting techniques, in order to explore the relationship between ICT and non-ICT industries. We intend to tackle a number of questions relating to the ability of ICT to accumulate national wealth, increase overall total productivity levels, boost industrial transformation and improve resource allocation.

We recognize, however, that there are also disparities in the development of ICT amongst different APEC economies; whilst some economies are already at an advanced state, others are still desperately trying to catch up. For the digitizing economies within APEC, the contributions of ICT development are complicated; therefore, our focus will remain on certain specific digitizing economies as our samples, these being the US, Australia, Canada, Japan

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and Chinese Taipei. As we review the development of ICT in Chinese Taipei, we find that resources and budgets are mainly focused on the government sectors, with the private sector seldom relating to the public sector. Both the WMRC e-government ranking, and the EIU e-readiness ranking, indicate that the competitiveness of Chinese Taipei, in terms of its establishment of the appropriate e-environment, was downgraded in 2003 (the EIU ranking was the same as 2002, but this had already taken a backward step as compared to 2001). When checking the WMRC profiles for Chinese Taipei, it also becomes clear that the weaknesses are in the disability accessibility and security policy, whilst the EIU's report indicates that the defects for Chinese Taipei, in terms of the e- environment, are in the area of support for e-services, as well as social and cultural areas. It is clear therefore that Chinese Taipei has to strengthen its e-power by establishing a strong consensus for cooperation.

Extracting the IMD's indicators on technological and scientific infrastructure by principal components analysis, we find that Chinese Taipei ranked sixth amongst the seventeen APEC economies, behind the US, Japan, Canada, Singapore and Australia. We also find that Chinese Taipei has advantages in general ICT development, R&D spirit, and ICT infrastructure but that there is room for improvement in R&D inputs and the necessary incentives for information and technology. This signifies that the government needs to allocate a greater budget, or other incentives (such as tax reductions, subsidies or appropriate supporting policies), for information and technology in order to improve R&D expenditure levels by both the public and private sectors so as to stimulate the overall development of ICT.

Our empirical study, using growth accounting techniques, shows that the increase in TFP has contributed significantly to economic growth in Chinese Taipei, but that the greater part of the contribution made by TFP is nevertheless derived from intra-industry technological progress effects. The tests for inter-sector externalities from ICT using cross-economy data show a positive sign with statistical significance. The policy implications from our empirical findings are that the APEC economies may be placing too much emphasis on ICT development, *per se*, whilst the use of information and communications technology still lags behind. It is therefore necessary to determine how to utilize ICT, from a universal perspective, and how best to use the digital dividends, not only for domestic rural areas, low income households and the disabled, but also on an international scale for the less-developed economies.

Keywords: Information communication technology (ICT), digitizing, economy, growth accounting, productivity.

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I. Motives

INTRODUCTION

Although US consumers have been spending considerable sums of money on IT products over the past three decades, the available statistics on productivity levels show no signs of any resultant gains prior to 1995. Huge investment in computer hardware, the use of new databanks and Internet information products during the 1972-1995 period, did not help to resolve the issue of falling productivity in the US, which has been a general trend since the 1970s. There is, therefore, some discussion as to whether the US economy has fallen into the 'Solow paradox' (Solow, 1987), or the 'Information productivity paradox' (IPP). As Solow's most famous quote goes: "You can see the computer age everywhere, but in the productivity statistics". The development and influence of information communication technology (ICT) also have some constraints on APEC. In a study of twelve Asia Pacific economies by Kraemer and Dedrick (1994), a significant positive correlation was found between growth in IT investment, and growth in both GDP and productivity, over a seven-year period, between 1984 and 1990. This finding was consistent with the notion of IT-led development and challenged the so-called 'productivity paradox', or the notion that investment in IT has not paid off in terms of productivity improvements.

There are in fact many projects involving ICT in the APEC economies, such as the 'Framework for Global Electronic Commerce' in the US, the Japanese 'e-Japan' project, South Korea's 'Cyber Korea 21', the 'Infocomm 21', otherwise referred to in Singapore as 'Singapore One', and the 'Green Silicon Island Plan' in Chinese Taipei. All of these projects aim to improve the application and development of ICT to accumulate national wealth and to improve the quality of life, but the impacts brought about by the application of digital technologies still need to be discussed. There are also differences in the needs and capabilities of the various APEC economies for advancement towards a KBE, including innovation structures, mechanisms and incentives, and clearly, such disparities must be taken into consideration. Therefore, in this study, we attempt to evaluate the development and influence of ICT on the APEC economies.

Objectives and Research Framework

The general objectives set for APEC by the Osaka Action Agenda (OAA) were: (i) to provide key inputs for science and technology (S&T) policymaking, allowing APEC economies to advance in the KBE and narrowing their knowledge disparities; and (ii) to build up constructive dialogue amongst APEC economies that will allow continuous communication and learning in the S&T policymaking process.

It is clear that amongst the APEC economies, there are patterns of industrial specialization and national idiosyncrasies, and that both the development and influences of ICT are multi-dimensional. This study focuses on a number of topics as a means of evaluating the impacts of ICT so as to shed some light on industry-related policies. Our intention is that this project will enable the quantification of the differences in ICT development for the APEC economies. The research areas focus on macro- and economic-oriented aspects, with the aim of tackling questions relating to whether ICT has the ability to accumulate national wealth, increase total productivity levels, boost industrial transformation and improve resource allocation. We recognize, however, that there are also disparities in the development of ICT amongst APEC economies; some economies are already at a very advanced state, whereas others are still desperately trying to catch up. The contributions from ICT development for the APEC digitizing economies are complicated, and in order to avoid confusion of the results from biased inputs, our focus will remain on certain specific digitizing economies as our samples, these being the US, Australia, Canada, Japan and Chinese Taipei.

In line with the agenda of the STPAR-APEC round of December 2000, the objectives of this paper are: (i) to develop a consistent framework as a means of understanding the advancement of the APEC economies within the KBE and to narrow their knowledge disparities; (ii) to establish constructive dialogue between the APEC economies that will help in evaluating the impacts of ICT in these economies whilst allowing continuous communication and learning in the S&T policymaking process; (iii) to distinguish between the patterns of industrial specialization and national idiosyncrasies within the APEC economies so as to enable the coordination of related policies; (iv) to confirm the relationship between ICT investment and GDP growth through growth accounting or panel data regressions in order to guide the development of ICT and evaluate its side effects; (v) to communicate the experiences of ICT within the APEC economies in order to secure gains, avoid losses and accumulate a learning effect; and (vi) to engage in foresight and assessment of the development of ICT so as to improve budget allocation. The conceptual basis of this study can therefore be plotted as follows:

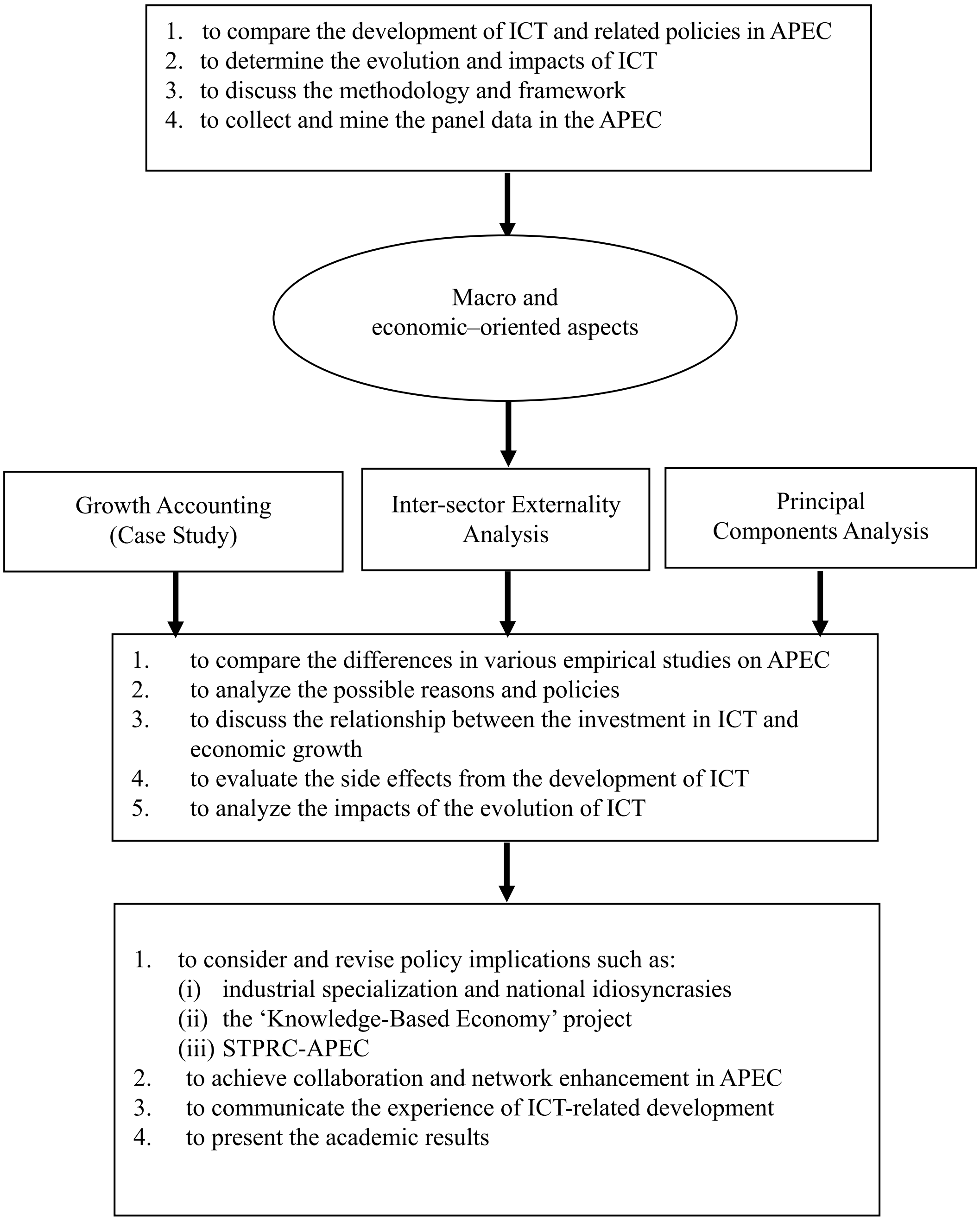

Figure 1.1 Conceptual research framework

II. Literature Review

INTRODUCTION

Even in the US, the economic effects of IT investment were not particularly discernible for a considerable period of time. With Solow (1987) having expressed doubts at to whether investment in computers had any contribution to productivity growth, Baily and Gordon (1988) and Oliner and Sichel (1994) subsequently attempted to examine the 'Solow paradox' by analyzing output and productivity data at industry level. However, with the expansion of the US economy and accumulation of such economic data, it became clearly evident that IT investment had contributed greatly to productivity growth within the US economy. Jorgesen (1999), and others, reported that growth in productivity in the US during the 1990s was achieved through capital deepening induced by the rapid fall in IT product prices.

Since the conclusions drawn from the various examples within the literature were multifarious, it is clear that in our review of the literature, we need to focus on the data definitions, treatment of such data, and the sample periods used.

Kraemer and Dedricks (1994)

Research Samples: Asia-Pacific economics including Japan, Australia, New Zealand, South Korea, Chinese Taipei, Hong Kong (China), Singapore, Indonesia, India, Malaysia, the Philippines and Thailand.

1. Sample Period: 1984-1990
2. Data definition: The study defined the IT sector as including hardware, software and related services, and treated telecommunications, semiconductors and other electronics industries as part of the IT resources which supported and complemented the production and use of computer products and services.
3. Methodology: Pearson correlation test
4. Conclusions: The study examined the environmental factors influencing investment in information technology, and the payoffs - in terms of productivity and economic growth - from investment in IT usage. The examination revealed a significant positive correlation between growth in IT investment, as well as growth in both productivity and overall GDP, over the seven-year sample period. Economies with higher IT investment growth rates achieved consistently higher GDP and productivity growth rates, a finding which was consistent with the notion of IT-led development, and which challenged the so-called productivity paradox, or the notion that investment in IT had not paid off in terms of productivity improvements.

Jorgenson and Stiroh (1999)

1. Case study: US
2. Sample period: 1958-1996
3. Data definition and source: The Bureau of Economic Analysis (1998) provided detailed investment data for 35 types of producers' durable goods, 48 types of residential assets and 22 types of non-residential structures. The investment data included a breakdown of computer equipment into mainframe computers, personal computers, direct-access storage devices, printers, terminals, tape drives and storage devices. For each asset, including computers, this study calculated capital stock using the perpetual-inventory method and depreciation rates from Fraumeni (1997).
4. Methodology: The study employed a Christensen and Jorgenson (1973) framework to distinguish between investment and consumption goods outputs, and the input of capital and labor services. The output of investment goods (I), consumption goods and services (C) and flow of services from consumer durable goods (S) were created by the inputs of capital services (K), consumer durable services (D), labor input (L) and technology (T). In order to isolate the impact of computers the study decomposed C, S, K and D into computer and non-computer segments.
5. Conclusions: The study estimated the sources of growth for the US private domestic economy for 1948-1996, broken down into three sub-periods, 1948-1973, 1973-1990 and 1990-1996. For the entire period, output grew by 3.4 per cent per year, with capital and consumer durable services being the most important sources of growth, accounting for 43 per cent of the total, whilst labor accounted for 32 per cent. The total factor productivity (TFP) residual accounted for the remaining 25 per cent. The growth in both output and TFP slowed sharply after 1973, with a subsequent, smaller decline, from 1990 onwards. The output growth rate for 1990-1996 was 2.4 per cent per year, around half a per cent less than the annual average of 2.9 per cent for the period 1973-1990. By contrast, the growth rate for 1948-1973, at 4.0 per cent per year, had been over 1.0 per cent greater.

Klein, Duggal and Saltzman (2000)

1. Case study: US Motor Vehicles and Parts and the Transportation Equipment sectors.
2. Sample period: 1972-1996
3. Data definition

   (1) The 'Stock of Information Technology Capital' comprised of the following asset classes: mainframes, personal computers, direct access storage devices, computer printers,

computer terminals, computer tape devices, computer storage devices, other office equipment, communications equipment, instruments, photocopiers and related equipment, and telecommunications.

(2) The 'Information Technology Services B2B' input comprised of the following asset classes: computers and office equipment, audio, video, communications equipment, communications equipment (other than TV and radio), computer and data processing services.

4. Methodology:

(1) The study incorporated all intermediate inputs from the six I-O tables in 1972-1996, and interpolated linearly between successive tables to construct a 'pseudo sample' of annual data.

(2) The study employed the KLEMI production function to examine the statistics for the degree of returns to scale. Capital stock (K) was divided into information technology capital stock (ITS) and K0 (other capital). Labor inputs, energy inputs, non-information materials and services, and information services were respectively denoted as L, E, M and I.

(3) The study considered technological change as having both disembodied and embodied elements, with the disembodied change being proxied by the time trend, and the embodied change being inherent in an increasing K/L ratio, whilst labor was weighted by information technology capital stock.

(4) The empirical model:

$$\ln X = C_1 \ln K + C_2 \ln L + C_3 \ln M + t^{C_7} + \frac{C_6 \cdot K}{ITS \cdot L} + C_4 (ITS) \cdot I - \frac{C_5 \cdot L}{ITS \cdot I} + C_8$$

5. Conclusions: In order to observe where, and how, any unusual technical progress had occurred, the focus of the study was at industry level, rather than at the macro level. A principal finding was that the target sectors were significantly affected by IT (stocks and flows, final and intermediate) and that they appeared to be operating under conditions of increasing returns to scale. The results revealed that if adequate demand existed, an annual industry output growth stream of 6 to 8 per cent could be sustained by the auto sector alone. For the larger sector, transportation equipment, growth of 4 to 6 per cent could be sustained if sufficient demand existed.

Klein and Kumasaka (2000)

1. Case study: US
2. Sample period: 1978-1997
3. Data description:

(1) Classification of industrial sectors employing non-farm private sectors as the sample, these were:

a. Construction
b. Manufacturing, decomposed to durable goods and non-durable goods
c. Transportation and public utilities
d. Communications
e. Whole trade and retail trade
f. Finance, insurance and real estate
g. Services

(2) The 'Stock of Information Technology Capital' comprised of the following asset classes: mainframes, personal computers, direct access storage devices, computer printers, computer terminals, computer tape devices, computer storage devices, other office equipment, communications equipment, instruments, photocopiers and related equipment, telecommunications.

(3) Non-IT capital stock: The aggregate capital stock minus the stock of IT capital.

(4) Rental Price: The Bureau of Labor Statistics (BLS) calculated the rental price of capital stock for each industry, with the derivation being:

$$\text{ct} = \frac{(1 - u_t Z_t - e_t)(p_t \gamma_t + p_t d_t - \dot{p}_t)}{1 - u_t} + p_t x_t$$

where ct is the rental price; u_t is the corporate income tax rate; Z_t is the present value of \$1 of tax depreciation allowances; e_t is the effective rate of investment tax credit; γ_t is the nominal rate of return on capital; d_t is the average rate of return on capital; p_t is the deflator for new capital goods; $\dot{p}_t$ is the reevaluation of assets due to inflation in the price of new goods; x_t is the rate of property taxation in wealth.

(5) Real Gross Product originating for each industry: US Department of Commerce, Bureau of Economic Analysis (BEA)

(6) Labor Input for each industry: The following data for each industry was available from the BLS: (i) epw: total number of production workers; (ii) awe: average weekly earnings of production workers; (iii) awh: average weekly hours of production workers; (iv) awo: average weekly overtime hours of production workers; and (v) epw: total number of production workers.

The study created labor input data for white-collar workers by subtracting the data on production workers from the total labor data.

4. Methodology: The study used the non-linear econometrics technique assuming the following production function:

$$y = Ak_1^{\alpha} k_2^{\beta} L^{\gamma} e^{pt}$$

where, y: real gross product originating; k1: real net information capital stock; k2: real net non-information capital stock; L: labor input in terms of man-hours; p: disembodied technical progress rate; t: time; P: price deflator of y; r1: rental cost of k1; r2: rental cost of k2; and W: wage rate.

By dual theorem, the cost function form would be:

$$c = y^{\frac{1}{\alpha+\beta+\gamma}} (\alpha+\beta+\gamma)\left(\frac{1}{Ae^{\alpha}}\right)^{\frac{1}{\alpha+\beta+\gamma}} \left(\frac{\gamma_1}{\alpha}\right)^{\frac{\alpha}{\alpha+\beta+\gamma}} \left(\frac{\gamma_2}{\beta}\right)^{\frac{\beta}{\alpha+\beta+\gamma}} \left(\frac{\omega}{\gamma}\right)^{\frac{\gamma}{\alpha+\beta+\gamma}}$$

In the assumptions of minimum cost, scale economics (SCE) was defined as:

$$1 - \frac{\partial \log c}{\partial \log y},$$

thus, $\frac{r_1 k_1}{\rho y} = \alpha e_1$, $\frac{r_2 k_2}{\rho y} = \beta e_2$, $\frac{\omega L}{\rho y} = \gamma e_3$, with e_1, e_2 and e_3 referring to the error terms

Taking the logarithm and calculating the average of both sides during the sample period:

$$\frac{\beta}{\alpha} = \exp\left[\frac{1}{n}\sum \log\left(\frac{\gamma_2 k_2}{\gamma_1 k_1}\right)\right] \qquad \frac{\gamma}{\alpha} = \exp\left[\frac{1}{n}\sum \log\left(\frac{\omega L}{\gamma_1 k_1}\right)\right]$$

where, n refers to the number of samples.

A new variable, $\hat{Z}$, was then created:

$$\hat{Z} = \log(k_1) + \left(\frac{\beta}{\alpha}\right)\log(k_2) + \left(\frac{\gamma}{\alpha}\right)\log(L)$$

so: $\log(y) = \log(A) + \hat{\alpha} \cdot \hat{Z} + \hat{\rho} t + u_t$

To calculate $\hat{Z}$:

the value of $(\frac{\hat{\beta}}{\hat{\alpha}})$ was calculated from $\exp\left[\frac{1}{n}\sum \log \frac{\gamma_2 k_2}{\gamma_1 k_1}\right]$

and the value of $(\frac{\hat{\gamma}}{\hat{\alpha}})$ was calculated from $\exp\left[\frac{1}{n}\sum \log \frac{\omega L}{\gamma_1 k_1}\right]$

thus: $$\hat{Z} = \log(k_1) + \left(\frac{\beta}{\alpha}\right)\log(k_2) + \left(\frac{\gamma}{\alpha}\right)\log(L)$$

The equation, $\log(y) = \log(A) + \hat{\alpha} \cdot \hat{Z} + \hat{\rho}t + u_t$, was then regressed to obtain the estimated value of $\hat{\alpha}$, and subsequently, to calculate $\hat{\beta}$ and $\hat{\gamma}$. Using $\hat{\alpha}$, $\hat{\beta}$, $\hat{\gamma}$ the value of SEC could then be calculated.

5. Conclusions: From the estimation results of the CD production, and two- and three-level CES production function, the study found that the US non-farm private sector had increasing returns to scale of 10 to 15 per cent, implying that the IT economy knowledge base displayed characteristics of the endogenous growth model, i.e., that knowledge bears knowledge.

Miyagawa and Harada (2002)

1. Case study: Japan

2. Sample Period: The study aimed to determine the spillover effects from the IT economy on the 'by-industry'. The industrial classification comprised of thirteen (two-digit) manufacturing and nine (one-digit) non-manufacturing industries.

3. Data definition and treatment: The Japanese government does not publish IT capital stock series; instead, it publishes capital stock series of all assets for the 'by-industry'. The study therefore constructed 'by-industry' original IT and non-IT capital stock series.

(1) The non-IT capital stock series was constructed as follows:

a. Other industry benchmark stocks were set based on the National Wealth Survey 1970.

b. Using the 'by-asset' aggregate investment series of the National Account and the Fixed Capital Formation Matrix, a 'by-industry' investment series was constructed.

c. Using the perpetual inventory method and the depreciation rate of Fraumeni (1997) and Hulten and Wykoff (1981) a 'by-industry' capital stock series was then constructed.

(2) The IT capital stock series

a. The study obtained the investment series of IT assets from the Fixed Capital Formation Matrix (since this matrix is published only every five years, we construe data for the intervening years using a linear trend).

b. The study calculated benchmark stock from the IT investment series. Assuming a constant investment growth rate, the benchmark stock ($k_{IT,t-1}$) was expressed as:

$$k_{IT,t-1} \cong \frac{I_{IT,t}}{g+\delta}$$

where, $I_{IT,t}$ is IT investment at period *t*, *g* is the growth rate of IT investment, and δ is the depreciation rate of IT assets. The benchmark stock of IT capital for 1974 was then calculated using IT investment data from 1975 to 1998, and the IT asset depreciation rate of Fraumeni (1997).

c. Having calculated the benchmark stock, this was then used to construct a 'by-industry' IT capital stock series using the perpetual inventory method.

4. Methodology: The productivity growth rate was decomposed into the contributions of labor input, capital input and TFP.

(1) Labor productivity growth *G(y)* was decomposed into the contribution, in terms of growth, in the non-IT capital/labor (K/L) ratio,*(G(k))* , the contribution of growth in the IT K/L ratio, $G(Z)$, and growth in total factor productivity*(G(T))*.

$$G(y) = \alpha G(k) + \beta G(Z) + G(T)$$

where, α refers to the share of non-IT capital; and β refers to the share of IT capital.

(2) The study decomposed each K/L ratio into intra-sectoral K/L ratio and the reallocation effect of labor.

$$G(k) = \sum_i S_{k_i} G(k_i) + \sum_i \frac{k_i - k}{k} S_{L_i} G(S_{L_i})$$

$$G(Z) = \sum_i S_{Z_i} G(Z_i) + \sum_i \frac{Z_i - Z}{Z} S_{L_i} G(Z_{L_i})$$

where, $G(S_{L_i})$ represents the growth in the proportion of labor in industry *i*, whilst the second term shows the increase in aggregate capital deepening by labor movement from a lower K/L ratio sector to a higher K/L sector.

The study then rearranged the equations to obtain:

$$G(T)=\sum_i S_{y_i}G(T_i)+\sum_i\left(\frac{y_i-y}{y}-\alpha\frac{k_i-k}{k}-\beta\frac{Z_i-Z}{Z}\right)S_{L_i}G\left(S_{L_i}\right)$$
$$+\sum_i\left(\frac{r_{k_i}-r_k}{r_k}\right)\alpha S_{k_i}G(k_i)+\sum_i\left(\frac{r_{Z_i}-r_Z}{r_Z}\right)\alpha S_{Z_i}G(Z_i)$$

where, the first term on the right hand side is sectoral growth in TFP; the second term is growth in aggregate TFP through reallocation of labor; and the third and fourth terms represent efficient resource reallocation of each capital stock.

In summary, the study decomposed labor productivity growth as:

$$G(y)=\alpha\sum_i S_{k_i}G(k_i)+\beta\sum_i S_{Z_i}G(Z_i)$$
$$+\sum_i\left(\frac{r_{k_i}-r_k}{r_k}\right)\alpha S_{k_i}G(k_i)+\sum_i\left(\frac{r_{Z_i}-r_Z}{r_z}\right)\alpha S_{Z_i}G(Z_i)$$
$$+\left\{\alpha\sum_i\frac{k_i-k}{k}+\beta\sum_i\frac{Z_i-Z}{Z}+\sum_i\left(\frac{y_i-y}{y}-\alpha\frac{k_i-k}{k}-\beta\frac{Z_i-Z}{Z}\right)\right\}S_{L_i}G\left(S_{L_i}\right)\ +\sum_i S_{y_i}G(T_i)$$

where, the first and second terms on the right hand side represent intra-sectoral *k* deepening effect; the third and fourth terms represent the efficiency effect of *k* deepening; the fifth term represents the efficiency effects of labor shifts; and the last term represents intra-sectoral TFP growth rate.

5. Conclusions: The study found that intra-sectoral capital deepening effects was the dominant factor in productivity growth; however, the recent slowdown in productivity was caused by the absence of the reallocation effects of labor. The study further estimated the production and TFP growth functions, examining the network externalities of IT capital. As a result, both inter-industry and intra-industry spillover effects were found on the input side.

Peng, et. al. (2001)

1. Case study: Chinese Taipei
2. Sample period: 1981-1999
3. Data definition: In order to calculate the contribution to productivity stemming from ICT development, the study decomposed the economy into ICT manufacturing industries, ICT service industries and non-ICT industries. The ICT manufacturing industries included computer products, computer peripherals, data storage media, computer components,

electronic video and radio products, communications apparatus, electronic tubes, semiconductors, opto-electronic components and materials, and electronic components and parts. The ICT service industries included telegram and telephones, and data processing and information services. The non-ICT industries were treated as residuals.

4. Methodology: Growth accounting was undertaken by estimating the production function. The calculation of TFP (λ) was decomposed into intra- and inter-industry technical change.

$$\lambda = \sum_j s_{X_jY}\lambda_j + \left(\sum_j s_{X_jY} s_{K_jX_j} g_{K_j} - s_{KY} g_K\right) + \left(\sum_j s_{X_jY} s_{L_jX_j} g_{L_j} - s_{LY} g_L\right)$$
$$+ \left(\sum_j s_{X_jY} s_{M_jX_j} g_{M_j} - s_{MY} g_M\right) + \left(\sum_j s_{Y_jY} g_{P_j} - g_p\right)$$

where the first term is industrial-weighted TFP, with the weight being the share of industrial output to aggregate GDO; and the second to fifth terms were treated as the resource reallocation effect. At the equilibrium level, reallocation was almost zero. The second term was denoted as the capital reallocation effect; the fourth term was the imported intermediate inputs reallocation effect; and the fifth term was the domestic intermediate inputs reallocation effect.

5. Conclusions: According to the empirical results, the estimate for economy-wide TFP was 3.30 per cent for the whole period, and the contribution to GDO growth was around 28 per cent. TFP in the ICT industries was higher than in non-ICT industries; the contribution to TFP made by intra-industry technical change was 96.39 per cent for the whole period; the remainder accounted for by inter-industry technical change was almost zero. These results suggest that there was no significant effect on the redistribution of resources during the sample period.

III. The Contribution of ICT to the APEC Economies

INTRODUCTION

Since IT products can serve as intermediate products, consumer durables or investment goods, there are two channels through which they may have an impact on the economy as a whole. The first of these is the changes which they can cause in the allocation of capital and labor inputs, and the second is the effect of stimulating changes in technology. In order to investigate the impact of the development of ICT within APEC, we begin by calculating the contribution of ICT to economic growth, and then compare the digital environment, using the e-readiness rankings provided by several organizations, such as the EIU and the WMRC.

The Contribution of ICT to the APEC Economics

The real GDP growth rate within APEC, achieved an average of 3.67 per cent between 1995 and 2000, with the Asian economies enjoying the highest growth. As Table 3.1 shows, during that period, despite the ravages of the Asian financial crisis in 1997-1998, mainland China achieved a growth rate of 8.24 per cent, the highest in the region, whilst Vietnam, Singapore and Chinese Taipei registered 6.7 per cent, 6.35 per cent, and 5.76 per cent respectively. Indonesia and Thailand, the main victims of the financial crisis, saw growth of less than 1 per cent, whilst Japan and Russia, dogged by weak domestic demand, were also hit by the crisis, with their average growth rates being less than 2 per cent. Although South Korea was also hit severely, the country's economy quickly began to get back on track in 1999. Mexico was the only APEC member outside of the Asian region with a growth rate higher than 5 per cent, and this was mainly because of the benefits from the North American Free Trade Agreement (NAFTA). The economies of Australia, Canada and Chile all grew moderately, at around 3.5 to 4.5 per cent, whilst the US economy grew at an average rate of 4.19 per cent, an historical high since the Kennedy Administration of the early 1960s.

According to neoclassical theory, capital and labor inputs are the main factor inputs for economic growth. Looking at the third and fourth columns of Table 3.1, although most economies with high investment-output ratios and high employment growth rates enjoyed high economic growth rates within APEC, it is clear that there are some exceptions. The US and Canada, for example, invested less than 25 per cent of their GDP into the economy, in contrast to most of the Asian economies, which committed more than 30 per cent of their GDP into economic investment.

Table 3.1 Real GDP growth, investment output ratio, and employment growth rate in the APEC economies, 1995-2000

Unit: %

	Real GDP growth rate	Investment/GDP	Employment growth rate
Australia	4.00	23.60	1.79
Brunei	2.86	-	3.34
Canada	3.66	20.70	1.75
Chile	4.54	27.20	0.61
China	8.24	38.20	0.96
Hong Kong	3.40	34.50	2.07
Indonesia	0.68	31.80	2.00
Japan	1.45	28.70	0.04
Malaysia	4.67	42.80	3.13
Mexico	5.51	25.90	3.49
New Zealand	2.29	21.10	1.33
Papua New Guinea	0.61	21.10	2.62
Peru	2.53	24.00	2.62
Philippines	3.55	24.80	2.19
Singapore	6.35	38.90	1.87
South Korea	4.77	34.20	1.40
Chinese Taipei	5.76	22.76	1.00
Thailand	0.24	33.30	0.93
US	4.19	19.50	1.84
Vietnam	6.70	28.30	1.73
Russia	1.14	22.80	-0.24
Average	3.67	28.21	1.74

Sources: World Bank, World Development Indicators (2002); Chinese Taipei data is provided by the Directorate General of Budget, Accounting and Statistics (DGBAS).

As for labor force inputs, employment grew by over 3 per cent only in Brunei, Malaysia and Mexico, whilst Japanese employment grew by a mere 0.04 per cent and Russia experienced a decline in the total number of employed persons. Therefore, it is clear that investment capital and labor inputs, in isolation, cannot sufficiently explain economic growth.

There is considerable variety within APEC, in terms of economic structure, as shown in Table 3.2; indeed, some of the APEC economies are still dominated by their agricultural and industrial sectors. Many of the Asian economies, such as China, Malaysia, Indonesia, the Philippines, Thailand and Vietnam, and those of Chile, Mexico, and Peru in America, still derive more than 10 per cent of their GDP from their agricultural sectors. More than 50 per cent of GDP is derived from the industrial sectors of both China and Thailand, largely because these economies are still engaged in catching up with the advanced economies, and thus, this reflects their different stages of economic development, whereas Australia, Canada, Hong Kong, Japan, New Zealand, Singapore, Chinese Taipei and the US derive a higher proportion of their GDP from the service sector. However, the development of information and communication technology (ICT) industries is scattered throughout the APEC economies, irrespective of which stage they are at in terms of economic development (see Table 3.3).

Table 3.2 Industrial structure in the APEC economies, relative to GDP, 1997

Unit: %

	Agriculture	Industry	Services	Total GDP
Australia	3.9	29.4	66.7	100.0
Canada	3.3	37.2	59.5	100.0
Chile	10.4	36.5	53.1	100.0
China	20.9	51.0	28.2	100.0
Hong Kong	0.9	27.4	71.8	100.0
Indonesia	19.6	42.4	37.9	100.0
Japan	1.7	32.6	65.7	100.0
Malaysia	14.5	42.7	42.8	100.0
Mexico	10.2	40.1	49.7	100.0
New Zealand	7.0	26.9	66.2	100.0
Peru	10.8	51.3	37.9	100.0
Philippines	21.9	26.2	51.9	100.0
Singapore	1.1	41.3	57.6	100.0
South Korea	5.5	41.5	53.0	100.0
Chinese Taipei	3.1	33.8	63.1	100.0
Thailand	10.3	54.5	35.1	100.0
US	1.3	27.7	71.0	100.0
Vietnam	14.5	27.6	57.9	100.0
Russia	3.3	40.8	55.9	100.0
Average	8.6	37.4	53.9	100.0

Source: GTAP database, version 5.

Table 3.3 GDP share of ICT

Unit: %

	Electrical and Electronic Machinery (A)	Communications	ICT/(A)	Information and Communication Technology (ICT)
Australia	0.3	2.8	51.1	3.0
Canada	0.7	2.3	62.9	2.7
Chile	0.1	2.5	0.0	2.5
China	1.9	1.7	57.4	2.7
Hong Kong	1.1	2.1	64.9	2.9
Indonesia	2.7	1.3	47.7	2.6
Japan	3.6	2.1	68.8	4.5
Malaysia	6.4	0.6	78.4	5.6
Mexico	1.4	2.6	49.5	3.3
New Zealand	0.3	2.6	43.4	2.8
Peru	0.9	2.5	0.0	2.5
Philippines	1.0	1.1	93.1	2.0
Singapore	7.0	1.7	86.1	7.7
South Korea	2.2	2.5	75.8	4.1
Chinese Taipei	5.3	2.0	70.6	5.8
Thailand	9.4	0.9	71.1	7.6
US	1.4	2.0	70.3	3.0
Vietnam	0.5	0.4	0.0	0.4
Russia	0.6	3.3	0.0	3.3
Average	2.5	1.9	52.2	3.6

Source: GTAP database, version 5.

Singapore, Chinese Taipei, Thailand, and Malaysia derive more than 5 per cent of their GDP from ICT-related manufacturing products, whilst Australia, Canada, Chile, Hong Kong, Russia and the US place greater emphasis on ICT software, i.e., communications products. Although Singapore, Chinese Taipei, Thailand and Malaysia are placing more than 5 per cent of their GDP into the ICT industries, after taking away ICT manufacturing from electrical machinery, the difference in ICT development amongst the APEC economies is relatively small; only Vietnam places significantly less emphasis on ICT development. In fact, as Table 3.4 shows, when compared to the average growth rate of 5.98 per cent for 1995-1999, and 11.14 per cent for 1990-1999, the growth rate for ICT products has been rather slow. Whilst China and the Philippines maintained parallel growth paths for the first half of the 1990s, Indonesia, South Korea, Malaysia, Singapore and Thailand grew at only half this pace.

Table 3.4 ICT production growth, 1990-1999

	1995-1999	1990-1999
Australia	2.30	3.00
Canada	1.40	4.00
China	20.10	19.80
Hong Kong	-4.80	-0.40
Indonesia	6.50	19.40
Japan	-4.00	2.30
Malaysia	9.00	20.10
Philippines	22.00	18.40
Singapore	0.70	11.90
South Korea	4.20	10.80
Chinese Taipei	9.00	12.70
Thailand	6.90	17.00
US	4.40	5.80
Average	5.98	11.14

Source: OECD, Information and Communication Technology Outlook, 2002.

Nevertheless, the incremental rate of growth of ICT products, in terms of imports and exports, is higher than that of other products, as indicated in Table 3.5, which reflects the growth in economic trading activities on an international scale. The US is the only exception, since it has maintained an identical pace of growth for both total imports and ICT imports. This may reflect the fact that the US is still quite conservative in terms of allowing foreign goods into the US market, and also the more advanced stage of the economy’s level of technology, not just in its ICT industries.

Table 3.5 Average growth rates of import and export products, 1997-2000

	Total Imports	Imports of Electrical and Electronic Products	Imports of ICT Products	Total Exports	Exports of Electrical and Electronic Products	Exports of ICT Products
Australia	4.8	4.7	7.4	0.5	-5.5	-6.0
Canada	6.8	9.3	10.7	8.7	12.9	14.9
Chile	-2.8	-4.8	3.3	3.0	-	-
China	16.5	28.8	36.0	10.9	24.6	27.8
Hong Kong	0.1	6.5	10.2	2.5	9.3	12.7
Indonesia	-7.0	-23.9	-35.0	5.1	34.2	47.3
Japan	3.9	11.6	13.2	4.4	4.7	4.4
Malaysia	1.2	8.1	10.8	7.7	33.8	14.8
Mexico	19.4	23.5	26.8	14.7	19.8	24.7
New Zealand	-1.4	-0.3	3.3	-2.0	0.1	2.3
Peru	-4.7	-7.5	-8.4	0.5	-	-
Philippines	-4.3	-2.8	-1.3	14.7	21.5	22.3
Singapore	0.5	4.5	6.6	3.3	4.3	6.0
South Korea	3.5	12.0	17.0	8.2	17.6	20.3
Chinese Taipei	7.0	17.3	19.7	6.7	11.8	15.4
Thailand	-0.5	3.4	7.9	5.7	9.9	12.1
US	11.9	12.0	12.2	2.6	3.9	4.7
Vietnam	7.7	-1.2	-5.1	33.5	32.7	2.6
Russia	-12.4	-19.3	-19.1	5.6	10.7	-
Average	2.6	4.3	6.1	7.2	14.5	14.2

Source: UNCTAD, 2000

ICT DEVELOPMENT ENVIRONMENTAL READINESS

It is clear that across the globe there are patterns of industrial specialization and national idiosyncrasies, and that both the development and influence of ICT are multi-dimensional. It is also difficult to employ certain indicators or criteria as a means of grouping the level of ICT development; they may only be treated as a guide to whether an economy's environment is conducive to digital-based opportunities. Since these indicators can span a wide range of factors, from the sophistication of the telecommunications infrastructure, to the security of credit card transactions and literacy of the population, we review some of these indicators and report on the general environmental readiness. The e-readiness rankings provide a guide to the relative preparedness of the world's main markets for the e-business era. These rankings are useful, not only for executives keen on using the Internet to expand into new markets, but also as a means of providing an invaluable benchmark for the economies themselves.

ICT Industry Classification

The US government revised the North America Industry Classification System (NAICS) in order to better fit the needs of the future. According to the 'Second Annual Report - Towards Digital eQuality', compiled by the US Government Working Group on E-Commerce in 1999, ICT industries were defined as including computer hardware manufacturing, software services, telecommunications equipment manufacturing and telecommunications service industries. Furthermore, according to the report 'Measuring Electronic Business Definitions, Underlying Concepts and Measurement Plans', compiled by the US Bureau of Consensus in 1999, the digital economy includes infrastructure, e-business and e-commerce.

Measurement of Environmental Readiness

The indicators used to measure global ICT development, may be classified into two types, the first of which is cardinal indicators, such as internet users, mobile phone subscribers, and so on (Table 3.6 provides an overview of ICT development for several economies showing, for example, that Chinese Taipei ranked second in mobile phone subscribers, providing a clear signal of a competitive mobile phone market). The second type is ordinal indicators, which are certain kinds of reports on national competitiveness rankings produced by the Inside Politics Organization or the Economist Intelligence Unit (EIU). In these types of indicators, certain criteria or categories are fed into the rankings using specific steps or methodologies, which thereby provide an overall index to determine the current situation within an economy.

Since the former type is more restricted and partial, they are little used these days, whereas the latter type are more general; therefore, we employ the e-government rankings reported by the Brown University Taubman Center for Public Policy (funding for this project was provided by the World Market Research Centre of London, England), and the report on e-readiness by the EIU/Pyramid Research. We begin by discussing e-government rankings. An examination of Table 3.7 demonstrates that the rankings for 2002 and 2003 are significantly different from those for 2001. There are, however, four economies which have consistently maintained their place in the top ten, Chinese Taipei, Canada, the US and Singapore, which seems to reflect the high level of competitiveness of their digital economies.

The report, which placed significant emphasis on the features available online through national government websites, found that many economies had not made much progress in placing their official government services online; indeed there were wide variations across different economies and regions of the world, with regard to the extent to which citizens could gain access to government services through the Internet. Only 12 per cent of government websites provided a single entry point to help citizens to acquire national government information through 'one-stop' online services, with portals providing integration of e-government service offerings across different agencies. Such portals reduce the need to log on to different agency websites to order services or to gain information. In this regard, Chinese Taipei was ranked second in 2001, first in 2002, and fifth in 2003, which reveals that the efforts of the government have been worthwhile.

Table 3.6 ICT development indicators

Countries	Mobile Telephone Subscribers (per 1,000 people)	Computers Per Capita (per 1,000 people)	Internet Users (per 1000 people)	Internet Telephone Access Charges ($ per 30 off-peak hours)	Suitable Internet access	Total Expenditure on R&D (US$ million)	Total Expenditure on R&D (% of GDP)
Year	2001	2001	2001	2001	2002	2000	2000
Australia	610.3	585	464.85	2.60	8.52	5,617	1.55
Austria	820.8	429	389.90	17.21	8.92	3,399	1.801
Belgium	694.3	455	348.31	27.52	8.17	4,921	1.961
Canada	345.2	604	534.82	-	9.24	12,881	1.811
Chile	324.0	103	173.40	-	8.63	426	0.603
China	116.0	22	26.27	0.14	6.19	10,844	1.004
Denmark	719.5	609	541.24	-	9.31	3,627	2.086
Finland	831.3	614	512.52	10.62	9.77	4,013	3.319
France	610.0	419	208.61	-	7.29	27,787	2.143
Germany	651.7	436	308.76	-	8.56	45,921	2.46
Hong Kong	846.4	389	427.37	-	8.98	761	0.481
Iceland	731.0	603	545.01	13.96	9.16	218	2.556
Indonesia	29.3	12	14.88	0.20	5.78	187	0.092
Ireland	753.5	461	289.47	16.45	6.00	1,109	1.608
Italy	862.4	347	307.03	17.62	6.33	12,265	1.04
Japan	528.4	430	383.95	27.67	6.75	148,566	3.118
Korea	608.9	399	510.04	-	8.98	12,249	2.653
Malaysia	328.8	127	99.28	0.24	7.77	440	0.491
Mexico	216.8	76	52.63	-	6.59	1,939	0.401
Netherlands	730.8	510	448.53	16.40	8.53	8,060	2.024
New Zealand	190.6	517	412.99	-	8.63	734	1.136
Norway	751.4	610	532.01	20.64	9.08	2,606	1.697
Philippines	141.3	28	17.46	-	6.48	51	0.078
Russia	52.5	77	68.29	0.14	5.80	2,723	1.084
Singapore	687.9	580	468.95	0.12	8.81	1,746	1.883
Spain	731.4	231	199.25	-	6.09	5,033	0.897
Sweden	792.0	626	554.18	21.35	9.22	9,176	3.782
Switzerland	767.0	600	466.85	30.87	8.88	8,083	2.731
Taiwan	881.0	394	351.53	-	7.71	6,326	2.045
Thailand	126.8	40	58.17	0.75	6.43	317	0.26
United Kingdom	754.8	492	401.75	-	7.64	26,964	1.849
United States	435.0	639	522.10	3.50	9.13	265,322	2.687

Sources: World Bank (2001), World Development Indicators; Statistical Abstract of Transportation and Communication (2002), ROC.

Table 3.7 WMRC global e-government rankings

2003 (198 Economies, 2,166 Web-Sites)			2002 (198 Economies, 1,197Web-Sites)			2001 (196 Economies, 2,288 Web-Sites)		
Rank	Economy	Score	Rank	Economy	Score	Rank	Economy	Score
1	Singapore	46.3	1	Chinese Taipei	72.5	1	United States	57.2
2	United States	45.3	2	South Korea	64	2	Chinese Taipei	52.5
3	Canada	42.4	3	Canada	61.1	3	Australia	50.7
4	Australia	41.5	4	United States	60.1	4	Canada	49.6
5	Chinese Taipei	41.3	5	Chile	60.0	5	Great Britain	47.1
6	Turkey	38.3	6	Australia	58.3	6	Ireland	46.9
7	Great Britain	37.7	7	China	56.3	7	Israel	46.2
8	Malaysia	36.7	8	Switzerland	55.4	8	Singapore	44.0
9	Vatican	36.5	9	Great Britain	54.8	9	Germany	40.6
10	Austria	36.0	10	Singapore	53.5	10	Finland	40.2
11	Switzerland	35.9	11	Germany	52.6	11	France	40.1
11	China	35.9	12	Vanuatu	52.0	12	Lesotho	40.0
12	New Zealand	35.5	12	Bahrain	52.0	12	St. Kitts	40.0
12	Finland	35.5	12	Qatar	52.0	12	Vatican	40.0
12	Philippines	35.5	12	Vatican	52.0	15	Bahamas	39.7
12	Denmark	35.5	12	Japan	52.0	16	Malaysia	39.0
13	Maldives	35.2	12	Mexico	52.0	17	Iceland	38.3
14	St. Lucia	35.0	12	Togo	52.0	18	Belgium	38.0

Sources: http://www.insidepolitics.org/PressRelease02int.html
http://www.brown.edu/Departments/Taubman_Center/polreports/egovt01int.html

Indeed the government sectors have demonstrated admirable preparedness for the Internet era.[1] The first round of the EIU e-readiness rankings, published to mark the May 2000 launch of the EIU e-business forum, combined the EIU business environment rankings (which encompassed 70 indicators) and the Pyramid connectivity scores. The new model, from 2001 onwards, was more robust, tallying the scores for six categories (including the business environment rankings) and 19 additional indicators (see Table 3.8).

[1] For detailed information, refer to the following websites: http://www.insidepolitics.org/PressRelease02int.html, and http://www.brown.edu/Departments/Taubman_Center/polreports/egovt01int.html)

Table 3.8 EIU e-readiness rankings

EIU E-Readiness Rankings								
2003			2002			2001		
Rank	Economy	Score	Rank	Economy	Score	Rank	Economy	Score
1	Sweden	8.67	1	US	8.41	1	US	8.73
2	Denmark	8.45	2	Netherlands	8.40	2	Australia	8.29
3	Netherlands	8.43	3	UK	8.38	3	UK	8.10
3	US	8.43	4	Sweden	8.32	4	Canada	8.09
3	UK	8.43	4	Switzerland	8.32	5	Norway	8.07
6	Finland	8.38	6	Australia	8.30	6	Sweden	7.98
7	Norway	8.28	7	Denmark	8.29	7	Singapore	7.87
8	Switzerland	8.26	8	Germany	8.25	8	Finland	7.83
9	Australia	8.25	9	Canada	8.23	9	Denmark	7.70
10	Canada	8.20	10	Finland	8.18	10	Netherlands	7.69
10	Hong Kong	8.20	11	Norway	8.17	11	Switzerland	7.67
12	Singapore	8.18	12	Singapore	8.17	12	Germany	7.51
13	Germany	8.15	13	Austria	8.14	13	Hong Kong	7.45
14	Austria	8.09	14	Hong Kong	8.13	14	Ireland	7.28
15	Ireland	7.81	15	Ireland	8.02	15	France	7.26
16	South Korea	7.80	16	Belgium	7.77	16	Austria	7.22
17	Belgium	7.78	17	France	7.70	17	Chinese Taipei	7.22
17	New Zealand	7.78	18	New Zealand	7.67	18	Japan	7.18
19	France	7.76	19	Italy	7.32	19	Belgium	7.10
20	Chinese Taipei	7.43	20	Chinese Taipei	7.26	20	New Zealand	7.00
21	Italy	7.37	21	South Korea	7.11	21	South Korea	6.97
22	Portugal	7.18	22	Spain	7.07	22	Italy	6.74
23	Spain	7.12	23	Greece	7.03	23	Israel	6.71
24	Japan	7.07	24	Portugal	7.02	24	Spain	6.43
25	Israel	6.96	25	Japan	6.86	25	Portugal	6.21
26	Greece	6.83	26	Israel	6.79	26	Greece	5.85
27	Czech Republic	6.52	27	Czech Republic	6.45	27	Czech Republic	5.71
28	Chile	6.33	28	Chile	6.36	28	Hungary	5.49

Sources: http://www.ebusinessforum.com/index.asp?layout=rich_story&doc_id=367,
http://www.ebusinessforum.com/index.asp?layout=rich_story&doc_id=3331.

Each variable is scored on a scale from 1 to 10, with the six categories being as follows:

1. Connectivity (25 per cent). Connectivity measures the access which individuals and businesses have to basic fixed telephone and mobile phone services. Affordability and availability of services also figure as determinants of connectivity.

2. Business environment (20 per cent). This screens 70 indicators covering criteria such as the strength of the economy, political stability, the regulatory environment, taxation and openness to trade and investment.

3. Consumer and business adoption (20 per cent). Payment and logistics systems form the backbone of this set of criteria.

4. Legal and policy environment (15 per cent). The legal framework governing e-business is a vital factor than can either enhance or inhibit the development of electronic trading. This category considers the extent of legal support for vital transactions and digital signatures.

5. Social and cultural infrastructure (15 per cent). These services include portals and other online intermediaries, web-hosting firms, application service providers (ASPs), as well as website developers and e-business consultants.

6. Supporting e-services (5 per cent). The resultant rankings offer a proxy for judging an economy's relative preparedness for the Internet era, dividing the 60 economies into four groups as follows:

(i) E-business leaders. These economies already have most of the elements of e-readiness in place; they include Sweden, Denmark, the Netherlands, the US, the UK, Finland, Norway, Switzerland, Australia, Canada, Hong Kong (China), Singapore and Germany.

(ii) E-business contenders. Although these economies have both satisfactory infrastructures and good business environments, parts of the e-business equation are still lacking. These economies include Austria, Ireland, South Korea, Belgium, New Zealand, France, Chinese Taipei, Italy, Portugal, Spain, Japan and Israel. Chinese Taipei ranks in just twentieth place.

(iii) E-business followers. These economies, which include Russia, India, and so on, have a great deal of work still to do.

(iv) E-business laggards. These economies face major obstacles to e-business growth, primarily in the area of connectivity. They include economies such as China and Indonesia.

Although the contents of the indicators have been revised, after comparing the rankings in the 2002 and 2003 reports to those in the 2001 report, we find that Chinese Taipei has experienced a decline from sixteenth to twentieth place. This indicates that some of the other economies have managed to overtaken Chinese Taipei, which has itself made no significant improvements in the development of its e-environment. Nevertheless, through a comparison of the WMRC e-government rankings and the EIU e-readiness rankings, and as we consider here the e-readiness performance of the government and private sectors, we find that the budgets and the overall application of the related projects or policies continue to be concentrated largely on government sectors. Clearly the private sector will not take off unless the government moves boldly and firmly towards gearing up the necessary regulatory regime.

IV. Empirical Results and Analysis

INTRODUCTION

There are clearly defined patterns of information communications technology (ICT) development strategies and industrial specialization within the various APEC economies. In this chapter, in order to shed light on their industrial-related policies, we evaluate the influence of ICT development on the competitiveness of these economies, by first of all referring to the IMD annual report 2002. Our examination of the data provided within this report focuses specifically on technical and scientific infrastructure. In order to extract and summarize the information that is of importance to our examination, we will employ a principle components analysis for 17 of the economies within APEC. Important data was missing on Brunei, Papua New Guinea, Peru and Vietnam; therefore, these economies are excluded from our analysis.

Following the global estimates, using the APEC economies as our sample and Chinese Taipei as a case study, we continue with an analysis of ICT development in an effort to determine its impacts on Chinese Taipei at both macro and industry levels. Since ICT products can serve as intermediate products, consumer durables, or investment goods, there are two channels through which they may have an impact on the economy as a whole. The first of these is the changes which they can cause in the allocation of capital and labor inputs, whilst the second is the effect that they may have in terms of stimulating changes in technology, so that total factor productivity (TFP) rises along with the development of information technology (IT). In order to undertake a complete evaluation of the influence of ICT development, we employ growth accounting to estimate the overall impact, stemming from the ICT sector, on productivity within the Taiwanese economy.

GROWTH ACCOUNTING

Empirical Model

Growth accounting is undertaken by estimating the production function. The calculation of total factor productivity (TFP) is based upon the conceptual framework of the decomposition of the growth rate of real GDP, or gross domestic output (GDO), into the contribution from changes in capital and labor, with the remainder termed as TFP under the assumption of constant returns to scale. Here, we refer to the analysis of Lin (2000) and Jorgenson and Stiroh (1999)

Total factor productivity for the aggregate economy (λ)

Since we take into account both imported and domestic intermediate inputs in our empirical model, this leads to the use of gross domestic output (GDO) as opposed to gross domestic product (GDP) as our study object. The production function is therefore assumed as:

$$Y_t = F(K_t, L_t, M_t, t) \tag{1}$$

where Y is real GDO, K represents real capital inputs, L represents labor, M is imported intermediate inputs, and t is a proxy for time. Considering the form of growth rate, Equation (1) can be rewritten as:

$$g_Y = s_{KY} g_K + s_{LY} g_L + s_{MY} g_M + \lambda \tag{2}$$

where, g is a proxy for the rate of growth and s is treated as the share, which means that:

$$g_Y = \left(\frac{dY}{dt}\right)/Y; \quad S_K = \frac{F_K K}{Y} = \frac{P_K K}{P_Y Y}$$

at the equilibrium level:

$$F_k = \frac{\partial F}{\partial K} = \frac{P_K}{P_Y}; \quad \lambda = (\frac{\partial Y}{\partial t})/Y$$

where, λ is the aggregate TFP, which can be regarded as the residual.

Total factor productivity for industries (λ_j)

The j industrial production function is assumed as:

$$X_{jt} = F_j(K_{jt}, L_{jt}, M_{jt}, D_{jt}, t) \tag{3}$$

where Xj are the j industrial real outputs, Kj are the j industrial real capital inputs, Lj is the j industrial labor, Mj are the j industrial imported intermediate inputs, and Dj are the j industrial domestic intermediate inputs. If considering the form of growth rate, Equation (1) can be rewritten as:

$$g_{X_j} = s_{KjX_j} g_{k_j} + s_{LjX_j} g_{L_j} + s_{MjX_j} g_{M_j} + s_{DjX_j} g_{Dj} + \lambda_j \tag{4}$$

Similarly, g is a proxy for the rate of growth and s is treated as the share.

TFP linkage for the aggregate economy (λ) and industries (λ_j)

It is to be assumed that aggregate nominal output equals the sum of industrial nominal output; that is:

$$P_t Y_t = \sum_j P_{jt} Y_{jt} = \sum_j (P_{jt} X_{jt} - P_{jt} D_{jt}) \tag{5}$$

where P is the price for the real aggregate outputs, and Pj is the price for the j industrial outputs, so that $P_j D_j = \sum_j P_{ji} D_{ji}$ is the j industrial output as the sum for the other industrial intermediate inputs. The above equation can be rewritten as:

$$g_Y = \sum_j s_{XjY} g_{Xj} - \sum_j s_{DjY} g_{Dj} - \sum_j s_{YjY} g_{Pj} - g_P \quad (6)$$

where, s_{XjY}, s_{DjY}, s_{YjY} are denoted as the share for $P_j X_j$, $P_j D_j$ and $P_j Y_j$ to PY, so $\sum s_{YjY} = 1$.

If we take Equation (4) into Equation (6), then:

$$g_Y = \sum_j s_{X_jY} s_{K_jX_j} g_{K_j} + \sum_j s_{X_jY} s_{L_jX_j} g_{Lj} + \sum_j s_{X_jY} s_{M_jX_j} g_{M_j} + \sum_j s_{XjY} \lambda_j + \sum_j s_{Y_jY} g_{P_j} - g_P \quad (7)$$

which can be linked to the aggregate TFP (λ) and the industrial TFP (λ_j) as:

$$\begin{aligned} \lambda = \sum_j s_{X_jY} \lambda_j &+ \left(\sum_j s_{X_jY} s_{K_jX_j} g_{K_j} - s_{KY} g_K \right) + \left(\sum_j s_{X_jY} s_{L_jX_j} g_{L_j} - s_{LY} g_L \right) \\ &+ \left(\sum_j s_{X_jY} s_{M_jX_j} g_{M_j} - s_{MY} g_M \right) + \left(\sum_j s_{Y_jY} g_{P_j} - g_p \right) \end{aligned} \quad (8)$$

The right hand side of Equation (8) includes five items. The first item is the industrial weighted TFP, with the weight being the share of industrial output to aggregate GDO. The second to fifth items are treated as the resource reallocation effects. At the equilibrium level, these effects are almost zero. The second term is denoted as the capital reallocation effect; the third term is the labor reallocation effect; the fourth term is the imported intermediate inputs reallocation effect; and the fifth term is the domestic intermediate inputs reallocation effect. If resources move from the less productive industries to the more productive industries, the outcome will be positive, otherwise it will be negative. We can rearrange Equation (8) as:

$$\lambda = \sum_j s_{X_jY} \lambda_j + TRE \quad (9)$$

here, TRE = $\left(\sum_j s_{K_jY} g_{K_j} - s_{KY} g_K \right) + \left(\sum_j s_{L_jY} g_{L_j} - s_{LY} g_L \right) + \left(\sum_j s_{M_jY} g_{M_jY} - s_{MY} g_M \right)$

$$+\left(g_Y - \sum s_{Y_jY} g_{Y_j}\right)$$

Syrquin (1984) established $\sum s_{XjY}\lambda_j$ as the TFP-weighted growth rate of intra-industry technical change, and TRE as the total reallocation effect of inter-industry technical change. In order to evaluate the contribution of ICT in Chinese Taipei, we divide the aggregate outputs into three industries, ICT manufacturing industries, ICT service industries and non-ICT industries, with the sample covering the period from 1981 to 1999. The results are divided into 10-year periods, representing the 1980s and the 1990s. In order to avoid any distortion caused by the business cycle, estimates were also produced using the whole sample period (1981-1999).

EMPIRICAL RESULTS AND ANALYSIS

Economic Growth Sources and their Contribution

In order to evaluate the contribution of ICT, we divided the aggregate outputs into three industries, ICT manufacturing industries, ICT servicing industries, and non-ICT industries, with the sample covering the period from 1981 to 1999.

The ICT manufacturing industries are included as numbers 096 to 105 in the input-output tables for 1996, covering items such as computer products, computer peripheral equipment, data storage media, computer components, video and radio electronic components and materials, electronic components and parts. The ICT servicing industries are included as numbers 133 and 142, in the categories of telegrams and telephones, and data processing and information services. The non-ICT industries serve as residuals.

We begin by considering the rate of change in TFP. As Table 4.1 shows, in the 1980s, this was 3.43 per cent, giving a contribution rate of 30.70 per cent; however, in the 1990s, the respective rate of change in TFP and contribution rate were lower, at 1.48 per cent and 24.28 per cent. As to changes in factor inputs, in the 1980s, imported intermediate inputs had a higher contribution rate, at 34.29 per cent, whereas in the 1990s it was capital inputs that had a higher contribution rate, at 41.79 per cent.

Looking at the industry-specific data in Table 4.2, it is clear that in the 1990s, the rate of change in TFP for the ICT manufacturing industry had a contribution of 30.01 per cent, higher than in the 1980s. Over the course of the whole period covered by the sample, the contribution made by TFP to the GDO growth rate in the ICT manufacturing industry was approximately 25.15 per cent, slightly lower than the figure for the economy as a whole, which was 28.33 per cent. As to the contribution made by different factor inputs, the contribution rate of imported intermediate inputs was highest, at 36.43 per cent. This shows just how important imported raw materials are to the ICT manufacturing industry.

Table 4.1 Sources of aggregate GDO growth

Unit: %

	Sample Period	Real GDO	Imported Intermediate Inputs	Labor Inputs [a]	Capital Inputs [b]	Total Factor Productivity
Rate of Change [c]	1981-91	8.82	11.77	1.24	8.45	2.71
	1991-96	6.72	6.97	1.72	10.56	1.19
	1996-99	5.28	6.34	-0.10	6.31	1.85
	1991-99	6.08	6.69	0.91	8.67	1.48
	1981-99	7.52	9.36	1.08	8.56	2.13
Share [d]	1981-91	100.00	25.68	44.29	30.03	-
	1991-96	100.00	24.66	46.92	28.42	-
	1996-99	100.00	24.37	44.95	30.68	-
	1991-99	100.00	24.56	46.14	29.30	-
	1981-99	100.00	25.16	45.09	29.75	-
Contribution [e]	1981-91	100.00	34.29	6.23	28.78	30.70
	1991-96	100.00	25.59	12.02	44.67	17.73
	1996-99	100.00	29.23	-0.88	36.65	35.00
	1991-99	100.00	27.02	6.91	41.79	24.28
	1981-99	100.00	31.33	6.50	33.85	28.33

Notes:

[a] Labor inputs uses the number of hours worked during a year.
[b] Capital inputs uses capital stock deflated by capacity utilization rate.
[c] The rate of change is treated as the average growth rate.
[d] Share is calculated from the percentage of inputs to GDO
[e] Contribution is estimated by rate of change multiplied by share, giving the rate of change in real GDO.

Source: Calculated by the authors.

Table 4.2 GDO growth sources, by industry

Unit: %

	Sample Period	Real GDO	Labor Inputs [a]	Capital Inputs [b]	Intermediate Inputs		Total Factor Productivity
					Imported	Domestically produced	
ICT Manufacturing Industries							
Rate of Change [c]	1981-91	14.55	3.22	16.17	16.48	15.74	3.23
	1991-96	13.91	2.43	14.50	14.86	13.13	3.87
	1996-99	8.54	2.01	9.60	6.52	6.32	3.02
	1991-99	11.52	2.24	12.32	11.15	10.10	3.46
	1981-99	13.11	2.76	14.35	13.96	13.07	3.30
Share [d]	1981-91	100.00	37.45	10.32	30.29	21.94	-
	1991-96	100.00	36.34	9.07	39.06	15.53	-
	1996-99	100.00	30.51	13.47	37.62	18.41	-
	1991-99	100.00	34.11	10.62	38.73	16.54	-
	1981-99	100.00	35.82	10.56	34.23	19.40	-
Contribution [e]	1981-91	100.00	8.29	11.46	34.33	23.74	22.18
	1991-96	100.00	6.35	9.46	41.73	14.66	27.80
	1996-99	100.00	7.17	15.14	28.73	13.62	35.34
	1991-99	100.00	6.64	11.36	37.49	14.51	30.01
	1981-99	100.00	7.53	11.55	36.43	19.33	25.15

Table 4.2 (Contd.)

Unit: %

	Sample Period	Real GDO	Labor Inputs [a]	Capital Inputs [b]	Intermediate Inputs: Imported	Intermediate Inputs: Domestically produced	Total Factor Productivity
ICT Servicing Industries							
Rate of Change [c]	1981-91	13.53	4.07	12.71	24.66	15.82	0.42
	1991-96	11.11	3.03	14.23	5.32	12.10	0.81
	1996-99	10.49	4.87	8.13	5.89	5.89	4.12
	1991-99	10.83	3.85	11.52	5.57	9.34	2.29
	1981-99	12.25	3.97	12.15	15.62	12.75	1.14
Share [d]	1981-91	100.00	18.95	34.60	6.73	39.72	-
	1991-96	100.00	18.58	30.75	11.43	39.25	-
	1996-99	100.00	20.31	30.52	10.62	38.54	-
	1991-99	100.00	19.09	30.76	11.16	39.00	-
	1981-99	100.00	19.09	33.03	8.43	39.44	-
Contribution [e]	1981-91	100.00	5.70	32.50	12.26	46.44	3.09
	1991-96	100.00	5.07	39.40	5.47	42.75	7.30
	1996-99	100.00	9.44	23.64	5.97	21.65	39.31
	1991-99	100.00	6.78	32.71	5.74	33.62	21.14
	1981-99	100.00	6.18	32.75	10.75	41.04	9.28
Non-ICT Industries							
Rate of Change [c]	1981-91	8.52	1.09	8.19	11.04	9.06	1.28
	1991-96	6.15	1.66	10.34	5.34	6.46	0.53
	1996-99	4.87	-0.30	5.54	6.30	6.33	0.57
	1991-99	5.58	0.79	8.21	5.77	6.40	0.52
	1981-99	7.13	0.95	8.20	8.54	7.80	0.95
Share [d]	1981-91	100.00	24.49	16.11	13.33	46.07	-
	1991-96	100.00	28.08	16.81	12.48	42.63	-
	1996-99	100.00	28.36	18.28	12.37	40.98	
	1991-99	100.00	28.10	17.35	12.43	42.12	-
	1981-99	100.00	25.99	16.72	12.94	44.36	-
Contribution [e]	1981-91	100.00	3.14	15.49	17.28	49.01	15.09
	1991-96	100.00	7.58	28.26	10.84	44.77	8.56
	1996-99	100.00	-1.73	20.79	16.00	53.20	11.74
	1991-99	100.00	3.98	25.50	12.84	48.29	9.39
	1981-99	100.00	3.46	19.22	15.51	48.54	13.26

Notes:

[a] Labor inputs uses the number of hours worked during a year.
[b] Capital inputs uses capital stock deflated by capacity utilization rate.
[c] The rate of change is treated as the average growth rate.
[d] Share is calculated from the percentage of inputs to GDO
[e] Contribution is estimated by rate of change multiplied by share, giving the rate of change in real GDO.

Source: Calculated by the authors.

The contribution rate of domestically-produced intermediate inputs was almost 20 per cent; clearly, this is also very important. The contribution made by labor inputs to GDO growth in the ICT manufacturing industry was the smallest, at just 7.53 per cent for the whole sample period, from 1981 to 1999.

Within the ICT service industry, the disparity between the rate of change in TFP in the 1980s and the 1990s was significant. In the 1980s, the contribution rate was less than 5 per cent, but during the 1990s, it rose to 21.14 per cent. Over the whole sample period, the contribution rate was 9.28 per cent; only the labor input contribution rate was lower, at 6.18 per cent. Amongst the various factor inputs, domestically-produced intermediate inputs had the highest contribution rate, at over 40 per cent, and capital inputs had the second highest contribution rate, at 32.75 per cent, whilst the contribution rate of imported raw materials was relatively low, at around only 10 per cent.

When comparing the contribution made by different factor inputs in the ICT manufacturing industry and the ICT service industry, it is clear that the ICT manufacturing industry is most dependent on imported raw materials, followed by domestically-produced raw materials, whilst the importance of capital inputs and labor inputs is relatively low. In the ICT service industry, the emphasis is on domestically-produced raw materials and capital inputs; the contribution made by imported raw materials and labor inputs is relatively low.

As to the rate of change in TFP in the non-ICT industries, over the whole period covered by the sample, the average contribution rate was only 13.26 per cent; the impact of the rate of change in TFP was thus relatively limited. This figure seems very low by comparison with the contribution from the rate of change in TFP for industry as a whole (28.33 per cent), or for the ICT manufacturing industry (25.15 per cent), although it is relatively high when compared to the figure for the ICT service industry (9.28 per cent). As to the contribution made by the various factor inputs, domestically-produced intermediate inputs had the highest contribution rate, at 48.54 per cent; the contributions rates for other factor inputs were all under 20 per cent, indicating that their contribution was relatively limited. In particular, the contribution rate for labor inputs was less than 5 per cent, a very low figure.

Connectivity Analysis

By inference from the model, the sources of output growth can be divided into the contribution made by the rate of change in factor inputs, and the contribution made by the rate of change in TFP. As Table 4.3 indicates, on average, the former accounts for around 71 per cent, whilst the latter accounts for slightly less than 30 per cent. This means that both are of considerable importance.

Table 4.3 Aggregate and industrial TFP linkages

Unit: %

Sample Period	Items	Aggregate GDO Growth rate (1)=(2)+(3)	Contribution of all inputs (2)	Total Factor Productivity (TFP)						
				Aggregate TFP (3)=(4)+(5)	Intra-industry technical change (4)	Inter-industry technical change (5)	Resource Reallocation Effect			
							Labor Inputs	Capital Inputs	Intermediate inputs	
									Imported	Domestically-produced
1981-91	Rate of Change	8.82	6.11	2.71	2.64	0.06	0.00	0.03	0.02	0.02
	Contribution	100.00	69.30	30.70						
				100.00	97.63	2.37				
						100.00	-6.70	43.27	34.37	29.06
1991-96	Rate of Change	6.72	5.53	1.19	1.09	0.10	-0.01	0.02	0.10	-0.02
	Contribution	100.00	82.27	17.73						
				100.00	91.74	8.26				
						100.00	-9.26	20.61	103.88	-15.23
1996-99	Rate of Change	5.28	3.44	1.85	1.69	0.16	0.00	0.07	0.09	0.00
	Contribution	100.00	65.00	35.00						
				100.00	91.52	8.48				
						100.00	-0.88	43.17	57.20	0.51
1991-99	Rate of Change	6.08	4.61	1.48	1.35	0.13	-0.01	0.02	0.12	-0.01
	Contribution	100.00	75.72	24.28	24.28					
				100.00	91.21	8.79				
						100.00	-5.30	16.02	93.28	-4.01
1981-99	Rate of Change	7.52	5.39	2.13	2.05	0.08	0.00	0.03	0.05	0.00
	Contribution	100.00	71.67	28.33	28.33					
				100.00	96.39	3.61				
						100.00	-3.82	33.96	65.57	4.29

Source: Calculated by the authors.

The rate of change in TFP can also be broken down into the rate of change in TFP in different industries. This represents the effects of improvements in technology within the same industry, and the effects of improvements in technology between industries resulting from the shifting of resources. Since the 1980s, the main source of TFP growth in Chinese Taipei has been technological progress within the same industry, with a very high contribution rate of 96.39 per cent. The contribution of technological progress between industries is quite small, at less than 5 per cent. This shows that the technological progress effect as a result of the reallocation of resources between the IT sector and non-IT industries has been relatively small. Whether in terms of labor, capital or intermediate goods, transfer between the IT sector and the non-IT sector has been minimal.

If we examine inter-industry technological progress in terms of production factor inputs and the final output reallocation effect, it is clear that the replacement effect is greatest in the case of imported intermediate inputs wherein transfer can be facilitated more efficiently. The second highest reallocation effect is found in capital inputs. In the case of labor inputs, the reallocation effect is actually negative, which indicates that the allocation of labor inputs between the IT and non-IT sectors has been inappropriate, i.e., labor inputs have not been allocated efficiently. Analysis applying an empirical model to the existing data thus indicates that the rapid development of Chinese Taipei's IT sector has had no substantial impact on other industries; the spillover effect is neither marked nor widespread.

Inter-Sector Externality Test

In this section, we hypothesize the existence of beneficial externality effects of production for ICT industries over non-ICT industries. Within the literature, it is widely believed that ICT sectors tend to be more productive than non-ICT sectors, with one of the reasons being that competition in the international markets induces innovation, adaptability and efficient management. A further reason is that the ICT sector is usually free of constraining regulations in areas such as foreign exchange and credit rationing.

In order to determine the externality effects of ICT industries over non-ICT industries, suppose that the production functions of the non-ICT industries can be written as follows:

$$Q_n = F(K_n, L_n, Q_e)$$

$$Q_e = G(K_e, L_e)$$

where Q_n = output from the non-ICT industries, Q_e = output from the ICT industry processing zones, K_n = the capital stock of the non-ICT industries and L_n = employment within the non-ICT industries.

Suppose that the ICT industries affect the production of the non-ICT industries with a functional form of constant elasticity, i.e.:

$$Q_n = Q_e^{\theta} \cdot H(K_n, L_n)$$

where θ is a parameter representing the externality effects. Apart from such externality, it is proposed that productivity differences exist between the ICT and non-ICT industries, and that the ratios of their marginal factor productivities deviate from unity by a factor, δ, i.e.:

$$(G_K / F_K) = (G_L / F_L) = 1 + \delta$$

where the subscripts denote partial derivatives. It is hypothesized that marginal productivities are likely to be lower in the non-ICT industries, i.e., δ >0.

Following the lines of Feder (1983), it is assumed that a linear relationship exists between the real marginal productivity of labor in a given sector and the average output per laborer within the economy as a whole:

$$F_L = \beta * (Y / L)$$

where *Y* denotes gross domestic product (GDP), and by definition:

$$Y = Q_n + Q_e \,.$$

After some manipulation, we have:

$$\frac{\dot{Y}}{Y} = \alpha \frac{I}{Y} + \beta \frac{\dot{L}}{L} + \left(\frac{\delta}{1+\delta} - \theta\right) \frac{\dot{Q}_e}{Q_e} \frac{Q_e}{Y},$$

where *I* is the total investment within the economy. This is the empirical model adopted in the following regression analysis, with the regression results being shown in Tables 4.4 and 4.5.

Table 4.4 tests the externality effects of ICT within the APEC economies. The coefficient of $\frac{\dot{Q}_e}{Q_e} \frac{Q_e}{Y}$ is 0.213, showing a positive spillover effect from the ICT sector to the economy; however, the coefficient is statistically insignificant with a *t* value of only 0.131. The adjusted R square is also as low as 0.226. The limited sample size is one of the reasons for statistical insignificance and the lack of goodness of fit. We extend the sample to include India and OECD economies such as Finland, France, Germany, Italy, the Netherlands, Sweden and the United Kingdom, as shown in Table 3.7. Although the adjusted R square is raised to 0.522, the coefficient of $\frac{\dot{Q}_e}{Q_e}\frac{Q_e}{Y}$ is still insignificant. Inter-sector externality may exist, but it is not strongly supported by Feder's approach.

Table 4.4 Regression results of externality effects of ICT within APEC

Explanatory Variables	Coefficients	t-Statistics
Constant	-0.016	-0.536
I/Y	0.167	1.756
$\dot{L}/L$	0.728	0.954
$(\dot{Q}_e/Q_e)(Q_e/Y)$	0.213	0.131
$\overline{R}^2$	0.226	
No. of observations	15	

Note: The dependent variable is $\dot{Y}/Y$

Table 4.5 Regression results of externality effects of ICT with eight additional economies

Explanatory Variables	Coefficients	t-Statistics
Constant	-0.014	-1.038
I/Y	0.156	2.548
$\dot{L}/L$	0.805	2.026
$(\dot{Q}_e/Q_e)(Q_e/Y)$	0.289	0.262
$\overline{R}^2$	0.522	
No. of observations	23	

Note: The dependent variable is $\dot{Y}/Y$

Principal Components Analysis

Principal components analysis is widely used in signal processing and has proven to be a useful tool for the categorization of data since it can separate the dominating features of a dataset. We apply the principal components analysis to the IMD competitiveness report in an effort to investigate the characteristics of ICT development and its influence on national competitiveness. The IMD national competitiveness rankings are multi-dimensional; therefore, in order to focus on ICT development, we consider the indicators that are grouped into the categories of technological and scientific infrastructure. As a result of missing data, some of the indicators are dropped, leaving 37 indicators in the dataset.

The sample data is reviewed prior to embarking on the empirical study, and when plotting the per capita GDP (*RY*) with investment in telecommunications, as a proportion of GDP (ICT), if we ignore some outliers such as China, we find that the per capita GDP is directly proportional to the ICT investment ratio. This means a higher income level will result in the input of much greater ICT investment (see Figure 4.1).

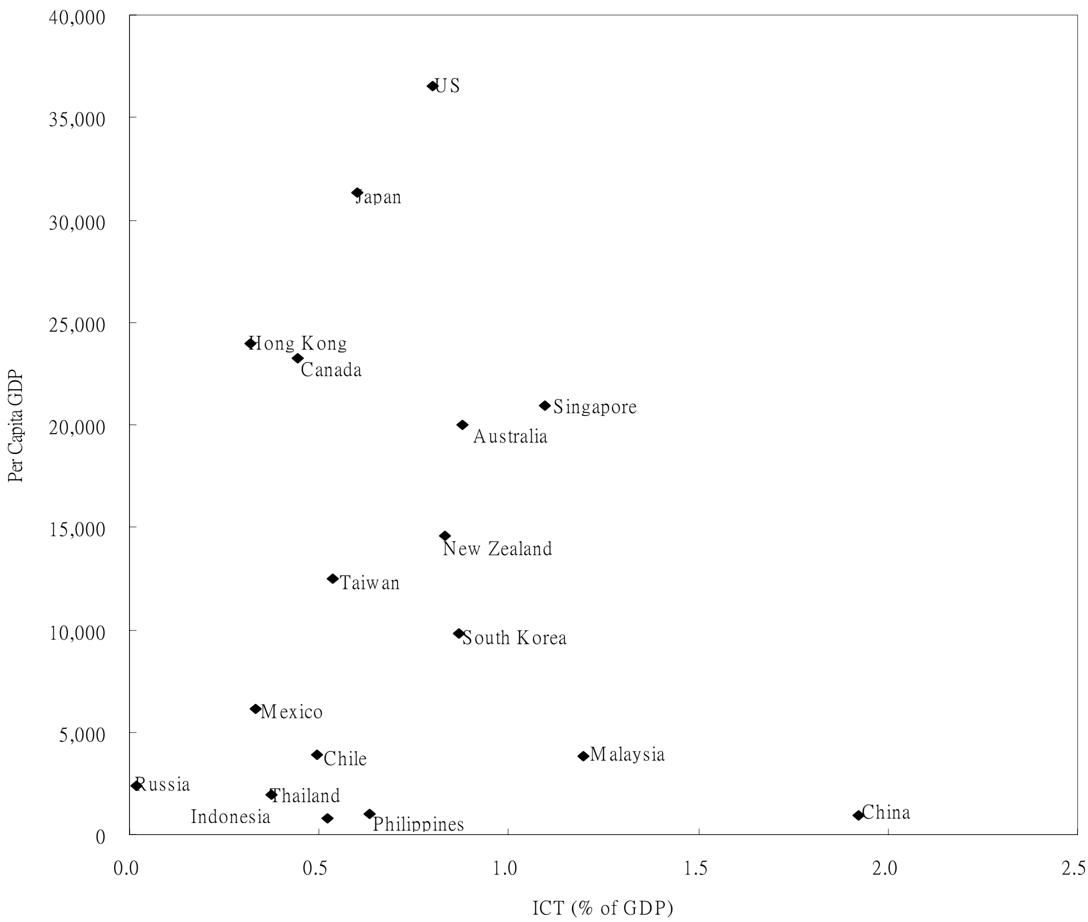

Figure 4.1 Comparison of 2000 investment in telecommunications and 2002 per capita GDP

The overall results of the principal components analysis are shown in Table 4.6, with the figures for the APEC economies being shown in Table 4.7. We can see that the first principal component can explain 48 per cent of the variance, and if we choose five principal components, the explanatory ability is below 92 per cent, which provides a good signal. We find that the first component can be treated as a measure of overall ICT development since the first eigenvector shows approximately equal loadings for all variables. This may be regarded as 'General ICT Development'.

Table 4.6 Principal components analysis results

Components	General ICT Development	R&D Inputs	R&D Spirit	ICT Infrastructure	ICT Incentives
Eigenvalue	17.90	7.072	3.215	2.578	1.690
Proportion	0.484	0.191	0.107	0.080	0.056
Cumulative	0.484	0.675	0.782	0.862	0.917
Eigenvectors					
2002 per Capita GDP (US$)	0.218	0.052	0.011	-0.083	-0.101
2000 Investment in Telecoms (% of GDP)	0.027	-0.011	0.052	0.388	0.115
2001 Fixed Telephone Lines per 1000 people	0.216	-0.034	0.087	-0.147	-0.132
2003 International Fixed Telephone Costs per 3 min peak hours to USA (for US to Europe) (US$)	-0.146	0.151	0.059	0.092	-0.356
2002 Mobile Telephone Subscribers per 1,000 people	0.155	-0.121	0.070	0.083	-0.321
2001 Mobile Telephone Costs per 3 min peak hours (local) (US$)	0.023	-0.072	0.094	-0.492	0.226
2003 Adequacy of Communications	0.194	-0.169	-0.100	0.022	-0.101
2003 New Information Technology	0.204	-0.165	-0.062	0.055	-0.035
2002 Global share of Computers in Use	0.143	0.249	-0.188	0.039	0.163
2002 Computers per Capita per 1,000 people	0.217	-0.050	0.031	-0.134	-0.030
2002 No. of Internet Users per 1000 people	0.213	-0.079	0.068	-0.090	-0.185
2003 Suitable Internet Access	0.191	-0.157	-0.122	0.004	-0.173
2003 Information Technology Skills	0.184	-0.149	-0.062	-0.108	0.133
2003 Technological Cooperation	0.218	-0.102	-0.050	-0.009	0.073
2003 Development and Application of Technology	0.197	-0.175	-0.069	0.091	0.068
2003 Funding for Technological Development	0.214	-0.104	-0.031	0.153	-0.040
2001 High-tech Exports (US$ millions)	0.158	0.220	-0.092	0.229	0.041
2001 Proportion of High-tech Manufactured Exports	0.032	-0.084	-0.055	0.390	0.132
2003 Data Security	0.179	-0.222	-0.047	-0.043	0.061
2001 Total Expenditure on R&D (US$ millions)	0.154	0.259	-0.153	0.018	0.087
2001 Total Expenditure on R&D per capita (US$)	0.197	0.173	0.056	-0.006	-0.103
2001 Proportion of GDP Expenditure on R&D (%)	0.180	0.126	0.208	0.005	-0.136
2001 Business Expenditure on R&D (US$ millions)	0.153	0.258	-0.160	0.020	0.093
2001 Business per Capita Expenditure (US$)	0.187	0.203	0.039	0.025	-0.091
2001 Total R&D Personnel Nationwide	-0.020	0.228	0.388	0.004	0.171
2001 Total R&D Personnel Nationwide per 1,000 people	0.146	0.090	0.341	-0.195	0.100
2001 Total R&D Personnel within enterprises	-0.010	0.233	0.396	-0.022	0.143
2003 Basic Research	0.207	-0.013	0.115	0.049	0.168
1998 proportion of Science and Engineering Degrees (%)	0.019	0.011	0.281	0.424	-0.130
1999 Scientific Articles Published	0.152	0.240	-0.177	-0.006	0.183
2003 Science in Schools	0.130	-0.184	0.248	0.089	0.301
2003 Interest in Science and Technology	0.096	-0.199	0.211	0.211	0.273
2002 Nobel Prize Awards	0.134	0.202	-0.262	0.016	0.238
2000 No. of Patents Granted	0.132	0.273	0.065	-0.012	-0.140
2003 Patent and Copyright Protection	0.212	-0.098	0.010	-0.059	0.059
2000 Number of Patents in Force Per 100,000 people	0.195	0.014	0.208	-0.060	-0.248
2000 Patent Productivity	0.143	0.177	-0.110	0.000	-0.159

Table 4.7 Principal components analysis for APEC economies

Economies	General ICT Development	R&D Inputs	R&D Spirit	ICT Infrastructure	ICT Development Incentives
US	9.133	5.294	-3.566	0.313	1.471
Japan	4.607	4.739	2.604	-0.273	-1.613
Canada	4.249	-3.334	1.942	2.929	0.310
Singapore	3.622	-2.055	0.799	-0.910	-0.024
Australia	2.803	-2.561	0.690	-2.487	0.592
Chinese Taipei	2.104	-0.974	0.804	0.732	-1.026
Hong Kong	1.528	-2.893	-0.472	-0.223	-1.191
South Korea	1.071	-2.162	-0.403	-2.391	0.450
New Zealand	0.438	0.649	0.277	0.147	-2.321
Malaysia	-0.493	-2.431	-0.811	2.174	1.470
Chile	-1.735	-1.487	-1.168	-0.686	-0.344
Russia	-3.474	-0.881	-1.892	0.678	1.308
China	-3.825	0.032	-1.544	0.071	-0.116
Philippines	-4.164	2.547	3.404	-2.092	2.553
Thailand	-4.171	2.400	1.760	2.736	0.756
Mexico	-4.956	1.134	-1.620	-1.185	-0.948
Indonesia	-6.736	1.984	-0.804	0.467	-1.327

The second eigenvector demonstrates high positive loadings on number of patents granted, business expenditure on R&D, total expenditure on R&D and the global share of computers in use, so the second component may be referred to as the ‘R&D inputs’. The third component has high positive loadings on total R&D personnel within enterprises, total personnel nationwide, total R&D personnel nationwide per 1,000 people and the proportion of science and engineering degrees, so this may be regarded as ‘R&D spirit’. The fourth component has high negative loadings on mobile telephone costs and positive loadings on the proportion of science and engineering degrees, the proportion of high-tech manufactured exports and investment in telecoms (as a proportion of GDP), so we may regard this component as ‘ICT Infrastructure’. The fifth component has negative loadings on international fixed telephone costs and mobile telephone subscribers and positive loadings on science in schools and interest in science and technology, so we may refer to this as ‘ICT Development Incentives’.

If we rank the APEC economies by the first component, we find that the US is in first place and Chinese Taipei is ranked sixth. Chinese Taipei’s score is positive in components 1, 3 and 4, and negative in components 2 and 5, so we may conclude that Chinese Taipei is well positioned in general ICT development, R&D spirit and ICT infrastructure, but could improve on R&D inputs and ICT development incentives. In order to provide a form of reference, we plot the principal components analysis results for selected economies in Figure 4.2.

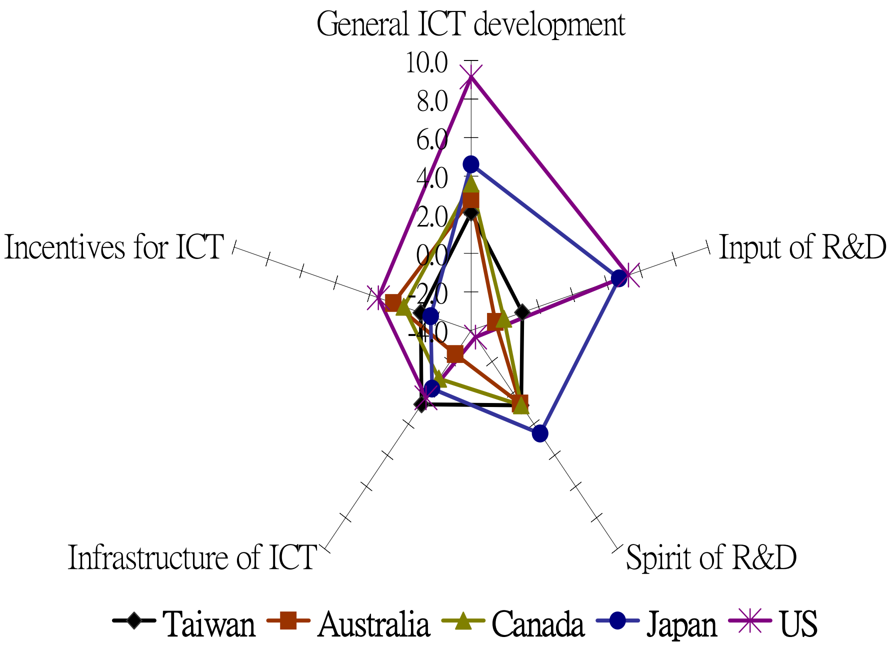

Figure 4.2　Selected economies plot using the principal components analysis results

V. ICT Development Policies

ICT development involves not only innovation in computer-related products, but also an historic transformation of society, which requires considerable backup in terms of infrastructure and regulations. The US, European and Asia-Pacific economies are, therefore, aggressively developing both their IT infrastructure and related policies. Figure 5.1 demonstrates that the ICT programs within the US, such as the 'National Information Infrastructure' (NII) and 'Global EC framework', may be regarded as navigators of the global knowledge-based society now being followed by many economies. Indeed, there have been many projects and policies involving ICT in recent years, such as the Japanese 'e-Japan' project, the 'Infocomm 21' project in Singapore, the 'UK online' project, South Korea's 'e-Korea' and Chinese Taipei's related policies. All of these projects aim to improve the development and application of ICT so as to accumulate economic development and to improve the overall quality of life. The strategies and frameworks may differ significantly in different economies; for example, the view of the US government is that in the early stages of development, the private sector should lead. Indeed, the private sector does play an active role in the policies and regulations concerning the knowledge-based economy in many economies; however, in Korea, Japan, Singapore and Chinese Taipei, it is the government which plays a more active and dominant role in the establishment of the e-society policy environment.[2]

ICT Development in Chinese Taipei

Chinese Taipei has recently implemented two policies related to ICT development. They are 'The Plan to Develop the Knowledge-based Economy in Chinese Taipei' and 'Two Trillion, Twin Stars Plan'. These two policies are illustrated briefly below:

The 'Plan to Develop the Knowledge-based Economy (KBE) in Chinese Taipei'

This plan, which is one of the driving forces for Chinese Taipei's transformation into a 'green silicon island', contains three dimensions, the knowledge-based economy, society with justice, and sustainable environment.

[2] For details of the actions of each economy, refer to the following websites: http://www.kantei.go.jp; http://www.noie.gov.au; http://www.ic.gc.ca; http://www.ida.gov.sg; http://www.cepd.gov.tw; http://www.s-one.gov.sg; http://www.ecommerce.gov; http://www.mic.go.kr

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
US	▲93 NII		★95 EC Working Group		▲97 Global EC Framework	★98 1st Report	▲99 2nd Report eGovernment eSociety		★01 3rd Report	▲02 Public Telecommunications Facilities Program	
Canada		★94 Information Highway Advisory Council				▲98 Canadian E-Commerce Strategy		▲00 Personal Information Protection and Electronic Documents Act Bill, Canadian E-Business as Opportunities Roundtable			
Australia						▲98 A Strategic Framework for the Information Economy	▲99 E-Commerce beyond 2000 Report	▲ 00 Online Australia; Networking the Nation			
Japan			▲95 The S&T Basic Law				▲99 Millennium Program	▲01 e-Japan		▲02 e-Japan Priority Policy Plan	▲03 Basic Policies for Economic and Fiscal Management and Structural Reform, e-Japan Strategy II, Asia Broadband Program
Chinese Taipei		▲94 NII			▲97 NII Mid-term project	▲98 e-government		▲01 NICI		▲02 Two trillion, Twin stars plan	
UK				▲96 Information Society		▲98 Building the Knowledge Driven Economy	▲99 e-commerce@its.best.uk ★Modern Government ★eGov Services for the 21st Century	▲00 UK Online			
Singapore				▲96 Singapore One	★97 IT in Education	▲98 Electronic Transactions Act NCIP Programme		▲00 Infocomm 21 Wired With Wireless Programme			▲03 Ultra – Wideband Programme
South Korea	▲93 KII	★94 MIC	▲95 BAPI				▲99 Cyber Korea 21			▲02 e-Korea	▲03 Korea Internet White Paper

Figure 5.1 ICT policies and programs

Motivation. The rise in globalization means that cost-saving in production can no longer support continuous economic development. Therefore, Chinese Taipei must encourage innovation and foster new ventures as a means of maintaining its global competitiveness. On the other hand, the Internet expedites the distribution of information and knowledge, which makes it easier to combine such knowledge with appropriate factors, and achieve better economic results. The advanced economies, such as the US, which make good use of 'cyberspace' to disseminate knowledge and information, have created impressive profits.

Opportunities. The application of knowledge and the Internet, as well as the integration of knowledge and core competences within existing industries, can no doubt enhance the island's international competitiveness and profitability. This is a key strategic area which Chinese Taipei should pursue vigorously.

Strategies. The key strategies for success include (see CEPD, 2003):

1. the setting up of mechanisms to encourage innovation and foster new ventures.
2. the expansion of IT and Internet usage in production as well as in daily life.
3. laying the groundwork for an environment supportive of Internet usage.
4. considering appropriate modification of the education system in a drive to meet the development of personnel needs by training and importing a sufficient pool of knowledge workers.
5. the establishment of service-oriented government.
6. the formulation of precautionary measures against social problems arising from transformation of the economy.

The 'Two Trillion, Twin Stars Plan'

Motivation. Chinese Taipei's industrial development is currently facing both internal and external challenges. Following the accession into the World Trade Organization by mainland China, the availability of cheap labor, the low cost of land and the opening up of the huge market in the mainland together represent a very high level of attraction for investors, which in turn, is accelerating the exodus of Chinese Taipei's labor-intensive and low added-value industries from the island. As a result, Chinese Taipei has become highly dependent on the vigorous development of its leading industries as well as its newly emerging industries to maintain the island's economic growth and future development.

Internally, the quality and discipline of Chinese Taipei's workforce, which was clearly very important in the development of the traditional manufacturing sector, is, nevertheless, not capable of tackling the challenges of a knowledge-based economy. Chinese Taipei must therefore actively nurture the technological and innovative capabilities of its engineers and skilled professionals. Consequently, Chinese Taipei is now focusing its strategies for industrial development in the new century on technological R&D, as well as innovation. On the one hand, it will strengthen the foundations of those industries that have already achieved considerable success (semiconductors, LCDs, etc.) to enable them to achieve a leading position on a global scale, and from there, exert a strong global influence (The Two Trillion Plan). On the other hand, using as capital, the fine technological innovation and good living environment that Chinese Taipei has already established, the aim will be to integrate the innovative resources of the Asia-Pacific region with the rest of the world and seize the opportunity to emerge as new global 'star industries' (digital content, biotechnology) to trigger a new economic boom (the Twin Stars Plan).

Development prospects for the 'Two Trillion, Twin Stars' industries

The 'Two Trillion' industries refers to the semiconductor and display industries, each of which are expected to reach an annual production value in excess of NT$1 trillion within the next few years. Production value in the semiconductor industry is expected to reach NT$1.59 trillion by 2006, whilst over the same period, production value in the display industry (with its focus on flat panel displays in the first stage of development) is expected to reach NT$1.37 trillion (including NT$730 billion from flat panel displays and NT$640 billion from LCD monitors).

The 'Two Star' industries refers to the digital content and biotechnology industries, which are set to count amongst the future 'star industries'. Production value in the digital content industry (including software, computer games, electronic media, publishing, music, animation and Internet services) is expected to reach NT$370 billion by 2006, whilst business volume in the biotechnology industry is expected to reach NT$250 billion over the same period. Investment over the next five years is expected to total NT$150 billion, with forecasts of over 500 biotech firms being founded within the next decade (Industrial Development & Investment Center, MOEA, 2003)

ICT Development in Japan

The elements comprising the basic strategy for national IT development in Japan include the enactment of the 'IT Basic Law' in November 2000, which set out to promote measures aimed at forming an advanced information and telecommunications network society following the so-called 'IT revolution'. The aim of the 'Strategic Headquarters for the Promotion of an Advanced Information and Telecommunications Network Society' (IT

Strategic Headquarters, January 2001) was to promote measures aimed at forming an advanced information and telecommunications network society, intensively and expeditiously, through the creation of ‘priority policy programs’ and the holding of discussions on prioritization plans.

The main objective behind the ‘e-Japan Strategy’ (January 2001) was to make Japan the world’s leading IT economy by the year 2005, with four priority policy areas comprising of (i) the establishment of an ultra high-speed network infrastructure and competition policies, which is broken down into three sub-policies; (a) the completion of high-speed access (30Mbps) to 30 million households, and ultra high-speed access (100Mbps) to 10 million households within a five-year period; (b) easy access to the Internet at an extremely low rate within a year; and (c) managing the shift to IPv6; (ii) the facilitation of e-commerce by establishing the framework and market rules by the year 2002; (iii) the realization of e-government, effectively handling electronic information, in the way that paper-based information was handled in the past, by the fiscal year 2003; (iv) nurturing high-quality human resources to achieve a 60 per cent Internet usage rate by 2005, upgrading information literacy by making Internet access available to schools and public sites, and increasing the overall number of IT instructors, technical experts, researchers and digital content creators.

The ‘e-Japan Priority Policy Program 2002’ (June 2002) was targeted at the realization of the e-Japan strategy, with the government running ‘priority policy programs’ comprising of five main priority policy fields: (i) the formation of the world’s most advanced information and telecommunication networks; (ii) the promotion of education and the development of human resources; (iii) the facilitation of e-commerce; (iv) the digitization of administration and application in public fields on an IT basis; and (v) ensuring the security and reliability of the advanced information and telecommunications networks.

The overall budget allocation for the related policy measures for FY 2003 was JP¥ 1,536 billion (about 1.8% of its general account). The first phase for the e-Japan strategy (January 2001-June 2003) was the development of an appropriate IT infrastructure, with realization targets of 30 million households on ‘high-speed access’ and 10 million households on ‘ultra high-speed access’, the world’s cheapest level of monthly charges for such access, and the establishment of an institutional framework for e-government and e-commerce.

The second phase of the e-Japan strategy (July 2003-   ) relates to the utilization of IT. The country expects to establish a ‘vibrant, safe, impressive and convenient’ society, and to aggressively utilize its IT infrastructure for the effective transformation of the country’s socio-economic systems. The leading measures cover seven important areas, including medical care, food, livelihood, financial assistance for SMEs, intellect, employment/work and government services. There is a clear need to pursue the development of a new social IT infrastructure, which includes the development of an appropriate information infrastructure suitable for the next generation, the establishment of a secure and safe environment for usage, the promotion of R&D to create the necessary intellect for the next generation, the fostering of IT human resources and promotion of education for the utilization phase, and the establishment of new international relations centered on IT (Udaka, 2003).

ICT Development in Canada

An 'Information Highway Advisory Council' (IHAC) was formed by the Canadian Ministry of Industry in 1994 to advise the government on a national strategy for the development of the information highway. The Council asserted that in the new information economy, success will be determined by a competitive, unregulated marketplace. The IHAC claimed that innovation in information technology would ensure an increase in productivity and a growth in jobs, thus the government set about the creation of minimal ground rules and the overall promotion of e-commerce.

'Connecting Canadians', as its access policy was referred to, may well fulfill the IHAC's hope of getting Canadians onto the information highway, since the Council suggested that this would whet consumers' appetites for electronic consumer goods and services. The main objective of this campaign was to bring enough consumers to the information highway to attract the necessary private sector investment required for its continued construction. It was hoped that this investment and the resultant increased use of IT would, in turn, spur higher levels of productivity and wealth. Therefore, in combination with the provisions of the legal and policy framework for e-commerce, the 'Canadian E-Commerce Strategy 1998', became the top priority for the Canadian government.

Aimed at the creation of a mass consumption market, the Canadian Government's access policy was based on the fundamental strategy that the construction of the information highway, and the services offered over it, should be determined by the market and achieved by the private sector. The government's supporting role essentially involves promoting the development of a consumer market on the information highway; thus, it espouses the rhetoric of the IT ideology in order to convince Canadians that the information highway is the foundation of economic growth in a knowledge-based economy.

ICT Development in Australia

In order to enhance ICT in Australia, in 2002, three flagship initiatives were recommended by Professor John Houghton, at the Centre of Strategic Economic Studies. These initiatives were: (i) the establishment of a platform for production to support both producer and consumer industries; this would be established by fostering innovation, developing the necessary infrastructure and regulatory framework and enhancing skills and professionalism; (ii) building better businesses by fostering business improvement, enabling market access and expansion and actively facilitating cluster development; and (iii) achieving scale by creating an attractive investment environment, establishing an investment fund and engaging in proactive investment attraction.

Professor Houghton also argued that the government must recognize that having a local ICT research and production capability would facilitate the rapid take-up and deployment of ICT across the economy as a whole. It was seen as equally important to realize that ICT production and trade play a significant role in driving employment and productivity growth; thus, by joining with industry in providing vision and leadership, the government could effectively underpin ICT development in Australia; alternatively, by failing to do so, they could effectively undermine it (Houghton, 2002).

IT Development in the US

In 1994, the leading initiative of the Clinton Administration, the 'National Information Infrastructure' (NII), represented a coordinated government strategy comprising of areas of social, economic and technology policy. This was a follow up to the 'Information Infrastructure Task Force' (IITF), an agenda for action, published in 1993, to highlight: (i) the 'essential role' of carefully-crafted government action; (ii) the encouragement of private sector investment; (iii) ensuring that advanced ICT became available to all, at affordable prices; and (iv) the establishment of charges for government information based on the cost of dissemination rather than the acquisition costs. The government was seen not only as a regulator, but also as a major promoter of ICT development. The 1996 Telecommunications Bill introduced subsidies to ensure that ICT could reach remote regions, and also implemented the deregulation of, and greater competition in, cable TV and local telephone services.

VI. Conclusions

It is clear that within the APEC economies, there are patterns of industrial specialization and national idiosyncrasies, and that both the development and influence of ICT are multi-dimensional. This study has undertaken a review of the related empirical studies on macro and economic-oriented aspects, evaluated the contribution of ICT to the APEC economies and investigated the policy implications for these economies.

In the review of the literature covering the influence of ICT development on productivity or competitiveness, and the e-readiness rankings provided by several organizations, we find compelling stories on individual economies. The economies that are most active in ICT development, such as the US, Japan, Canada and Australia, continue to vie for the top slot through their wholehearted embracing of the digital society and the ways in which they have sought to revolutionize both their business and government sectors. Indeed, governments all around the world have undertaken significant investment to ensure the success of their ICT development; nevertheless, the gap between the leaders and the followers grows ever wider as time passes.

Chinese Taipei has taken enormous strides, spurred on by an ambitious government and heavy spending on the necessary infrastructure; nevertheless, all of its resources and budgets continue to focus on the government sector, especially in the areas of transportation and electronics, whilst the private sector remains very weak in terms of overall ICT development. The government has provided incentives and rewards to the private sector, such as subsidies and tax incentives, but the level of these provisions are far less than adequate. According to the WMRC e-government ranking and the EIU e-readiness ranking, the environment in Chinese Taipei was essentially downgraded in 2003. Clearly, therefore, the digital revolution should not be led by government, business or consumers in isolation; only through cooperation can ICT development produce the benefits that it has shown in the advanced nations.

In terms of ICT development policies, we have reviewed the policies adopted in the US, Canada, Australia, Japan and Chinese Taipei, and whilst the US and Canada are both liberal states, and very distinct from the others, Canada has put some weight behind establishing universal access to information facilities, which has unavoidably transformed itself into a bureaucratic problem that has to be well managed. The government in Australia realizes the importance of its ICT industries, and whilst already being a user of ICT, also intends to become a major producer of ICT. In the second phase of the e-Japan strategy, it is expected that a 'vibrant, safe, impressive and convenient' society will be established, aggressively utilizing its IT infrastructure for the transformation of Japanese socio-economic systems. Chinese Taipei's knowledge-based plan is expected to incorporate social justice and the sustainable development of the environment in order to transform Chinese Taipei into a 'green silicon island'.

In this study, we have employed growth accounting techniques to evaluate the development of ICT in Chinese Taipei, and found that the island is well developed in general ICT development and ICT infrastructure, but that there is room for improvement in terms of ICT incentives. In particular, having used growth accounting to estimate the impact of the ICT sector on productivity, our results show that the increase in TFP has contributed significantly to economic growth in Chinese Taipei; indeed, the contribution accounts for almost 30 per cent of the island's economic growth rate. The greater part of the contribution made by TFP is, however, derived from intra-industry technological progress effects, with no significant spillover effects from inter-industry technological progress. Thus, the ICT industry has not stimulated any real technological progress in other industries. The tests on inter-sector externalities from ICT show a positive sign, although not statistically significant. This result is consistent with the results obtained from the growth accounting approach, with the spillover effects again not being found significant in ICT development in Chinese Taipei.

The policy implications from our empirical findings are that APEC economies may be placing too much emphasis on ICT development, *per se*, whilst the actual use of information and communications technology still lags well behind. Therefore, it is important to determine how to utilize ICT from a universal perspective, and how to allocate the digital benefits not only for rural domestic areas, low income households and the disabled, but also internationally for the less-developed economies.

Appendix

We have attempted to bring the analysis and discussion of the influence of ICT on productivity change in the Chinese Taipei economy to a finer level of observation and measurement, focusing on industry level, rather than macro level. Our aim is to observe where and how unusual technical progress has occurred. We have applied econometric production function methods to estimate how original inputs (capital and labor) interact with intermediate flows in the extension of KLEM production functions to KLEMI functions as in Klein (2000). The estimation results are provided in Table A.1.

A time series analysis was employed for Chinese Taipei industries with the estimated production functions being as follows:

$$\ln X = C_1 \ln K_0 + C_2 \ln K_1 + C_3 \ln L + C_4 * \frac{(K_0 + K_1)}{K_0 * L} - C_5 * \frac{L}{K_0} + C_6 * T + C_7$$

where, X represents real output; capital stock (K) is divided into IT capital stock (K_0) and other capital (K_1); and L and T are respectively denoted as labor inputs and the time trend.

We find the estimation results to be very complicated, and feel that they may be improved by further detailed study. We will not therefore pursue this issue until these results are ready for presentation.

We can see from the estimation results in Table A1 that the value of R-Bar Squared of most industries (electricity, gas and water; manufacturing; food manufacturing; tobacco manufacturing; leather, fur and related products; printing and related products; electrical and electronic equipment; transportation equipment) are greater than 90 per cent, that is, over 90 per cent of the variation in output is explained by the six independent variables. The model fits quite well the empirical data on Chinese Taipei industries. Furthermore, there is sufficient evidence to infer that ICT capital stock has made a real contribution to growth in output within certain industries, including electricity, gas and water, tobacco manufacturing, leather, fur and related products, pulp and paper. The outcome of the t-test has proven that capital stock has replaced labor inputs in industries such as electricity, gas and water, leather, fur and related products, pulp and paper, electrical and electronic equipment, and transportation equipment. Finally, in the pulp and paper industry, and the transportation equipment industry, manpower resources have replaced ICT capital stock to generate outputs.

Table A1 Estimation results of the non-linear production function in Chinese Taipei, the general form

		Industry (Industry Code)									
		Mining (B)		Electricity, Gas & Water (D)		Manufacturing (C)		Food Manufacturing (C11)		Tobacco Manufacturing (C12)	
		Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Independent Variable	Constant	-8.8655	-0.4979	-1.7048	-0.3000	2.3073	0.2601	-3.9511	-1.2190	3.2709	0.6124
	ICT Capital Stock(K_0)	0.0059	0.0394	0.3047	1.7100	0.0614	0.2826	0.0189	0.5982	0.2288	3.8339
	Non ICT Capital Stock(K_1)	0.9418	0.5860	0.8621	2.0010	0.0018	0.0037	0.0730	0.2645	0.3876	1.0647
	Labor	0.3390	0.5269	0.1117	0.1742	0.7121	4.0146	0.7759	1.6189	0.0511	0.2384
	Trend	-0.0119	-0.1746	0.0385	1.3152	0.0507	0.7576	0.0062	0.2979	-0.0033	-0.3085
	Interaction 1(K_0+K_1/K_0*L)	0.0001	0.6916	0.0001	1.8868	0.0001	0.9818	0.0001	0.0090	0.0001	1.4698
	Interaction 2(L/K_0)	-0.0429	-0.7437	-0.3358	-1.3120	-0.0006	-0.0551	-0.0002	-0.0278	-0.1481	-1.4278
	Output (-1)	0.5257	1.3912	-0.3741	-1.4515			0.4644	2.1191		
R-Squared		0.8964		0.9995		0.9967		0.9603		0.9557	
R-Bar Squared		0.8238		0.9992		0.9949		0.9294		0.9291	
D.W.		1.6017		2.6133		1.9197		2.2134		1.8105	
D.h.		-		-				-1.0271			

Table A1 (Contd.)

		Industry (Industry Code)									
		Textile Mill Products (C13)		Leather, Fur & Related Products (C15)		Pulp & Paper (C18)		Printing & Related Products (C19)		Plastic Products (C25)	
		Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Independent Variable	Constant	1.9652	0.2179	-1.6403	-0.7057	-8.0845	-1.0841	2.3716	0.6330	-4.0261	-0.8401
	ICT Capital Stock(K_0)	0.2658	0.5724	0.1375	2.1569	0.3171	2.0765	0.0197	0.5182	0.0423	0.1990
	Non ICT Capital Stock(K_1)	0.1309	0.1922	0.6267	1.3675	0.4850	0.9800	0.0342	0.2286	0.1455	0.7623
	Labor	0.1008	0.1707	0.2432	0.5958	0.9924	1.0814	0.6283	1.3479	1.0332	5.2162
	Trend	-0.0062	-0.1499	-0.0856	-1.6960	-0.0831	-1.4085	0.0235	3.6426	0.0487	0.9373
	Interaction 1(K_0+K_1/K_0*L)	0.0001	1.4261	0.0001	2.4183	0.0001	1.9175	0.0001	0.7374	0.0001	0.3198
	Interaction 2(L/K_0)	-0.0034	-0.1159	-0.00001	-0.2267	-0.0044	-2.0353	-0.00007	-0.2464	-0.0015	-0.5936
	Output (-1)	0.3209	0.9432	0.2350	0.6477						
R-Squared		0.6921		0.9783		0.7307		0.9801		0.9224	
R-Bar Squared		0.4526		0.9614		0.5692		0.9681		0.8759	
D.W.		2.2808		1.9026		2.0550		2.1867		2.0573	
D.h.				-							

Table A1 (Contd.)

		Industry (Industry Code)					
		Electrical & Electronic Equipment (C31)		Transportation Equipment (C32)		Miscellaneous Manufacturing Industries (C39)	
		Coeff.	t-value	Coeff.	t-value	Coeff.	t-value
Independent Variable	Constant	-12.0948	-1.3425	-15.2787	-0.9277	-6.1801	-0.5333
	ICT Capital Stock(K_0)	0.1725	0.2219	0.1189	0.5788	0.3060	0.9408
	Non ICT Capital Stock(K_1)	0.1134	0.1332	2.2417	2.0598	0.1155	0.0653
	Labor	1.7219	1.9819	0.4935	0.7009	0.8713	1.1283
	Trend	-0.0550	-0.6364	-0.2405	-1.7950	-0.0190	-0.1289
	Interaction 1(K_0+K_1/K_0*L)	0.0001	1.8918	0.0001	1.7656	0.0001	0.2976
	Interaction 2(L/K_0)	-0.1559	-1.1126	-0.1031	-2.0485	-0.0026	-0.1670
	Output (-1)	-0.0881	-0.3989	-0.3581	-1.1435	0.3051	0.9883
R-Squared		0.9977		0.9720		0.8202	
R-Bar Squared		0.9962		0.9502		0.6943	
D.W.		1.8504		2.5751		2.0074	
D.h.		0.9083		-		-	

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