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GlobDev 2010

Proceedings Annual Workshop of the AIS Special Interest Group for ICT in Global Development

12-12-2010

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Abstract

Previous research at the cross-national level has found that IT investment is associated with significant productivity gains for developed countries but not for developing countries. Notwithstanding the lack of evidence of productivity gains, developing countries have increased their investment in IT dramatically. Given all of this investment, there is a need for research to study whether the investment has begun to pay off in greater productivity for developing countries.

In this study, we employ production function analysis on new data on IT investment and productivity for 49 countries from 1985-2004, and compare the results from 1994-2004 with the earlier years (1985-1993) that were covered by Dewan and Kraemer (2000). The goal is to find out whether developing countries have been able to achieve significant productivity gains from IT investment in the more recent period as they have increased their IT capital stocks and gained experience with the use of IT. We also incorporate a set of complementary factors missing from previous studies, including telecommunications investment and prices, human resources, and foreign direct investment, to determine whether these factors have an impact on the relationship of IT to productivity.

We find that for developing countries, there was no significant effect for IT capital for the 1985-1993 sample, but the relationship is positive and significant for the 1994-2004 sample. On the other hand, for developed countries, IT capital is significant across all time periods. Non-IT capital stock and labor hours also are positive and significant across all samples and time periods as expected. We also find developing countries with higher levels of tertiary education and lower telecommunication prices achieve greater productivity gains.

To our knowledge, this is the first empirical research to find productivity impacts from IT investments in developing countries. The finding that developing countries only began to realize payoffs from IT investment in more recent years suggests that there may be some critical level of IT capital stock, or some minimum level of accumulated experience (human capital) required before such gains become evident. For policymakers in developing countries, these findings provide evidence that IT investments are likely to lead to productivity gains and give support for policies to promote IT investment and use.

1. Introduction

The question of whether IT investments lead to greater productivity has been studied extensively at the firm and national level (see Dedrick et al., 2003 for a critical review of the IT and productivity literature), with strong evidence that the returns to IT investment are positive and significant for firms (e.g., Brynjolfsson and Hitt, 1996, Lichtenberg, 1995; Dewan and Min, 1997), and for the U.S. economy (e.g. Jorgenson 2001; Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000; Bosworth and Triplett, 2000).

Research at the cross-national level has found that IT investment is associated with significant productivity gains for developed countries but not for developing countries (Dewan and Kraemer, 1998, 2000; Pohjola, 2001; Schreyer, 2000). Notwithstanding the lack of evidence of productivity gains, developing countries have increased their investment in IT dramatically. For instance, China had fewer than 10 million PCs in use in 1998 and barely 1 million Internet users (Dedrick and Kraemer, 1998). Today, China is the world's second largest market for PCs, with sales of about 40 million in 2009 (Shangguan, 2010) and the largest Internet user, with over 400 million users (Internet World Stats, 2010). Similar rapid growth in places such as India, Latin America, Southeast Asia and Eastern Europe have transformed the landscape for IT use in developing countries. Given all of this IT investment, there clearly is a need for research to study whether the investment has begun to pay off in greater productivity for developing countries. Yet there have been no cross-country studies using more current datasets.

In addition, most prior studies employed a production function approach with labor, IT capital and non-IT capital as inputs, and GDP as the output.[1] They failed to incorporate complementary assets or other factors that might affect the productivity impacts of IT. Yet factors such as human capital, foreign investment, government policy, and communications infrastructure and pricing are important variables that may directly interact with the use of IT to improve productivity (Dedrick and Kraemer, 2001). They already have been shown to be determinants of IT investment (Shih et al., 2007, 2008). It is important to determine whether these factors will also have an impact on productivity gains from IT investment. If so, governments and firms will have guidance to make investments that are most likely to

[1] An exception is Pohjola, 2001, which incorporates human capital in an empirical study of IT and productivity across 39 countries.

complement their ongoing IT investments. Researchers will have evidence to better understand the nature of complementarity among IT and other assets and the ability to develop more fully-estimated models of the impacts of IT investments.

In this study, we utilize new data on IT investment and productivity for 49 countries from 1985-2004, and compare the results from 1994-2004 with the earlier years (1985-1993) that were covered by Dewan and Kraemer (2000). The goal is to find out whether developing countries have been able to achieve significant productivity gains from IT investment in the more recent period as they have increased their IT capital stocks and gained experience with the use of IT. We also incorporate a set of complementary factors missing from previous studies, including telecommunications investment and prices, human resources, and foreign direct investment, to determine whether these factors have an impact on the relationship of IT to productivity.

2. Literature Review

IT and productivity

Most of the research on IT and productivity on an international or cross-country basis, and involving both developed and developing countries, was conducted in the mid-late 1990s. The consistent finding in these studies has been that IT investment is associated with significant productivity gains for developed countries but not for developing countries (Dewan and Kraemer, 1998, 2000; Pohjola, 2001; Schreyer, 2000).

At the time of these studies, various explanations were offered for the lack of productivity gains from IT investment in developing countries. One explanation was that developing countries lacked complementary assets such as human capital and telecommunications infrastructure needed to support IT use (Pohjola, 2001). Another was that developing countries had less experience with IT, and as a result had not learned to use IT effectively, or to make complementary organizational and process changes needed to achieve productivity gains from IT (Dewan and Kraemer, 2000). In addition, the very low levels of IT capital stock in developing countries meant that it was difficult to capture the impacts of IT on productivity in standard production function models.

The data in the various studies came mostly from the late 1980s through the mid-1990s, a time when most developing countries had very limited experience and low levels of IT capital stock. IT investments have grown steadily since then, and in some cases accelerated greatly, raising the prospect that IT capital stock has risen considerably and therefore can be captured more readily in production function models, and that real productivity impacts have been achieved from these investments.

Factors influencing productivity impacts

The foregoing cross-country IT and productivity studies generally do not examine the factors that might influence the productivity impacts of IT. However, studies of IT use, diffusion or penetration do examine such factors, and it is likely that these factors also influence productivity impacts. The factors identified in the literature can generally be classified as complementary assets and government policy.

The availability of complementary assets will partly determine the value of IT investments, and thus likely influence the level of productivity related to IT investment in a country. One resource necessary to support IT use is *human capital,* including general education as well as IT-specific knowledge in areas such as computer science and management of information systems. IT has been shown to be a skill-biased technology whose value is closely linked to the skill levels available to the firm or country (Krueger 1993, Bresnahan et al. 2002). Educated workers not only have the skills to use computers, but are generally more flexible and more readily adapt to the introduction of new technologies (Bartel and Lichtenberg 1987, Robison and Crenshaw 2002). Several multi-country empirical studies have found a strong association between the level of education and IT investment (Pohjola, 2003; Shih et al., 2007; Caselli and Coleman, 2001). A specific study of developed and developing countries found education to be especially important for developing countries, but less so for developed ones (Kiiski and Pohjola, 2001).

Another important complement to computer use is *telecommunications infrastructure*. Much of the value of computers comes when they are networked via the Internet, organizational intranets, and other types of networks. Such networks require an underlying telecommunications infrastructure to link individuals and organizations. Previous empirical studies show a positive association between IT diffusion and the various measures of telecommunications infrastructure

(Shih et.al., 2007, Oxley and Yeung 2001, Robison and Crenshaw 2002; Kaufman, et al, 2009). Research also shows that there is an interactive effect between computer and network use, with greater PC use leading to greater Internet use and Internet use in turn influencing greater PC use (Dewan et al, 2009).

In terms of government policy, one factor that is likely to influence the impacts of IT on productivity is a country's *openness to the global economy*, which can provide access to a broad range of technical and managerial knowledge that exists beyond its borders (Grossman and Helpman 1991, Ben-David and Loewy 2000). Foreign trade and investment can provide access to such knowledge, by providing channels through which knowledge can flow between firms and individuals in different countries (Coe et al. 1997). Openness to foreign investment can attract multinational corporations who introduce new uses of IT and transfer knowledge to local employees, particularly in developing countries. The presence of such firms in a country also can drive IT investment by local firms to compete with, or do business with, multinational corporations who are sophisticated users of IT.

In addition to policies related to external openness, IT use is influenced by governmental regulation that affects the *cost of telecommunications.* As mentioned above, computer, Internet and telephony use have been found to be positively correlated with physical communication infrastructure. One study found that the number of Internet hosts in a country was negatively associated with telephone service costs (Oxley and Yeung, 2001). Various policy studies on telecommunications regulation have indicated that the high cost of telecommunications is a major inhibitor of adoption and IT use, particularly in developing countries, and have advocated greater competition in telecommunications and Internet markets to extend use to larger populations and reduce prices (OECD, 1996, 2002).

3. Methodology: IT and Production Function

A two-step analysis is used in this paper to establish productivity payoffs and the role of complementary assets. The first step uses standard production function analysis to determine the productivity impacts of IT investments in developing countries at two periods in time to determine whether longer experience with IT use shows productivity payoffs not present in previous studies. We compare developing countries with developed countries for the same time periods to see whether the productivity gap is growing or lessening.

To estimate productivity impacts, we adopt an inter-country production function of the form

$$Q_{it} = F(IT_{it}, K_{it}, L_{it}; i, t) \quad (1)$$

In equation 1, Q_{it} is the annual GDP, and we model it as a function of IT capital stock (IT_{it}), non-IT capital stock (K_{it}), and total labor hours employed annually (L_{it}). The*i* and *t* following the semi-colon are dummy controls for country and year specific effects. Equation one is modeled using a panel dataset that covers 49 countries over 20 years (1985-2004).

Following Dewan and Kraemer (2000) and Dewan and Min (1997), the function form adopted is the Cobb-Douglas production function. Together, these authors have shown that this particular form is a good approximation in the IT and productivity context. Using the production function, we have for Country *i* ($i = 1, 2, \ldots, N$) in Year *t* ($t = 1, 2, \ldots, T$):

$$\log Q_{it} = \alpha + \lambda_t + \beta_{IT} \log IT_{it} + \beta_K \log K_{it} + \beta_L \log L_{it} + v_i + \varepsilon_{it} \quad (2)$$

In the above equation, λ_i is a year dummy that captures the effect of years in the regression, v_i is the country specific effects invariant over time, and ε_{it} is the random error term in the equation that represents the net influence of all unmeasured factors impacting output. One useful feature of adopting the Cobb-Douglas production function is that we can focus our analysis strictly on B_{IT}, B_K, and B_L, which captures the increase (or decrease) in output associated with changes in corresponding input (IT capital, non-IT capital, and labor). In other words, the parameters can be interpreted as elasticity effects of input factors on output.

Equation 2 can be simply estimated using regression techniques that can account for differences among the countries and across time. Generally, there are two types of models for modeling cross-sectional heterogeneity – the fixed effects and random effects model. The random effects model requires stringent assumptions regarding the structure or distribution of the error term that we cannot meet and, therefore, the fixed effects model is adopted in our analysis.

The second step in our framework evaluates factors that might influence the level of productivity payoffs among developing countries. These include complementary assets and national policy (telecoms pricing). To investigate the impacts of these factors, we split developing countries by each factor into above average and below average groups across all years. Regression analysis was then conducted for each sub-sample for comparison purposes.

4. Data and variables

Our database contains macroeconomic and IT investment data for 49 developing and developed countries from 1985 to 2004. The list of developed and developing countries in our dataset can be found in Table 1.

Table 1. List of Countries in Dataset[2]

Developing	Developed
1. Argentina	1. Australia
2. Brazil	2. Austria
3. Bulgaria	3. Belgium
4. Chile	4. Canada
5. China	5. Denmark
6. Columbia	6. Finland
7. Czech Republic	7. France
8. Egypt	8. Germany
9. Hungry	9. Great Britain
10. India	10. Greece
11. Indonesia	11. Hong Kong
12. Korea	12. Ireland
13. Malaysia	13. Israel
14. Mexico	14. Italy
15. Philippines	15. Japan
16. Poland	16. Netherlands
17. Romania	17. New Zealand
18. Russia	18. Norway
19. Saudi Arabia	19. Portugal
20. Slovakia	20. Singapore
21. South Africa	21. Slovenia
22. Thailand	22. Spain
23. Turkey	23. Sweden
24. Venezuela	24. Switzerland
	25. USA

[2] Countries are listed as developed or developing based on status at the beginning of the time series, as defined by the World Bank. This is consistent with the Dewan and Kraemer (2000) definitions.

Data for the current analysis came from four primary sources. Data on IT spending were from the International Data Corporation (IDC, 2005). Labor statistics are from the International Labour Organisation through the World Bank's (2009) World Development Indicators Database Online (hereinafter, World Bank Database). Capital stock information was obtained from Penn World Tables (PWT) version 6.1 (Heston et al, 2002). Data on other variables (openness to global economy, investment, human capital, telecom infrastructure and cost of telecommunications) were collected from the World Bank Database (World Bank, 2009).

Dollar values of capital stock, IT capital stock, non-IT capital stock and GDP/capita are expressed in international dollars. The "international dollar" refers to currency conversion based on purchasing power parities so that real quantity comparisons can be made across countries and time (Heston et al., 2002). An international dollar has the same purchasing power over total U.S. GDP as the U.S. dollar in a given base year (1996 in PWT 6.1).

The first step in creating variables for the production function analysis was to compute the key capital stock series for each country over time. We calculated three capital stock values: total capital stock, IT capital stock and non-IT capital stock. Penn World Tables 5.0 (PWT 5.0) provided the only available series of data on *Total capital stock per worker* (KW) in international dollars (Heston and Summers, 1991). However, PWT 5.0 only provides data up to the year 1993. Capital stock was not updated in the current version of PWT 6.1 so it left us with a shortened series on a variable that is critical to our analysis. In order to generate our own series of capital stock for analysis, we first converted the existing KW series into 1996 international dollars. Then for each country, we ran a regression relating KW growth rate with real investment growth from 1985 to 1993. Specifically, we estimated Equation 1 for each country where KWG is capital stock per worker growth and I is real investment growth.

$$KWG_t = \alpha + \beta_1 I_t + \beta_2 I_t^2 + \beta_3 I_{t-1} + \beta_4 I_{t-1}^2 + \varepsilon_t \qquad (3)$$

We then applied the estimated capital stock per worker growth rate to the existing series and extrapolated it to 2000. Total capital stock is then computed by taking the extrapolated series and multiplying by the total labor force.

Total IT capital stock is computed from the aggregation of annual total IT spending available from IDC. We have annual IT spending from 1985 through 2004. The flow of IT spending is first converted into constant 1996 dollars using the Computers and Peripherals price index obtained from the U.S. Bureau of Economic Analysis (Oliner and Sichel, 2000). Next, the series is converted into 1996 international dollars. To compute stock, we stretched the series back to 1975 based on the price adjusted logistic curve used in Gurbaxani and Mendelson (1990). The flow was aggregated into net IT stock using the depreciation profiles based on the work of Oliner (1996). In computing the depreciation profile for total IT from its component depreciation profile, we used the following weights: Mainframes (1/3), PCs (1/3), Printers, Displays & Storage Devices (1/9 each).

Non-IT capital stock was computed by subtracting total IT stock from total capital stock for each country over time.

GDP per capita was taken directly from the Penn World Tables, which is updated beyond the last year of our analysis.

The last factor of production is *Labor*. We computed billions of total labor hours per year for each country by taking the total labor force, adjusted by the unemployment rate, and multiply by the average number of worker hours.

Figure 1 and 2 present scatter plots of the country-level IT capital investment as a percentage of GDP denominated in 1996 international dollars. Figure 1 shows the picture from 1985-1993 and Figure 2 from 1984-2004. Comparison of the average annual growth rate from the data in the figures indicates that both developed and developing countries have increased the level of IT investments in the latter period (27% and 31% respectively), and that the developing country increase has been considerably greater in the second period than earlier (32% versus 22%). We therefore expect to IT to show up in the productivity analysis for developing countries.

<< Insert Figures 1 and 2 Here >>

We next created the variables for the second step in our analysis framework—the regression analysis of complementary assets and government policy. *Telecommunications* *infrastructure* was measured by the amount of telecommunication investment as a percentage of GDP from the World Bank Database (World Bank, 2009). *Human capital* was measured by percent tertiary school enrollment (of gross school enrollment) for each country and is also from the World Bank database *Openness to the global economy* is measured by the total amount of foreign direct investment from OECD nations and is from the World Bank Database.

The *cost of telecommunications*, which is influenced by government policy, might operate directly through regulatory action setting prices for telecommunications services or indirectly through promoting competition among private telecommunications providers to drive down prices. In either case telecommunications pricing would influence IT use and productivity. We use the monthly cost of a business telephone subscription as a cost or pricing measure. It is from the World Bank Database.

The descriptive statistics for our data are presented in Table 2.

Table 2. Descriptive statistics

	Developing Countries		**Developed Countries**	
	1985-1993	**1994-2004**	**1985-1993**	**1994-2004**
GDP per Capita	$6,742.11	$9,015.45	$15,668.61	$18,686.23
IT Capital Stock	$.093B	$16.31B	$11.59B	$105.42B
Total Non-IT Capital Stock	$205.99B	$303.86B	$529.22B	$905.75B
Total Labor Hours	30.43B hrs.	91.13B hrs.	73.50B hrs.	74.97B hrs.
FDI / GDP	1.47%	3.17%	1.28%	4.50%
Tertiary Enrollment %	21.08%	31.42%	43.24%	55.22%
Telecom Investments / GDP	.59%	.98%	.64%	.65%

5. Results

IT investment and productivity

We divided the sample into two time periods in order to assess the impact of IT on productivity. The first period runs from 1985 – 1993 corresponding to the years used analyzed in Dewan and Kraemer (2000). The second period runs from 1994 – 2004, the last years for which we have reliable data. As can be seen in Table 2, across all years (1985 – 2004), there is substantial difference in the GDP per capita between developed and developing countries. However, when comparing the averages across the two time periods, GDP per capita experienced only 16.14% growth in developed countries while it experienced 25.22% growth in developing countries.

Among input factors, non-IT capital stock is 8.59 times IT capital stock in developed countries in the later periods, and 18.63 times in developing countries. In developed countries, the ratio of non-IT capital to IT capital decreased from 45.66 times to 8.59 times. The ratio dropped from 221.49 times to 18.63 times in developing countries. But since developing countries are starting from a much lower amount, their overall stock of IT capital is still relatively low compared to developed countries.

We estimated the first difference model of Equation 2 to control for serial correlation. The results of our regression analysis for the developing and developed country samples are as shown in Table 3. For developing countries, there was no significant effect for IT capital for the 1985-1993 sample ($B=-.018$, $t=-.443$, $p>.05$), but the relationship is positive and significant for the 1994-2004 sample ($B=.052$, $t=1.986$, $p<.05$). On the other hand, for developed countries, IT capital is significant across all time periods ($B=.045$, $t=1.804$, $p<.05$ and $B=.058$, $t=2.462$, $p<.05$ for the 2 samples respectively). Non-IT capital stock and labor hours also are positive and significant across all samples and time periods as expected.

Table 3. Production function estimates – First difference model

	All Countries		Developing Countries		Developed Countries	
	1985-1993	**1994-2004**	**1985-1993**	**1994-2004**	**1985-1993**	**1994-2004**
B_{IT}	.004	.050	-.018	**.052***	**.045***	**.058***
	(.213)[1]	(2.594)	(-.443)	(1.986)	(1.804)	(2.462)
B_K	.061	.040	**.046***	**.089***	**.059***	**.051***
	(2.697)	(2.924)	(2.390)	(3.395)	(2.791)	(2.669)
B_L	.688	.254	**.644***	**.367***	**.738***	**.118***
	(7.828)	(4.264)	(2.831)	(2.614)	(8.934)	(2.806)
R^2	.549	.332	.400	.362	.632	.562

[1]t statistics are in parenthesis. Asterisk *indicates significance <.05.

Complementary assets and government policy

To investigate the impacts of complementary assets and national policy on the relationship of IT to productivity within developing countries, we split developing countries by level of foreign investment, tertiary education, telecommunications investment, and telecommunication pricing into above average and below average groups across all years. For telecommunications pricing, systematic data were only available for the 1994-2004 period (Table 4). Regression was then conducted for each sub-sample for comparison purposes. The results are reported in Table 5.

Table 4. Telecommunications pricing, 1994-2004

Telecommunications cost	**Developing countries**		**Developed countries**	
	Above average price	**Below average price**	**Above average price**	**Below average price**
Annual business connection cost	232.08	74.64	280.65	112.80
As percentage of GDP per capita	3.31%	1.27%	1.11%	1.02%

Table 5. Influence of complementary assets and government policy on IT productivity among developing countries

	FDI / GDP		**% with Tertiary Education**		**Telecom Investment / GDP**		**Telecom Pricing**	
	Below Average	**Above Average**	**Below Average**	**Above Average**	**Below Average**	**Above Average**	**Below Average**	**Above Average**
B_{IT}	.019 (.586)[1]	.021 (.601)	**.055*** (1.434)	**.123*** (2.583)	.014 (.421)	.048 (1.102)	**.046*** (1.966)	**.014*** (.526)
B_K	.114 (2.575)	.083 (3.127)	.129 (2.643)	.095 (2.949)	.129 (3.075)	.095 (3.064)	.113 (5.029)	.065 (2.202)
B_L	.379 (2.416)	.279 (1.984)	.081 (1.947)	.319 (2.669)	.317 (1.848)	.375 (2.451)	.285 (2.665)	.824 (3.483)
R^2	.259	.388	.421	.569	.364	.384	.328	.451

[1]t statistics are in parenthesis. * indicates significance <.05.

As the table shows, there was no perceptible difference in the pattern of parameters when developing countries are split along foreign direct investment and telecommunication investments. However, when developing countries are split by level of human resources and telecommunication pricing, we observed changes in the effects of IT capital stock. In particular, the IT capital stock parameter went from .055 (t=1.434, p>.05) for below average human resource levels to .123 (t=2.583, p<.05) for above average human resource level. The parameter went from .014 (t=.526, p>.05) for countries with above average telecommunication pricing to

.046 (t=1.966, p<.05) for countries with below average telecommunication pricing. This pattern of results suggests that countries with a higher level of human resource development and more competitive telecommunication pricing are more able to capture the productivity payoff of IT capital. On the other hand, the level of telecommunication investment does not appear to pay a role, suggesting perhaps that deregulation of the telecommunication industry (affecting prices) might be more important than additional investments in telecommunications in driving the effect of IT. The reason may be that when telecommunications costs are lower, people and organizations make more use of networked technologies, and thus are able to realize greater benefits from their investment in IT equipment.

5. Discussion

This study revisited the issue of whether IT investment leads to greater economic output, looking across a large sample of developed and developing countries. With 49 countries over 20 years, this is by far the largest study of IT and productivity at the national level that we are aware of, and the first to include data from the 1994-2004 period. During this period, the nature of IT changed significantly with the widespread adoption of the Internet, electronic commerce, PCs, client-server computing, and a variety of enterprise and inter-organizational systems. Also, IT investment in the developing world grew at a dramatic pace, lessening the gap in IT capital between developing and developed countries. These changes were accompanied by rapid globalization of manufacturing and services, as well as greater flows of capital and labor across borders. In such a changing environment, we might expect to see new relationships between IT and productivity, and we did.

The findings in this study include two important new results. First, there is strong evidence that developing countries are now enjoying productivity growth associated with IT investment, as the developed world had experienced in earlier years. This addresses one of the major concerns raised by prior studies of IT and productivity, which had failed to find such a relationship and thus raised questions about whether the majority of the world's population was being left out of the IT productivity story. For the first time, there is now empirical evidence that the positive impacts of IT at the country level extend to both developed and developing countries.

Second, we find evidence that two additional factors—human resources and the cost of telecommunications—influence the relationship of IT investment to productivity in developing countries. Developing countries with above average levels of tertiary education and lower telecommunications prices exhibited greater productivity impacts. This suggests that the impacts of IT depend not only on the level of use, but on the availability of complementary resources and government policy supporting technology use—in this case the cost of telecommunications. Although these relationships had been posited in the literature before (Dedrick and Kraemer, 2001), and had been found to influence IT investments, this study provides the first empirical evidence linking them with productivity.

Implications

These results have both academic and policy implications. For IS researchers, they reduce concerns that the strong relationship of IT investment to productivity at the national level was specific to richer countries and thus limited in applicability. The finding that developing countries only began to realize payoffs from IT investment in more recent years suggests that there may be some critical level of IT capital stock, or some minimum level of accumulated experience (human capital) required before such gains become evident. Indeed, other research that examined productivity differences among countries concluded that economic growth was associated with abundant stock of human capital, and that convergence of developing and developed countries only occurs if sufficient levels of human capital are accumulated (Kryiacou, 1992). It is possible that the same is true for more IT-specific skills associated with experience in IT use.

The significant moderating effects of human capital and telecommunications prices on the productivity impacts of IT shows that better models need to be developed to capture such important factors that influence the impacts of IT. There are rich opportunities for further research in quantifying the cumulative impacts of IT investment and experience, and in identifying other complementary resources or other country-level variables that might affect the relationship of IT to productivity.

For policymakers in developing countries, these findings provide evidence that IT investments are likely to lead to productivity gains and thus higher sustainable economic growth rates. Thus a case can be made for policies to support IT use, and to avoid policies that discourage use such as raising IT prices through taxes or tariffs, raising barriers to Internet use, or favoring IT production at the expense of use. They also point to the importance of policies to increase tertiary education and to reduce telecommunications costs in order to realize greater benefits from IT investment. These policies are desirable on their own merits, but the fact that such resources enhance the value of IT is another reason to pursue them.

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Figure 1. Scatter plot between average annual IT investment as a percent of GDP against mean GDP per worker, developed and developing countries, 1985-1993

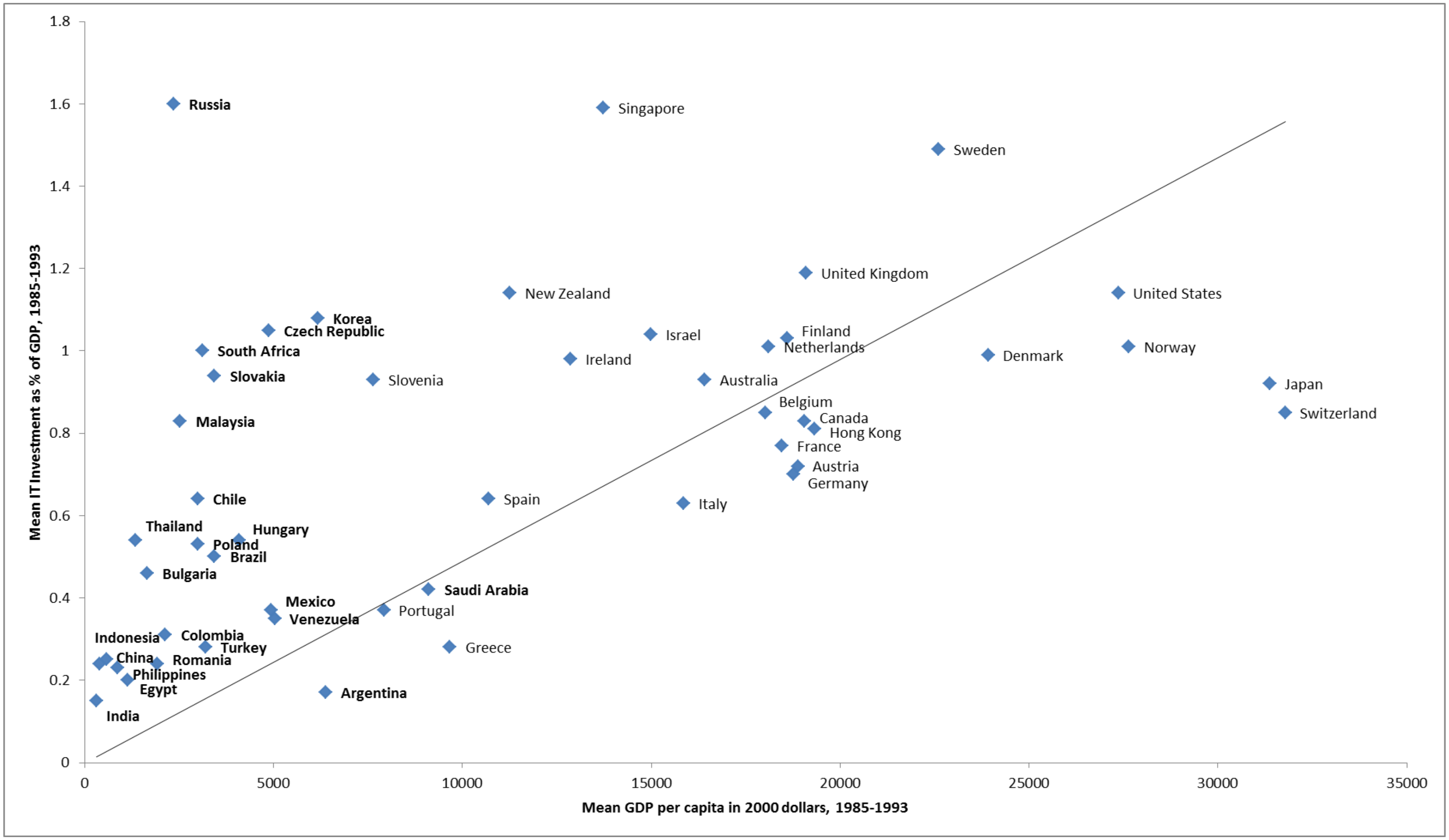
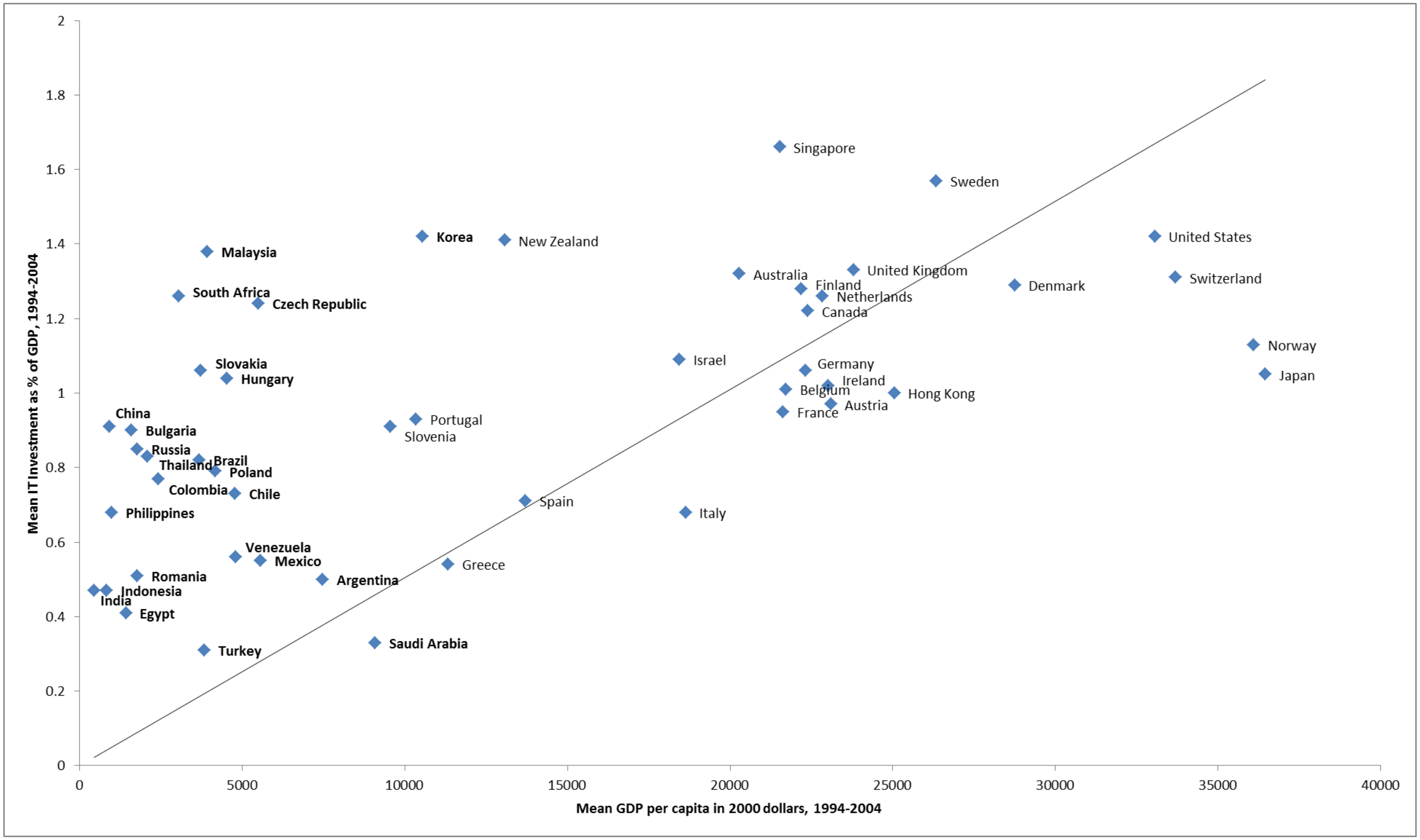


Figure 2. Scatter plot between average annual IT investment as a percent of GDP against mean GDP per worker, developed and developing countries, 1994-2004



Mean IT Investment as % of GDP, 1994-2004
Mean GDP per capita in 2000 dollars, 1994-2004
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
5000
10000
15000
20000
25000
30000
35000
40000
Singapore
Sweden
Korea
New Zealand
United States
Malaysia
Australia
United Kingdom
Finland
Netherlands
Canada
Denmark
Switzerland
South Africa
Czech Republic
Norway
Japan
Israel
Germany
Ireland
Belgium
Austria
Hong Kong
France
Slovakia
Hungary
China
Bulgaria
Russia
Thailand
Brazil
Poland
Colombia
Chile
Philippines
Portugal
Slovenia
Spain
Italy
Venezuela
Mexico
Greece
Argentina
Romania
Indonesia
India
Egypt
Turkey
Saudi Arabia