The Information Age: Which Nations Will Benefit?

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This study assumes that broader diffusion of computers leads to greater economic and social benefits for a nation state and seeks to learn the determinants of diffusion. Using a data base of 41 nations and the colony of Hong Kong in the early 1990s, the following hypotheses are explored and found supported: (1) economically advanced nations are more likely to adopt computers, (2) nation states with more educated populations and ones with more open access to information are more likely to adopt computers, and (3) nation states that have a higher saturation of information mediums, such as televisions and telephones, are more likely to adopt computers. The paper considers what countries can to do to ensure greater computer adoption and therefore benefits given the above findings.

The Information Age: Which Countries Will Benefit?

For years it has been debated to what extent computers lead to payoffs. And there is evidence to suggest that there are costs as well as benefits. Still, political leaders assume that computers like other technologies lead to economic and social progress. For example, the President and Vice-president of the US are concerned that the children of their country are ill-prepared for the Information Age. Two-thirds of new jobs in the US demand some experience with computers. It has also been pointed out that computer experience brings higher wages. Consequently, US officials talk of every eighth grader having computer access in their classrooms. The presumption is that one will be left behind in job skills and social avenues if one does not have computer access. This presumption is also made on the nation state level, i.e., nations with little or no computer access will be left behind economically and socially.

It is important to consider which nations have the edge in the Information Age and why in order to address what countries can do to ensure greater computer adoption and therefore benefits. Just as the Industrial Revolution changed the face of economic and political power, so too may the Information Revolution. The Industrial Revolution was machine driven with the invention of the steam engine and the cotton gin. The Information Revolution is also machine driven with the invention of the mainframe computer and more recently the personal computer and the means to connect the machines, specifically the internet and the intranet and the telephone networks on which the internet rides.

The present study assumes that broader diffusion of computers leads to greater benefits and seeks to learn the determinants of diffusion. Using a database of 41 nations and the colony of Hong Kong in the early 1990s, this study hypothesizes that wealth education, open access to information, the profusion of televisions and telephones each determines the likelihood of a nation state being computerized.

The data tell the not unsurprising tale of the rich getting richer and, therefore, the poor getting poorer. The key issue for countries is that computers are closer to the printing press that revolutionized the world centuries ago than they are to the cotton gin and steam engine. True, computers area means of making money, but, maybe just as importantly, they area means for gathering and conveying information without having to have personal contact. It is this latter character of computers that poses a dilemma for countries which seek economic benefits from computers but want to limit access to information.

Data

The database is 41 countries and the colony of Hong Kong (for ease they will be referred to as 42 countries from now on), which were identified by a major computer manufacturer as promising outlets for computer sales (Appendix A). Therefore, countries with literally no computers per person (to the third decimal) are excluded from the data set and will not be able to suppress correlations by their sheer dominance of cases. Among the 42 countries studied, the lowest per capita number of computers is 0.001. The highest is 0.287. This study is asking, then, among the countries targeted for sales efforts, what explains the differences in computer adoption?

It is also true that information for the variables chosen to be studied is not available for all countries in the world. The sample not only represents promising outlets for computer sales but also nations for which key information is available.

Information on variables comes from many different sources, ranging from UN statistics to those kept by the computer industry. Appendix B lists the sources of all variables in this study. It should be noted that data was obtained as close to 1993 as possible. The year 1993 was chosen to keep as stable and complete a sample base as possible.

Longitudinal data would be better, but earlier data reduce the sample by over half, making statistical analysis very distorted and near impossible in terms of statistical significance. It should be noted that GDP per capita, like all the other independent variables, is extremely correlated with prior years' values. Data available on number of computers per person, which come from an industry source, are available as far back as 1986 but only for 31 countries until 1993 when 42 countries have available data.

Hypotheses

Hl. Economically advanced nations are more likely to have adopted computers.

The assumption is that economically advanced nations have the financial conditions for individuals, companies and government to take advantage of computers as productivity boosters. The economic state of a nation is measured by per capita GDP in US dollars in 1993.

H2. Nation states with more educated populations and ones with more open access to information are more likely to have adopted computers.

The assumption is that a nation state cannot leap into the Information Age if it does not have the social base of educated, literate citizens who are also free to access information and said information is not limited. Use of the computer requires the ability to read and write at a level far beyond basic literacy. Literacy typically refers to a mere ability to read and write enough to get around in daily life; a third grade education in the US represents this level. In fact, many computer tasks require the ability to understand sophisticated statistical and financial software packages.

But having an educated population may not be sufficient to open the nation to computers. It may also be very important that the nation state is characterized by having a free press and greater tolerance of civil liberties. The issue is that computers increase citizens' ability to access information both within and outside the country; consider the use of the internet. Therefore, countries that want to limit citizen access to information as well as limit citizen ability to convey information to media and international sources may face a dilemma with computer adoption. In sum, nation states may need a certain social infrastructure to be able to leap into the Information Age.

This measure of social infrastructure is an index composed of percent secondary school enrollment, percent tertiary school enrollment, newspaper readership per 1000, and measures of press freedom and civil liberties. This index was not created by the authors. The index values for nations were taken from The Delta Shuttle World Paper, but the sources cited are respected sources for said information (see Appendix B).

H3. Nation states that have a higher saturation of information mediums are more likely to adopt computers.

The assumption is that nation states have a mindset toward information mediums that shapes the diffusion and acceptance of new ones. For example, if a society presumes that everyone must own a phone or a television, then the acceptance and diffusion of computers can proceed at a greater pace. It is also true that some mediums such as telephones have a direct effect on computer adoption because they can expand the usefulness of computers.

This measure of saturation of information mediums is an index composed of number of telephone lines per 100 households, radio ownership per 1000 inhabitants, television ownership per 1000 inhabitants, fax ownership per 100 inhabitants, cellular phones per 100 inhabitants, and cable/satellite television coverage. This measure will be referred to as the information infrastructure.

Findings

In the following section data that support each hypothesis will be discussed. The analysis will not only address whether, for example, a nation's information infrastructure plays a role in computer adoption but also what is it about that infrastructure(television or phone penetration) that contributes to higher computerization. After each hypothesis is discussed separately, the section continues by exploring the interactive role of the three independent variables. Given the likelihood, for instance, that a measure of information infrastructure may be a surrogate for GDP, the independent and relative role of each independent variable will be considered.

Hl. Economically advanced nation states are more likely to have adopted computers.

It is strongly supported and significantly so that the higher the GDP is per person, the higher the number of computers in that nation per person (Table 1) . GDP is not, though, a linear predictor of computers per person. Another words, it is not simply the case for each unit increase in GDR, a constant unit increase in computers per person will result. The relationship between the two is curvilinear: as the GDP of a nation state increases, computers increasingly become more common. Using SPSS's curve fit function, the relationship between GDP and computers per person was found to best be described as a power base relationship. Thus, the GDP-computers relationship was converted to a power base in order to perform statistical analysis, which assumes linearity, with which the power base conversion is consistent.

GDP is a broad measure of the economic development level in a nation. Obviously, it takes financial resources for a government or corporation or individual to purchase and maintain a computer. So it is not surprising that a strong association exists between GDP and computer penetration in a nation.

Since the last machine driven revolution changed the face of economic power among nation states by creating the manufacturing base over the agricultural, the role of computers in manufacturing was explored. Another words, the relationship between GDP and computers was explored to see if it stood up after factoring out the influence of computers used in manufacturing operations. About one third of this association can be attributed to the nation's productivity in manufacturing (Table 2). This finding may speak to the important role computers play in this economic sector. Computers are not only used in the administrative side of manufacturing but also in the design, assembly, and delivery of products.

H2. Nation states with more educated populations and ones with more open access to information are more likely to have adopted computers.

This hypothesis is just as strongly supported as the first one (Table 1). It too is not linear. The greater the social infrastructure of a nation is , the much greater the nation's adoption of computers is. This curvilinear relationship was converted to a growth base for analysis purposes, again using SPSS's curve fit function to find the best curvilinear base to describe the relationship between the social infrastructure and computers per person.

Table 3 presents the results of a component analysis of the social infrastructure index. In terms of education, what level of education is key to computer diffusion in a nation? The answer appears to be university education. The percent of a nation's population with some secondary education has no effect on the relationship between a nation's social infrastructure and computer penetration. (Complimentary, while not shown in the table, the literacy rate of a nation also has no effect on the level of computerization.) Still, university education, while important, only has a small effect on the relationship (0.16 in Table 3). Newspaper circulation has a negligible effect (0.06). What is interesting is that when one controls on the three measures of education and newspaper circulation together, one sees a large cumulative effect (0.37). The effect of these variables together, which comes from tertiary education and newspaper circulation only, is almost twice as great as they are individually. In other words, the more people who have attended a university and the higher the newspaper circulation in a nation, the much higher likelihood that computers have penetrated into that society.

This cumulative effect is not due to a change in the number of nations in the analysis. It is often the case that the combined or cumulative effect of independent variables is not the same as simply adding the independent effects. Often, the cumulative effect is less, but it is also possible, as is the case here, that university education when paired with high newspaper circulation has a heightened effect.

What could explain this heightened effect? A hint is provided by the fact that about half of the association between social infrastructure and computer diffusion is attributable to press freedom and civil liberties, the other components of the index (these are not controlled for in Table 3, but because they are the other components of the index, press freedom and civil liberties have to explain what education and newspaper circulation cannot) As was suggested earlier, the education level of its citizens is only one ingredient in a nation's ability to utilize computers. The more highly educated a population is, the more likely that the nation can utilize computers for sophisticated tasks, from graphic design, inventory and budgetary control to scientific and military research. But it appears also to be important that press freedom and tolerance of civil

liberties be present for truly high computer adoption. Countries that want to limit citizen access to information and their ability to convey information are face a dilemma then with computer use.

A large newspaper circulation and a highly educated population are two conditions for a society's openness to information, perhaps necessary but not sufficient conditions by themselves. Press freedom and tolerance of citizen expression are even more important. A country could have a large newspaper readership, but the information in the newspapers may be censored. A country's population may have an impressive level of university education, but information in the classroom and in professional quarters may be tightly controlled. Taken together, education and newspaper circulation expand the possibility of information flow. To these add uncensored information in the media and a tolerance for citizen expression, and a nation has an exponential ability to use and grow from information. Computers are just the medium for realizing this ability.

H3. Nation states that have a higher saturation of information mediums are more likely to adopt computers.

This hypothesis is the most strongly and significantly supported (Table 1). The data indicate an almost perfect linear relationship between a nation's information infrastructure and its adoption of computers.

It was suggested earlier that the information infrastructure of a nation may affect its computer adoption in two ways: one through a societal mindset that assumes new information mediums are the natural province of its citizens and two through a direct supportive link. In order to explore these two ways, a component analysis was done.

As Table 4 indicates, about one fourth of the relationship between the information infrastructure of a nation and its adoption of computers can be attributed to how common televisions are and another one fourth to how common telephones are. Cellular phones contribute half as much or one eighth. Note that these three devices are independent of each other and thus have an additive role in explaining what parts of the electronic infrastructure are associated with computer adoption. The overlap among the three measures is a negligible 0.06.

These data suggest that both an information medium mindset as well as a direct supportive link likely exist. For example, telephones can enhance the power of computers by connecting one computer to another and by expanding data retrieval possibilities, such as through the internet. That being the case, it would make sense to accept that telephone penetration may have a direct supportive link to computer adoption. At the same time it is hard to imagine how televisions enhance the power of computers. (Soon television will be a

means to connect to the internet and get e-mail.) Thus, why television penetration is independently and strongly associated with computer adoption may be more readily explained by what has been referred to as an information medium mindset. A society saturated with information mediums, some of which are seemingly unable to enhance the usefulness of computers such as televisions, likely will be more aware of, interested in, and willing to learn about new information mediums such as computers. It is also possible that a society used to looking at a television screen can more easily adapt to looking at a computer screen. Probably most likely is that there is an order to information medium adoptions. Zhou Tiehai, an artist in Shanghai, China, explains the "People want a happy life, but to them, happiness means money. First you buy a TV, then a house and car. . . "(LA Times February 24, 1997, p. 10). To this list can be added "and then you buy a computer." In sum, the data suggest that nations with a strong information infrastructure will expand that infrastructure by a dramatically higher adoption of computers.

Economic, Social, and Information Infrastructures

The information infrastructure of a nation is the dominant influence of the three explored on the extent that a nation is computerized. As Table 5 indicates the information infrastructure, even when broken into its component parts, is the only statistically significant predictor, with one exception, of the extent to which a nation is computerized. If the influence of television saturation is eliminated, then telephone and cellular phones are still predictors before social and economic infrastructures. And when the cellular telephone measure is left out of the regression equation, it is still true that the remaining telephone measure is the only significant predictor (Table 5). The only exception occurs when the television and regular telephone measures are not included in the equation, then the social infrastructure measure is more important than the cellular phone one.

The economic, social, and information infrastructures of a nation are not independent of each other. But there is not dramatic overlap between the measures. Controlling on the information infrastructure totally eliminates the association between social infrastructure and computers per person and also totally eliminates the association between GDP and computers per person (Table 1). But controlling on GDP or social infrastructure has minimal influence (0.12 or 0.13 reduction) on the association between the information infrastructure and computers per person ill a nation Table 1). Hence, the information infrastructure index is neither a surrogate for the economic level of a country nor for the educational and political tolerance levels.

These findings are interesting and even surprising. One would think the economic level of a country drives the information infrastructure level and the computerization. This may well still be the case but in a special

way. What the data suggest is that the information infrastructure of a country is the key component of the economic level that shapes computerization. The past economic and social levels of a nation drove its ability to make, import, and diffuse radios, televisions, and telephones, and these same devices may well have played a role in the continuing economic and social advancement of the nation. But once given the existence of these information mediums, it is the infrastructure created by the commonness of the devices that plays the most direct linkage to the computerization of that nation. And the extent to which the economic or social level of a nation independently shapes its chances to leap into the Information Age is weak (.10 direct, not shown in table) once the information infrastructure is matured (Table 1).

Conclusions

This study was an attempt to explain which nations have the edge in the Information Age and why. Economic, social, and information infrastructure factors were explored and were found to each have a significant and strong association with the likelihood of a nation being computerized. In other words, the more economically advanced a nation is, the greater its adoption of computers. In addition, the higher the university education level of a nation and the more open the nation is to the sharing and dissemination of information, the greater its adoption of computers. Finally, the higher the saturation of information mediums in a nation, the greater its adoption of computers.

The economic and social levels of a nation shape the spread of information mediums, such as televisions and telephones. But once the information infrastructure is established, it is the infrastructure which predominately appears to shape the rate of computerization.

Does this mean the rich get richer? It appears that well off nation states have the decided edge utilizing computers for economic and social gain. But the story is a bit more complicated. It also appears that being rich is not the only determinant. A country also needs a very highly educated population. Moreover, the society needs to be open to the sharing of information as indicated by its tolerance of civil rights and press freedoms. These economic and social factors set the stage for the building of a massive information infrastructure, and the economic and social infrastructures may gain from the building of said information infrastructure. But it is the information infrastructure which is key to a nation's ability to use and gain from computers.

These findings bode well for the US and Japan. US and Japanese children are infamous for their addiction to television and other information mediums, from radios to compact discs to telephones. It is this addiction

which may make children the quick learners and frequent users of computers. Expect the drive to adopt computers to continue with the US and Japan on the forefront.

Other countries that lack this level of information mediums will be the losers in terms of computer adoption and therefore potential payoffs. What could be done to help such countries? The answer is not a simple one of shipping computers to that country. We may be able to give computers to a foreign nation state, but that state may have political reasons to control their use and spread. The US has found it difficult in the past to influence the internal freedoms of a country, and such freedoms appear to play a role in a country's computer use. It is also true that the US has a vested role in the spread of computers. Computers can be used for military preparedness; the power balance between nations is therefore an intertwined issue. Obviously, computers have great economic potential, and the balance of trade is another intertwined issue.

Will the Information Age change the face of economic and political power? The data make one lean toward saying no. The economically advanced nations and nations with greater social freedoms are the most likely to have computers and thus the most likely to benefit from them. Nations that attempt to limit access or free flow of information, therefore, face a dilemma. While they might desire to limit access for political stability (for example China and Singapore), by doing so, they reduce the potential benefits of computers. This is not a problem for a country like Singapore which is already developed, but it is a problem for a country like China which seeks accelerated economic development. Such development is likely to come much slower, even with the growth of telecommunication networks if access and information flows are constrained. When computers are used alone there are benefits but they are nowhere near as great as when computers are connected in networks, whether local, intranet or internet. Moreover, the greater the number of connections as with the internet, the greater the benefits because an individual is able to communicate with more people and access more information. In other words, computers and telecommunication networks offer network economies in which benefits increase exponentially as the number of people and amount of information on a network increases. This is one of the reasons why liberalization of telecommunication networks is important. Control of information or access to networks limits the benefits. It also limits computer adoption. The key to broader diffusion of computers, and the social and economic benefits associated there with, is extensive telephone networks.

Unlike advanced countries like the US and Japan, many countries of the world are behind in both computers and telecommunication networks. Moreover, unless they take concerted action, they will fall further behind. Investment in computers and telecommunication networks is important but so is access and

free flow if you want the benefits and if you want accelerated development. It is the only hope for less developed countries to catch up with those already way ahead economically.

Finally, computers could affect political power given that they are a means of disseminating information to one's supporters internally and externally, exposing human rights violations and rallying comrades. But it appears the countries most likely to fear such computer dissemination may hurt themselves economically because to restrict information sadly affects the rate of computerization and its benefits. Intriguingly, the connection between television access and computerization is not obviously apparent. Perhaps the spread of television as a consumer product may serve as an unsuspecting stimulus to the drive toward computerization, opening up its political potential.

TABLE I

Pearson Correlations between Economic, Social, Information Infrastructure Variables and Computers per Person

	Computers Per Person 1993	Controlling on GDP	Controlling on Social Infrastructure	Controlling on Information Infrastructure
GDP 1993/Per Capita[a]	.78*		.52*	.07
Social Infrastructure[b]	.79*	.53 *		.07
Information Infrastructure[c]	.93 *	.81 *	.80*	

*Significant at .05 level.
[a]Curve fit is power based.
[b]Curve fit is growth based.
[c]Curve fit is linear based.

TABLE 2

Pearson Correlations between GDP and Computers per Person Controlling on Economic Components

GDP	Controlling on Productivity in Manufacturing
.78*	.49*

*Significant at the .05 level.

TABLE 3

Pearson Correlations Between Social Infrastructure Index and Computers per Person Controlling on Index Components

	Controlling On			
Social Infrastructure Index	% Secondary School	% Tertiary School	Newspaper Circulation per 1000	All Three
.79*	.79* (.00)[a]	.63* (.16)	.73* (.06)	.42* (.37)

*Significant at the .05 level.

[a]Number in parentheses represents the portion of the zero-order correlation that is attributable to the component(s) controlled on.

TABLE 4

Pearson Correlations Between Information Infrastructure Index and Computers per Person Controlling on Index Components

	Controlling On			
Information Infrastructure Index	TVs	Phones	Cellular Phones	All Three
.93 *	.69* (.24)[a]	.70* (.23)	.81 * (.12)	.28* (.65)

*Significant at the .05 level.
[a]Number in parentheses represents the portion of the zero-order correlation that is attributable to the component(s) controlled on.

TABLE 5

Regressions of Computers Per Person by INFORMATION,
SOCIAL, and ECONOMIC Infrastructure Variables

Variables entered in equation[a]	R^{2b}
INFORMATION, Social, GDP	.86
TV, CELL, PHONE, Social, GDP	.85
PHONE, CELL, Social, GDP	.75
PHONE, Social, GDP	.73
Social, Cell, GDP	.77

[a]Order of statistical inclusion in equation.
[b]R^2 is the percent of significant variation in computers per person explained by the variables in bold.

APPENDIX A

Argentina
Australia
Austria
Belgium
Brazil
Canada
Chile
China
Czechoslovakia
Denmark
Finland
France
Germany
Greece
Hong Kong
Hungary
India
Indonesia
Ireland
Israel
Italy
Japan
Korea, Republic of (South)
Mexico
Netherlands
New Zealand
Norway
Philippines
Poland
Portugal
Russia
Singapore
South Africa
Spain
Sweden
Switzerland
Taiwan
Thailand
Turkey
U. S.
UK
Venezuela

APPENDIX B

VARIABLE NAME	DEFINITION AND SOURCE
CMPPR93	Computers per person in 1993. Computer Industry Almanac
WTDR1C4	GDP per capita (US$) 1993. World Telecommunication Development Report 1995
SOCIII	Social Infrastructure. June 1996 Delta Shuttle World Paper which lists index values for nations and cites the following sources: Dorling Kindersley World Reference Atlas 1994; Freedom House News 1995; UNDP Human Development Report 1992/1995.
INFOIII	Electronic Infrastructure. ITU Statistical Yearbook 1994; UNDP Human Development Report 1990/1995; Dorling Kindersley World Reference Atlas 1994.
TVper93	TVs per person 1993. Computer Industry Almanac.
W2DR2C5	Main telephone lines per 100 inhabitants, 1994; World Telecommunication Development Report, 1995.
WTDR9C2	Cellular mobile telephone subscribers per 100 inhabitants, 1994; World Telecommunication Development Report, 1995.
WTDR15C2	Telecommunication investment per inhabitant in US$ 1994. World Telecommunication Development Report 1995.
Var614	Productivity in manufacturing 1992 in US$: Manufacturing value added per manufacturer. World Competitiveness Report
Ed2nd92	% of population with some secondary education; UNESCO Statistical Yearbook, 1995
Edter92	% of population with some tertiary education; UNESCO Statistical yearbook, 1995
Newscirc	Newspaper circulation per 1000 inhabitants; UNESCO Statistical Yearbook, 1995
literate	Literacy, Grolier Encyclopedia, 1995