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Growth and the Internet: Surfing to Prosperity?

by David Altig and Peter Rupert

Do countries that inhibit the quick integration of new technologies pay a price in slower economic growth? This *Economic Commentary* suggests they do. Focusing on the level of Internet use as an indicator of the absorption rate of emerging computer technologies, the authors argue for the view that faster technology absorption leads to increased economic growth.

In the late nineteenth century, the economist Thomas Malthus made a simple prediction of economic theory that would result in the discipline being forthwith known as the dismal science. The pessimistic extrapolation for which Malthus is famed foretold of long economic cycles in which widespread famine must be an inevitable part.

Malthus's proposition relied on the entirely valid principle of diminishing returns, the tendency for the incremental returns to labor (or any input into the productive process) to fall as more and more of it is employed. The argument goes as follows: The amount of cultivatable land available to feed a society is effectively fixed. As the population grows and more and more people apply their labor to the production of food, the additional fruits of that labor decline, reflecting diminishing returns. But that, by definition, means that production per worker falls. In Malthus's calculation, average food output would ultimately decline to levels insufficient to avoid famine.[1] The somewhat gruesome outcome would be a rise in mortality that would persist until the population declined enough to allow marginal workers to produce at the level necessary for sustenance.

From the vantage of industrialized, nonagrarian economies, Malthus's prediction appears quaint and obviously wrong. The real shortcoming in Malthus's analysis was in part due to the fact that he omitted the role of reproducible factors of production other than labor (capital, for instance). But even more critically, he neglected the powerful and pervasive influence of technological advance. In fact, some estimates imply that technological advance in capital accounts for about 50 percent of long-term growth in advanced economies.[2]

Although this statement has a nice precise ring to it, it is not all that precisely defined, except in a rather trivial sense. As a matter of (what is now) traditional growth accounting, *disembodied* technological advance is just that component of gross domestic product (GDP) growth that cannot be accounted for by the growth in quantities of capital and labor. In other words, it is the residual growth that cannot be accounted for by inputs that can actually be measured. A cynic might think of it as a measure of our ignorance.

With some interpretative leeway, technological progress can be thought of as the inexorable march of human know-how, that amorphous, hard-to-pin-down, but very real capability that provides the means for wealth creation in excess of the rate at which productive inputs expand.

Because this definition says nothing about whether an economy adopts a new technology, it implies that all economies should share equally in the benefits of technology growth; once a technology is invented, the definition sees it as available to all. Our experience tells us quite the opposite, of course. All economies do not simultaneously benefit from technological progress.

There are a number of factors which explain the uneven distribution of technological innovations. Patents and other inventor rights may inhibit the widespread use of newer technologies. Profit-maximizing motives may induce some firms to maintain older vintages of capital even when more advanced tools, equipment, or manufacturing facilities are available.[3] And any number of social, political, and legal elements may make the practical application of emerging production capabilities more rapid in some countries than others. These factors are just different, not mutually exclusive, explanations for why economies may differ in the rate at which they adopt new technologies.

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The natural presumption is that those countries most able to implement newer technologies will do so, and will thus enjoy the fastest economic growth, at least in the early stages of the technologies' life-cycles. Is this presumption warranted?

This is the question addressed in this *Economic Commentary*. The focus is on the adoption of computer technology specifically, which we will attempt to capture by exploring country-specific levels of Internet use. Our hypothesis has two key elements. First, we propose that average cross-country growth rates since the mid-1970s can be partially explained by the absorption rate of emerging computer technologies. Second, this rate can be proxied by the breadth of Internet usage across the different economies that we examine.

The result of our analysis is that Internet use does seem to be related to the pace of economic expansion over the past several decades. Because the United States has been ahead in such usage relative to comparably developed countries, one prediction might be that the growth rates in, for instance, Japan and Western Europe will accelerate relative to the United States as the deployment of computer technologies in those countries converge to American levels.

The Internet and Growth: A First Pass

The highest concentrations of Internet usage are found in the Nordic countries, the United States, and Canada. Not surprisingly, many emerging economies report little or no usage.

Figure 1 plots average GDP growth against Internet use. The graph includes data for a representative set of countries —42 total, 33 of which reported some degree of Internet use, and 9 of which reported none.[4] Specifically, figure 1 plots GDP growth in each of these countries against the fraction of people in that country who reported using the Internet. As noted, the proposition in this *Economic Commentary* has two components. The first is that higher rates of technology adoption result in higher rates of output growth. The second is that Internet usage in a country is a reasonably good proxy for all of the factors which promote or inhibit the adoption (or rate of adoption) of new technologies, at least over the period covered in figure 1. If both of these conditions are true, then a line drawn through the points ought to have an upward slope, rising from the lower left-hand corner of the graph toward the upper right-hand corner.

It is clear that the points in figure 1 do not demonstrate the presumed positive relationship between growth and Internet use. In fact, the points in the figure seem to draw a picture of a negative relationship, suggesting that a higher fraction of the population using the Internet is associated with lower average GDP growth. One obvious explanation is that one or both of the maintained assumptions are not true: Either growth is not related to the pace of technology adoption or the adoption rate is not captured by Internet use.

There is another, not too strained, explanation. It is possible that a second "X-factor" has contributed to GDP expansion in addition to Internet penetration. If such a factor were negatively related to the average rate of economic growth and positively related to the fraction of the population with Internet access, it could obscure the underlying relationship between Internet use and growth. If the influence of the X-factor is strong enough, failing to control for its effects could impart a downward slope to the plot in figure 1, even if the relationship between growth and the Internet is positive when all else is held constant.

Is there a candidate X-factor? Yes, and it is illustrated in figure 2, which is the same as figure 1 but with country names added to identify individual points. Notice that among those countries that exhibit high average GDP growth and low Internet adoption are the so-called "Asian tigers." These are the growth miracles, the economies that expanded rapidly from low levels of GDP following World War II.

This observation is important because well-known theories of economic growth predict that observed rates of economic growth over snapshots of time will be negatively related to the level of GDP from which the growth measurement begins. In other words, the lower the level of GDP at the beginning of the period, the faster an economy's growth is. Because it also likely that Internet use is a normal good (and hence *positively* related to the level of income), there clearly exists the potential for a spurious correlation to show through in a picture like figure 1.

To address this problem, the Internet/growth relationship should be examined *after* statistically controlling for the initial level of GDP in each country in the study. Before proceeding to that exercise, however, it may help to provide some intuition as to the role that such level effects exert on cross-country growth observations.

Why Poorer Countries Grow Faster Than Richer Ones

The most basic of accepted growth theories is associated with work done in the 1950s by economists Robert Solow and Trevor Swan. The Solow–Swan framework, often referred to as the neoclassical growth model, postulates that, in the long run, the rate of growth is tied to an "exogenous" rate of technological advance. The term "exogenous" means that the theory does not explain why technology (or, equivalently, productivity) expands—it just does, and with it comes the ability to produce more with the same amount of land, labor, and capital.

One implication of this view is that, in the long run, all economies respond to technology growth in the same way, growing at a given rate of technology expansion (a prediction that is usually called the "convergence hypothesis"). However, economies that are some distance from their long-run growth paths will tend to grow faster as they "catch up" to their ultimate rate of expansion.

Roughly, think of the process as follows: At low levels of income, the capital stock of an economy is also relatively low. But that means there is a lot of bang for the buck in investment that raises the amount of capital available for production. As the capital stock grows and the economy matures, the incremental boost to production from investment declines from the higher levels associated with the begin-

FIGURE 1 GDP GROWTH, 1974–92

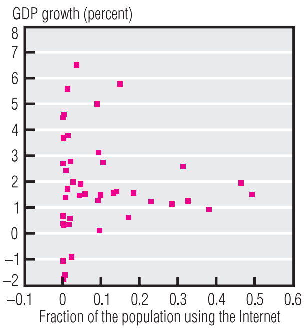
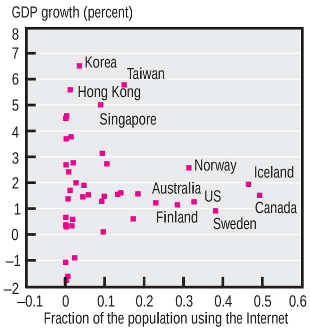


FIGURE 2 GDP GROWTH, 1974–92 WITH COUNTRY NAMES



SOURCES: U.S. Department of Commerce, Bureau of Economic Analysis; and International Communications.

ning of the growth process. Eventually, the returns from investment will settle into levels comparable to those of more developed economies, and with that, rates of GDP increase will converge to the common long-run experience.

Statistical studies of cross-country growth patterns suggest that these types of effects are of real-world importance. Before concluding that there is no relationship between growth and the Internet—or anything else, for that matter—it is reasonable to control for possible convergence effects by adjusting for any influences on cross-country growth patterns that can be attributed to start-of-sample GDP levels.

■ The Internet and Growth: A Second Look

In fact, once we control for convergence effects, a positive relationship between growth and Internet use is significant in both statistical and economic terms. To give some idea of the magnitude of the relationship, our simple empirical exercise yields an estimate that implies 100 percent Internet usage would be associated with almost four percentage points of economic growth.[5]

This is a very large number. Frankly, too large to be believable on its face. It is certainly true that factors beyond Internet use might help to explain economic growth, and that we have omitted such factors (excepting the initial postwar GDP level that we introduced to control for convergence effects). It is very likely that the Internet usage proxy might pick up the influences of some of these other contributors.

In other words, we suggest that the Internet variable captures, in part, the constellation of hard-to-measure factors that influence technology adoption. For example, the percentage of the population with Internet access might be related to the absence of onerous regulations in the communications industry, or low taxes that make computer ownership more broadly accessible, and so on. In fact, this possibility is what motivated the inclusion of the Internet variable as a proxy for technology adoption in the first place. The magnitude of the effects we identify in our simple statistical exercise are therefore more plausible to the extent that Internet penetration is capturing the wide array of considerations that affect the speed at which economies are able to exploit technological advances.

■ Who's Got Mail?

Because the level of development is an important determinant of observed cross-country growth rates, comparing apples to apples is most easily accomplished by considering economies that are at like levels of development. With that in mind, we will compare Internet usage in the United States, Western Europe, and Japan.

As of 1999, 45 percent of households in the United States owned personal computers. The corresponding statistic in Europe is only about half that, at 23 percent. In Japan it is even lower, with only 17 percent of households reporting ownership of at least one PC. In addition, virtually 100 percent of computers sold in the U.S. have modems, a pretty good indication of Internet communications accessibility. In Europe, by contrast, only about 50 percent of new personal computers sold come equipped with modems.

This disparity in home computer use evidently extends to the business community as well. A survey conducted in the United Kingdom of the directors of large companies found that, in the United States, nearly 100 percent reported using computers. The same survey found that only 84 percent of German directors employed computers in their business activities. In England, affirmative responses fell to two-thirds of those surveyed.

The picture that these facts draw is reinforced by the statistics on computer technology expenditure shares. In 1998, roughly 4.08 percent of U.S. real GDP was spent on information technology hardware. The shares in Japan and Western Europe were 2.51 percent and 2.26 percent, respectively.

■ Surfing to Prosperity?

In our own thinking about the results of our analysis, we interpret Internet use as a general proxy for the constellation of factors that influence the rate at which economies adopt and absorb emerging technologies. The very same elements that inhibit widespread public access to the Internet—high taxes, labor market policies that raise the costs of production, capital market imperfections and regulations that retard the creation of start-up enterprises, tariffs, and so on—are likely to more broadly interfere with optimizing the promise of technological progress. In other words, economic infrastructure matters, and those policies and regulations that interfere with creative access to new technologies have a very real negative impact on the wealth of nations.

What to make of all this, then? Focusing on recent economic development patterns, real GDP in the United States expanded by almost 29 percent from 1988 through the end of 1998. Over the same period, output growth in both Europe and Japan was in the 23 percent–24 percent neighborhood.

It would be far-fetched, to say the least, to attribute these differentials to the discrepancies in Internet usage. Nonetheless, it does appear that the fraction of a country's population that has access to the Internet is, at least, correlated with factors that help to explain average growth performance. This in itself may have some important policy implications that bear further consideration. Whether by means of the gradual process of working around impediments to technology adoption or the relaxation of the policies that create those impediments, one might suppose that as we see increasing computer technology penetration in Europe and Japan in the next decade, we will also see the closing of the growth gaps between the United States and these major trading partners that have emerged over the course of the past ten years.

Footnotes

1. The precise formula postulated that population growth was exponential but food production geometric.

2. These numbers are taken from Michael Gort, Jeremy Greenwood, and Peter Rupert, "Measuring the Rate of Technological Progress in Structures." *Review of Economic Dynamics*, vol. 2, no. 1, January, 1999.

3. See Michael Gort, Jeremy Greenwood, and Peter Rupert "How Much of Economic Growth is Fueled by Investment-specific Technological Progress?" *Economic Commentary*, Federal Reserve Bank of Cleveland, March 1, 1999.

4. The data on Internet use were compiled by International Communications, a firm specializing in international business services. All of the Internet use data reported here can be found on the company's Web site at http://www.headcount.com.

5. This number is obtained from the simple linear regression estimates:
(real GDP growth rate) = 0.0959–0.010*(real GDP in 1950) + 0.0372*(fraction of the population using the Internet). Our model amounts to calculating the correlation between growth rates and the Internet variable after subtracting out variations in growth that are attributable to 1950 GDP levels.

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