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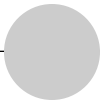
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## Remarks

### Robert E. Hall

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After reading and hearing the papers at this conference, I'd like to take the opportunity to summarize my own positions on some of the key issues of the conference set forth in my own papers. I was gratified to see that these papers have had some impact on the work of this conference, but there has been remarkable confusion about what paper said what. So let me just spend a few minutes on this topic, because all these papers, I believe, are completely central to the topics addressed at this conference.

The first paper, "The Stock Market and Capital Accumulation," came out in the *American Economic Review* (AER) in December 2001. That paper infers the total amount of capital, tangible and intangible, in the economy—specifically in the nonfinancial corporate sector of the U.S. economy—from the value of the securities that are claims on that capital. An important factor in that paper is the recognition that one of the reasons that the market values capital at prices above or below its creation cost is scarcity arising from adjustment costs.

A standard view of the stock market that I inherited in this research was that—because short-run supply curves are upper sloping—an expansion of the economy will generate rents that show up in the stock market. This view, which we attribute very closely to James Tobin, has also been run in reverse in the  $q$  theory to infer adjustment costs from values in the stock market. I approached it in a different way, which was to try to remove the rents associated with adjustment and then infer from that how much

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capital there was after taking care of adjustment costs. So that's the basic idea, the new idea in that paper.

What it shows is that scarcity rents are a fairly small factor in the movements of the stock market, with what I would take to be realistic adjustment costs. The conclusion, then, is that the amount of capital in the economy is very different from the amount that you get by accumulating observed investment. In fact, the correlation is, I believe, a little bit negative. Central to the subject of this conference is that the amount of capital that that calculation reveals is about double the recorded amount of capital. In other words, we have as much intangible capital as we have tangible capital. Now, people disagree, and of course it depends on what the stock market is doing the day you do that calculation, but basically there isn't much doubt that there's a big excess.

One thing I want to stress in this thinking is to remember that if you did the same calculation in 1980, the apparent amount of capital inferred from securities markets was about half the amount of capital that you got by accumulating past investment. So this process works in both ways, and of course the  $q$  theory has always stressed this. Values of  $q$  are found to be between one-half and two.  $q$  is close to a random walk, but fluctuating within that range, at least over the times we've looked at it. So that was one exercise.

Then I wrote a paper that is a little bit of a lark, especially in retrospect, which was published in the *Brookings Papers on Economic Activity* in late 2000. That paper was written during the height of the dot-com boom and was entitled "e-Capital." It's basically a spin-off from the first paper, asking the following question: Suppose that you took seriously the idea that there is something besides physical capital, that the valuable stuff that corporations own goes beyond the physical capital and includes a lot of valuable intangibles. And let's call those intangibles another factor of production.

Then the question is this: can you build a coherent story within the entire body of aggregate analysis that macroeconomists bring to this kind of a subject? In particular, can you make sense out of the labor market of the 1990s by invoking another factor of production that we didn't know we had before until we looked in the securities markets? And the answer is unambiguously yes: you get a completely coherent story about, for example, why the wages of college-educated workers, whose skills are complementary with e-capital, have risen relative to those who haven't been to college. There's been a dramatic difference between college graduates and others over that period. The underlying idea was to take the intangible number from the AER paper and push it to see if it made sense from the point of production economics.

The third in the set of published papers is my Ely lecture. Many people seem to cite the Ely lecture when they actually mean the AER paper, so I would appeal to you to straighten that out, because the Ely lecture is actu-

ally on a fairly different topic. There's very little overlap. Its title is "Struggling to Understand the Stock Market." It does one thing that is routine that I won't dwell on. It makes the case from financial economics that we really have no reason to condemn the stock market as irrational. If it were irrational, fortunes would be made by arbitraging the irrationality. And there's absolutely no evidence that such fortunes are being made. In fact, there are so many spectacular examples when fortunes were lost in that enterprise. So let's just take as given that the stock market is rational. Then it raises the question: can you make sense in a rational valuation framework of the high volatility of the stock market? And the answer that's given there is yes because the stock market values prospective earnings, and prospective earnings are highly volatile.

That has led into ongoing research of mine to try to understand the volatility of earnings. I would mention here that I think the biggest unresolved question in intangibles is the third leg of the intangible story. The intangible story has basically three legs. One is that we have data on the formation of intangibles, and there's a lot of interesting material in papers in this conference on that point, which I think is terrific. Then we have the work that I've done and which Erik Brynjolfsson and other people have done that uses security markets to try to get the value of intangibles. The third leg, and the one that I've been working on recently—and that I think in some ways is the toughest—is that intangibles should have earnings, right? We're putting all this money in intangibles so they need to provide a return at some point. And tracking the return of intangibles right now is the biggest mystery.

From the rational valuation perspective, a lot of that growth could be in the future. You could tell a completely coherent story about individual firms and about the stock market as a whole in which the big payoff lies in the future. And the growth optimists, like Dale Jorgenson, say yes, that's going to happen. The economy's going to grow a lot, and that means the earnings will grow a lot and it's all going to work out. And we can understand why the stock market is at an all-time high today relative to earnings. It all makes sense, but it all lies in the future.

The one thing that has not happened is the tremendous shortfall—for example, between the cumulative earnings of corporations in the postwar period today and the return to the stock market over the same period. Three, four hundred basis points' difference. Where is it? It's all in appreciation of the stock market that's occurred, apparently in anticipation of earnings that will occur in the next decade or two. So if you're following the numbers here, you're holding your breath because if it doesn't come true, then the stock market isn't going to remain at anything like its current level relative to earnings.

I've already hinted at some of the stuff that I'm working on now. There are a couple of papers that are available on my Stanford web site. I've built

what I call the “industry dynamics model,” which looks at all these issues in several dozen industries and in particular goes back to the adjustment cost topic and finds adjustment costs, using a new identification scheme, that are very similar to those that I got from Matthew Shapiro’s work. I see it as a strong endorsement of Matthew’s Ph.D. dissertation.

I find that rent from adjustment costs isn’t the big part of the story. Of course, that makes the mystery of intangibles even more interesting. I think it says that most of the thinking that you see in this conference is on the right track. The  $q$  theory is not what we see. We see intangibles, or something like them.

Let me just say something about the resulting view that I hold of the issues in this conference. First and foremost, the rise in the stock market invites the interpretation that lots of intangibles were formed in the 1990s. Furthermore, as many papers in this conference show, there’s lots of other evidence. There’s confirmatory evidence everywhere you look. If you look at individual industries, if you look at various types of intangible formation, if you look in particular at the role of information technology, all those things seem to converge on the notion that something really important happened in the 1990s and, in particular, some real heroes in terms of individual firms that we have talked about a lot. Companies such as Dell and Wal-Mart really figured out how to take advantage of information technology and formed a huge amount of intangibles. Wal-Mart is valued at six times the cumulative value of its investment. So what does that mean? It’s an intangible engine—a remarkable organization.

I would say that, if you do the calculations in my AER paper, it’s only borderline plausible that the volume of intangibles revealed in the market is simply the cumulative amount of investment that actually occurred. In other words, are the intangibles there just because they were formed, or have there been capital gains in intangibles? Are they worth more than their investment cost?

I wouldn’t rule out the capital gains hypothesis. As I said in the AER paper, it’s a stretch to get enough invisible investment in the 1990s to cumulate to the kind of valuation for intangibles that I get in that paper. So I would certainly consider that the great heroes—Wal-Mart, Dell, eBay, the companies that have built business models in a completely new framework—have actually earned substantial capital gains. I believe that Dell has earned a capital gain on its business process, which is totally different from the way companies were ever run before. That releases you from trying to say that it’s only worth the investment. It says that ideas can command values higher than the cost of creating the ideas.

My own view is that finding the investment cost is really important, and I’m happy to see that much of the research we’re talking about in this conference has to do with that. Measuring capital gains is another thing. The thing I would demote, although I know there are people here today who

will make a spirited case in the opposite direction, is that it was irrational markets that (even today) were valuing things that are just never going to happen.

Now, of course, it's easy to go through valuations in February 2000 and say, "Boy, did we get it wrong." Yahoo was worth \$130 billion in February of 2000 and it's worth, what, \$5 billion today? So we got it really wrong on Yahoo. (As of the revision of these remarks, Yahoo had rebounded to \$48 billion.) Now, there are many people who would say, "Well, we were just crazy. You know, we went through a period of craziness." But I don't buy that—partly because I was there and it did seem like there was something special going on. I'm not sure I ever believed it was worth \$130 billion, but I thought that I respected those market values. And some of the companies that I found out about and thought had something important going on, meriting a high value, like eBay, have sustained those values. eBay is worth today almost what it was in February 2000. It's an amazing accomplishment.

It's not that the whole dot-com idea was crazy and was a wave of irrationality; it's that we overstated the earnings potential of some models. Others, like eBay, had at all times a solid revenue model—it was always a joke at breakfast when some new dot-com came out and we'd say, "What's the revenue model?" Sure enough, Yahoo's lack of a revenue model as opposed to eBay's solid revenue model actually worked out. So that turned out to be the right question.

So I would say I'm against the idea that it's all irrational and eventually it will all disappear. I am in favor of balancing between the capital gains view and the capital formation view, and I respect both of those views.

I remind you again though, before you get completely carried away with trying to understand where all the extra value comes from today, or in the '90s, do remember that we have to explain what appear to be negative intangibles, a shortfall in capital market value, that occurred in the '70s and '80s. So I would be very cautionary on that point.

I've mentioned that it's important to look at the industry- and company-level data and findings like the Brynjolfsson multiplier of 15 that tell you that there's something important that you can learn from looking at these issues at a more micro level. There's a lot of that in this conference, which I strongly applaud. I would like to be able to say that the line of research of my own that I've summarized here is completely self-contained and completely absent from contradictions. It may or may not be right, but it all fits together, it's all coherent, and it explains a lot. That's not quite true. Interestingly, the one fact that I can't explain is what appears to be a dramatic overvaluation of debt. It's impossible to explain in a view like mine. We've had this highly productive capital over the last decade and a half, and it's impossible to square that with what had been very low long-term interest rates over the same period. There's been an anomaly of overvaluation of

debt, which of course is an old story. But I just want to remind you that there is an issue here.

I think it's fair to say—and certainly the Brynjolfsson and Jorgenson views of the world that I have followed and that I think I buy say it—that the two great general-purpose technologies that have emerged in the last decade are the server, the completely generic, \$1,500 computer with almost unlimited power, and database software. Interestingly, database software gets much less coverage in discussions of this. Certainly, for example, Jorgenson's story is all silicon and not software at all. I would like to bring software into that story. The database is what makes eBay possible. The database is what makes it possible to create overnight a business model that does all kinds of amazing things without having to do a lot of custom programming.

If you look at what American Airlines went through to build the first airline reservation system, which took years of development and hundreds of millions of dollars in the 1960s, you could build a similar system in a few weeks today running on a database because it's all generic. It's all general-purpose technology. What's the other \$14 of the Brynjolfsson multiplier? A lot of it is database. A lot of it's other things, too, but I just wanted to call your attention to that fact.

I've benefited a great deal from looking at the papers of this conference. I think this is really an exciting area, and I think bringing together these three factors of formation, valuation, and return and getting that story completely straight is going to occupy a lot of good minds for a long time.

## Baruch Lev

I'm usually introduced as the guru of intangibles, and I tend to agree, because I remember well what Peter Drucker said about gurus: journalists like to use the term *guru* because *charlatan* is hard to spell.

Now, you all came here to hear about and to discuss intangibles, and I'm sorry to tell you that in the circles that I move in, which are mainly financial analysts, accountants, and chief financial officers, there has been some disillusionment with intangibles lately. To put it bluntly, people ask me where all the intangibles have gone. They seemed to have vanished with NASDAQ, with Enron. Chairman Greenspan, for example, in his semi-annual report on the state of the economy to Congress in February 2002, spoke eloquently about intangibles (“conceptual assets,” in his terminology) and provided the profound insight that they are not subject to the

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cyclicality of inventory and hence may lessen the severity of recessions. But he too noted that intangibles are very vulnerable because they are linked to the reputation of management, and he mentioned Enron several times, saying that when management's reputation is destroyed, the intangibles are gone too.

This was followed several weeks later by the *Wall Street Journal's* major article, which I'm sure many of you read, about the vanishing intangibles, and it particularly mentioned three companies: Enron, Winstar, and Global Crossing. About Enron the article said that its physical assets kept the company going for quite some time, but it was ultimately dragged down by the intangibles, and then Enron completely collapsed. Similarly, they talked about the vanished intangibles of Winstar, Global Crossing, and other tech companies.

So this really intrigued me, this vanishing-of-the-intangibles phenomenon, and I decided to look at data. I got the annual financial reports of these three culprits—Enron, Winstar, and Global Crossing—for the last three years and read them carefully with the assistance of a Ph.D. student. What I found was astounding, and I'm sure it will surprise you too, because these three companies were regarded as the epitome of the new economy—of intangibles-intensive enterprises.

The first thing I found was that none of the three companies invested in research and development (R&D) in the last three years of their existence. There is not a mention of significant R&D, not in Enron, not in Global Crossing, and not in Winstar's financial reports. There is also not a mention of substantial acquired technology, which in accounting goes by the name of "in-process R&D" and has some strange accounting rules attached to it. Enron had all of twenty patents to its name, mostly old patents, on physical assets. There is no mention of the cost of training employees; there is no mention of brand enhancement or of acquiring brands. The only intangible I could find for Enron was a total of 700–800 millions of dollars of software for energy trading, over several years, but this expenditure is dwarfed compared to Enron's investment in physical assets, about \$8 billion in the last three years of its existence.

Winstar spent some money on spectrum acquisition, which didn't give it much of a competitive advantage over others. So my question is this: where are all those intangibles that presumably have vanished? In fact, nothing much vanished, because the intangibles weren't there in the first place. Intangibles don't come from thin air, as you all know. The days of manna from heaven are unfortunately long gone. Nowadays, you have to invest in intangibles, in R&D, brands, information systems, human capital, and so on, and these companies, along with many other temporary highfliers of the late 1990s, didn't invest much in intangibles.

Surprisingly, these supposedly new-economy companies invested heavily in tangible assets, so the idea that they were intangible-intensive is absurd.

Enron, for example, spent in the last three years of its existence about \$8 billion on tangible assets, fixed assets—primarily electricity-generating facilities and gas pipelines. Global Crossing spent \$2 to \$3 billion on fiber optics. So these companies were in fact old-economy companies that collapsed partly because they overspent on physical assets financed by huge debt, and partly because of a failed business model, and not the least because they played games with their financial reports to investors.

I think that people are confused between intangibles and hype or fraud. The latter appear to create from time to time market value, at least for a while—recall Enron's \$70 billion capitalization in 2000. This was the case for Enron and firms like it. So if you just look at market minus book value of companies and ascribe the difference to intangibles, without careful examination, you will fall into a trap.

The problem is, and here I come to my main point, that we don't have reliable data to distinguish between the two—real intangibles and hype—in real time. This is a major problem. The data that we have on intangibles, the data that corporations disclose in financial reports, range from seriously deficient to useless, and I'll get back to this in a moment.

Now, I mentioned earlier Chairman Greenspan's comments about the vulnerability of intangibles. Intangibles, of course, are vulnerable, but I don't think this is because they are associated or linked with the reputation of managers, as he claimed. If Bill Gates's reputation were to be tarnished for some reason, I doubt that the huge intangibles of Microsoft related to its R&D, brand, and distribution channels would disappear overnight. Intangibles are vulnerable because, as we all know, their benefits are very difficult to appropriate (spillovers, partial excludability), and also because there are no markets in intangibles, and mainly because the information on intangibles to both corporate outsiders and insiders is wholly deficient. These are the major reasons for the high risk of intangibles. I work a lot with managers. They don't know much more than investors about intangibles. That's, to me, the main vulnerability: if you cannot measure or value an asset, you cannot manage and secure its benefits.

You, of course, work with R&D data extensively because this is the only intangible that is reported by managers. But even R&D information, as many of you know, is seriously noisy. I have seen cases where corporations include in R&D maintenance of equipment, which they call "R&D," or quality control expenses, information technology, and so on, all lumped into R&D because it's nice to have a large R&D figure in your income statement and auditors are not going to argue with you about a classification in the income statement that doesn't affect net income. So even this item, the only intangible that is publicly disclosed, is rather noisy.

I'm working now with a leading chemical company on improving their resource allocation model. In essence, I estimate for them the return on investments in three types of R&D: product, process, and facility cost-saving

R&D, along with the return on brand enhancement and creation. The raw data that I got from the accounting department on R&D—and these are the sort of data that are published for investors—were very noisy. I mean, they jumped all over the place, and I, like you, know that R&D is a very stable series. It turns out that the R&D numbers I received were affected to some extent by the political power of the R&D chief. If he was strong politically within the organization, he managed to get only small allocations of overhead costs from headquarters. If he was politically weak, he got significant allocations from top management, which increased the cost of R&D. This is just one example of extraneous factors that can affect R&D numbers.

Now R&D expenditures are at least reported publicly. All other intangibles are not reported and in many cases are not even internally known to management. Essentially, no company that I know of reports systematic data on information technology, brands, employee training, alliances, and the like. The pharmaceutical company Merck has some 200 alliances with other companies in which they develop and market drugs. You don't get much information from Merck about what is done within these alliances and how many of them are really performing—not even the share of total Merck revenues that come from alliances. Basically, there is no useful information on alliances. You cannot evaluate the efficiency of this important corporate activity.

There was some progress recently that I thought was really significant: after years of pressure, the Financial Accounting Standards Board (FASB) which is the body that sets accounting and reporting standards in the United States, officially added in January 2002 an intangibles disclosure item to its agenda. For those of you who are familiar with what the FASB is doing, this is a substantial development because if it's an agenda item, they have to come up with some kind of statement, some kind of a report. So this appeared to be promising. Alas, I now see on the FASB web site that they have frozen the intangibles project, given "more urgent" concerns in the wake of Enron and others.

My point is that until we get good information from corporations about intangibles, we definitely won't be able to make a clear distinction between real intangibles that create growth and market values, and the Enron-type impact of fraud and lies and hype on market values. And much of the data that you are using, including for the national accounts, is also partial—and contaminated. I therefore have a friendly and important suggestion for you: having spent lots of time with accounting regulators, both FASB and Securities Exchange Commission (SEC), I know that all they hear from are managers who tell them day and night that they don't need to disclose anything. Yes, managers generally repeat the same mantra: (a) additional disclosure is extremely costly, (b) nobody needs it, and (c) it opens them to litigation. Almost every letter to the FASB has these three points, as if all the

letters were dictated by the same person. Accountants often support managers. I think it's extremely important that the FASB and SEC will hear from you—and by *you* I mean the Federal Reserve, the Bureau of Economic Analysis, the Census Bureau. Just meet with them, tell them about your information needs. Counterbalance the gagging effect of managers and accountants.

Lastly, I want to make one point in passing. I find it somewhat ironic that I have heard the same comments at this conference that I hear in accounting and finance circles. People here said several times, and I'm sure with good reason, that intangibles are very uncertain—that we don't know much about them and about their consequences, and hence intangibles shouldn't be considered as assets in the national accounts. People here also said that we need to develop conceptual approaches for intangibles and that maybe R&D should be reported as an asset in satellite accounts, but not more. I hear exactly the same arguments in accounting circles. Intangibles are very uncertain, risky, and we don't know much about them. We shouldn't put them on corporate balance sheets—maybe in a footnote. And you know that when something is put in a footnote, it is buried there forever. No one pays much attention to footnotes. I doubt that people pay much attention to satellite accounts either. I wish they would. But this is a sure way to bury an issue.

You all hear now in the wake of Enron about the stock options debate, and you probably know that the FASB went to war in the mid-1990s about stock options, when they wanted companies to report stock options as an expense in the income statement. This created incredible antagonism, particularly by high-tech companies. Consequently, the FASB backed off, saying, the stock options information will not be in the income statement, but all of it will be in a footnote. Those who believe in market efficiency smiled and said, who cares whether the information is on page 2 or page 5 of the report? As long as the information is disclosed, it's fine. Investors are astute, and they'll take the cost of stock options from the footnote in page 5 and subtract it from earnings in page 2, and they'll have what the FASB wanted in the first place. But managers knew better, and they were happy with the footnote solution. They couldn't care less when the information is in a footnote because they know that if it's in a footnote, it's buried. Few care about it.

So if someone—and this is my second message—thinks seriously about intangibles, reporting them in some kind of a subsidiary or satellite account, at least from the private sector's experience, is like burying the issue. Better to face the issue: many intangibles, like patents, software, or brands, have attributable benefits and therefore can be valued. Don't hide behind “we still don't know much about intangibles, we need concepts.” We will never know much about intangibles, and we always will need better concepts. To paraphrase Nike, just do it! Face head-on the intangibles issue.

## Erik Brynjolfsson and Lorin Hitt

Herbert Simon once remarked that “economics is only a one-digit science.” In the case of intangibles, even that standard sometimes seems to be too optimistic.

The difficulties we are facing in measuring the quantity or price of intangibles with much precision might not be important if they didn’t account for such a large share of the economy. However, all indications are that intangibles account for trillions of dollars of capital in the U.S. economy today (Nakamura 1997; Brynjolfsson and Yang 1999). What’s more, knowledge, business processes, organizational capital, patents, trademarks, brands, and other intangible are likely growing as a share of the nation’s capital stock.

We have studied intangibles related to information technology (IT) especially closely and found evidence that they may exceed the value of computer hardware itself by an order of magnitude, or more. In particular, one of the biggest categories of IT investment is process-enabling IT, including systems for enterprise resource planning (ERP), customer relationship management (CRM), and supply chain management (SCM), among others. According to McAfee (2001), these systems account for the majority of IT spending in large corporations. These projects inevitably require extensive redesign of business processes and employee training, in conjunction with expenditures on new hardware and software. As we have noted in the past, the real costs, and the real value, from IT projects are not in the purchase of the hardware or software but rather in the complex and sometimes subtle interactions of capital, labor, and information.

There is a virtually infinite number of combinations and sequences in which to arrange the steps in most business processes, let alone the bits of information, the people, and the tangible components. Each of these combinations is likely to yield a different outcome, and some outcomes are vastly more valuable than others. But identifying, and then implementing, the more effective combinations is incredibly costly. It is a process of discovery and innovation. It is also a process of imitation and learning. What’s more, it occurs on many different levels. A firm’s chief executive officer,

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chief information officer, chief operating officer, chief financial officer, and others must make broad decisions about a company's strategy. But perhaps more important, if less widely noted, are the myriad small decisions, adjustments, ideas, and changes made by millions of employees as they work with the new systems or invent new ways to do their jobs, exploiting new technologies or new business processes. If it is true that people only think when confronted with a problem, then the implementation of new technologies has generally provided some of the most fertile opportunities for people at all levels of organizations to develop organizational innovations. Indeed, while many of the micro-innovation may be relatively insignificant, the fact that productivity often peaks only years after a new IT system is first installed (see, e.g., Brynjolfsson and Hitt 2003) suggests that the learning-by-doing process is important. Collectively, the value of the big and little process innovations, the explicit ones, and those that are only known implicitly by the firm and its workers, can be called "organizational capital," which is a key type of intangible asset in modern economies.

We have come to the conclusion that for many purposes it is useful to treat organizational capital on par with other types of capital. Indeed, we have run production functions, labor and capital demand equations, and market value equations in this way and found that organizational capital often behaves much like other types of capital, to the extent we are able to measure it.

In the data we analyzed, even the direct spending on the business process redesign and employee training dwarfs the technology spending. For instance, in joint work with David Fitoussi, we systematically interviewed managers of ninety-one such projects initiated since 1997 and found that computer hardware accounted for just 11 percent of the total initial costs. Software, while important, accounted for only 18 percent of the costs, with the rest being intangibles like business process reengineering, deployment, and training. As might be expected, most of the intangible costs were treated as current expenses, while most of the IT hardware was treated as capital investment. In some ways this is ironic, because in many cases the business processes have a significantly longer economic life than the hardware used.

Interestingly, the 10-to-1 ratio of hardware to other intangibles is in the same ballpark as the ratio found in the work of Brynjolfsson and Yang (1999), which looked at the value implicitly attributed computer-related intangibles using a series of market value regressions. If the ratios we found in our research, using both cost- and benefit-oriented approaches, also hold for the economy as a whole, then there are on the order of \$2 trillion worth of IT-related intangibles in the United States today, and this number is growing faster than the rest of the economy. Furthermore, there are many other intangibles that are not related to the computerization of firms.

## Measuring Intangibles

It is often remarked that the market value of firms—the sum of equity and debt—is much larger than the book value of the firm's assets. Other related metrics based on variants of Tobin's  $q$  tell a similar story. At least some of that gap is undoubtedly due to the value of intangibles.

Why are so many intangibles missing from the book value of firms? There are at least two reasons. First, the value of intangibles is typically highly uncertain, making it difficult to place a reliable value on them, whether by accountants, statisticians, or even markets. This point has been thoroughly made by a number of authors, most notably Baruch Lev (see, e.g., Lev 2001). As pointed out by Nadiri (1993), this is compounded by the fact that the marginal costs are often much lower than average costs for general knowledge, and as a result competitive markets are difficult to establish. Accountants are loath to include an asset on a balance sheet when its market value may fluctuate widely from year to year, or even month to month.

We have no doubt that the variability in the value of intangibles is an important reason for leaving so many of them off the balance sheets of corporations. However, intangibles are not entirely unique in this respect. Other assets also fluctuate greatly in value, and yet they are properly included among the assets of a firm. After all, the price of oil, and hence the value of oil reserves, can change dramatically in less than a year as well.

Accordingly, we would like to note another reason for the gap between the book value of a firm and its market value. As we noted in our paper with Shinkyu Yang (Brynjolfsson, Hitt, and Yang 2003), the value of any asset is contingent on the state of the world. In some states of the world, a glass of water is much more valuable to me than in other states. In the absence of a complete set of state-contingent markets, different people will have different values for different assets. In particular, an asset may have a very different value to equity holders than to debt holders. Equity holders are likely to care about the expected returns of a firm and its assets across all future states of the world. They will purchase firms and assets with greater expected returns, to the extent to which they are the residual claimants of those returns.

In contrast, debt holders are entitled to a relatively fixed rate of return. Their returns vary from this rate only in those bad states in which the firm fails to make its payments. In those cases, debt holders may be entitled to assume ownership of the firm's assets. By definition, these are exactly the states in which the firm is not generating a great deal of cash flow as a going concern. Hence, the organizational capital of the firm—the complex and subtle interactions of capital, labor, and information—is likely to have an especially low or even zero value in those states. In contrast, other as-

sets like unspecialized furniture, equipment, or oil reserves are likely to be nearly as valuable as they would be in other states, discounting any economywide cyclical effects.

Because there are (at least) these two basic types of claimants on the firm's returns, equity holders and debt holders, it thus may make perfect sense to have (at least) two distinct values for the firm. One, the market value, represents the expected returns of firm and its assets across all states of the world. This is what the equity holders care about most. The other, the book value, gives an indication of what the firm would be worth in those bad states of the world where it failed to generate sufficient cash flows to cover its required debt payments. This is the value that debt holders care about most.

A gap between the market value and the book value of the firm can thus be viewed as, in part, a reflection of the value of its organizational capital. Note that this gap would be present even if we could measure with great precision the value of the organizational capital in both good and bad states. Conversely, even assets with widely varying and uncertain valuations might properly be included in the book value of a firm insofar as debt holders expected to be able to salvage them if and when they took ownership of them.

As it turns out, organizational capital often has the properties of both being difficult to measure and, almost by definition, being nearly valueless if the firm ceases as a going concern and its assets are separated and sold. In fact, the interaction of these effects may even amplify their importance: when there is more discretion in valuing an asset, it becomes less reliable as collateral for a creditor, regardless of the expected value across states. However, it is worth noting that these are logically distinct characteristics and that this distinction can help us understand why and when intangibles may be difficult to measure and manage.

On one hand, this perspective suggests that although intangible assets may not survive the demise of the company that owns them, they need not necessarily be difficult to measure as long as the firm is a going concern. In fact, this is something that equity investors must do in real time, with real dollars at stake, whenever they trade on the stock market. On the other hand, this perspective reminds us that even if we were to somehow solve the measurement problem, we would not necessarily eliminate the gap between the market and book values of firms. An organizational economics perspective, not just a measurement framework, will ultimately be needed for a more complete understanding of the role of intangibles.

### **Revealing Intangibles Through Indirect Measurement**

These properties lead to different approaches for attempting to better understand the role of computers and their associated intangible assets.

One way to circumvent the measurement problem is to infer the role of intangibles from their resulting outcomes on firms.

Consider an analysis in which we relate the market value (MV) of a collection of firms to the balance sheet assets they possess, such as ordinary capital ( $K$ ), computer capital ( $C$ ), and other assets such as cash or accounts receivable ( $O$ ). In addition, assume there is an additional set of computer-related intangible assets ( $I$ ) that could be measured in the same terms as the other assets. To simplify discussion, we assume that all variables are measured as deviations from the sample mean, eliminating the need for an intercept in the regression, and that no additional control variables are needed for proper specification. If these were indeed all the relevant assets and the firm was in long-run equilibrium, then Tobin's  $q$  theory suggests that a dollar of additional assets should be associated with approximately a dollar of market value. This leads to a regression of the form

$$(1) \quad MV = \beta_1 K + \beta_2 C + \beta_3 O + \beta_4 I + \varepsilon,$$

where we expect the estimates to be  $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 1$ . Unfortunately, since we can rarely directly measure the intangible assets, we may only be able to run the regression without the intangibles variable:

$$(2) \quad MV = \beta'_1 K + \beta'_2 C + \beta'_3 O + \varepsilon.$$

Can this regression be useful in developing a greater understanding of the role of intangibles? Fortunately, the answer is yes, since the results of the two regressions are closely related. Suppose further that the relevant intangibles are correlated with computer capital but not the other capital components (this can be verified if one can measure intangibles, and it appears to be true for some we can measure—see Bresnahan, Brynjolfsson, and Hitt 2002). In this case, standard omitted variables arguments suggest that

$$(3) \quad \beta'_2 = \beta_2 + (C' C)^{-1} (C' I) \beta_4.$$

The contribution of intangibles will cause the coefficient on the computer term to exceed its “true” value. More specifically, the size of this bias is just the coefficient one would get of a regression of computers on intangibles (think of this as the dollar amount of intangibles per dollar of computers) multiplied by the market value of intangibles per dollar ( $\beta_4$ ). Even though the model cannot separately determine the “price” ( $\beta_4$ ) and quantity ( $I$ ) of intangibles independently (see Hall 2001 for an approach for performing this calculation using additional data), it can provide an estimate of the principal quantity of interest—the total value of the computer-related intangibles.

Results from estimating a variant of equation (2) with additional controls show that the coefficients on other capital components ( $K$  and  $O$ ) are

consistently around the theoretical value of 1, while the estimates of the computer market value range from about 4 to as high as 20 depending on the specification (Brynjolfsson and Yang 1999; Brynjolfsson, Hitt, and Yang 2003). This leads to our observation that the value of computer-related intangibles may exceed the value of computer assets by an order of magnitude.

Different econometric techniques can be applied to variants of equation (2) to control for unobserved firm heterogeneity such as fixed effects and long differences. However, to the extent that intangibles may be slower than other capital components to adjust to firm investments or economic conditions, this type of analysis may actually remove the true effect of intangibles, leading to a lower estimate of the computer coefficient. In the extreme case where the level of intangibles is fixed over the sample period, these analyses would miss the role of intangibles entirely. Similar arguments apply to instrumental variables techniques where the equation is estimated with instruments correlated with computers but uncorrelated with the unobserved effects, which include, among other things, intangible assets (Cummins, chap. 2 in this volume). Unfortunately, while instruments will help us get close to the true value of the computer investment alone, we cannot learn much about computer-related intangibles—which is precisely what makes the analysis interesting in the first place.

That is not to say that we cannot learn more about the properties of intangibles from these types of specifications. In fact, results using first differences tend to yield estimates of the computer coefficient indistinguishable from 1, while longer differences (greater than three years) yield estimates comparable to the ordinary least squares estimates (Brynjolfsson, Hitt, and Yang 2003).

Similar results also appear in a productivity framework—when we conduct productivity growth analyses using one-year differences, computers show a rate of return indistinguishable from their capital costs, the theoretical value. However, the coefficients steadily rise as longer difference lengths are considered to as much as five times as large. Moreover, if one considers the market value to be the discounted future value of productivity gains, a productivity contribution of intangibles of two to four times larger than their theoretical value is not unreasonable, since the future value of this amount of additional productivity contribution broadly consistent with a market value intangibles an order of magnitude larger than the direct value of computers.

Conversely, as was noted at the time and in subsequent discussions, the apparently high levels of computer-related intangible assets founded in data through 1997 “predicted” the subsequent surge in productivity, as conventionally measured. One test of whether the intangibles were real was their ability to create real output in subsequent years, beyond that accounted for by tangible inputs of capital and labor.

## Direct Measurement of the Value of Intangibles

Of course, it would be much more satisfying to directly measure these intangible assets so that their properties can be revealed and studied directly without recourse to econometric argument. Sometimes there is no substitute for gathering the requisite data. As mentioned earlier, it is known that as much as 80 percent of the expenditure in large-scale IT projects is for business process design and other organizational change investments. However, this raises the question of what changes these firms are actually making with these investments.

Although it has proven difficult to develop a general framework for measuring all intangibles, the task can be greatly simplified if it can be limited to a well-defined set of practices where there is a strong theoretical belief that they are related to computers. In particular, decentralized organizational decision making and high levels of human capital have frequently been argued to be complementary to computer investment (see Brynjolfsson and Hitt 2003 for a survey of these studies). Furthermore, there are reasonable measures of these constructs that can be used in organization-level surveys, largely developed from the human resources literature on “high-performance work systems” (see a survey in Ichniowski et al. 1996).

In 1996, we conducted a survey of 400 large firms focusing on these two aspects of organizational design and found a collection of these practices (which are summarized by a single variable that we labeled *ORG*)<sup>1</sup> to have some interesting properties. In particular, the *ORG* variable appears to be correlated with computer capital stock but not with the stocks of ordinary capital or other assets, consistent with our suggestion that there is a unique relationship between computers and these practices. When *ORG* is entered alone in a market value equation (replacing *I* in equation [1]) it generally has a positive coefficient. However, more interestingly, it has a very strong interaction with computer investment—firms that are both high in *ORG* and have high IT investment have a substantially higher market value than other firms (Brynjolfsson, Hitt, and Yang 2003). This interaction is also found in productivity analyses (Bresnahan, Brynjolfsson, and Hitt 2002). Thus, at least for the practices that we are able to measure, it is the combination of computer capital and organizational capital that appears to be associated with significant value.

Clearly, decentralized decision making and human capital are not the only potential complements to computers. Other organizational investments such as business processes, incentive systems, and new ways of interacting with buyers and suppliers play a substantial role in many of the

1. Specifically, *ORG* is derived from a principal components analysis of seven survey items covering organizational practices such as the use of self-managing work teams, decentralization of production decisions, screening for human capital and training (see Bresnahan, Brynjolfsson, and Hitt 2002 for further details).

success stories of computer-enabled organizational design (e.g., Dell, Wal-Mart, Cisco, Amazon, and many others). However, broadly speaking, a common thread in many of these practices is that they leverage the value of information, which is captured, stored, processed, and transmitted by IT. Following this logic, we conducted a more recent survey in 2001 covering a wide variety of practices of “information-intensive” firms. Our preliminary results suggest that additional practices such as widespread information access within the firm, clearly communicated organizational goals, performance-oriented incentives, and well-defined corporate culture tend to appear in firms that are both technology intensive and highly productive. However, one can only imagine that this is still the tip of a much larger iceberg of potentially successful practices, including practices unique to particular industries or activities or practices that may be valuable only in certain settings and economic conditions.

### Conclusion

Considerable work is still required to better understand these intangibles, but if we are to fully understand the role of computer investment in the economy this is where we will have to look. While we can measure the amount of IT entering the economy fairly well, without a better understanding of intangibles we will miss the largest contributors of both costs and benefits of technology investments.

While it is a well-worn cliché that economic measurement lags behind the activity of the economy, this is not the first time that technological progress has required a rethinking about the way the economy is measured. Economists likely faced similar quandaries in understanding the role of capital when it became apparent that we were shifting from an agrarian to an industrial economy. If we are becoming members of an “information economy,” it would be ironic if we had less information about the real factors of production than our predecessors who pioneered growth accounting in the twentieth century. Fortunately, intangibles need not be beyond calculation. They may be immense, but they are not immeasurable.

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