The Economic Development Case for Investment in Higher Education Information Technology

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In its report\textsuperscript{1} to President Clinton, the President’s Information Technology Advisory Committee (PITAC) wrote in 1999:

Information Technology will be one of the key factors driving progress in the 21st century—it will transform the way we live, learn, work, and play. Advances in computing and communications technology will create a new infrastructure for business, scientific research, and social interaction. Vigorous information technology research and development is [thus] essential for achieving America’s 21st century aspirations.

Information technology is, indeed, transforming the national economy. Yet, although the premise is now almost intuitively accepted, a question remains: How do we start “driving progress”? One answer for the higher education research community is that investments in public and private institutions that conduct advanced research in information technology can produce results that feed economic growth nationally and locally. The Web and electronic commerce were among the most fundamental developments of the 1990s. Many of the technologies that fueled these developments were launched in the higher education research community. The Web we surf today, which originated in 1989 at the European Laboratory for Particle Physics (CERN), had roots in the higher education community of networks.

Information technology in higher education has significant roles to play in driving the new information economy. It can provide a “train-to-retain” function, through programs and curricula that help students acquire the skills needed by the local information economy. “Brain power” is perhaps the single most important resource to an information economy, and a trained workforce is the single largest enabler of that resource. Higher education provides the fundamental training needed to drive the workforce of the information age.

Many institutions have been refining their focus in this regard over the past several years. Schools of informatics (information science) have begun to pop up across the nation’s campuses, and emphasis on the practical application skills of information technology has been added to a variety of programs, including those in business, engineering, and library and information science. Even computer science programs have begun to include tracks that add a practical “how-to” flavor to their traditions of pure computational science in an effort to provide enriched opportunities for graduates who, in the 1990s, were gobbled up by information economy companies and no doubt will be again.

Training alone, however, is insufficient to spur growth in information economy companies within the communities surrounding colleges and universities. In fact, many communities that produce significant numbers of qualified and talented graduates are experiencing a “brain drain” as these trained individuals relocate to geographic areas in which the information economy has taken root. Essentially, then, the train-to-retain programs have succeeded only partially; the workforce has been trained, but it has not been retained.
The goal for higher education in its capacity to help spur local and regional economies should evolve to “train and retain.” This revised strategy in no way reduces the emphasis on training; it remains a vital need requiring ongoing investment and attention. The key difference is that a train-and-retain approach places increased responsibility on higher education to establish its role in seeding opportunities for information economy enterprise within their communities.

Indiana University (IU) took a first step in this direction with the founding of the Pervasive Technology Labs. The goal of these labs is to perform fundamental research in information technology applications and to generate ideas and tools that can be leveraged to establish information economy enterprises within the state of Indiana. This research bulletin will examine that effort as a case study and suggest similar projects that can be undertaken by other universities seeking to drive community economic development. The bulletin will provide support for the concept that investments in higher education information technology are, indeed, wise investments to support both the future of the institution and the future of the regional community.

**Highlights of Information Technology Investment Strategies**

Investments in higher education information technology are focused internally within the institution and externally in the information economy sector. Within the institution itself, investments are made in academic curricula, research, and institutional infrastructure (hardware, software, networks, and support). Directly, these investments support the *train* component of the train-and-retain strategy. Successful institutions have steadily increased their financial commitment to information technology through reallocation of resources and additional budget derived from fees, tuition, contributions, and legislative support. They have established academic programs in information technology and encouraged growth and expansion of those programs. They have developed new courses and hired faculty to focus on information technology. They have worked to provide lifecycle-funded investments in computational and storage resources, communication networks, information systems, software (available to all via enterprise licenses), and technology staff who support use of these elements. In general, these investment strategies are fairly well documented and fairly well accepted within the higher education community.

Externally, the *retain* portion is less well established. Traditionally, the general university external investment model has been “Intellectual Property for Sale”—develop an idea, product, or technology, patent it, and then look for a buyer willing to pay the institution for it, either outright or in royalties. Another variation involves research collaboration with a community enterprise, wherein the research and development work is handled by researchers at the institution and then leveraged into production by the private sector enterprise, resulting in dividends for both. These traditional strategies are not invalid in the information economy; however, they are perhaps less likely to achieve results because information technology tends to be less dependent on the generation of a patentable idea.
Information economy enterprises today are focused more on software and service sectors and less on hardware gadgetry. In the software or service world, an idea of how to accomplish something is not necessarily unique; there is more than one way to accomplish a task programmatically or procedurally. A researcher may have developed an interesting piece of code to accomplish a given task, but this creation is simply a small element of a larger product that would eventually find its way into the economy. Information enterprises are not willing to pay a great deal of money to further develop these ideas and turn them into production products. Rather, enterprises would prefer to develop ideas in-house and have the intellectual property resolved internally.

An alternative role for higher education regarding external investments is to generate new tools and technology and then make them freely available to local information economy enterprises. This is the open-source model. Once the tools and technologies are shared, the institution can take the next step by making further investments from seed funds, by investing human resources (workforce), and by helping the enterprise seek further investments with the support of the institution. The institution benefits from the economic growth of its local and regional areas, and it retains its most valuable product—its graduates—within the community.

The key is to find an opportunity where the institution can leverage its internal investments in curricula, research, and infrastructure. Such opportunities exist broadly within the framework of research and services related to information technologies.

**An Opportunity for Indiana University—Pervasive Computing**

One of the major emerging macro-phenomena in information technology in the new information economy is *pervasive computing*. Pervasive computing—or pervasive technology—refers to a ubiquitous fabric of intelligent instruments, appliances, information sources, and information analysis tools, all tied together and making use of personal-software service agents that constantly search for, gather, analyze, and communicate information important to humans. Pervasive computing envisages a time when the relentless decrease in the price of microprocessors coupled with the relentless increase in their power allows these microprocessors to become integrated seamlessly into every aspect of our daily lives. As this process is aligned with advances in mobile, high-performance communications technology that enable these microprocessors to communicate effectively with each other, we should see a world in which computing, telecommunications, and information access all are truly pervasive.

The technologies that underlie pervasive computing include

- networked devices, sensors, instruments, and interfaces;
- information and computational resources, organized and accessible as a ubiquitous service grid;
converged telecommunications, including global wireless and broadband networks;
advanced high-bandwidth networking services;
ubiquitous tools for analysis of information;
human-machine interaction technology; and
software agent technology.

In late 1997, Indiana University saw pervasive technology as a key area in which investments in information technology could pay dividends in economic development for the state. The university had already made tremendous strides in achieving the train-to-retain goals, with the establishment of its School of Informatics and extensive development of practical training in information technologies throughout a wide variety of disciplines on campus. Additionally, through significant planned investments in information technology infrastructure, IU was on its way to becoming a leader in information technology in higher education in terms of having a highly networked, well-equipped, and well-supported information technology environment. These components, however, were not paying economic development dividends downstream because there was a failure to retain the trained talent. Hence, the next step—that of providing broader influence on the developing information economy in the state—would require initiatives beyond these internal successes.

The Approach

In 1998, IU began exploring the idea of obtaining gifted funding to establish a set of separate but coordinated labs to do research in the area of pervasive computing. In early 1999, the university made a formal proposal to the Lilly Endowment, a philanthropic foundation of the Eli Lilly family based in Indianapolis, Indiana. The Indiana Pervasive Computing Research Initiative (IPCRES) eventually received $30 million in funding from the Lilly Endowment in late 1999 to establish a broad strategy to

- advance fundamental research in information technology, specifically pervasive computing;
- leverage this investment in information technology research for economic development, such as the creation of new businesses and the modernization of existing ones; and, ultimately,
- build on these investments to improve employment opportunities for the citizens of Indiana and retain IU graduates.

The Lilly Endowment, as a foundation of a large, Indiana-based enterprise, is motivated to support economic advancement within the state. As such, it applies funding to help develop the economy of Indiana. The key to the IU-Lilly strategy was to significantly increase the research and development capabilities focused on areas of information technology that are fundamental to pervasive computing. IU believed—as did leadership of the Lilly Endowment—that investments in this type of research and the seeding of
technologies in local start-up enterprises were required in order to reverse the trends in the state with regard to economic makeup, occupational opportunities, and retention of skilled workers.

IPCRES was designed around several possible research areas. These include

- information grids and portals,
- human-computer interaction,
- smart devices,
- network agents,
- open software, and
- advanced telecommunications, which include high-performance networking, wireless and mobile communications, convergence, security and privacy, and distributed storage.

Several pervasive technology laboratories are currently being built around these research areas. Scientists are being recruited to this endeavor as directors and distinguished scientists for the individual labs. The funding used to attract and retain key scientists can further leverage this investment by generating proposals to other grant-funding agencies such as the National Science Foundation, which will in turn sustain the labs. Tangential or “spin-on” labs are also envisioned because related research work that dovetails with Pervasive Technology Lab (PTL) initiatives results in additional external funding opportunities. Through this series of leveraged investment, a “megalab” approach is being fostered, as the labs are attracting an increasing flow of research opportunities and funding.

Transferring Innovation

Successfully transferring innovation from the laboratory to the marketplace is fundamental to effecting change and impacting Indiana’s economy. Three ways have been identified in which spin-off technologies from the PTL will be developed into significant products that stimulate economic development in Indiana:

1. Establishing new companies that will acquire the rights to develop PTL research projects into products
2. Partnering with existing companies, where targeted companies are involved in the same basic research as the PTL (and may have even funded the PTL research)
3. Allowing PTL research products to produce public, open-source systems and tools

Of the three methods, the last has gained the greatest popularity. This is the most common way for academic research organizations to influence the world, and open sourcing is the model that the information technology community increasingly embraces.
as a way to ensure compatibility for core technologies upon which other markets depend. The scientists initially recruited to head PTL initiatives all are leaning conceptually toward this open-source model as the one that will have the best—and fastest—impact on economic development.

Providing services to Indiana business and industry is another key function of the PTL. PTL leaders work closely with technology-based firms within the state and also with various associations and organizations that are involved with regional economic and workforce development. The goal of these efforts is to create a local culture supportive of technology-based enterprise and to forge links between innovation sources and the private sector. In addition, these efforts emphasize developing, attracting, and retaining technology professionals within state enterprises; improving access to capital and support mechanisms for technology entrepreneurs; and highlighting technology-oriented policy and infrastructure. These goals are advanced through a number of PTL initiatives, including establishing training and outreach programs, facilitating inter-firm cooperation by fostering collaboration, and establishing close relations with local and state government to ensure that university research and commercialization efforts complement public policy and statewide economic growth objectives.

To move innovative, highly technical inventions to final products also requires a vibrant technology enterprise community and early-stage capital seed funding. When these two ingredients are brought together, the results can be most satisfying. Thus, in order to move exciting new PTL and Indiana University technology into the marketplace, the IPCRES grant also included the establishment of a $2 million Capital Seed Fund, managed by the PTL. The goal of the fund is to provide early-stage financing for promising technologies related to pervasive computing developed in (and around) the PTL, as well as elsewhere within Indiana.

**Launching the Pervasive Technology Labs**

With the strategy and plan in place, IU set out to establish the labs. Key tasks included

- Recruiting renowned and skilled scientists to head the individual labs
- Establishing space for the new labs close to the academic functions but also part of the planned landscape of information economy enterprises
- Establishing sound administration for the labs so that lab directors and scientists can focus on their research
- Branding the labs—establishing a logo and recognizable image for the labs within the economic development community
- Developing investment strategies for the capital seed fund

Recruiting was viewed as the most important step because the strength of the labs would be a reflection of the scientists who led them, and recruitment proved to be the most challenging task. Funding is not necessarily a sufficient enticement for big-name scientists entrenched in their current institutions and environments. In one instance, a leading scientist rejected Indiana’s offer because of family considerations. PTL
administrators quickly learned that top scientists typically are treated well by their university employers and are very, very difficult to entice. A more successful approach has been to recruit rising stars who are eager to establish their first major laboratory with excellent funding and superb support.

Finding space for the new labs, which are located on both the Bloomington and the Indianapolis campuses of IU, was less challenging. In Bloomington the labs are located within a 20-minute walk to the heart of campus. In Indianapolis, the labs ultimately will be housed in a new computing/technology complex currently under construction on the Indiana University Purdue University at Indianapolis campus. For now, they are conveniently housed just off campus in an industrial park. Both locations provide for a fairly modern and attractive set of facilities near the academic centers of each campus.

Administration for the labs is leveraged from the central information technology organization to cover contracts, grants administration, purchasing, budget and finance, and human-resource management. This model has worked very well, and it has helped to maintain a strong relationship between the PTL and the central information technology organization. Branding of the PTL has focused on development of an informative and attractive Web presence, frequent news releases from the individual labs, a forceful presence at supercomputing and other conferences and legislative gatherings, and frequent speaking engagements for the PTL leaders. These efforts are all designed to create enthusiasm about the PTL within the community and to involve PTL personnel as a bridge between the scientific and business communities within Indiana.

Developing strategies for using the seed funding of the Lilly grant has been especially interesting. As research begins to yield results, lab directors have submitted proposals for investing in private-sector enterprises that will further develop technology spawned from the labs. Lab administrators thoroughly review and vet these proposals. The rationale for using seed funding in this manner is clear: New technologies often must mature to a point where their potential value and risks can be established. A seed fund provides an appropriate source of additional resources to span the gap between grant-funded innovation and marketplace deployment. Investments are made only where there is a real chance for success, not as a way of continuing or expanding existing research. Established criteria for such investments include

- stage of technology being developed;
- intellectual property protection;
- demonstrated market need (thorough market research required);
- market size, growth, and penetration potential, as well as sustainability;
- competition (current and future);
- management team of enterprise to be funded (perhaps the most important item on the list);
time to market (determines financing needs and duration);

- total capital required (how big a bet is it?); and

- future value/time to liquidity (return on the investment).

To date, the PTL has progressed in line with the goals established in the proposal and has achieved all of its first 36-month objectives. Four labs have been firmly established, with another due to come online before the end of 2003. The “megalab” concept has already borne fruit with the establishment of a PTL-affiliate lab working on a contract with a military center located within the community. In addition, the first investments are on their way to community enterprises, seeking to further develop PTL technologies into tools, products, and services in the information economy.

Still to be seen, however, is whether these early successes will result in economic development. With the rise of the dot-com era in the 1990s and its contraction in 2000–2001, there is no guarantee that all information technology investments will provide for long-term, sustained economic growth. But the information economy is established, and the Internet economy continues to advance and will likely be one of the first sectors to recover, leading to a broader recovery in the economy. Investments in information technology do hold promise, and higher education investments can, indeed, begin driving progress in the 21st century.

What It Means to Higher Education

In *Preparing for the Revolution*, the National Research Council of the National Academies (NRC/NA) explores the role information technology can play in the future of the research university. The report describes two main factors: the evolution of technology in terms of rapid and ever-increasing advances in processor power and decreases in costs, and the rise and rapid growth of an Internet-driven economy. The report’s conclusion, which is supported by Katz and Oblinger and many others, is that we will be evolving from e-commerce, e-business, e-government, and e-learning to e-everything!

PITAC has developed a powerful and well-reasoned argument supporting a national research agenda devoted to advances in information technology. Observations of this committee support the idea that information technology will be a key factor driving progress in the 21st century, not only in business development and economic growth but also in areas of education, communication, health care, the environment, and government. The report notes that many of today’s technologies and information tools are the result of information technology research conducted by universities, and future prosperity and progress will depend on continued investment in information technology research.

PITAC has discussed four broad areas of information technology research, which together form the basis for the development of a 21st-century world in which computing is pervasive. These areas are software and distributed systems; networks and a scalable information infrastructure; high-performance computing; and socioeconomic
impacts of information technology. Pervasive computing research aligns well with a
number of key aspects of this national research agenda, particularly research in the
areas of software technologies and advanced telecommunications that are fundamental
to pervasive computing. Higher education institutions may wish to explore the economic
advantages of aligning with this conceptual framework.

Another key aspect of the PTL at Indiana University—and of the overall investment in
information technology suggested in information-economy-depressed regions—involves
a strong association with academic learning programs in information technology. Such
programs should be an integral part of any university's efforts to advance information-
technology-based economic development initiatives, and, along with solid information
technology infrastructure, they are a foundation for these initiatives. Efforts should be
made not only to train and retain the workforce but also to involve students in meaningful
ways in the process of university research.

As we examine these technologies and their economic potential, we must also be
mindful that all such advances have social and ethical impacts. As information about
us—our status, our health, our location, our purchases and consumptions, our waste—
becomes ever more monitored and shared, we should be aware that this fact alone
suggests a substantial social policy agenda. What does privacy mean in an era when
our personal communication and information tools merge with a ubiquitous sensor and
communication environment? How will cultures and political institutions evolve and use
(or potentially abuse) these technologies?

The impact on our lives of pervasive computing and ubiquitous information is not well
understood. Pervasive computing is, as the name suggests, virtually inescapable. It will
happen around us whether we want it to or not. How do we keep it from becoming
persely invasive? This is not to suggest that pervasive computing should not be
explored, developed, nurtured, and embraced. Rather, it suggests that social and ethical
implications should be researched in tandem with the technological developments. It
seems apparent that higher education is the best venue for these tandem research
efforts.

**Key Questions to Ask**

- What economic development needs exist for your community?
- In what ways is your institution working to support the development of the local
economy? Specifically, are there opportunities in information technology?
- What is the position of your institution’s governing agencies regarding
investment in information technology?
- Can your institution’s information technology infrastructure support growth in
research?
Are there industry philanthropic institutions interested in stimulating new economic development in your community or region specifically? How can you tap into those resources?

Where to Learn More

- The Pervasive Technology Labs at Indiana University, [http://www.ptl.iu.edu/](http://www.ptl.iu.edu/).
- The Lilly Endowment, [http://www.lilly.com/about/community/foundation/endowment.html](http://www.lilly.com/about/community/foundation/endowment.html).
- Information Technology News in Focus, Indiana University, [http://it.iu.edu/](http://it.iu.edu/).

Endnotes


About the Author

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