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Environmental Impacts of the Emerging Digital Economy: The E-for-Environment E-Commerce?

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ABSTRACT / The Internet-led digital economy is changing both the production and consumption patterns at the global scale. Although great potential exists to harness information technology in general and the Internet in particular and improve the environment, possible negative impacts of e-commerce on the environment should also be considered and dealt with. In this forum, we discuss both the potential positive and negative impacts of e-commerce. Drawing from insights gained from the complexity theory, we also delineate some broad contours for environmental policies in the information age. Given the paradoxical nature of technological innovations, we want to caution the scientific community and policymakers not to treat the Internet as the Holy Grail for environmental salvation.

New technologies affect the earth in its entirety. The more useful a technology is, the more unstablizing its effects can also be.
John von Neumann

This forum first reviews the recent development of the emerging digital economy and then summarizes and critiques the current discussions on the possible environmental impacts of e-commerce. Thus anchored in the basic principles of the complexity theory and non-linear dynamics, the paper also discusses possible environmental policy initiatives during the information age. The forum concludes by presenting a cautionary note on the potential positive impacts of technological innovations and the deeper cultural roots of environmental degradation caused by increasing consumption.

The Emerging Digital Economy

It is generally agreed among scholars and policy makers alike that the dazzling development of the Internet and its wide-range of applications during the past five years are going to change various facets of our society in very fundamental ways as we move into the 21st century (Castells, 1998). Among the many transformations the Internet brings to society, the most conspicuous, and perhaps the most important, is the so-called emerging (indeed, e-merging) digital economy as evidenced by the growth of Internet-based businesses for the delivery of goods and services on a global scale.

KEY WORDS: Digital economy; E-commerce; Environmental impacts; Environmental policies

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According to the two latest national studies released by the Department of Commerce, e-commerce is quickly becoming the engine for economic growth in the new millennium. This e-commerce-led growth could accelerate in the coming years not only in the information technology (IT) sector itself, but across all sectors of the economy as the number of people connected to the Internet multiplies and as its commercial use grows (Margherio, 1997; Tapscott et al., 1998). The U.S. Department of Commerce (2000) reports that the percentage of U.S. companies that sell their products over the Internet has jumped from 24% in 1998 to 56% by 2000. About $2.2 billion worth of business-to-consumers goods and services were sold over the Internet in 1997, and $5.3 billion for the fourth quarter of 1999 alone. By 2002, it is forecasted that online retail sales may reach $ 40 to 80 billion. However, business-to-consumer (B2C) transactions represent only 20% of the e-commerce, the remaining 80% is business-to-business (B2B) e-commerce. B2B transactions were $43 billion in 1998, expected to rise over to $1.3 trillion by 2003. There are currently 304 million Internet users world wide, up almost 80% from 1999. Also, for the first time the U.S. and Canada account for less than 50% of the global online population in fourth quarter of 1999. In the U.S., there are currently 30 million online households, and by 2003, it is estimated that nearly 75% of American families (53 million) will be surfing the Net and buying products and services directly from the manufacturer or distributor. The amount of information available online has increased tenfold over the last three years, to more than one billion discrete pages.

There is growing evidence that firms are moving their supply networks and sales channels online and

participating in new online marketplaces. Firms are also expanding their use of networked systems to improve internal business processes, such as coordinating product design, managing inventory, improving customer services, and reducing administrative and managerial costs. More and more B2B transactions are being conducted online electronically as well. Intel's Andy Grove even predicted "In five years' time, all companies will be Internet companies or they won't be companies at all." For the consumers, this means quick, unparalleled access to goods and services at a global scale with only the click of a mouse. For example, Buyer's Index alone provides a search engine to over 20,000 companies with 300 million products (www.buyersindex.com). Indeed, the Internet is quickly becoming the modern Agora freed from the limitations of space and time. Business-to-consumer (B2C) transactions can also expect to grow exponentially in the years ahead. We are possibly witnessing the emergence of a friction-free capitalism where businesses can be conducted at the speed of thought as Bill Gates (1995; 1999) predicted.

E-Commerce and the Environment

Historically, major technological innovations have not only brought fundamental change to the economic system but also far-reaching environmental impacts, for better or worse. Our ecological footprints on the environment are, in most cases, a reflection of human economic activities as mediated by technology (Mumford 1934, Landes 1969, Headrick 1990, Rees 1992, Bowers 2000). During the past 8000 years, as human society evolved from hunting and gathering to agriculture, and especially since the beginning of the industrial age in the late eighteenth century, we have increasingly transformed the earth's surface and caused our fragile environment to deteriorate at an increasingly rapid rate. In fact, contemporary environmental problems can be traced to the sudden acceleration in the rate and power of technological innovations. Now the information age is here. Many business leaders and scholars contend that sustainable development hinges on the further development of knowledge-based industry and deployment of innovative technologies, especially the Internet-led information technologies (Ausubel and Sladovich 1989, Ausubel and Langford 1997, Billates and Basaly 1997). Can the information technologies serve as one of the most important means to improve the environment? Do demands for the development of a sustainable economy compete or coincide with the new reality of the digital economy? Is e-commerce a truly clean, environmentally benign economy, which will simply lead to the substitution of information for physical resource flows along energy and transportation networks? Or alternatively, does e-commerce encourage more movement by generating new demands for material and energy that will further deteriorate the fragile environment? What kind of environmental policies should we develop in the Internet-led information age?

These questions pose some daunting challenges for both scientists and policymakers. The few reports available in the literature on this topic are anecdotal, speculative, and inconclusive (Rejeski 1999, Colien 1999, Brynjoolfsson and Smith 1999, Romm 2000, Caudill and others 2000). As of today, the scientific community still does not have any definitive statements on the relationship between the Internet and the environment. Obviously, the emerging digital economy in principle has great potentials for positive environmental impacts, which have been generally summarized as the three D's for the new economy: dematerialization, decarbonization, and demobilization. The argument is that by moving businesses online and marketing by pixels instead of packages, e-commerce can reduce the need for such wasteful products as printed catalogues, telephone books, newspapers, and magazines. The recent shifts, from books to bytes, from compact discs to MP3s, from snapshots to JPEGs, from checkbooks to clicks, are all seen as examples of this dematerialization process in which electrons are substituting for atoms, consequently leading to a putative reduction of material consumption. E-commerce also encourages mass customization via the modes of "just-in-time," "just-enough," and "just-for-you" manufacturing and marketing technologies, all of which can potentially reduce waste and the need for inventory and warehouse space. In addition, the growth of teleshopping can supposedly reduce the number of shopping centers and their inefficient use of land—what Nevin Cohen (1999) called "the de-malling of America." E-commerce has also been alleged to prevent waste by vastly increasing the efficiency of the market for secondary (reused and recycled) materials through online auctioning on a global scale. Some researchers even argue that the decline of energy intensity in the U.S. economy over the past ten years can be attributed in part to the growing e-commerce and IT sectors. Furthermore, according to Romm et al. (2000), the decreasing energy consumption would mean the reduction of the greenhouse gas (GHG) emissions and thus make the goals of Kyoto Protocol (the reduction of GHG by 7% of the 1990 levels between 2008–2012) easier to accomplish. The Internet has also turned many homes into offices and virtual shopping malls (Nilles 1998), and the continuing growth of telecommuting and teleshopping entails

the potential reduction, in some cases even elimination, of certain to work and to shop trips—demobilization—which in turn may reduce fuel consumption and conserve energy.

However, a closer look at the environmental impacts of the Internet quickly reveals that the potential positive impacts are only one side of the story. Although the potentials of the Internet to save material and energy cannot be denied, it is nonetheless too early to paint a rosy picture for the environmental impacts of the emerging digital economy. We do not believe that our society has quite reached the stage where our science and technology are ready to reconcile our economy and environment to effect the Copernican turn characterized by a hydrogen fuel economy, landless agriculture, and an industrial ecosystem in which waste virtually disappears. To the contrary, each potential positive impact is coupled with a potentially overwhelming negative impact as well. For example, moving business online can reduce waste such as printed catalogues, retail space, and transportation requirements, but we have to manufacture more energy intensive computers instead! There are already 50 million personal computers in U.S. households, another 150 million in businesses, and 36 million more are being sold every year (Mills 1999). The $50 billion per year semiconductor industry is the nation's largest manufacturing sector, having surpassed the auto parts sector in 1995. In the not-so-distant future, there will be one billion PCs globally on the Internet, which means not only a massive amount of material will be consumed to produce these computers, but also a global demand for kilowatt-hours equal to the entire current output of the U.S. electric grid. Preliminary calculations reveal that the appetite for electricity to drive the Internet has grown from essentially nothing ten years ago to 8% of the total U.S. electricity consumption (Mills 1998). Mills (1998) even projected that the Internet is responsible for one-half to two-thirds of all growth in the U.S. electricity demand in the last decade. For every 2000 kilobytes of data moving on the Internet, the amount of energy obtained from burning a pound of coal is needed to create the necessary kilowatt-hours (Mills 1998). Although Mills' prediction has been contested by some researchers (Koomey and others 2000), we cannot afford to ignore the basic fact that energy consumption will continue to increase. In addition, web-based marketing may encourage profligate rather than savvy consumption. Indeed, the Internet has already dramatically increased mass production on a global scale. The ease of pointing and clicking itself causes people to buy more. A German study found that customers at online bookstores are spending about twice the average amount they spent in conventional bookstores (Rejeski 1999). The material savings (dematerialization) caused by the substitution of atoms with electrons could potentially be offset by conspicuous consumption in developed countries and the population increase in developing countries as well (Gardner and Sampat 1998).

In terms of energy consumption, just-in-time (JIT) delivery tends to create a situation in which trucks are moving half empty. E-commerce also tends to favor faster transportation modes, which can increase fuel consumption exponentially. When we opt for trucks instead of boats or rail, energy use goes up by a factor of four to five (from 400≈500 BTUS per ton-mile to over 2000). Moving the same package by airfreight again increases the energy use dramatically (to over 14,000 BTUs per ton-mile). One company, Patagonia, calculated that the energy cost rose from 6% to 28% when shifting the modes of shipments from ground to air. The growth of e-commerce has further stimulated the expansion of the overnight delivery business. Federal Express handles one million packages on an average day at its Memphis hub alone. The amount of energy used to transport freight in the U.S. has increased steadily since 1984. It now exceeds five quadrillion BTUS (Rejeski 1999), enough energy to run the entire British economy for six months. Some of this increase in transport energy consumption can be attributed to the growth in e-commerce as it tends to encourage the consumer preferences to more energy-consumptive, faster deliveries. It is very likely that the increase in transport energy consumption may offset the energy savings from consumers traveling less to local stores unless e-commerce is seamlessly integrated with both B2B and B2C operations. Indeed, it is still an overwhelming challenge to further improve the U.S.'s energy efficiency (Casten and Pena 1998).

As for demobilization, the current findings about telecommuting are perplexing. At the level of individual home-based telecommuters, numerous emperical studies have found statistically significant reductions in the number of vehicle trips, basically due to the elimination of the commute (though not for everyone nor on every telecommuting day). Hypothesized increases in non-commute trips have not been found to a statistically significant degree, or to a degree that completely counteracts the savings (Mokhtarian and others 1995). For center-based telecommuters, frequencies of trips are not reduced at all. Center-based telecommuters still make the commute (albeit a shorter one), and sometimes two (home for lunch and back in the afternoon), on the days that they telecommute. New advances in telecommunications seem to complement traditional modes of transportation rather than substituting for

them. Studies in both North America and Europe have found that heavy users of information technology travel about the same amount overall as an otherwise similar, but non-heavy information technology-using group, although IT professionals did considerably more work-related traveling. Thus, appears unlikely that telecommunications will noticeably reduce travel at the system level (Mokhtarian 1998). Ample evidence shows that "The aggregate impact will remain relatively flat into the future, even if the amount of telecommuting increases considerably" (Mokhtarian and Meenakshisundaram 1999, see page 33). Contrary to the demobilization hypothesis, no strong support exists for drastic, or even smaller, reduction of travel attributed to telecommuting because of the small number of telecommuters and their low telecommute frequency. In fact, the automobile is still a major source of a variety of mobile pollutants such as sulfur dioxide, nitrogen oxide, carbon monoxide, and carbon dioxide, especially from those fuel-hungry sports utility vehicles and pickup trucks. E-commerce also allows physical spaces and flows to be reconfigured and reconstituted, thus generating new forms of environmental problems through dispersal of land uses, along with concomitant generation and enhancement of new travels. Newly released data on the office space vacancy rate in major U.S. cities has indicated that there has been growing demand for office spaces during the past five years (BOMA 2000). So far, telecommuting has not reduced demands for office spaces either.

Obviously, the Internet economy is a double-edged sword. Despite the growing literature on the three D's, our knowledge of the extent of, and mechanisms behind, the patterns of material use and energy consumption are very limited. The weight-based material intensity of the economy may be falling, but it is unclear at this point what, if any, economic and environmental significance that trend may have. Despite growing claims to the contrary, there is no compelling macroeconomic evidence that the U.S. economy is decoupling from material and energy input (Cleveland and Ruth 1999). We know even less about the environmental impacts of many changes in material use than the possible changes in energy uses. The aggregate significance of the dematerialization, decarbonization, and demobilization trend is unknown. We concur with Cleveland and Ruth (1999) that any generalizations about material use and energy conservation attributed to technological innovation should be viewed with suspicion.

What we believe has been under-appreciated so far are the so-called rebound effects (Ashton and Laura 1997)—or unintended consequences, according to revenge theory (Tenner 1996)—to especially macro effects from micro advances. In general, increased economic productivity (less resources being used per unit quality of life) at the micro-level has translated in the past into increases in economic activity, rather than increased environmental efficiency at the macroeconomic level (Allenby 1999). Because of rebound effects, the overall benefit in material and energy consumption caused by technological innovations will probably be much less than bottom-up microeconomic analysis indicates. For example, while the paperless office was predicted at the dawn of the computer age in the 1970s, paper consumption in the U.S. increased by 33% between 1986 and 1999, and even with the increasing computerization in various facets of society, paper consumption continues to rise both on a per capita basis and in the absolute amount at the global level (Abramovitz and Mattoon 1999). Perhaps the biggest irony is in the Bay area around San Francisco, the most wired region in the world. Traffic jams and environmental burdens there are no less than in other areas (SVTC 2000). Silicon Valley also has more superfund sites than any other county in the U.S., 80% of which are due to electronics and chip manufacturing (SVTC 2000). Energy consumption in Silicon Valley is by no means less or more efficient than in other regions in the U.S.

So, with both the negative and positive environmental impacts of the Internet considered, what are the combined net effects of the digital economy on the environment? The honest answer is that we don't know, and worse, that such impacts may not be knowable in the conventional sense because many aspects of the environmental impacts of digital economy defy quantification. Furthermore, according to Nicholas Georgescu-Roegen's groundbreaking work on the law of entropy and economic processes (Georgescu-Roegen 1971, 1976, Mayumi and Gowdy 1999), economic activity, as an extension of human biological evolution, is essentially an entropic process that unidirectionally dissipates material and energy as long as economic activity exists. In the information age, the information flows in the e-commerce should be viewed as an integral part of the global economy. We cannot obtain, transmit, or even keep in store information of any kind without an increase in the total entropy of the isolated system in which we act. In other words, the law of entropy points to the inevitability of environmental degradation, no matter how sophisticated our technologies are. Thus, we want to caution the scientific community and policy makers that the current pervasive optimism about the positive impacts of the digital economy is unwarranted at best and, worse, utopian by its nature. As of today,

evidence exists to show both potential positive and negative environmental impacts of the digital economy. The net environmental impacts of the emerging digital economy are too uncertain to paint a clear picture at this point.

Environmental Policies in the Digital Age

Obviously, the Internet is a game-changing technology for environmental policies. Environmental policymakers so far have entered this fast-paced world of disciplinary collisions and shifting technological landscapes with some heavy handicaps. Among the growing literature on Internet policies (NCGEC 1997, Litan and Niskanen 1998, Simon 2000), few have discussed the environmental aspects of the Internet. In addition to the aforementioned daunting complexities and uncertainties, we must realize that optimizing the environmental performance of an economy driven by information and knowledge creation is different from regulating one based largely on the processing of material. Many of our environmental policy tools are simply too blunt and reactive to steer technological and social innovation in an information economy in which traditional notions of borders, distance, jurisdiction, and time have been altered in very fundamental ways. Environmental policies have so far worked well by focusing on manufacturing rather than services; on technology and regulation rather than information and knowledge; on the details of the law rather than the dynamics of the system. Conventional policy initiatives were criticized for placing members of society at one end of a linear equilibrium, a cause-and-effect chain, as passive receptors of environmental risk. Environmental policies so far have focused on industry as the source of pollution with little or, in most cases, no attention to consumption. Although problems of production may tend to be industrial and local problems of consumption will tend to be problems for everyone at an increasingly global scale. Whereas residuals tend to disappear from the market domain, where everything has a price, they do not disappear from the natural world in which the economic system is embedded.

Admittedly, the environmental impacts of the Internet cannot be placed into a simple linear law taking the form of a statement with a single cause and a consequent effect. The defining characteristics of this new digital economy challenge much of the conventional wisdom in economics and policy science. Instead, we believe that insights gained from extensive research on non linear dynamics and complexity during the late twentieth century can help illuminate the convoluted relationship between the Internet and environment.

Complexity theory portrays the economy not as deterministic, predictable, and mechanistic, but as process dependent, organic, and always evolving (Arthur and others 1997, Kelly 1998). The new Internet-led economy affects, and is affected by multiple social, economic, and cultural factors. The digital economy is obviously out of equilibrium; in most cases it is a far-from-equilibrium system—ever-changing, showing perpetually novel behavior and emergent phenomena. So far the development of the emerging digital economy seems to resonate with the insights obtained from complexity theory, which entails uncertainty, unpredictability, path dependence, and non-linear dynamics. Furthermore, complex systems can be quite sensitive to even very small changes so that a minor mistake or malfunction can snowball into a major accident (Arthur 1994), as demonstrated by a college student in Philippines who sent the "ILoveYou" virus that shocked the system at the global scale.

The emerging digital economy is not only exceedingly complex, but also the pieces of it are highly interdependent, which tends to cause system effects, both good and bad, to multiply rapidly in unpredictable ways. Viewed from the perspective of non-linear dynamics, environmental effects could be much larger than anticipated and unpredictable. The behavior of the economic system as mediated by technologies is non-linear, and is characterized by random interactions, complex feedback loops, discontinuities, and trends that are not fully foreseeable. Indeed, complexity creates uncertainty, and uncertainty calls for human judgment. Society's current relationship with the Internet is best described as a blind date. Whether this blind date will evolve into romance or turn sour remains to be seen. We obviously need to keep a vigilant eye on possible consequences.

If we accept the premise that the digital economy is a complex system and that the relationship between the Internet and the environment is best captured from the theory of complexity, this will have serious policy implications (Elliott and Kiel 1999). The common finding in the study of non-linear dynamics is that economic structures can crystallize around small events and that lock-in is beginning to change policy in all of these areas toward an awareness that government should avoid both the extremes of coercing a desired outcome and keeping a strict hands-off approach. Instead, government should seek to push the system gently toward favored structures that can grow and emerge naturally. In Brian Arthur's words, government should exercise not a heavy hand, not an invisible hand, but a nudging (massaging) hand (Arthur 1999). We believe that this is the only viable policy guideline for the Internet and the

environment. Insights gained from non-linear dynamics also tell us that policies are more successful when they attempt to influence the market-driven process of formation of economic structures instead of forcing static outcomes. The new digital reality also demands flexibility, adaptation, and coevolution for any new environmental policy initiatives that we may come up with.

In lieu of the insights gained from complexity theory, macro-level patterns of adaptation have possible deterministic effects at the micro-level, both in society and the environment, and the best opportunities for change in those patterns actually arise during the course of micro-level intervention. Thus, the most sensible environmental policy in the information age, in our opinion, is to nurture a long sequence of small, corrective decisions via an intelligent exercise of day-to-day judgment. We would like to call for a fundamental paradigm shift from a top-down regulatory to a bottom-up participatory policy, which aims to raise the environmental consciousness of both the individual and business. New environmental policies in the information age should shift from regulating materials to regulating demands and supplies, from a predominant focus on production to more emphasis on consumption, and from controlling materials to disseminating information. We must balance our pursuit of technological opportunities for ameliorating environmental conditions with a soul-searching re-evaluation of our fundamental cultural value systems. Sustainable development requires at the micro level that individuals internalize awareness that they play an active role in the creation of pollution and other environmental changes.

Working with such complex, rapidly evolving technologies poses new challenges for industries as well as consumers. Concerns for profits rather than for a better environment are usually the driving force for the development of electronic commerce in the private sector and all business generally. Most companies have little interest in exploring the negative environmental impacts of e-commerce in spite of fact that both their companies and the environment would benefit from running a more environmentally conscious business (NAE 1994, Abe and others 1998, Nattrass and others 1999, Romm 1999, Hawken and others 1999). Identification of the things e-commerce firms can or should do to increase their performance and relying on market forces to encourage them to do it has proved sensible (O'Meara 2000). For example, an "environmentally conscious" retailer can put a note on their ordering screen that using surface freight, rather than air freight, will save about 90% of the energy costs associated with long-distance transport at a slight delay in delivery and then let the customer choose. The Internet can also empower consumers to identify—demand—products that are less toxic, more energy efficient, and longer lasting, by adding information to products about environment efficiency. The Internet can be used to exchange information, such as the International Standards Organization (ISO) 14000, and to track environmental impacts throughout the production lifecycle and beyond. Eco-friendly bots can be developed to search the global market place for the best combination of price and environmental attributes for any given product or service, such as clothing with organic cotton, eco-tourism packages, recycle-content products, verified carbon credits, or the lowest priced mid-sized sedan with the best gas mileage and lowest emissions. The list goes on and on (NRC 1997, Brower and Leon 1999).

The E-for-the-Environment E-commerce?

In their recent book *The Social Life of Information*, Xerox chief scientist-John Seely Brown and historian Paul Duguid (Brown and Duguid 2000) pointed out that one of the greatest traps in assessing the impact of information technologies is assuming that they will take us from one, to two, to a million, in terms of their benefits. What stands between us and the imagined benefits are people, and their behavior, phenomena much harder to predict than the energy consumption of Internet servers or pollutants from airplanes moving packages around the globe. In the end, people matter, and when we leave people out, our technological aspirations often fall prey to the mundane forces that shape our everyday lives.

Environmental problems at their very root are the consequences of large-scale cultural patterns, the summed effects of millions of people making individual decisions—the tyranny of small decisions that eventually leads to the tragedy of the commons (Khan 1966, Durning 1992, Lebergott 1993). The new economy may contain fewer warehouses or manufacturing plants, but it will not contain fewer people, especially in the United States, which has one of the highest population growth rates of any developed nation. In an event that received no significant media coverage, the U.S. Census Bureau released new projections for the U.S. population this past January (see http://www.census.gov for details). The conservative projection shows that the U.S. could grow from its present 276 million people to over 400 million by 2050, or put differently, continue the existing trend of adding 45,000 to 50,000 new people per week, or about 25 million every decade into the fore-

seeable future. So we can assume that the new economy will be more populated than ever by that capricious and voracious species *Homo consumptus*, a species that is rapidly replacing *Homo sapiens* throughout most of the developing world. Let us add to this picture the estimated $200 billion spent in the U.S. every year on advertising, much of it designed to drive growing numbers of new economy consumers directly into the hands of retailers—both online and at the mall. The Internet is obviously playing an increasingly integral role in both production and consumption. In fact, the Internet is becoming the largest advertising machine for goods and services targeted for every conceivable human desire and need. Further production and consumption always entail more material and energy usage, which are often translated into environmental degradation.

Admittedly, the future is not a blank page, but neither is it an open book. Trying to assess the true importance and function of the Internet now is like asking the Wright brothers at Kitty Hawk if they were aware of the potential of American Airlines Advantage miles. What we do know for sure is if together with the biotechnologies, information technology will redefine who we are, what kind of society we will create, or if it will alter the meaning of human existence. The environmental impacts created by the digital economy, both positive and negative, will also be enormous. Given the paradoxical nature of technological innovations, we want to caution the scientific community and the policy-makers to treat the Internet as the Holy Grail for environmental salvation.

In an insightful but under-appreciated essay, "Can We Survive Technology," the founding father of modern computer science and technology John von Neumann (1955) forcefully argued that technological power and efficiency is an ambivalent achievement. Its danger is intrinsic. Technological transformations are not a priori predictable, and most contemporary "first guesses" concerning them are often wrong. New technologies tend to create new demands for Lebensraum: an ever-broader geographical scope for technological activities, combined with an ever-broader political integration of the world. The crisis does not arise from accidental human errors. It is inherent in the technology's relation to geography, on the one hand, and to political organization, on the other, what von Neumaan terms the maturing crisis of technology. Von Neumann further argues that looking at the facts about the effects of technological progress is not sufficient. We must engage in some speculation. At this time, the scientific community must ask: can we survive the Internet?

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