White Paper

Networked Solutions for 21st-Century Challenges

The Economics of Complexity and Scarcity, and the Role of Networked Innovation

Author
Dimitri Zenghelis

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This paper should be read in conjunction with "The Resilient Society: Innovation, Productivity, and the Art and Practice of Connectedness," *by Albert Cho, Simon Willis, and Martin Stewart-Weeks.*[1] *It follows two papers addressing network-powered growth:* "The Economics of Network-Powered Growth" *by Dimitri Zenghelis and* "Network-Powered Growth" *by Peter Gruetter and Fred Thompson.*

Executive Summary

The world is reaching a pivotal point: There are the impacts of a changing climate, diminishing resources, evolving demographics, and a growing sense of unfairness and exclusion caused by social and financial inequality brought on by globalization and information and communications technology (ICT). This landscape threatens to undermine trust in the institutions responsible for grappling with mounting challenges. At the same time, we have an opportunity to induce innovation, monitor and manage the earth's resources, derive energy from renewable sources, and expand consumption using fewer and fewer inputs.

Network technology can enable good governance in today's increasingly connected world, offering governments myriad opportunities for success. Governments' capacity to succeed will depend on their ability to maintain and build citizen trust, in part by connecting and collaborating with a wider and more distributed mix of people and organizations. This new, transparent, and responsive world provides a platform for empowerment, choice, and collective action. Better technology and knowledge management will, in turn, enable institutional innovation, boost productivity growth and resource efficiency, and enhance resilience to mounting global pressures. Clear policies designed to prevent resource depletion can spur innovation and provide opportunities to restore civic engagement, engender trust, and reduce income inequality. Innovation is not a concept that applies just to technology; it also is about thinking in new and creative ways, changing behaviors, and redesigning institutions.

The stakes for non-business decision makers have rarely been higher. As complexities and market failures scale globally, the demands for information and knowledge management, collaboration, and effective government increase. This paper argues that to resolve market failures efficiently, governments must innovate to create new rules and institutions that steer businesses, civil society, and other governments toward effective innovation. This cannot be achieved by dictating from the center; it requires collaborative, broadly distributed problem solving enabled by the network. Managing the transition to new governance structures early on is essential; choices made today will determine the institutions, technologies, and infrastructures that will drive our economies for decades.

This paper outlines key social and economic challenges and actions policymakers can take to induce innovative solutions that address the economics of complexity and scarcity.

Understanding both cannot be oversimplified without loss of value. Yet, it is important to note that the global interlinkages that increase the complexity of socioeconomic challenges, making them seemingly intractable, are also the source for resolution—networked problems require networked solutions.

Challenges

Finite Resources, Demography, and Globalization

Mounting risks to continued socioeconomic development require concerted policy innovation to encourage sustainable connected technologies. Alongside substantial climate risks, society faces a crisis of essential and irreplaceable economic inputs (energy, materials, labor, and so on), with constraints on water, food, land, minerals,[2] and biodiversity. Food demand is expected to grow 70 percent by 2050, while yield growth slowed from 3 percent in 1960 to 1.5 percent in 2000 as soil and water resources declined.[3] Without explicit intervention, these crises are likely to increase with time as a growing global population and rising per-capita consumption increase pressure on resources.

The world also faces mounting demographic pressures, with current social security programs ill-equipped to cope with aging societies. Due to slowing birth rates and longer life expectancies, many people will have to work longer and devote an increasing amount of their income to supporting older people.[4] Much of this pressure can be alleviated through reforms that allow people to live longer, healthier, more active lives, enhancing their ability to contribute to the economy and society. However, this will require politically and culturally sensitive changes to norms and conventions. Key among these is late retirement.[5]

Globalization—an increase in the flow of goods, services, people, capital, and ideas across borders—is also changing societies in a number of powerful ways. Because of this, resources are being used more effectively by allocating production factors where they are most needed. Doing so has lifted billions out of poverty in countries such as China and India, and has alleviated demographic pressures in rich countries that accept young immigrants and whose aging citizens can invest their pensions more productively abroad.

In the past, globalization helped alleviate inflationary pressures by overcoming local supply bottlenecks and allowing for transfers of processes and technologies to low-wage-cost countries. Trade will continue to provide benefits and opportunities in the form of profitable global markets in resource-efficient energy products, transportation, and tradable land-use certificates, As a result, more people across the world can profit as new markets for sustainable, resource-efficient goods and services emerge. Nonetheless, governments also play a role in reducing some of the negative impacts of globalization. In the developing world, resource-consumption levels of the burgeoning global middle class are reaching those of the developed world.[6] Policies are required early on to ensure that such demand is met through resource-efficient, innovative development.

Furthermore, globalization has created tensions within rich countries by heightening inequality and widening income gaps. Low-cost imports and offshore production have exerted downward pressure on low-skilled workers' wages across the world as they compete with the least-expensive labor and production processes.[7] In addition, computers and automated technologies have raised the pay premium associated with skilled and creative work, widening the income gap between skilled and low-skilled workers. The average income of the richest 10

percent of the population of the 34 Organisation for Co-operation and Economic Development (OECD) member countries has grown to about nine times that of the poorest 10 percent. The ratio is lower than that of Nordic and Continental European countries, and is roughly 14 to 1 in the United States, where inequality has spread faster than in any other major economy.[8] Globalization combined with uncoordinated policy management has also prompted mounting economic imbalances. For example, mainland China was the top foreign holder of U.S. Treasury bills as of July 2011,[9] funding the nation's debt. As a result, financial markets are becoming distorted and capital is not being allocated efficiently.

There is an urgent need for institutions to breed trust and common purpose, yet continue to represent their people.

The impact of globalization and demographics has precipitated a loss of trust among citizens, government, and businesses. Reported trust[10] (trust in others) is correlated with income inequality. It is not a coincidence that compared with people of other nations, Scandinavians with relatively low-income inequality rank highest in trust and organizational activity. Trust plays a vital role in the long-term sustainability of any society. Reported trust in the United States, United Kingdom, and many parts of the Western world is falling, with individuals less inclined to trust governments or their fellow citizens.[11] By contrast, Scandinavian politicians are often held accountable to an engaged citizenry that expects them to serve their long-term interests.

There is an urgent need for institutions to breed trust and common purpose, yet continue to represent their people. In particular, the middle classes must feel that they have a stake in the sociopolitical model. Allowing the middle class to prosper is a key factor underlying the durability of the Chinese one-party state, for example, compared with the transient nature of some dictatorships in North Africa and the Middle East. A durable model requires representation and empowerment at the edge, subject to central guidance and rule setting, rather than diktats from the center.

Globalization's reach can be exaggerated—costs associated with travelling distances and crossing national borders still matter.[12] The impacts of globalization, technology, and demographics, however, have become powerful and entwined. National and international policies are inadequate, and institutions have not kept pace with the speed and ease with which information can now be accessed.

Growing Complexity Pushes the Limits of Markets

How can we continue to thrive in large, increasingly complex societies, and what is the role of network technology[13] in allowing us to improve the way sustainable growth and development are managed? The market remains the most efficient way to distribute scarce resources in any economy; it effectively coordinates vast amounts of information needed to match supplies and materials with consumer goods and services. Increased complexity, however, means that a growing number of public goods, market failures, and "missing markets" (markets that do not exist or are not monetized) will require well-designed public intervention to become economically viable.

Economists say that "externalities" (unintended consequences that affect a third party) and "market failures" abound. This implies that the provision of some goods, services, and investments will either not take place or be underprovided in uncoordinated markets driven by individuals pursuing their own interests[14] because the private sector is unwilling or unable to undertake the requisite investments alone. At the heart of such "failures" lie information and ownership issues that prevent the creation of working markets. Public intervention is required to address these failures by introducing laws that establish property rights and provide incentives to spur markets and foster innovation.[15]

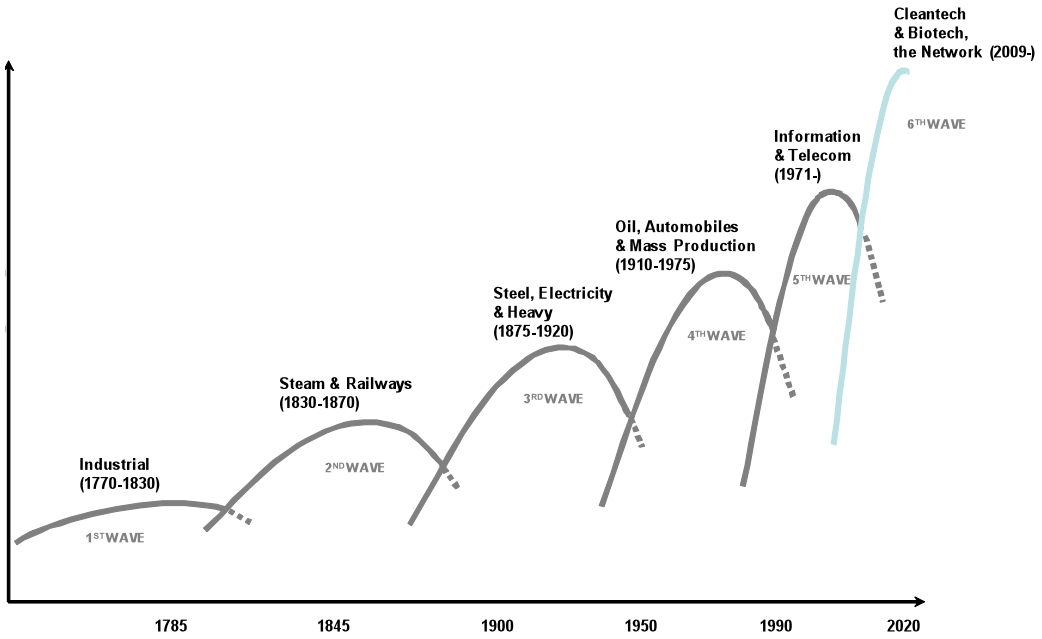
In particular, knowledge has the characteristic of a public good.[16] When an entrepreneur comes up with a good idea that cannot be patented, the market may lack incentive to engage in the product or activity due to the lack of potential profits from selling the idea.[17] The under-provisioning of innovation becomes costly because innovation yields learning and experience, which reduce the future costs of a technology, yielding great social benefits. When technology infrastructures (which can last many decades) are involved, this can lead to "path-dependency."[18]

With network externalities, when an enterprise joins a network, the organization fails to take into account the benefits to others from increasing network membership. Therefore, the market is likely to initially underinvest in the network. For example, the value of owning a telephone, joining a social media group, or investing in plug-in vehicles (which requires public infrastructure for charging batteries) depends on a network of users. Consequently, there will be an economic case for the public sector to assist in setting up the network, while encouraging competition. Without public sector guidance, the market will not provide the level of investment needed to benefit society.

Overcoming such barriers does not have to be expensive, but it does need careful analysis. Successful action requires transparency and commitments from policymakers to guard against well-known pitfalls such as short-termism, rent-seeking, and regulatory capture. The good news is that many emerging market economies such as South Korea and China understand this approach. China has embraced high-tech, low-carbon growth, notably in its 2008–2009 stimulus package and, more important, in its outline for the 12th Five-Year Plan,[19] which sets strong targets. China and other countries that recognize the way forward will lead the sustainability innovation race already under way. Expenditure involved in making the transition to a resource-efficient economy must be analyzed as an investment rather than simply as a net cost. This transition will likely be dynamic, innovative, and complex, mirroring previous periods of socioeconomic revolution.[20]

Figure 1 is a simple illustration of how each "revolution" (or wave of technological change) is built on the previous and therefore induces more innovation and productivity, not to mention changes in consumption. Inducing such change requires support not only from policymakers, but also from the public.

Figure 1. Waves of Industrial Innovation.



Source: Raising Consumption, Maintaining Growth, and Reducing Emissions: The Objectives and Challenges of China's Radical Change in Strategy and Its Implications for the World Economy," Nicholas Stern, World Economics, Vol. 2, No. 4, October–December, 2011; DONG Energy, 2009. Diagram is based on Perez (2002) drawing on report by Merrill Lynch, 2008.

Responding to market failures is not about impeding or opposing markets; it is about extending or creating new markets that otherwise would not have developed cost-effectively or would have matured slowly, or not at all, without public intervention. Doing so requires a policy framework to promote investment in networked infrastructure. It also requires knowing the limits of government and resisting the pressures to replace market failures with policy failures that serve particular interests at the cost of society as a whole. Where possible, nondiscriminatory broad market instruments such as pricing, product standards, regulations, technology, and supply chains should be used so that governments can avoid "picking winners" or awarding preferred contracts.[21] Such instruments are less susceptible to lobbying and rent-seeking by vested interests that want to influence policy decisions at the expense of consumers and citizens.

The size and scope of 21st-century market failures is such that they can result in nonmarginal consequences that can change the underlying state of the world. Such consequences may be irreversible by locking in infrastructure, creating avenues for technological innovation, and reversing climate change. Policymakers must use the appropriate tools to address challenges, while taking into account consequences for the rest of the economy.[22] Individual and social well-being can be enhanced over time if policymakers, households, businesses, and other decision makers within civil society begin to identify factors leading to market and policy failures and correct these failures where possible.

Opportunities and Solutions

The foregoing discussion outlined an extraordinary set of interrelated challenges associated with limited resources and growing international complexity. Weak or absent price signals mean that left entirely to the market, these problems will be resolved only through crisis. In the last 10 years, global food prices have increased 80 percent, while Brent Crude for most of 2011 was trading at around US$110 a barrel,[23] with the potential for further increases as a recovering global economy drives further demand.

Managing the transition to a resource-constrained economy—preemptively making the most of growing opportunities from connected technologies—is the alternative approach to waiting for market signals to indicate crises, pricing us out of conventional technologies. The last major wave of global institutional redesign followed the upheaval of World War II, prompting widespread use in welfare systems and social housing, increasing entitlement to healthcare and education, and establishing large multilateral organizations such as the United Nations, the International Monetary Fund, and The World Bank. Today's challenges are equally pressing, yet in most countries, engaging the public and winning consent for policy change has been a struggle.

Innovating for Sustainable Growth

Finding ways to grow sustainably is challenging. For billions of people, economic development is the only way out of poverty. Advances in education, healthcare, and local environmental protections; increases in equality; and our abilities to cope with a more "hostile" climate are often easier to achieve if total consumption and income grow. Moreover, research shows that growth makes us happier.[24] Therefore, the challenge is to grow without destroying the natural and social environment, and leaving an unjust legacy for future generations.

Evidence suggests that knowledge and innovation are key drivers of growth for rich countries. It is not the number of inputs used in production, but how smartly they are used.

Innovation is key to sustainable growth. Economic analysis shows that total factor productivity (TFP) growth—the know-how, processes, and technologies with which capital is utilized—rather than capital and input intensity is the main determinant of cross-country differences in productivity. Recent economic analysis has focused on the factors that drive innovation and growth in an attempt to understand technology's role in economic growth (or "endogenous growth theory"). Evidence suggests that knowledge and innovation are key drivers of growth for rich countries. It is not the number of inputs used in production, but how smartly they are used. Economist Paul Romer is fond of saying, "We do not produce anything. Everything is already there, we just rearrange things.[25]

Thomas Malthus, 17th-18th-century British scholar and minister, made the mistake of ignoring future science and innovation. He failed to consider that babies are born with brains as well as mouths; a rising population has indeed corresponded with accelerating consumption, but this has been matched by smarter ways of using resources such as land, food, water, minerals, and energy. The growth trajectory of living standards and population, however, means that innovation remains vital to extending resources and doing more with less. Innovation may

destroy jobs in the short run, but in the long run it will drive new markets and jobs, competition, wealth, and value creation.

Connected technologies—Internet, computers, mobile phones, and smart devices—enable us to have more while using fewer resources by spurring innovation, which improves the efficiency with which we rearrange inputs to generate valuable goods and services.[26] Network technology increases returns on investments in human/physical capital and R&D by 1) reducing the transaction costs of accessing and exchanging information and ideas, and 2) promoting collaboration across countries and disciplines. It also helps reduce start-up costs for small enterprises, which are the dynamos of innovation and productivity growth.

Network technologies have the potential to transform the way poorer economies (which traditionally use outmoded technologies and processes) operate, so that they can share in the dynamics of endogenous (that is, self-determined), innovation-led growth.

Access to knowledge is vital to the development of poor countries. Poor countries can catch up to rich countries only if institutions and frameworks allow. This is sometimes referred to as "conditional convergence," whereby developing countries with enabling institutions and suitably skilled workers can converge on technology leaders—initially by "copying" best practices and technologies—using lower labor costs, eventually becoming new technology leaders themselves. Structural determinants of economic development and people's desire to invest in a country or region include a country's level of education and due diligence to ensure that government limits corruption, graft, and size (oversized governments limit activity; undersized governments fail to provide or enforce enabling policies). Environments that encourage social inclusion, skills, creativity, and free enterprise tend to attract investment.[27]

Provided that there is appropriate political will and institutional support, network technology affords developing countries an opportunity to access the latest knowledge and processes to a degree that until now was unprecedented. Network technologies have the potential to transform the way poorer economies (which traditionally use outmoded technologies and processes) operate, so that they can share in the dynamics of endogenous (that is, self-determined), innovation-led growth. By contrast, there is compelling evidence that per-capita incomes of poor countries are curtailed because of shortcomings in institutional governance. Helping poor countries eliminate poverty will also lessen income inequality in rich countries, as lower wages in poor countries no longer outcompete and undercut the livelihoods of less-skilled workers in wealthy countries.

The Connected Revolution

Information and network technologies are unique: not only do they drive productivity in the technology sector, they also enable productivity in other sectors and encourage productivity for new products and services.[28] In 2007, economist Dale Jorgenson conducted a detailed input-output analysis of the U.S. National Accounts. He concluded that half of the growth in U.S. TFP will come from ICT, which equates to a third of all U.S. growth.[29] No other sector can make this claim. ICT is a unique and unparalleled driver of innovation and growth.

Networked ICT will be at the heart of addressing social and demographic challenges associated with public sector provision. Networked technology and virtualization will increase engagement among older citizens, initially in developed countries and then in the developing world, enabling them to contribute to the global workforce through flexible workplaces, gain access to care-at-a-distance services and low-cost geriatric healthcare, and engage more with friends and family. Younger generations will benefit from mobile education, distance learning, and customized skills training.

Citizens are increasingly demanding that the public sector respond to their individual needs.[30] They expect innovative, responsive, and interactive services despite fiscal challenges.[31] Such services will create growth and job opportunities in new, interactive technologies such as the digitization of public records and in educational services and health provision.[32] Governments will be in a strong position to harness new technologies such as cloud computing, which can significantly raise the efficiency of public service delivery.

There is no previous example of a new technology whose price has fallen so precipitously and diffused through the economy as swiftly as ICT. The effects of such technology are comparable to or bigger than those of steam, railway, electricity, or the telegraph. By boosting productivity and resource efficiency, new technologies provide an opportunity to promote sustainable growth.[33] In short, with challenges come opportunity, provided that the public sector works carefully to create markets and enable private innovation using nondiscriminatory policies that do not replace market failure with policy failure.

Institutional Innovation

The importance of credible policy in driving this revolution should not be underestimated. Innovation is not limited to technologies; it also occurs at an institutional level, in both the public and private sectors. Like technological and knowledge capital, these policy innovations drive TFP. Poor policy innovation is usually associated with inefficient uptake and innovation in physical and knowledge capital. Market failures require that governments transform rules and governance, and provide credible markets for technological innovation. Such markets are enabled by developing inclusive, stable, and transparent societies with clear and enduring rules incentives and ownership structures. In all countries, especially in the developing world, network technology can encourage inclusive, efficient, and transparent governance by enabling more accountable rules-based institutions.

Historically, policy innovation included property rights and protections against coercion.[34] For societies and economies to thrive, states must move beyond what Robert Nozick, the late 21st-century American political philosopher, termed the “night-watchman state” to enhancing opportunities. Rules must be extended to provision universal education, sanitation, and water; limit traffic congestion; increase child protection laws; safeguard the environment; and develop standards for buildings, transportation networks, urban planning, and so on. These rules are necessary to ensure that such services are provided by the private/public sector or by civil society. Such rules will also help galvanize innovation and collaboration across increasingly connected yet distributed segments of society.

Fresh responses to new problems require further innovation. Evolving rules that govern how people interact with one another and with the economy will be increasingly unworkable without connected ICT. Responses to issues caused by climate change, overfishing, water shortages,

societal conflict, marine piracy, deforestation, nuclear proliferation, and trade protection require accurate real-time data monitoring and management.[35]

A holistic approach to dealing with increasingly complex interrelationships and the synergies that address resource constraints will likely prove most effective and efficient. For example, electric vehicles alone may not improve resource sustainability; their success depends on Smart Grid support, a plug-in infrastructure, quality battery technology, and a renewable energy supply. In addition, sprawling cities without smart planning initiatives designed to reduce long-distance travel within the city and encourage use of other modes of transportation will limit the effectiveness of electric vehicles, which must cover long distances. Indeed, the materials involved in building such vehicles often draw more extensively from scarce materials than do conventional vehicles. Their contribution to sustainability is thus minimal without supportive policies in areas such as planning, energy generation, and efficiency

Resource sustainability requires policies that support technology, planning, and pricing. The appropriate policy package must be comprehensive and integrated. For example, commercial opportunities associated with policies that induce innovation in "smart sectors" are huge. Based on data from the International Energy Agency and the Electric Power Research Institute, Morgan Stanley Research anticipates that global markets in intelligent grid technologies alone will grow from roughly $22 billion in 2010 to $115 billion by 2030, an annual growth rate of roughly 9 percent.[36]

In another example, policy that supports mobile telephony and satellite-based Internet enables access to mobile healthcare education, training, and finance in the poorest and most remote parts of the world. Such policies also encourage civic engagement, undermine authoritarian rule, and prompt institutional innovation, with all the consequent benefits.

When innovation occurs at the institutional level, problems are no longer regarded and resolved in isolation. Since many problems are connected, they can be addressed via collaboration among governments and ICT providers. The knowledge spillovers are large, interrelated, and, in some cases, unpredictable. In fact, new technologies are potentially harmful if not accompanied by rules that address sustainability. Basic rules are essential for individuals to interact commercially, but they need popular support. Institutional innovation requires reforms to exploit opportunities profitably and serve the public interest.

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Connected Understanding and Rebuilding Trust

In time, advances in education and improvements in governance through use of collaborative and interactive technologies can transform the way politicians engage with voters. Trust, shared information, and common understanding are what drive long-term policy planning and international agreements. Trust and a shared understanding of challenges require information, knowledge, and responsive institutions. This, in turn, requires data, engagement, and education. Governments' capacity to succeed in this new environment will depend on their ability to

maintain and build citizen trust, in part by connecting and collaborating with a wider and more distributed mix of people and organizations.[37]

Today's increasingly connected world offers the public sector huge opportunities, providing a platform for empowerment, choice, and personalization. Such organizations can build relationships with citizens by placing skills and resources directly at their disposal and enabling them to play a greater role in public policy. Local governments can increase their effectiveness by transcending the limitations of location. Local communities in touch with local concerns can invent and experiment with limited direction from central government.[38] The networked information economy enables decentralized, coordinated action through radically distributed nonmarket mechanisms that downplay proprietary rights associated with knowledge creation and sharing[39] (one example is Wikipedia). Transparency enables citizen involvement and contribution, and public agencies across the world are beginning to improve citizens' ability to access information and provide and view feedback from other citizens.[40]

A global survey of 114 public-sector leaders by the Cisco® Internet Business Solutions Group (IBSG) showed "rising alarm" at the recent convergence of diverse and unpredictable hazards: declining resources, rising consumer demands, aging populations, increasing social tensions and cybercrime, rising food prices and climate change, and increasing exposure to natural disasters.[41] Respondents also indicated concerns that public institutions might be incapable of anticipating and managing these threats, pointing to a critical link between the capacity to respond to new and disruptive changes and the capacity to engage stakeholders in novel forms of collaboration. Connecting stakeholders is key to responding to disruption.[42] Bringing stakeholders together may be difficult for institutions that lack the capacity and culture for effective engagement with and participation by citizens. Resilience, the survey argues, is closely related to the ability to collaborate on setting priorities and identifying solutions.

Network technologies also have the potential to reduce public trust. For example, ideological websites contain links to websites that espouse similar beliefs, hindering exposure to alternative interpretations and arguments, and thereby fueling partisan and extreme views that can impede effective governance based on common values, census, and trust. Governments must ensure that collaboration technologies drive an open and informed dialogue with citizens. Governments must not succumb unnecessarily to vested interests who will lobby against change, regardless of whether it is in the public interest.

Managing Information; Generating Knowledge

Coping with complexity requires knowledge management. For starters, we must determine what to measure and monitor. Currently, we are not measuring all the things that matter. For example, the benchmark of economic performance, GDP, does not fully value the depreciation of natural assets. When measuring broader social welfare, no informative assessment can be reduced to a single dimension such as output, income, or happiness. The most practical and informative approach is to monitor several indicators in addition to GDP, rather than force all social ends into a single metric to replace GDP. Therefore, it would make sense for governments to adopt a "dashboard" of indicators in addition to GDP. These measures will include human development indices such as health, education, environment, happiness, freedom of expression, and transparency.

More generally, conventional statistics have not kept up with the challenge of measuring the growing intangible economy[43] (for example, services such as research, development, and

design), although new technologies are providing innovative data-monitoring possibilities.[44] Improved methods of measuring intangible assets related to innovation must be developed in tandem with innovative intellectual property protections that reward innovation while reflecting growth opportunities associated with free-content business models.[45] Such institutional and technological innovations are likely to induce additional capital-market funding in R&D.

New global institutions will be required to defend intellectual property and handle and interpret data in a transparent and credible manner. There are risks associated with pervasive connectivity, including questions of privacy and cybersecurity. Eschewing connectivity, however, is not the way to respond. Innovation requires evolving rules on data protection and privacy that safeguard the efficient flow of information. Increased volumes of digital data will create new demand for advanced analytics that enable governments and businesses to better understand and gain insights from data patterns. The Institute for Global Futures estimates that 1 million exabytes of information is being generated from healthcare, logistics, media, entertainment, security, industry, the web itself, and countless other data-creation sources.[46] This information offers enormous potential to improve the way societies are designed, provided that the technological capacity is available to process and interpret the information efficiently. User-driven insights can foster efficient and effective analysis of complex data, sometimes through direct crowdsourcing (distributed problem solving), which relies on the network.

Network technologies allow for better monitoring and management of data and information, enabling individual, corporate, and public interaction and engagement. Such real-time connectivity, data collation, and processing power are a precondition to accessing the necessary synergies to address complex global problems and adopt an integrated approach. In a world where problems become increasingly nonmarginal and irreversible, resource constraints become more apparent and easier with which to deal.[47]

Network technology provides the means to address complexity by automating resource management (such as smart energy), improving decision making, and informing the public. Digital intelligence will be central to economizing on resource use. Futhermore, increased public-private collaboration through networked information, which in some cases can provide real-time accountability, will result in innovative and responsive policy application. For example, people can use their mobile phones to track market prices, weather conditions, agricultural diseases, or militia hotspots—information that can be mapped, aggregated, and made available to other users.

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Connected Cities

Smart and connected cities will form the cornerstone for sustainable living. If we do not carefully design the urban environment, we will not meet the resource challenge. More than half of the world's population lives in urban areas, and that proportion is growing quickly. The World Bank estimates that more than 90 percent of urban growth is in the developing world, adding an estimated 6 million new residents to urban areas every month.[48] Cities are built to overcome the

costs of transporting people. Even in an age of hyperconnectivity where work can be conducted remotely, people are still attracted to city clusters. The most connected industries in the world include Silicon Valley's tech industry and London and New York's financial clusters. Connectivity and ubiquitous information are not substitutes for face-to-face contact; they are complements that allow more innovative interpretation of information.

Cities are often in a better position than national governments to offer unique governance structures and deliver integrated policy programs that are more responsive to citizens' demands. The complexity of managing cities as living systems, however, may very well define the future.[49] Attempts to address complexity and resource sustainability without understanding urban challenges will, by necessity, be incomplete at best, especially when trying to analyze green-growth policies in rapidly urbanizing countries like India and China. Cities are evolving into systems of connected networks that need advanced ICT to succeed. Cities that think, adapt, and evolve will learn to optimize their natural and man-made resources, and enable urban planners and city managers to interact and transact with people.

Conclusion

A prosperous, innovative, and sustainable world resilient to mounting social, economic, and environmental pressures is within our grasp. Choices made today will determine the institutions, technologies, and infrastructures that will drive our economies for decades. If the world standardizes on resource-intensive infrastructure capable of lasting many decades; is expensive to retrofit or replace; and fails to induce innovative, smart development, the costs of coming to terms with mounting challenges later may be prohibitive. The stakes have rarely been higher. The barriers to resolving the most pressing socioeconomic challenges are not technological or economical; they are—more than ever—institutional, cultural, and political.

Meeting these challenges presents great opportunities to entrepreneurs, but taking advantage of this requires credible, long-term policy steering. Clear standards, regulations, and price signals that prevent resource depletion can induce innovation, resulting in solutions that allow society to live smarter.

For more information, contact:

Dimitri Zenghelis, Senior Economics Adviser
Public Sector Practice
Cisco Internet Business Solutions Group
dzenghel@cisco.com

Endnotes

1. http://www.cisco.com/web/about/ac79/docs/ps/The-Resilient-Society_IBSG.pdf
2. The most important minerals are phosphorous and potassium, both essential for fertilizing plants. According to some estimates, accessible reserves of important raw minerals such as silver, lead, and copper may be only a few decades from depletion. "Earth's Natural Wealth: an Audit," David Cohen, *New Scientist,* Issue 2605, May 23, 2007.

3. "How to Feed the World in 2050," High-Level Expert Forum, Food and Agriculture Organization of the United Nations, October 2009; "Environment and Economic Costs of Soil Erosion and Conservation Benefits," David Pimentel, et al.; *Science,* Volume 267, No. 5201, pp. 1117–1123, February 24, 1995; and "Losing Ground," Craig Cox, Andrew Hug, and Nils Bruzelius, Environmental Working Group, April 2011.
4. The United Nations expects the median age globally to rise from 39.7 in 2011 to 45.7 by 2050. "Population Division, Population Estimates and Projections Section."

   The Office for National Statistics projects that the number of people over 85 in the United Kingdom will more than double over the next 25 years. http://bit.ly/utC8c3

   If work patterns remained unchanged, there will be one older inactive person for every worker in Europe by 2050. "The 2005 Projections of Age-Related Expenditure (2004–50) for the EU-25 Member States: Underlying Assumptions and Projection Methodologies," Economic Policy Committee and the European Commission, Special Report, Number 4, 2005.
5. Some critics argue that the aging population may still present a major fiscal predicament for global governments. This is because medical and nursing costs can be expected to rise and as increased life expectancies correspond with associated increases in debilitating illnesses, especially mental illnesses, "Red Ink Rising: The Road to Fiscal Sustainability," Deloitte Research, 2010.
6. Emerging economies accounted for 52 percent of global GDP at purchasing power parity in 2010, up from 33 percent in 1990. "Why the Tail Wags the Dog: Emerging Economies Now Have Greater Heft on Many Measures than Developed Ones," *The Economist,* April 6, 2011.
7. "Offshoring of American Jobs: What Response from U.S. Economic Policy? Jagdish Bhagwati and Alan S. Blinder, *The MIT Press,* 2009.
8. Income inequality measured by the Gini coefficient—a measure that ranges from zero when everybody earns the same amount to one when all income goes to only one person—rose from 0.28 in the mid-1980s to 0.31 in the late 2000s, with the largest increases in the United States. "Growing Income Inequality in OECD countries: What Drives It and How Can Policy Tackle It?" OECD, May 2011.
9. http://1.usa.gov/twiXRg
10. "Reported trust" is the proportion of the population aged 15 years and over reporting that people can "almost always" or "usually" be trusted. "Quality of Life Survey 2008," The Social Report, 2010.
11. Some commentators argue that the 2011 London riots were a symptom of a breakdown in civic trust among disenfranchised youth and business and political leaders. "Democracies in Flux: The Evolution of Social Capital in Contemporary Society," Robert Putnam, Oxford University Press, August 15, 2002; "Americans and Social Trust: Who, Where, and Why," Pew Research Center, February 22, 2007; "Distrust, Discontent, Anger, and Partisan Rancor: The People and Their Government," Pew Research Center, April 18, 2010.
12. Trade within the United States and Canada and across the border is a classic example of how globalization's reach can be exaggerated. Borders have a significant impact on trade and allow for large deviations in prices of potentially tradable goods. Typical

reasons include tariff barriers and different industry standards, and technical requirements such as electricity voltage or right-hand-drive cars. But the presence of a national border—even among developed economies with open borders, the same language, and legal systems and standards similar to the United States and Canada, for instance—significantly increases the dispersion of prices and inhibits trade in a way that is often hard to explain theoretically. Therefore, globalization can be overexaggerated, and a strong "home bias" remains. "How Wide Is the Border?" Charles Engel and John H. Rogers, *American Economic Review,* 1996.

13. "Network technology" refers to a range of sectors—from mobile applications, social media, superfast broadband, and cloud computing to advanced analytics.
14. "Underprovided" in this context means that the overall welfare gains from an alternate outcome outweigh the losses to individuals from switching to that outcome in such a way that some individuals could be made better off without anyone being made worse off, once winners have compensated losers.
15. For example, markets may fail to properly measure and value natural assets that are owned collectively, leading to overuse of scarce resources such as fish or clean air. No individual owner takes responsibility for his or her stewardship and collective agreement is required to limit resource depletion. Examples of such market failures include pollution of the commons, where damages are social and not captured in private costs. Market failures also exist in the investment in technology and innovation, where early innovators fail to monetize returns to their investments because knowledge and information spillovers are free with characteristics of public goods, so the full benefit of the innovation accrues to society at large and not just the innovator. In addition, corporate governance structures may inhibit private risk taking among innovators to a degree where the public sector can afford to undertake riskier but potentially extremely fruitful innovation.

    In her book, *The Entrepreneurial State,* Professor Mariana Mazzucato notes many examples in which leading, innovative "entrepreneurial force came from the state rather than from the private sector."

    Another key example is the "principal agent" problem, were the investor does not reap the gains from investment—for example, when a landlord invests in energy efficiency so that the tenant may reap the benefit of lower fuel bills.
16. In economics, a public good is a nonrival, nonexcludable good. "Nonrivalry" means that consumption of the good by one individual does not reduce the amount available for consumption by others; "nonexcludable" means that no one can be effectively prevented from consuming the good. Street lighting, defense, and ideas are common examples of things that have public-good properties.
17. For information on the power of connected technologies in motivating the free provision of knowledge, see "The Wealth of Networks: How Social Production Transforms Markets and Freedom," Yale University Press, 2006.
18. In the absence of public intervention, innovation will tend to be biased toward existing "dirty" technologies, which are likely to prove more costly in the long run in terms of energy and environmental costs. "Rethinking Industrial Policy," Philippe Aghion, et al, Bruegel Policy Brief, June 2011; and "The Environment and Directed Technical Change," Daron Acemoglu, et al, Harvard University, April 28, 2010.

19. Of the seven "magic growth sectors" identified in the 12th Five-Year Plan, three are low-carbon industries: clean energy, energy efficiency, and clean energy vehicles; others include high-end manufacturing. http://planningcommission.nic.in/plans/comments/inter.htm
20. "Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages," Carlota Perez, Edward Elgar Publishing, April 2003.
21. Nondiscriminatory market instruments include pricing, standards, and regulations across products, technologies, and supply chains; and planning decisions to improve the sustainability of spatial infrastructures. Inducing low-carbon innovation also requires incentives for 1) accelerating investment in low-carbon technologies to spark innovation that may not be privately viable and 2) encouraging measures to avoid deforestation and reduce/reuse waste. Policy must also apply to institutions, which are able to implement common accounting standards, calculation methods, and budgeting and disclosure processes.
22. "Fighting Climate Change: the Case for Using All the Tools in the Tool-Box," Alex Bowen, Grantham Research Institute, The London School of Economics, 2011.
23. Trading Economics, http://www.tradingeconomics.com/commodity/brent-crude-oil
24. "Report by the Commission on the Measurement of Economic Performance and Social Progress," Joseph Stiglitz, et al, Commission on the Measurement of Economic Performance and Social Progress, 2009; "Prosperity Without Growth?—The Transition to a Sustainable Economy," Sustainable Development Commission, March 2009; and "Happiness: Lessons from a New Science," Richard Layard, Penguin Press, January 2005.
25. "The Origins of Endogenous Growth," Paul M. Romer, *Journal of Economic Perspectives,* 1994; and Paul Romer's ideas on charter cities, http://bit.ly/rG3dyu
26. For a thorough review of the evidence on innovation and growth, and the role of connected technologies, see "The Economics of Network-Powered Growth," Cisco Internet Business Solutions Group, January 2011.
27. "Sources of Economic Growth," Robert J. Barro and Jong-Wha Lee, Carnegie-Rochester Conference Series on Public Policy, Volume 40, Pages 1–46, June 1994; "The World in 2050: Quantifying the Shift in the Global Economy," HSBC Global Research, January 2011; and "Economic Growth in a Cross Section of Countries," Robert J. Barro, *The Quarterly Journal of Economics,* Vol. 106, No. 2., pp. 407–443, May 1991.
28. "The Economics of Network-Powered Growth," Cisco Internet Business Solutions Group, January 2011.
29. "A Retrospective Look at the U.S. Productivity Growth Resurgence," Dale W. Jorgenson, et al, Federal Reserve Bank of New York Staff Reports, No. 277, February 2007.
30. "Network-Powered Growth: How Governments Can Serve as Catalysts for Sustained Economic Growth," Cisco Internet Business Solutions Group, June 2010.
31. Public and private services at all levels of administration are transforming the way the public sector interacts with citizens. Examples include the Open Government Initiative in the United States, District of Columbia's Digital Public Square, FixMyStreet and They Work for You in the United Kingdom, and Cisco's Urban EcoMap and Planetary Skin projects.

32. "Where Will the Jobs Come From?" Accenture, 2010.
33. "The Economics of Network-Powered Growth," Cisco Internet Business Solutions Group, January 2011.
34. "Anarchy, State, and Utopia," Robert Nozick, Basic Books, November 11, 1977.
35. "OECD Green Growth Strategy," OECD, September 2011.
36. *Morgan Stanley Investment Management Journal,* February 2009; and *Pictures of the Future: The Magazine for Research and Innovation,* Siemens AG. Similar growth rates are forecast for the renewable energy sector in "Who's Winning the Clean Energy Race?" The Pew Charitable Trusts, 2010.
37. "The Connected Republic 2.0: New Possibilities & New Value for the Public Sector," Cisco Internet Business Solutions Group, August 2007.
38. "The Resilient Society: Innovation, Productivity, and the Art and Practice of Connectedness," Cisco Internet Business Solutions Group, August 2011. This paper provides examples of local connected activism from Mumbai, London, and New York.
39. For examples such as the development of Wikipedia and Open Source software, see "The Wealth of Networks: How Social Production Transforms Markets and Freedom," Yochai Benkler, Yale University Press, April 3, 2006.
40. Examples include Data.gov in the United States, London.gov.uk, and NYC Open Data.
41. "Architecting Resilience: Perspectives from Public Sector Leaders," Cisco Internet Business Solutions Group, July 2011.
42. Ibid.
43. "Rethinking Industrial Policy," Philippe Aghion, Julian Boulanger, and Elie Cohen, *Bruegel Policy Brief,* Issue 2011/04, June 16, 2011.
44. "2011 Global Futures Forecast," Institute for Global Futures; "The Economics of Enough: How to Run the Economy as if the Future Matters," Diane Coyle, Princeton University Press, March 6, 2011.
45. "Emergence of the 'Freemium' Market," Joseph J. Bradley and Douglas P. Handler, Cisco Internet Business Solutions Group, 2011.
46. "Global Futures Forecast: The Top Technology and Innovation Trends," Dr. James Canton, Institute for Global Futures, 2010.
47. Transparency of method and data is a key issue. To safeguard resources globally, actions must be credible and verifiable, without intrusive infringements of sovereignty—a source of sensitivity in the developing world. There must be trustworthy alternatives to foreign inspectors on the ground if key countries are to participate. New remote-sensing technologies combined with earth observation and data management systems will play a key role in overcoming intrusiveness and sovereignty.
48. "Cities and Climate Change: An Urgent Agenda," The World Bank, Vol. 10, December 2010.
49. "Green Economy Report," Chapter 12, United Nations Environment Programme, Green Economy Initiative, 2011.

More Information

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