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ICT/Cyber benefits and costs: Reconciling competing perspectives on the current and future balance

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ABSTRACT

Information and communications technology (ICT)/cyber technologies become ever-more embedded in our economies and societies, bringing both benefits and risk-related costs. The balance between those benefits and costs, over time and across countries, remains poorly understood. This gives rise to conflicting narratives about the future of ICT: either (1) continued rapid benefit growth with new waves of ICT technology; or (2) increasing cyber-attack costs will come to swamp benefits.

We explore how the balance between benefits and costs might change at the global, country-grouping, and country-level out to 2030. Because the existing literature provides little foundation for integrated analysis, we did extensive conceptual research and data gathering from diverse sources. The benefits include the growth of the ICT sector itself, its contribution to broader productivity as a general purpose technology, and its benefits for consumers as value for price rises very significantly. The costs include security spending, the impact of adverse cyber events, and opportunity foregone if the technology is underutilized.

We extended International Futures (IFs), an existing multi-issue, multi-country, long-term forecasting system with formulations driving ICT/cyber advance and impact. In Base Case analysis we found that, while annual costs related to cyber-attacks and cyber-security spending do come to outweigh the annual incremental economic benefits from ICT use in high-income countries, over time the compounding nature of the benefits versus the more additive nature of the costs means that the cumulative benefits will outstrip the cumulative costs by tens of trillions of dollars over even medium-term forecast horizons. For lower-income and middle-income countries both annual and cumulative analyses suggest that benefits will continue to outweigh costs. On a global basis the cumulative net benefits could exceed $100 trillion through 2030. Four scenarios with significantly different assumptions about technological development and the unfolding of adverse events changed the total values of benefits and risk-related costs, but not the overall conclusion.

1. Introduction

The media shower us with two competing narratives regarding information and communications technologies (ICT). They tout the benefits of the latest and greatest technological developments and speculate often breathlessly about how much greater those benefits will be in the future, even while maintaining a steady drumbeat of dire warnings concerning the threats that cyber-activism (hacktivism), cybercrime, cyber-espionage, and even cyberwar and cyber-terrorism pose to economies and governments around the world. The more analytical literature on the economic benefits and costs of ICT technologies reinforces this clash of narratives, with some analysts seeing ICT continuing to spur significant economic growth for decades to come, while others argue that the benefits have largely been reaped and that the cost of maintaining adequate cybersecurity and the damage from cyber-attacks is becoming so great that the technologies will become a liability and a net drag on growth. But which is it? What is the balance between the benefits and costs of ICT, and how might that balance vary over time and across countries? With ICT technologies becoming ever-more ubiquitous, it is important that we reconcile these two seemingly opposed narratives.

In this paper, we explore the economic benefits and costs of ICT technologies and investigate how the balance between them may change out to 2030 for 186 developed and developing countries around the world. In doing so, we have: (1) constructed typologies of benefits and costs of ICT and identified the primary drivers of change in each element; (2) gathered a wide-range of data on ICT use and pervasiveness; (3) drawn insights from many individual studies of those elements and (4) augmented the International Futures (IFs) model—a dynamic, highly-integrated system for forecasting long-term human development futures across many

Abbreviations: IFs, International Futures; ICT, information communications technologies.

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issue areas—to enable the forecasting of possible trajectories of ICT pervasiveness, benefits, risks, and costs.[2] We present our findings in terms of four alternative scenarios built from some of the key uncertainties surrounding the technologies.[3] Note that we use information and communications technology (ICT) and cyber interchangeably in this study.

Our typology, built upon recent literature, breaks both economic benefits and costs of the technologies into three major categories[4]:

- Economic benefits of ICT:
  - o Direct contributions to growth from increases in the size of the ICT-producing sector
  - o Indirect contributions to growth from enhanced production and productivity across the wider economy thanks to the progressive embedding of ICT into the economy's capital stock
  - o Consumer-captured surpluses thanks to steadily and rapidly decreasing prices or improved capacity and quality offered at the same price as old systems
- Economic costs of ICT (borne by households, firms and other organizations, and governments):
  - o The spending required to defend against adverse cyber events (cybersecurity)
  - o The cost of adverse cyber events—broken down by actor-threat and target
  - o Opportunity costs—potential economic benefits that remain unrealized by forgoing the use of ICT out of fear of cyber-attacks or for other reasons such as social control

ICT's greatest economic benefit has been its contribution to productivity in the economy at large. Estimates of its past contribution range from 20 to 30% of annual economic growth, or depending on the country about 0.6 to 1.5 percentage points of absolute contribution. Many studies, however, focus more narrowly on the economic impact of individual technologies, like broadband, rather than ICT as a whole (Atkinson and Stewart, 2013; Czernich et al., 2011). Broadband, of course, is only a recent entry in a series of technology waves. Today's latest wave, cloud services, build on a foundation of broadband networks, while, already, several other future waves are visible, including the internet of everything and artificial intelligence (see MGI, 2013). Such waves complicate the analysis and forecasting of ICT's economic impacts, leading some analysts to point to saturation (Gordon, 2012, 2014; Cowen, 2011; Theil, 2011) with respect to annual economic impacts and others to anticipate an acceleration (MGI, 2013; Oulton, 2012; Kurzweil, 2006).

Our analysis of the costs of ICT reinforces a wider perception held in both the literature and the media: the annual costs from adverse cyber events and the cybersecurity spending to combat them has been increasing over time as a share of GDP. Estimates are that direct cybersecurity spending by firms worldwide has grown by roughly 8% per year over the last several years, reaching 0.1% of global GDP in 2015 (Gartner, Inc., 2014). Governments are also increasingly becoming more security conscious, with the US government's cybersecurity spending estimated at $13.3 billion in 2015, up from $8.6 billion in 2012 (Smith, 2011). The economic costs of adverse events are especially difficult estimate. In 2014, the cost of cybercrime and cyber-espionage, combined, ranged from an estimated 0.1% or less of GDP in Japan to 1.6% of GDP in Germany (CSIS, 2014).

The above discussion suggests that the two greatest uncertainties surrounding future ICT benefits and costs are (1) the unfolding of the technologies themselves, and therefore the potential extent of their impact on growth, and (2) the cost of adverse cyber events, especially around cyberwar and cyber-terrorism. These will shape the scenario analysis.

It could be that the benefits of ICT will trend downward as impact from the current wave of technologies saturates. It could also be that ICT is so closely linked to human knowledge expansion that ICT could follow the path of other general-purpose technologies (GPTs) like electricity. It could even set up a positive feedback loop generating exponential advances, moving us to an impending singularity with respect to artificial intelligence (Kurzweil, 2006). Nor does the debate over trends in adverse event costs help us greatly narrow the range of possible futures—while one side argues that offense will always have an advantage, causing costs and cybersecurity spending to soar with increasing ICT pervasiveness (Mandiant, 2013), other analyses like that of Microsoft's (Burt et al., 2014) around malware suggest that defensive capabilities are increasingly winning the battle.

This paper thus, while offering an admittedly imprecise understanding of the relative benefits and costs of ICT, attempts to fill in the gaps in the existing literature by (1) building an exhaustive typology of the different benefits and costs; (b) assessing contemporary and future monetary and economic values of individual and total benefits and costs; (3) encompassing a wide range of ICT types; and (4) exploring ICT futures in countries at all levels of development. We first delve into the conceptual, data, and formulation issues underlying our efforts to produce a quantitative model of ICT benefits and costs. We then turn to our analysis and forecasting across four scenarios designed to explore the major uncertainties of ICT futures.

2. Materials and methods: ICT and its benefits and costs

In order to analyze the competing benefit and cost narratives for ICT, four steps are necessary. First, in this section we must discuss the pattern(s) of likely advance in ICT. Second, also in this section, we must systematize the benefit and cost narratives by conceptually and empirically elaborating our typologies of benefits and costs. Third, in the next section we must represent both ICT advance and its benefits and costs in IFs. Finally, we must use the augmented IFs system for Base Case and scenario analysis.

2.1. The future advance (and impact) of ICT

Briefly stated, the different schools of thought regarding ICT's advance (and therefore its lasting role in driving productivity and growth) are: (1) the Pessimist school, which views major gains from ICT as a thing of the past; (2) the Optimist school, which believes that the gains are likely to continue, and even grow significantly, as new technologies arrive; and (3) a variation or extension of the Optimist school, that ICT should be regarded as a general-purpose technology (GPT) with especially wide and long-lasting economic impacts, like the steam engine and electricity before it.

According to the Pessimist school, earlier technologies like electricity, sanitation, and the automobile already claimed most of the low-hanging productivity fruit—i.e. they provided lasting productivity gains that cannot be replicated by existing or future technological innovations (Gordon, 2012, 2014; Cowen, 2011; Theil, 2011). For pessimists,

[2] The IFs model is housed at the Pardee Center for International Futures at the University of Denver and is available for research and further development without cost, at www.pardee.du.edu.

[3] This paper is a distillation of work done in a larger project on systemic cyber risks commissioned by the Zurich Insurance Group and in partnership with the Atlantic Council's Brent Scowcroft Center for International Security. We would like to thank Zurich for its support. The final report released to the public is at http://www.atlanticcouncil.org/cyberrisks/. An extended report is at http://pardee.du.edu/sites/default/files/Cyber%20Risk%20Pardee%20Extended%20Report..pdf.

[4] We recognize there are a host of benefits and costs to ICT/cyber beyond those directly related to economic growth, from the societal benefits of keeping in touch with friends and staying up to date with the latest YouTube sensations to costs like the loss of privacy and cyber-bullying. The largely economic focus of this paper should not signal insensitivity to the importance of these other benefits and costs.