DIGITAL GOODS AND THE NEW ECONOMY

by

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Digital goods are bitstrings, sequences of 0s and 1s, that have economic value. They are distinguished from other goods by five characteristics: digital goods are nonrival, infinitely expansible, discrete, aspatial, and recombinant. The New Economy is one where the economics of digital goods importantly influence aggregate economic performance. This Article considers such influences not by hypothesizing ad hoc inefficiencies that the New Economy can purport to resolve, but instead by beginning from an Arrow-Debreu perspective and asking how digital goods affect outcomes. This approach sheds light on why property rights on digital goods differ from property rights in general, guaranteeing neither appropriate incentives nor social efficiency; provides further insight into why Open Source Software is a successful model of innovation and development in digital goods industries; and helps explain how geographical clustering matters.

I. Introduction

As documented elsewhere in this Handbook (and attested to by journalistic frenzy in the late 1990s' dotcom boom) the New Economy means different things to different observers. Possible dimensions to the New Economy range from e-commerce, e-government, the Internet, the productivity paradox, knowledge-intensive work, social mass-mobilization, and globalization, all the way through auction proliferation, electronic payment systems, venture capital financing saturation, and business restructuring. In less guarded moments, popular conception held that with the New Economy, inflation might be forever conquered, explosive income growth might be hereafter the norm, and stock markets be always stratospheric.

Whether those possibilities are real, now or in future, is not this Article's concern. Rather than studying the New Economy—whatever it might mean—by beginning from ad hoc implicit economic frictions that the New Economy can then purport to overcome, this Article adopts the opposite attack. It takes a background perspective of markets in perfectly competitive Arrow-Debreu equilibrium, and asks, What is distinctive about the New Economy in general or digital goods in particular that could affect economic performance?

This strategy, in the current author's view, preserves analytical rigor and discipline. But, perhaps more important, since many observers consider the ideal of zero transaction cost, instantaneously buyer/seller-matched, friction-free, transparent, perfect-information markets to be the end result of the New Economy in any case, studying what happens at that limit point—i.e., what textbook economics has always assumed in the Arrow-Debreu model—might yield more enduring insight than will studying the hypothesized transition towards it.

This Article provides a definition of digital goods in the New Economy and describes a number of scientific, social, and commercial developments relating to that definition. The Article considers both traditional and recent formulations of the economics of digital goods—ideas; knowledge and economic growth; intellectual property; and nonrivalry, infinite expansiblity, discreteness, aspatiality (or, weightlessness and spacelessness), and recombination. Of course, not all these conceptualizations were designed originally with an eye to what I call digital goods in this Article, but the underlying economic principles nevertheless apply. This Article, therefore, takes the economics of austere high science, technology, and R&D to apply with equal force to videogames, movies, and pop music, as to biotechnology and computer software. In this framework, some digital goods and some parts of the New Economy have a lot to do with knowledge, skills, and productivity; others, hardly at all.

The discussion to follow considers, among other things, the difference between nonrivalry and infinite expansibility. Traditionally, economists have taken these two properties to be equivalent; indeed, for many interesting questions they should be treated thus. However, in recent work on pricing ideas without the artifact of intellectual property rights, the distinction between nonrivalry and infinite expansibility matters. This Article explains that difference.

Theories of increasing returns and network externalities apply to digital goods as a special case. Consequently, digital goods and the New Economy can be expected to display behavior such as cumulative causation, path dependence, production and consumption spillovers, and what Sherwin Rosen labeled the economics of superstars. But, even if particularly pronounced for digital goods, such predictions are not special to them. Indeed, as interpreted by the contributors to those literatures, their analyses apply to a wide range of economic activity, including traditional manufacturing. Since those ideas are sufficiently rich and intricate to merit detailed exposition elsewhere, this Article steers clear of them and focuses instead on what is unique to digital goods in the New Economy.

A What is a digital good in the New Economy? What isn't?

A *digital good* is a payoff-relevant bitstring, i.e., a sequence of binary digits, 0s and 1s, that affects the utility of or payoff to some individual in the economy. Easiest is to think of a digital good as a *recipe*: Encoded in the digital good (and, indeed, identical with it) is a set of economically valuable instructions. The phrasing allows digital goods to be consumed and to be produced; they are not just technologies to improve productivity on the supply side of an economy.

Any copy of a digital good is the good itself. There is no distinction between an original and a copy. No one holding a digital good relinquishes possession of it when yet others gain it; no one acquires a digital good by necessarily confiscating it from someone else. Indeed, the first owner will be unaware altogether of additional acquisition not of copies—which would not be at all unusual—but of the good itself.

Ideas and knowledge, computer software, visual images, music, databases, videogames, blueprints, recipes, DNA sequences, codified messages, and so on are all digital goods. Are there visual images that are *not* digital goods? Yes, examples include works of art for which the smell of the canvas, the texture of the oilpaint, or the perceived brushstroke by a long-dead artist, distinguish the original from its copies.

In this definition, a useful distinction is between digital goods that are *robust* and those that are *fragile*. If the economic value of the good is unchanged when a sufficiently small but positive fraction of the bitstring is randomly removed or re-assigned (i.e., the bitstring is contaminated), then say that digital good is robust. Otherwise, say the digital good is fragile. Typical lists of instructions that are the machinecode for a piece of computer software will refuse to execute when contaminated in the slightest, and so are fragile. Similarly, vector encodings of images—lists of abstract instructions—are fragile. Digital music recordings and bitmapped digital images, on the other hand, are robust: Indeed, that is how compression techniques such as JPEG and MP3 encodings work, producing shorter bitstrings with the same economic value as the original. Such compression—permanently changing the data and shedding the ability to re-create the uncontaminated original—differ from so-called lossless compression, where the original can be recovered perfectly from a compressed image, even though the latter is a strictly shorter sequence of 0s and 1s. In lossless schemes, the compressed image is generated deterministically, not randomly, from the original. Given current state of knowledge in genetics—although some recent research disputes this—contamination confined to the 97% of gene sequences in so-called "junk DNA" in human cells produces no change in the effectiveness of human DNA in coding and manufacturing proteins. However, contamination occurring over the remaining 3% results in mutation. Thus, we might usefully consider human DNA—compared to other digital goods—to display a sliding scale of fragility. Almost all of what follows in this Article applies simultaneously to both fragile and robust digital goods, but the distinction sometimes matters and so is useful to keep in mind.

Innovation, in this analysis, is the instantiation, i.e., the first creation, of a digital good. The New Economy, then, is an economy where digital goods figure prominently in determining aggregate economic outcomes—innovation, production, and consumption.

Economics has traditionally viewed digital goods as ideas, i.e., scientific knowledge, engineering blueprints, and technological innovation. That historical identification makes it natural to associate digital goods with improvements on the production or supply side of the economy. In that view, the New Economy is a knowledge-driven

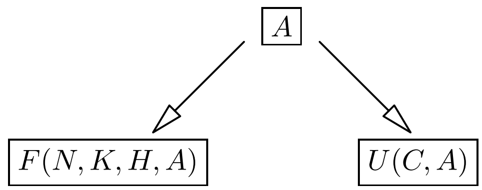

Figure 1: Let A denote digital goods. The left arm in the Figure points to firms' production functions F; the right, consumers' utility U. Potentially different A's enter production and consumption. What matters is that they all share the same essential economic properties. In production function F, symbol N denotes labor; symbols K and H, physical and human capital, respectively. In utility function U, symbol C denotes ordinary consumption goods. The Figure illustrates, therefore, the traditional view, that digital goods contribute to production on the supply side of an economy, as well as the newer view taken in this Article, that digital goods can also contribute directly to utility from their consumption by final consumers on the demand side.

economy, with productivity rising when technology advances due to knowledge accumulation.

To emphasize this historical association, turn to Fig. 1 and call digital goods A, the traditional symbol denoting technology in economic growth theory. The left side of Fig. 1 shows a production function F, mapping to total output the state of technology A and factor inputs (N, K, H), labor and physical and human capital. In this stylization, improvements in A raise productivity and drive economic growth. Obvious examples of such A include engineering blueprints, chemical formulas, and industrial innovations, i.e., intellectual property protected by either formal institutions such as patents or informal ones such as trade secrets. Call items of knowledge that can be so encoded *codifiable*. Call *tacit* all other items of knowledge—since in the framework of Fig. 1 these are embodied in economic agents, we might as well call this human capital.

(This terminology, although sufficient for the purposes of this Article, does serious injustice to long-established literatures in economic history, technology, epistemology, and sociology, among others. Robin Cowan, Paul David, and Dominique Foray provide a useful summary of some of these disparate strands of thinking across the social sciences more generally.)

The right side of Fig. 1 adds the possibility that digital goods directly affect consumers' utility. Compared to traditional views on knowledge in economic growth, this might at first appear peculiar. However, a moment's reflection readily provides examples: videogames, digital images and music (i.e., new media and entertainment), computer software, biotechnology, and significant portions of the telecommunications industry and the Internet. To be clear, genetically-modified frost-resistant tomatoes, say, should certainly be expected to influence productivity; but picture messaging, music, and games on mobile telephone handsets—features driving new-generation telephony—less obviously so. However, these last and numerous other examples like them comprise large and growing shares of some modern economies. Indeed, considering the impact of this part of the New Economy, the real paradox would be if supply-side productivity measurements *were* affected!

The two arms in Fig. 1 flag perspectives that are both analytical and empirical. Just as the economics of digital goods in production differ from that in consumption, so too might measurement of the New Economy usefully consider developments on both the demand side and the supply side. Empirical analysis of the New Economy might profitably study not only whether computers raise labor productivity, say, but also how risk allocation and consumption patterns, political organization and mobilization, and so on are evolving with increasing computer and Internet proliferation.

Notably omitted from Fig. 1 are those considerations in the traditional economics of information and uncertainty—risk and agency, moral hazard and adverse selection, signalling, and strategic behavior under asymmetric and imperfect information. (See, for instance, the textbook presentation in Jack Hirshleifer and John Riley.) While common parlance holds that a growing New Economy entails the rising importance of information in economic activity, that description is usefully distinguished from how economics has traditionally taken information to matter. The economics of valuing and disseminating, say, an MP3 music file differs from the economics of moral hazard in sharecropping or of adverse selection in insurance.

How are biotechnology products also digital goods? Biological development entails manipulating genetic material. This last is just a DNA sequence, i.e., a string of subunits comprising one of four nitrogen compounds, Adenosine, Cytosine, Thymine, and Guanine (or, the letters A, C, T, G). DNA sequences translate into sequences of 0s and 1s, and thus are bitstrings that code for—bear information allowing selected cell sites to create—different proteins in plants and animals.

While useful, making this last specific connection explicit potentially disguises how the digitization idea applies more generally. It is a commonplace that numbers are digital, either directly or when translated into binary representation. Increasing intrusion of computers and the Internet into everyday activity has made familiar the idea that software, music, images, and so on are digital.

What is perhaps less well-known but useful to clarify in an article on digital goods is how digitization—the identification of the humble bitstring with many objects in the modern world—might be one of the surprise (and implicit) grand unifying themes of 20th-century science and economic progress. The next section briefly describes some of that intellectual background. While not absolutely essential to the remainder of this Article, it usefully provides a broader framework to the discussion.