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Observations on the technology and economics of digital emissions

Amelia Rickard [a], Jeffrey Wagner [b, *], Jonathan Schull [c]

[a] Center for Governmental Research, Rochester, NY, USA
[b] Department of Economics, Rochester Institute of Technology, USA
[c] Center for MAGIC (Media, Arts, Games, Interaction, and Creativity), Rochester Institute of Technology, USA

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ABSTRACT

Unwanted digital information such as spam is often sent to recipients who did not request it. In the absence of policy intervention, the rate of these “digital emissions” will exceed the social optimum, causing a market failure. Some scholars have noted the similarities between this type of digital market failure and market failures observed in other domains—namely, pollution such as sulfur dioxide emissions in the natural environment. The purpose of this paper is to extend the analysis of these market failures to explore the applicability of analogous mechanisms in these seemingly unrelated domains. We argue that several mechanisms developed for environmental regulation can indeed be applied to digital domains such as labor markets and social media. Doing so could increase equity as well as efficiency.

1. Introduction

This paper focuses upon the specific technology policy challenge of modulating the increasing rate of digital transmissions in networks. Notwithstanding the benefits from generating and having access to more information, there is need for additional policy that enables recipients of digital information to easily identify the subset of most important signals. Not only do avalanches of digital information cause recipients to spend increasing amounts of time sorting signals, the signals can contain harmful malware.[1] We introduce the term “digital emissions” to capture the recipients' sense that they are exposed to digital signals that cause nuisance, if not harm, analogous to exposure to environmental pollution such as sulfur dioxide. We explore this analogy between environmental and digital emissions and argue that technology policy levers that have performed well in the regulation of environmental emissions could be quite useful in the digital emissions domain. We focus in particular upon the merits of cap-and-trade approaches in the environmental regulation arena for use in the digital network arena. Progress along these lines contributes as well to understanding of a more general topic of technology policy concern: clarifying and enforcing property rights and individual rights in digital markets.

Our economy—where we work and where we buy things—is organized according to property rights that arbitrate how citizens can participate. Each citizen plays multiple roles—certainly as both producers and consumers, but also at micro-roles, perhaps as parents, voters, investors/shareholders, and civic leaders charged with nurturing the social good. The multiple roles citizens play change as part of a larger evolving structure of individual human rights that determine what one may and may not do in various roles.[2] This is an important consideration, because the general long-run trend in rights management is to distinguish more and more precisely defined human rights and to establish limits below which human rights must not fall. The right to an attorney if a citizen cannot afford one is an example, as is the right for the accused to appear before a judge and be charged or released. The establishment and

* Corresponding author. Department of Economics, Rochester Institute of Technology, 92 Lomb Memorial Drive, Rochester, NY, 14623, USA.
E-mail address: jeffrey.wagner@rit.edu (J. Wagner).

[1] Our approach is related in some important ways to the literature regarding “attention economies” [10]; and [9] are two key references. However, our work differs from Ref. [10] in that he is focused upon the signal sender and does not take into account the preferences of signal receivers. And neither Ref. [10] nor [9] nor others, to our knowledge, consider a cap-and-trade approach to enhancing efficiency in digital markets.

[2] Indeed, [20] and [11] discuss how the evolution of commerce in the digital domain enabled expansion of self-reliance and do-it-yourself engagement of technology in society.

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enforcement of rights has long been linked to the economic health and justness of societies.

The evolution of rights—both property rights and more general human rights—is important to economists on several grounds. Adam Smith argued that once government establishes clear rights and demonstrates the power to enforce them, the Invisible Hand would allocate economic resources in the best interests of society. By contrast, when rights are not clear or enforceable, economic forces cannot reliably allocate resources correctly. Weakly defined and weakly enforced rights enable undesirable practices to slip through the fingers of the Invisible Hand—practices like spam that clog recipient in-boxes and make recipients more vulnerable to digital fraud, including identity theft. It's worth asking why the Invisible Hand often fumbles in digital contexts and what more can be done to better define the rights structures that exist.

Digital goods and bads have two physical properties—nonrival and nonexclusive consumption—that can lead to market failures such as inefficiently high rates of digital emissions and consequent social costs associated with identity theft. Nonrival consumption is exemplified by the fact that one person's consumption of a digital good or bad does not typically draw down consumption opportunities for others. Indeed, digital goods and bads can be emitted to an unbounded number of consumers at low or zero marginal cost to the creator. The unbounded dissemination of digital goods would seem to raise the utopian possibility of low cost and virtually unlimited profit: If information creators could only charge a penny from each consumer, they could still make a fortune. The unbounded dissemination of digital bads raises the dystopian (and familiar) prospect of spam and malware.

Nonrival consumption also introduces a perception among some emitters that sending and receiving digital emission does not involve scarce resources. However, the receipt of a digital good or bad does involve other scarce resources—namely the time and attention recipients spend exploiting valuable information and weeding out useless information. This leads to the second physical property that characterizes digital markets: It is not straightforward for recipients of digital emissions such as spam to exclude themselves from consumption. In economics jargon, digital emissions tend to exhibit non-exclusivity in consumption.[3] Thus, digital goods markets that also exhibit digital emissions require digital rights management policies or technologies to strengthen exclusivity so that those who desire digital goods receive them and those who are harmed by them can avoid them or be compensated for harm incurred.

Interestingly clean air, water, and soil suffer from the same relatively weak (but evolving) rights structures as digital goods and bads. Ecosystems are similarly vulnerable to nonrival and nonexclusive consumption, and are therefore vulnerable to spam and congestion (pollution) and viruses (of the traditional biological kind). For several years, economists have advocated the creation of "splints" for Adam Smith's Invisible Hand in the environmental context. In the 1960s and 1970s, the United States implemented relatively blunt policy instruments such as the ban on leaded gasoline; however, more recent policy instruments for controlling "environmental spam" such as sulfur dioxide emissions are increasingly sophisticated. For these emissions, a national cap-and-trade mechanism is considered by many to have been so successful that the cap is no longer needed.[4] We review these and other environmental policy mechanisms in what follows, and propose that some of the latest policy approaches that have enabled progress in the prevention and clean-up of environmental pollution could be extended to address pollution in the digital domain such as spam.

Our paper proceeds as follows. In Section 2, we present a model of the basic externality problem to be addressed in both digital information and environmental quality markets, wherein individual decision-making tends to diverge from the social optimum. Along the way, we review the salient literature regarding price and quantity policy instruments that can possibly bring individual and social decision-making into alignment for both digital and environmental spam. Section 3 discusses how digital rights management policies could be extended to mimic cap-and-trade mechanisms of increasing interest in environmental pollution control contexts. We conclude in Section 4 with our take-away points and with discussion of some areas for future research.

2. The basic model

The main idea set forth in the Introduction is that emissions problems of undesirable information flows and of undesirable pollutants share essential characteristics. The market forces in both contexts can be usefully illustrated in equation and graphical form. Suppose we have individuals engaged in an activity like sending digital signals S to one another. Each individual derives private benefit$B_p(S)$ from the sending of such signals and incurs a private cost $C_p(S)$.[5] This private cost can comprise both material and time costs; individuals may be billed per digital emission, but even if not, individuals may incur a cost of spending so many seconds or minutes of otherwise free time when sending each signal. (The model can also be extended to deal with cases in which there is only a fixed or lumpy cost to design a signal to send to a conceptually infinite number of individuals.) The individual would maximize his or her net benefit $NB_p(S) = B_p(S){-}C_p(S)$ from engaging in signal sending by choosing the privately optimal rate S_p such that:

$$\frac{dB_p}{dS} = \frac{dC_p}{dS} \text{ or } MB_p = MC_p \tag{1}$$

Social problems are encountered, however, if emitting private signals creates costs for others. In the digital realm, these imposed costs to recipients can take the form of spam that in addition to burdening them with sorting costs can increase the risk of identity theft or other breaches of private information (e.g., when unsuspecting recipients click on unsolicited emissions and software vulnerabilities are exploited).[6] Let us represent this spillover or external cost to private digital emissions by $C_e(S)$ such that the social cost is the sum of the private cost and the external cost: $C(S) = C_p + C_e$. For simplicity, we assume that there are no external benefits from such emissions, such that the marginal private benefit is the same as the marginal social benefit. In this scenario, one's private decisions about sending signals would comport with the social efficiency of sending signals if S were chosen to maximize the net benefit function $NB(S) = B(S){-}C_p(S){-}C_e(S)$. The first-order condition is (in three alternative notations):

$$\frac{dB_p}{dS} = \frac{dC_p}{dS} + \frac{dC_e}{dS} \text{ or } MB = MC_p + MC_e \text{ or } MB = MC_{p+e} \tag{2}$$

The differences in public versus private optima suggested by

[3] See Ref. [4] for an excellent overview of these concepts of nonrivalry and nonexclusivity.

[4] See Ref. [18].

[5] The marginal benefit function is typically decreasing because of the Law of Diminishing Marginal Utility, and the marginal cost function is typically nondecreasing—that is, marginal cost can be zero (coinciding with the x-axis) or positive, and it may or may not be increasingly positive at the optimum.

[6] See Ref. [17] regarding the economics of spam and see Refs. [2,3]; and [1] regarding digital breaches of private information.