Discontinuous Technological Change and Relaxations of Regulatory Restrictions to Achieve Societal Objectives for the Environment, with Focus on IP Protections

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Abstract

We address cases where improvements in information technology for measurement and monitoring should result in regulatory relaxation, in contrast with much recent research, which focuses on situations where these improvements should result in increased regulatory restrictions on the actions permitted by large platform operators. We focus specifically on the problem of reducing environmental degradation, and we explore how regulatory restrictions associated with intellectual property (IP) rights should be relaxed in the presence of demonstrable reductions in environmental impact that result from improvements made by parties other than the owners of the IP. We explore how Environmental Impact Merit should be used to compel the owner of the IP to adopt improvements and to compel compensation to the improver. Future research will develop additional examples where regulatory relaxation is appropriate.

Keywords: Regulatory Policy, Regulatory Relaxation, Intellectual Property Rights Protection, Environmental Impact Merit

1. Introduction and Context

1.1. Regulatory Relaxation in Specific Contexts

We explore mechanisms to encourage more rapid adoption of technologies and new processes to produce goods and services with less environmental damage, even when those goods and services enjoy strong IP rights protections. We seek to encourage the adoption of production processes that are less environmentally harmful, even when this would violate existing IP protections. We know that there is no universally accepted definition of economic fairness, but we understand that the developer of the improved processes and the owner of the original IP must both receive economic gains.

We start by examining how infringement of copyright, patent, and other forms of IP rights protection should be modified when the infringements would unambiguously be beneficial to society. We ask how infringement should be evaluated when the effects of the infringement are Pareto optimal, leaving some parties better off and no parties worse off.

It is generally assumed that laws and regulations are designed ultimately to protect citizens, or, more broadly, to protect society. In Western democracies, even misguided regulations like the Eighteenth Amendment (Prohibition) are widely believed by their proponents to benefit society. We will briefly address a problem that has previously been studied, that of IP rights protection in the presence of easy copying with significant Creative Merit (Clemons et al., 2022d). Much has been written about the need to increase protections in the presence of new technology-enabled capabilities; see, for example, prior work on the need for tighter regulatory restrictions to protect consumers from online political manipulation from new media and new forms of fake news distribution (Clemons et al., 2019), from new forms of monopoly power enabled by new online business models (Clemons et al., 2022e; Rowe et al., 2022), and new forms of marketing manipulation enabled by the increased information endowment of online platforms and online sellers (Clemons et al., 2022c; Trzaskowski, 2021). This is not the first time that technological progress has enabled regulatory relaxation. Probably the best-known example is the improvements in digital switching technology that enabled interoperability and interconnectivity of competing telecommunications carriers, which led directly to deregulation of telecommunications in the US and to the break-up of AT&T. However, almost all recent studies of big technology platforms and of regulation now call for increased regulation. This is one of very few papers that recommend regulatory relaxation in the presence of new technology-enabled capabilities and new sources of business power.

We believe that human civilization faces a growing threat from environmental degradation (Díaz et al., 2019; Secretariat of the Convention on Biological Diversity, 2020). Society should want to adopt superior production processes that reduce environmental degradation, even if that might allow innovators to infringe on existing IP rights. However, the originator of the

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protected design does own protected IP and was encouraged to make the investments that led to the development of the protected design. The originator of the protected design also deserves fair compensation when innovators are allowed to infringe on protected designs, and society needs formal procedures for calculating what fair compensation should be. As the dangers from environmental degradation become greater and more obvious, any balance between IP protection and environmental protection must be reexamined, because any balance that was previously optimal in the past will become suboptimal going forward.

This is an example of a broader problem, deciding how to relax existing laws, regulations, and restrictions, to achieve greater social value, in the presence of new capabilities enabled by information technologies. Copyright law is designed principally to benefit society. All IP protection seeks to balance the *increased supply* of innovation by protecting the creators of new works and *increased access to* new works by limiting the extent of protection provided to the creators. A recent paper argues that if technology makes it easier to create new works by reusing existing material, and if these new works have Creative Merit, then any balance that had been optimal before will surely be too restrictive going forward. Determination of the new balance, and the calculation of payments owed to the initial creator of the protected work, are complex and interesting (Clemons et al., 2022d).

The problem of achieving new optimality in legal codes and legal restrictions is indeed a truly "wicked problem" (Marshall, 2008; Rittel et al., 1974). We focus here on relaxations in restrictions to require changes in operations, to adopt innovations with reduced environmental degradation, which we call Environmental Impact Merit.

1.2. Context and Goals of the Paper

This paper represents a novel use of mandatory licensing, compelling the owner of protected intellectual property, to share that IP to achieve socially desirable reductions in environmental degradation. Mandatory licensing is not new (Ullrich, 2015). It involves forcing the owner of protected IP to share that IP in exchange for a licensing fee when there are clear and compelling societal benefits from doing so (Bernardini, 2021). One well-known example involves compelling the licensing of vaccines to deal with a medical emergency, as a means to rapidly increase supply (Kianzad et al., 2021). A second less well-known example involves mandatory licensing by the winning prime contractor, allowing second and third-place entrants in a defense contract competition to participate in the final construction (Brown, 2010).

Mandatory licensing is not a windfall for the IP owner. Indeed, if the licensing fee represented a supernormal profit it would not need to be mandatory and the IP owner would not need to be compelled to permit licensing. As with Duty to Deal and the Essential Facilities Doctrine (Pitofsky et al., 2017), setting an appropriate fee can be complex. When AT&T was compelled to share its local loop with MCI AT&T argued that it was losing revenue of perhaps $2.00 by letting MCI compete as a long-distance service provider, while MCI argued that AT&T had an opportunity cost of zero since the line was already in use. Tariff separation ultimately awarded AT&T far less than it demanded ("MCI Communications Corp. v. AT&T Co.," 1983).

As with the Essential Facilities Doctrine, the most interesting question in mandatory licensing involves determining the appropriate licensing fee, one that in some sense is socially optimal while also being in some sense fair. Our case is novel since we are not trying to increase the supply of an item protected by IP, but rather improve upon the way the protected item is produced. More specifically, we assume that the item can now be produced in a manner that creates less environmental degradation. Because our focus is on determining the correct licensing fee we do not need to be concerned with many of the details that would be of interest to environmental engineers. We make the following critical assumptions: (1) At each step of the production process, the incremental environmental degradation and the cost of remediation are both known. (2) An environmental degradation tax (DAT) is imposed at each step along the way, and the consumer pays the ultimate DAT based on the sum of each DAT imposed along the way, as is the case with traditional value-added taxes. (3) The DAT is not punitive, but rather is used to fund remediating environmental degradation from producing the product.

We do not model how remediation is achieved, since that will vary with each firm, with each product, and with each technology that is deployed in the initial production processes. We note that remediation is the ultimate goal of our DAT. We do not describe how remediation is achieved for each product. Our model describes one way to set a licensing fee. Not surprisingly, our model shows that consumption increases if the new process allows the DAT and thus the resulting market price to decrease; this is a well-known result. It is not a contribution of our model but merely an indication that the model is behaving reasonably. Not surprisingly, our model also shows that when the tax is decreased both consumer surplus and producer profits increase, and this is also a well-known result. Our contribution simply addresses the net gain to society from these increases.

1.3. Structure of the Paper

Section 2 explores rapid and discontinuous change in the business ecosystem, driven by rapid technological

progress. We analyze this in terms of punctuated equilibria in biological evolution, creative destruction among previously dominant businesses, and competence-destroying innovation and change. We explore how changing capability and changing business models create changing legal challenges and require adaption and change in what had previously been optimal levels of restrictions.

Section 3 provides a short review of wicked problems. Section 4 provides a short review of the main assumptions and main findings of our paper on how to relax copyright restrictions on creative works, based on the increased possibility of reuse with significant Creative Merit. This is the closest analog to the relaxations we are proposing here. Section 5 reviews our assumptions for our model of mandatory relaxation of IP rights restrictions when an "improver" can reduce the environmental impact associated with producing a good or service that enjoys IP rights protection. As noted in the section, our findings are consistent with the economic analysis of taxes that are designed to limit consumption.

Section 6 reviews different models, under slightly different assumptions about changes in ecological impact, changes in the determination of the taxes imposed on products that create environmental degradation, and changes in production costs associated with improved ecological impact. Section 7 provides our conclusions, including the contributions and limitations of this work, and directions for future research.

2. Evolution, Punctuated Equilibria, Changing Capability, and Regulation

2.1. The Theory of Evolution

Modern extensions to Darwin's theory of evolution provide a useful metaphor for discontinuous change in a wide range of disciplines. There are times in history when rapid changes in technology produced rapid changes in business models, in power, and in abuse of power. The industrialization of the 1880s and 1890s required the first antimonopoly laws, which were demonstrably unable to deal with the emergence of national telecommunications monopolies. We explore theories of evolution in biological systems, to motivate rapid and discontinuous change in regulatory frameworks.

The theory of evolution, as proposed by Charles Darwin, assumed that species gradually evolved to become better suited to their environment. (Darwin, 1872). Based on the historical record, Gould extended the theory to encompass cladistics, or punctuated equilibria, in which periods of relatively static species' change would be interrupted by far more rapid change (Gould, 2007; Gould et al., 1972), and this has been confirmed by empirical observation (Lamichhaney, 2022; Lamichhaney et al., 2016). We will rely more on Gould in the work that follows than on Darwin.

We seek to understand patterns that are emerging in business and in environmental policy and to use them to address a specific issue in the relaxation of IP protection to achieve environmental objectives. Like Gould, we believe that complex ecosystems evolve through periods of relative tranquility and periods of rapid and discontinuous change. An emerging awareness of the current environmental crisis, improved ability to measure and monitor environmental harm, and improved ability to reduce and remediate that harm will combine to yield discontinuous change in regulatory policies. One policy that will undergo that change is strict IP protections for goods and services that produce environmental harm, when less harmful alternatives become available.

2.2. Business Evolution

When the business environment changes sufficiently slowly, dominant firms evolve and often maintain their dominance; this exhibits competence-enhancing change (Anderson et al., 1991). In contrast, periods of incremental change in the business environment are punctuated by discontinuities, periods of rapid change in which previously successful strategies may become less effective. These periods are characterized by competence-destroying change (Tushman et al., 1986), in which changes can cause the strengths of a dominant industry participant to become irrelevant; this often enables new entrants to emerge and rapidly become successful. In the 1970s massive corporate mainframe computers in remote centralized data centers began to be replaced with departmental minicomputers, a trend that IBM initially failed to notice and to which IBM initially failed to respond. This enabled minicomputer manufacturers like Digital Equipment Corporation, Pr1me, and Data General to capture the market for smaller machines. Later, IBM and Apple led the move into personal computers, which minicomputer manufacturers ignored, leading to the eventual disappearance of the companies that had dominated the market for minicomputers.

Clinging to previously successful strategies at times of rapid change has been documented by numerous authors in numerous industries, and it appears irrational only in hindsight, after the value of new strategies and the power of new technologies have become clear; see Hayes et al. (1988), Tushman et al. (1985), Henderson (1993), Hamilton (1986), and others.

These discontinuities correspond to punctuated equilibria in biology. They correspond also to Schumpeter's Creative Destruction, where new industries replace and ultimately destroy others (Schumpeter, 1994 [1942]). Much as extreme changes in the business environment, driven by technology or regulation, can allow

companies and even entire industries to fail, rapid changes in their ecosystem can lead to the rapid replacement of one species by another in the biological world.

2.3. Evolution, Punctuated Equilibrium, and Creative Destruction, Caused by Change in Information and in Information Systems

IS research has implicitly used the study of discontinuous change to facilitate research on information-based strategy, without explicitly using or extending the theory of punctuated equilibria in business. The philosophy of punctuated equilibrium analysis in biological evolution allowed examination of how emerging and discontinuous change in the business and technological environments would affect the evolution of business strategy. Like Wallace, researchers did not wait for data to become available but rather used abductive reasoning to postulate what changes in business strategies would emerge. These approaches allowed accurate predictions early, but there are also clear limitations to the precision of their predictions. Researchers published about online search in 1992, before online search existed (Clemons et al., 1992), but were unable to predict that Google would be the ultimate winner rather than Gopher, Alta Vista, or Yahoo. Researchers wrote about outsourcing and predicted dramatic increases in business process outsourcing, but were unable to predict that Infosys and Wipro would emerge as early giants, or that Accenture would come to surpass them in sales volume.

2.4. New Business Models, New Forms of Power and Abuse, and Punctuated Equilibria in Regulation

More recently, business school IS research has begun to focus on issues of abuse of monopoly power and other regulatory concerns, rather than on opportunities in business strategy. New business models often create new sources of power, which in turn lead to new abuses of power. When those business models are sufficiently novel these abuses are not limited by existing regulations, and additional restrictions are essential to protect consumers from abuse of monopoly power (Clemons et al., 2022e), manipulation of public opinion (Clemons et al., 2019), or unfair marketing practices (Clemons et al., 2022c). For example, the earliest work in the information systems community on platform envelopment is due to Eisenmann, Parker, and Van Alstyne (Eisenmann et al., 2011; Parker et al., 2016). Their work focused on new business models and new business opportunities. In contrast, the Wharton group focused on the potential abuses of power associated with these new business models and the regulatory problems this would create (Clemons, 2018; Clemons et al., 2022a; Clemons et al., 2022e). The group has argued consistently that changes in technological capability have produced such dramatic changes in business models and in power that regulatory policy needs more than gradual evolutionary change; this requires discontinuous change. For example, the EU's decision to fine Google $5.4 billion for abuse of platform power through Android's Mobile Application Distribution Agreement (European Commission, 2018) does not have clear or universally acknowledged antecedents in prior generations of antitrust law.

2.5. Offsetting the Need for Regulatory Relaxation

This paper represents a different regulatory focus and a more optimistic view of changes in business capability. Rather than focus on places where regulations need to be augmented to protect consumers from corporate abuses enabled by novel uses of information technology, this paper focuses on areas where regulatory restrictions need to be relaxed, to enable consumers to obtain more of the benefits that corporations can create through novel applications of information technology. Since we are focusing on discontinuous change, we draw inspiration from Gould (2007), and since we do not yet have data to support our analyses we draw inspiration from Wallace (1962).

3. Wicked Problems

Wicked problems share some or all of the following characteristics (Marshall, 2008; Rittel et al., 1974).

First, the problems have multiple and perhaps competing objectives. Returning to the example of "Environmental Impact Merit," the owners of protected IP will have objectives for changing the restrictions that protect them, and these objectives are almost certainly different to some degree from the objectives of the innovators seeking to improve on the practices of the owners the protected IP. While the owners of the protected IP will want to maintain existing protections, the innovators will almost certainly seek greater ability to infringe on existing IP rights. Some consumers will be more concerned with short-term costs while others may be more concerned with long-term environmental quality and sustainability. Society clearly has an incentive to reduce environmental degradation, but mechanisms to do so may involve taxing purchases of goods and services based on the harm that is created by their consumption, which will raise short-term prices. Some consumers may object to any practices that raise their short-term expenses. And, without a doubt, consumers will place different priorities on environmental preservation and on lower prices. These objectives clearly compete: decreasing IP protections and rewarding innovators who infringe on existing protections clearly benefits some parties more than others and harms some.

Economists can judge whether or not proposed mechanisms are economically efficient, that is, whether they provide benefits to society without making any parties worse off. But economists cannot tell us if a proposed solution is fair because economics alone cannot tell us how to assess competing objectives.

More precisely, while economists can assess whether an economic outcome is efficient, there is no generally agreed-upon economic measure of fairness. Allowing landlords to convert existing residential rental properties into Airbnb homes seems fair to owners of property, but tenants who cannot afford the rents paid by vacationers may view the change as unfair. Vacationers who get to stay in historic districts of old cities where hotels are not permitted surely will believe that the conversion of historic properties to Airbnb listings is fair to them, while individuals and corporations who invested heavily in the construction of hotels may view the change as unfair. City taxpayers may view the change as unfair as well, if Airbnb rentals produce lower taxes than hotel rentals, forcing higher taxes on city businesses or on city residents.

Next, wicked problems entail a high degree of subjectivity and room for disagreement on what is being measured. There is a high degree of subjectivity, from what constitutes Creative Merit to what constitutes a relationship of value to society. Likewise, there is room for disagreement on how to allocate royalty payments for reuse of protected works when the reuse is judged to have Creative Merit. For example, the paper on copyright relaxation and Creative Merit explicitly provides multiple values for royalty payments to owners of protected IP when infringement is authorized, and each provides a different outcome for different participants in the economy. The choice among them is determined by what society considers to be fair, which as we have already noted is subjective and not easily specified.

Wicked problems invariably entail factors that cannot be fully understood, that is, critical unknowns. It is not possible to know with certainty how an individual reuse will affect an individual creative artist in the future. For example, allowing a performer to reproduce the sound of a jazz horn player in a classical work may not appear to infringe on the future recording possibilities of the jazz player. However, both Benny Goodman and Wynton Marsalis began their recording careers as jazz trumpeters, and both expanded into the classical repertoire. That is, neither we nor the artists fully know how actions of others will affect the value of their protected IP in the future. There are also unknown unknowns, things that we don't know and don't know that we don't know (Pawson et al., 2011). Persuading the Chinese to have smaller families appeared beneficial when the one-child policy was introduced (Potts, 2006), but this has resulted in problems that are quite clear today, including gender imbalance and an aging workforce (Feng et al., 2016). The adoption of all transformative technologies is inevitably accompanied by some unanticipated changes (Healy, 2012). And the problems all exhibit a high degree of entanglement; they are not easily divided into separate problems, each of which can be solved independently of the others.

4. Creative Merit and Mandatory Relaxing of IP Rights Restrictions

A recent paper on copyright law examines the relaxation of restrictions on the artistic use of protected material and provides an example of the type of research we are considering here (Clemons et al., 2022d). The paper starts by stating the basic role of copyright law, which is to benefit consumers by achieving the optimal balance between promoting the supply of innovation and promoting access to innovation. Promoting supply is achieved by providing incentives to the creators of valuable innovations; this paper focuses on patents, copyrights, and other forms of protections that allow the creators' monopoly rights to the use of their work. Promoting access is achieved by limiting the period in which the creators enjoy monopoly rights.

Recent advances in digital technologies enable copying and transformation of existing artistic works, allowing the production of new works derived from the originals but offering significant Creative Merit in their own right. Reuse is more creative and now generates both economic and aesthetic value. The existing design of copyright restrictions can no longer be optimal. Current designs that seek to balance promotion of the supply of innovation and promotion of access to innovation are no longer optimal. Current designs are now too restrictive, if the benefits that artistic reuse offers society have increased while the restrictions on this reuse have not changed.

It is not sufficient to note that designs are too restrictive. The paper classifies reuse of protected property in terms of its impact on the original creator's profits, the reuser's profits, consumer surplus, and total societal value, defined to be the sum of the three. The most interesting cases are those where total societal value increases, since in that case, regulations should encourage reuse. The most complex case occurs when societal value increases but there is future harm to the originator of the protected material; when the future harm cannot be calculated it is impossible to determine an effective royalty rate and modification to copyright requires a reduction in copyright duration. When reuse provides value to society and neither benefit nor harm to the originator the regulators' role is the clearest: regulators are able to determine a royalty rate that achieves society's beliefs about fairness. For example, regulators can

compel the originator to allow reuse of its creative work and set a royalty rate that ensures that consumer surplus and originator profits from reuse are equal, or can set a royalty rate that ensures the originator profits and reuser profits from reuse are equal.

This work provides the starting point for this paper's modeling of reuse to achieve societal goals from improvements that achieve Environmental Impact Merit, rather than achieving Creative Merit. The analyses in the two papers are completely different. Unfortunately, the classification of forms of Creative Merit is not applicable. Moreover, the assumption that there is little or no cost to market entry in the production of artistic work do not apply to heavy manufacturing industries, which are among the greatest source of environmental degradation; heavy manufacturing usually requires large fixed investments in physical plant, creating entry costs, and these investments usually cannot readily be recovered if operations are halted, creating exit costs.

5. Environmental Impact Merit and Mandatory Relaxing of IP Rights to Reduce Environmental Impact

Next, we analyze the environmental impact of relaxing IP rights protections to encourage the discovery and adoption of process improvements to reduce the environmental impacts of the production of protected goods and services. This analysis is the central contribution of this paper. It is a special case of the analyses that attempt to develop quantifiably optimal solutions to the problems associated with the need for regulatory change that is driven to some degree by increases in technological capability.

This analysis assumes an existing technology, to produce an existing good or service, and it assumes that the good or service enjoys some form of IP rights protection. Hereafter we will refer only to a *product that enjoys IP protection*, or more tersely a *protected product*, without specifying either the nature of the product or the nature of the protection. This analysis assumes an alternative technology that can be used to create the protected product, and that can do so with demonstrably lower environmental degradation. And it assumes the deployment of information technology and monitoring capability needed to quantify the reduction in negative environmental impact.

The following assumptions are common to all of the cases we analyze. There is an *originator*, who currently sells the product, and an *improver*, who has developed an improved process to produce the same product. Consumers are heterogeneous concerning their willingness to pay for the protected product, and the distribution of consumers is linear in their willingness to pay for the protected product. Consumers do not all agree on the importance of paying to reduce environmental impact, but at the time being considered by our analysis society has implemented a formal DAT (damage added tax) on every product, so that all consumers are paying a penalty for making purchases of goods and services that are environmentally harmful.[1] Note that the DAT measures the lifetime expected environmental impact from the consumption of the protected product, greatly increasing the role of monitoring and analysis, and increasing the role of information technology as an enabler of this change in taxation and in environmental policy. This tax is used to remediate the environmental harm resulting from consumption of the product or service. Although the DAT also serves the added purpose of increasing cost and reducing consumption of the environmentally harmful product or service, this is different from punitive taxes designed solely to reduce consumption; taxes on tobacco products are designed principally to increase costs and reduce consumption, while the DAT is designed to remediate ecological damage, leaving environmental regulators largely indifferent to changes in consumption.

Note that we are assuming that environmental harm can be measured, in terms of the *quantities* of particulates realized burning gasoline, or the amount of CO_2 released using coal in electrical power generation, or the amount of NOx released as a result of air travel. And we are assuming that the cost of *removing* particulates, or CO_2, or NOx, can be approximated. We are not modeling optimal policies for removing or reducing pollution, and we are not modeling the economic harm from pollution; we are assuming that these will be accomplished and that they are enablers of the work we are doing here. Likewise, we are not performing punctuated equilibrium analysis on environmental policy or legal policy. We are stating that when new production processes are developed that are demonstrably superior for the environment, existing IP protections must be relaxed, so that protections enjoyed by firms using older technologies cannot be used to continue environmental harm.

We considered an alternative assumption, without introducing a DAT. We considered the possibility that when the protected product has demonstrable, audited superior environmental impact there is a new

[1] Our findings are consistent with the analysis of an excise tax designed to limit consumption, such as taxes on tobacco and alcohol. Increasing excises taxes reduces sales and profits. This is not the contribution of our paper. Our paper deals with altering IP rights. The analysis is included because it provides guidance for sharing profits from protect IP when society deems it is beneficial to relax those IP rights. It is important to note that our results are consistent with analyses of excise taxes.

willingness to pay curve, with many consumers willing to pay more for the product. There is simply insufficient willingness to pay for lower environmental impact among many populations. Consumers are heterogeneous in their willingness to pay for "clean" products voluntarily but have no choice about whether or not to pay the DAT if they make a purchase. Remember why in the US gas pumps had smaller nozzles for unleaded, so consumers could not cheat and use leaded gas in newer cars that were designed for unleaded gasoline (The Henry Ford, 2022). There are a number of behavioral reasons why societies would impose a DAT rather than rely on consumer altruism.

6. Analysis of Improvements with Environmental Impact Merit, When Products are Functionally Equivalent

6.1. Analysis When Damage Added Tax Covers Full Cost of Remediating Damage

Since this paper does not follow the structure of a typical technology research paper, our conclusions will not follow the typical structure as well.

In this case, both the original protected product and the product resulting from improved productive processes are functionally equivalent. Both products have the same production cost C. We assume initially that the DAT is set to equal the full cost of remediation of environmental harm from the consumption of the product; we will relax this assumption in subsequent analyses. The new production process has lower environmental impact. We have called this Superior Environmental Impact Merit. This is analogous to artist merit in the case of artistic reuse of protected materials (Clemons et al., 2022d).

The following notation is useful:

- The Reduction in Environmental Impact is ΔEI
- The DAT $\equiv$ EI
- The change in tax resulting from improvement is ΔDAT $\equiv \Delta$EI.

Figure 1 below shows the impacts of the improved production process with Environmental Impact Merit. We can see by inspection that there is a decrease in the producer's profit-maximizing price and a reduction in the price paid by consumers. There is an increase in consumer surplus and an increase in total seller profit. There is no reduction in environmental impact because we have assumed that the DAT is sufficient to fully remediate any harm caused by the production of the protected product. Regulators should strongly encourage adoption of this process, even require this, even though there is no net change in environmental impact, because consumers are now able to purchase more of a product whose availability had been limited by environmental concerns. Moreover, since there is an increase in total profit, therefore there is money available for payments between the originator and the improver, as compensation for the improver's contribution to total social welfare.

Figure 1 displays a standard price-quantity demand curve for a monopolist seller, where willingness to pay drops linearly with a consumer's distance from the actual product in a hypothetical product attribute space. This representation has been used to study consumers' responses in markets as diverse as craft beer and voting for political candidates; see, for example, Clemons et al. (2006). For convenience and for ease of comparison we model two scenarios within a single figure. The left side represents the product market under the original production process, and the right side represents the same market under the new production process, with superior Environmental Impact Merit, and with lower DAT.

The tax DAT represents an increase in the price paid by the buyer and a cost that must be paid by the seller. Although it is paid by the buyer it does not contribute to the seller's profits, and thus plays a role exactly analogous to unit production costs in more traditional versions of this figure. P1 and P2 represent profit-maximizing prices; remember that the IP rights protection enjoyed by the producer creates an effective monopoly, allowing it to charge its profit-maximizing price. Q1 and Q2 represent the quantities sold, corresponding to these profit-maximizing prices. CS1 and CS2 represent aggregate consumer surplus, and Π1 and Π2 represent aggregate profits.

For algebraic simplicity, we set P and Q both equal to 1. Remember that we are assuming that the Originator enjoys monopoly pricing power through its control over its IP. Using the well-known result for determining a monopoly seller's profit-maximizing price we determine that P1 = ½ (P + DAT1) = ½ (1 + DAT1).

We can readily calculate that Q1 = Q * (P – P1)/P = Q * (1 – P1)/P = ½ (1 – (DAT1 + C))

Taking first derivatives we can easily see that reducing the tax DAT1 decreases the profit-maximizing price and increases total sales.

Figure 2 allows us to show how profits change as the DAT is reduced. The gain from reducing the price charged is shown in the narrow vertical box; this comes from increasing total sales volume. The loss from reducing the price charged is shown in the rectangular box; this comes from reducing the revenue on continuing sales volumes at the previous price. As we know from the definition of profit-maximizing price, the loss from decreasing the price would exceed the gain if nothing else changed. Here, the price drop results from calculating a new profit-maximizing price as taxes decrease, and the change in profits is positive.

As we derived above, Pi = ½ (1 + Di) and Qi = ½

(1 – Di).

Thus $\Delta P = \frac{1}{2} (D1 - D2) = \frac{1}{2} (DAT1 - DAT2) = \frac{1}{2} \Delta DAT$; the price charged decreases as taxes decrease.

$\Delta Q = \frac{1}{2} (1 - D1) - \frac{1}{2} (1 - D2) = - \frac{1}{2} \Delta DAT$; the quantity sold increases as taxes decrease.

The loss in profits =

$$\begin{aligned} \Pi Loss &= \Delta P * Q1 \\ &= \frac{1}{2} \Delta DAT * \frac{1}{2} (1 - D1) \\ &= \frac{1}{4} \Delta DAT - \frac{1}{4} D1 * \Delta DAT \end{aligned}$$

$$\begin{aligned} \Pi Gain &= (P2 - D2) * \Delta Q \\ &= (P2 - D2) * \frac{1}{2} \Delta DAT \\ &= ((\frac{1}{2} (1 + D2) - D2)) * \frac{1}{2} \Delta DAT \\ &= \frac{1}{2} (1 - D2) * \frac{1}{2} \Delta DAT \\ &= \frac{1}{4} \Delta DAT - \frac{1}{4} D2 * \Delta DAT \end{aligned}$$

Thus $\Delta\Pi = \frac{1}{4} (\Delta DAT)^2$. When $\Delta DAT = 0$ there is no change in profit, and when taxes are eliminated by setting DAT2 = 0 then the change in profits achieves its maximum value, $\frac{1}{4} (DAT1)^2$.

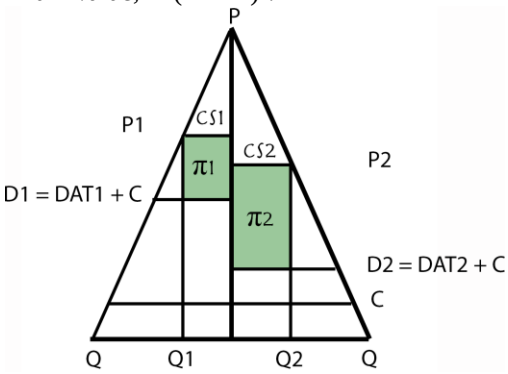

Figure 1. Market before and after process improvement, when process improvement reduces environmental impact, does not alter quality and does not alter cost.

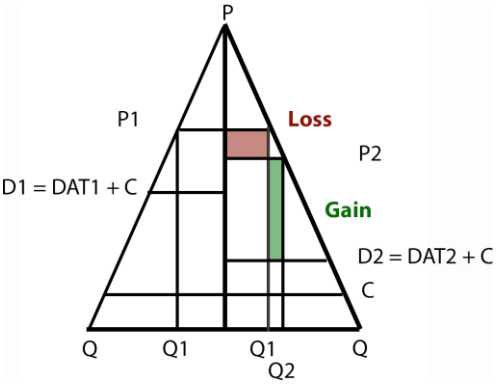

Figure 2. Geometric analysis of change in profitability when DAT is reduced.

There are alternative ways society could choose to share production between the originator and the improver: (1) If we are dealing with a fully contestable market (Baumol et al., 1983), without entry barriers or exit barriers, and without economies of scale in production or distribution, we would not care how society distributes production between the two parties. (2) Since these assumptions are seldom fully met in practice, we chose what will probably be the simpler mechanism to implement: The originator is allowed to retain monopoly rights to produce the protected product, and is required to pay the improver some portion of the increase in originator profits that would result from implementation of the improvement.

We note the following: first, that regulators can decide how to divide the increase in profits resulting from the improved production process. Moreover, regulators can determine when the payments to the improver should begin, since there will surely be expenses incurred in implementing the improvements to the production processes.

7. Conclusions

7.1. Contributions

The first contribution of this work is to make explicit the relationships among technological progress, punctuated equilibria in business practices, and punctuated equilibria in regulatory restrictions. There are times when change in business practices and the development of new business models are so profound that a change in regulatory philosophy is required. We believe that current changes in information technology and the changes in business practices that they enable do now require such a change in regulatory philosophy. Other studies have reached similar conclusions. Most prior studies of regulatory change driven by enhancements in information technology capability have concluded that restrictions need to be increased, including the need to restrict the power of search, or of online social media, or of online platforms and online sellers. In contrast, we study the reduction of regulatory restrictions. We provide mechanisms for assessing when regulatory relaxations should be considered and when it should be mandatory, and we provide numerous examples of where regulatory relaxation might be appropriate now or in the future.

The second contribution of the work is to examine in detail the reduction of IP protections to achieve a specific policy objective, the reduction of environmental degradation while improving consumer welfare. We discuss cases where consumer surplus is increased while holding environmental impact fixed, and cases where consumer surplus is increased and environmental impact is simultaneously reduced. And we describe the nature of transfer payments between the owner of the protected IP and the developer of improved processes, where these transfer payments can be set to achieve societal policy objectives that cannot be determined by economics alone. Our solutions are economically efficient, but only society can decide what is fair. One

possibility, which we have not yet explored, is to solve for the level of licensing fee that would make the Originator indifferent between paying the fee to use the new technology or accepting the fee to grant the Innovator permission to produce the protected item.

7.2. Limitations

We are hampered by a general lack of actual data on the full environmental costs associated with current goods and services and with the current process used to create them. We do not have data on the current cost of remediating the damage from these processes. We do not have data on new processes that have not yet been developed, nor do we have data on how these new processes will reduce quantities of specific pollutants, nor do we have data on how the costs of these new processes will differ from traditional production costs currently in use.

There is the possibility that the work is difficult to generalize to different problem domains. Our analysis of reductions in protection for reuse of protected content when the reuse has significant Creative Merit has little in common with our analysis of the reuse of protected product design when new production processes offer significant Environmental Impact Merit. We hope that consideration of more cases will lead to a single theory, based on a single result that applies across a range of domains.

And there are limitations to the applicability of the simple model we created. In many cases, the cost of remediation will be inestimably high. There is no easy way to remove particulate pollution once it has been released into the atmosphere, and the most reasonable approach to managing this form of pollution is to trap it at the source. In this case, our model would suggest that the dramatic reduction in environmental impact resulting from the new process would require that the owner of the IP would be forced to adopt the new process and share virtually all profits with the developer of the new process. Society might be unwilling to do this, rendering our model useless. Alternatively, society might indeed implement this policy, which would place enormous pressure on owners of protected IP to develop superior production processes themselves and thus to retain the increased profits from the innovation.

7.3. Directions for Future Research

First, there are the limitations to this model. We assume in section 6 that the new process does not alter customers' willingness to pay for the product that enjoys IP protection. This is not necessarily the case. The new process might result in a product with lower quality, lowering customers' maximum willingness to pay for it. Alternatively, consumers might feel that a product whose production results in lower environmental impact was of greater value and this might increase the maximum amount that consumers would be willing to pay for it. This is especially likely to be true if the DAT does not pay the full cost of environmental remediation.

Additionally, there is a large and emerging research literature on social welfare computing (Clemons et al., 2022e; Trzaskowski, 2022; Rowe et al., 2022; Clemons et al., 2022b), which seeks to increase the restrictions on large technology platform companies to reduce the harm that they cause to consumers without limiting innovation and without limiting the benefits that consumers receive from the services offered by these companies. This paper identifies two areas where consumers would benefit from relaxing restrictions. There are certainly more. The first step in our future research will be to identify and study several additional examples in order to develop a more complete understanding of areas where consumers benefit from regulatory relaxation, and in order to classify them according to some structural taxonomy. We will then work with this taxonomy and attempt to develop a general functional form for determining appropriate mechanisms to share the benefits that result from regulatory relaxation, and to apportion benefits among consumers, the original provider whose protections are being relaxed, and the innovators and improvers who are enabled by regulatory relaxation.

8. References

Anderson, P., & Tushman, M. L. (1991). Managing through cycles of technological change. *Research-Technology Management*, *34*(3), 26-31.

Baumol, W. J., Panzar, J. C., & Willig, R. D. (1983). Contestable markets: An uprising in the theory of industry structure: Reply. *The American Economic Review*, *73*(3), 491-496.

Bernardini, J. (2021). Leveraging Mandatory Licensing under the Clean Air Act-A Novel Framework to Domestic Reduction of Greenhouse Gases. *Environmental Law*, *51*(1), 301-332.

Brown, A. (2010). Companies Raise Intellectual Property Protection Issues. *National Defense*. http://www.nationaldefensemagazine.org/archive/2010/July/Pages/CompaniesRaiseIntellectualPropertyProtectionIssues.aspx

Clemons, E. K. (2018). *New Patterns of Power and Profit: A Strategist's Guide to Competitive Advantage in the Age of Digital Transformation*. Springer.

Clemons, E. K., Gao, G. G., & Hitt, L. M. (2006). When online reviews meet hyperdifferentiation: A study of the craft beer industry. *Journal of Management Information Systems*, *23*(2), 149-171.

Clemons, E. K., & Kleindorfer, P. R. (1992). An economic analysis of interorganizational information technology. *Decision Support Systems*, *8*(5), 431-446.

Clemons, E. K., Schreieck, M., Hermes, S., Rowe, F., & Krcmar, H. (2022a). The cooperation paradox. *Electronic Markets*, *32*(2), 459-471.

Clemons, E. K., Schreieck, M., Krcmar, H., & Bui, T. (2022b). Social Welfare Computing and the management and regulation of new online business models. *Electronic Markets*, *32*(2), 411-414.
Clemons, E. K., Schreieck, M., & Trzaskowski, J. (2022c). *New Business Models and the Need for Regulatory Change: Punctuated Equilibria, New Business Models, New Sources of Power, And New Abuses of Power* Platform Strategy Research Symposium, Boston.
Clemons, E. K., & Teilmann-Lock, S. (2022d). Revising Copyright Law to Match Technological Evolution: Maintaining an Optimal Balance between Supply of Innovation and Access to Innovation in an Era of Digital Transformation. *Research Policy (under review)*.
Clemons, E. K., & Waran, R. V. (2019). *The Use of Personal Data for Crafting and Precision Targeting of Fake News* 30th Workshop on Information Systems Economics, Munich, Germany.
Clemons, E. K., Waran, R. V., Hermes, S., Schreieck, M., & Krcmar, H. (2022e). Computing and Social Welfare. *Electronic Markets*, *32*(2), 417-436.
Darwin, C. (1872). *The Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* (6th ed. ed.). John Murray.
Díaz, S., Settele, J., Brondízio, E. S., Ngo, H. T., Agard, J., Arneth, A., Balvanera, P., Brauman, K. A., Butchart, S. H., & Chan, K. M. (2019). Pervasive human-driven decline of life on Earth points to the need for transformative change. *Science*, *366*(6471).
Eisenmann, T. R., Parker, G. G., & Van Alstyne, M. (2011). Platform Envelopment. *Strategic Management Journal*, *32*(12), 1270-1285.
European Commission. (2018). *Antitrust: Commission fines Google €4.34 billion for illegal practices regarding Android mobile devices to strengthen dominance of Google's search engine* https://ec.europa.eu/commission/presscorner/detail/en/IP_18_4581
Feng, W., Gu, B., & Cai, Y. (2016). The end of China's one-child policy. *Studies in family planning*, *47*(1), 83-86.
Gould, S. J. (2007). *Punctuated Equilibrium*. Belknap Press: An Imprint of Harvard University Press.
Gould, S. J., & Eldredge, N. (1972). Punctuated equilibria: an alternative to phyletic gradualism. In T. J. M. Schopf (Ed.), *Models in Paleobiology* (pp. 82-115). Freeman Cooper.
Hamilton, W. F. (1986). Corporate strategies for managing emerging technologies. In M. Horwitch (Ed.), *Technology in the modern corporation* (pp. 103-118). Elsevier.
Hayes, R. H., Wheelwright, S. C., & Clark, K. B. (1988). *Dynamic manufacturing: Creating the learning organization*. Simon and Schuster.
Healy, T. (2012). The unanticipated consequences of technology. In A. S. Khan (Ed.), *Nanotechnology: ethical and social Implications* (pp. 155-173).
Henderson, R. (1993). Underinvestment and incompetence as responses to radical innovation: Evidence from the photolithographic alignment equipment industry. *The RAND Journal of Economics*, *24*(2), 248-270.
Kianzad, B., & Wested, J. (2021). 'No-One Is Safe until Everyone Is Safe'-Patent Waiver, Compulsory Licensing and COVID-19. *European Pharmaceutical Law Review*, *5*(2), 71-91.
Lamichhaney, S. (2022). *Adaptive evolution in Darwin's Finches*. https://scholar.harvard.edu/sangeet/adaptive-evolution-darwins-finches, accessed on April 14, 2022.
Lamichhaney, S., Han, F., Berglund, J., Wang, C., Almén, M. S., Webster, M. T., Grant, B. R., Grant, P. R., & Andersson, L. (2016). A beak size locus in Darwin's finches facilitated character displacement during a drought. *Science*, *352*(6284), 470-474.
Marshall, T. (2008). Wicked Problems. In *Wörterbuch Design* (pp. 454-454). Springer.
MCI Communications Corp. v. AT&T Co., (7th Cir. 1983).
Parker, G. G., Van Alstyne, M. W., & Choudary, S. P. (2016). *Platform Revolution*. W. W. Norton & Company.
Pawson, R., Wong, G., & Owen, L. (2011). Known knowns, known unknowns, unknown unknowns: the predicament of evidence-based policy. *American Journal of Evaluation*, *32*(4), 518-546.
Pitofsky, R., Patterson, D., & Hooks, J. (2017). The essential facilities doctrine under US antitrust law. In R. Greaves (Ed.), *Dominance and Monopolization* (pp. 357-376). Routledge.
Potts, M. (2006). China's one child policy. *British Medical Journal*, *333*(7564), 361-362.
Rittel, H. W., & Webber, M. M. (1974). Wicked problems. *Man-made Futures*, *26*(1), 272-280.
Rowe, F., & Markus, M. L. (2022). Taking the measure of digital giants: Amazon and the social welfare computing research agenda. *Electronic Markets*, *32*(2), 437-446.
Schumpeter, J. A. (1994 [1942]). *Capitalism, Socialism and Democracy*. Routledge.
Secretariat of the Convention on Biological Diversity. (2020). *Global Biodiversity Outlook 5*.
The Henry Ford. (2022). *Leaded Gasoline Fuel Nozzle, 1992*. https://www.thehenryford.org/collections-and-research/digital-collections/artifact/140619, accessed on May 3, 2022.
Trzaskowski, J. (2021). *Your Privacy Is Important to Us! – Restoring Human Dignity in Data-Driven Marketing*. Ex Tuto Publishing.
Trzaskowski, J. (2022). Data-driven value extraction and human well-being under EU law. *Electronic Markets*, *32*(2), 447-458.
Tushman, M. L., & Anderson, P. (1986). Technological discontinuities and organizational environments. *Administrative Science Quarterly*, *31*(3), 439-465.
Tushman, M. L., & Romanelli, E. (1985). Organizational evolution: A metamorphosis model of convergence and reorientation. *Research in Organizational Behavior*, *7*, 171-222.
Ullrich, H. (2015). Mandatory licensing under patent law and competition law: different concerns, complementary roles. In R. M. Hilty & K.-C. Liu (Eds.), *Compulsory Licensing* (pp. 333-375). Springer.
Wallace, A. R. (1962). *The Malay Archipelago: the land of the orang-utan and the bird of paradise; a narrative of travel, with studies of man and nature*. Courier Corporation.