TECHNOLOGICAL PROGRESS AND RENT SEEKING *

Vincent Glode Guillermo Ordoñez

University of Pennsylvania

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Abstract

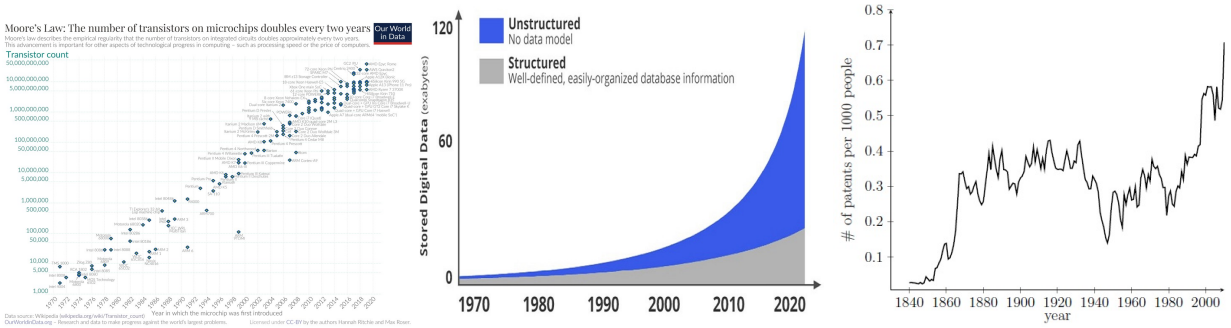
We model firms' allocation of resources between surplus-creating (a.k.a., productive) and surplus-appropriating (a.k.a., rent-seeking) activities. We show that industry-wide technological advancements, such as the recent progress in the collection and processing of big data, induce a disproportionate and socially inefficient allocation of resources towards surplus appropriation, even when the associated productivity gains are far larger for surplus-creating activities than for surplus-appropriating activities. As technology improves, firms lean more on rent seeking to obtain their profits, endogenously reducing the impact of technological progress on economic progress and inflating the price of the resources used for both types of activities.

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1 Introduction

The last few decades have featured exceptional technological progress, as evidenced by striking increases in computer processing power, data availability, and patented innovation (see Figure 1). Standard economic theories highlight the importance of technological progress that boosts firms' productivity in generating long-term economic growth. Technological advancements embodied in capital, in labor, in methods used to combine inputs, and in the creation of new varieties of intermediate goods can all increase the output of an economy persistently. Yet, in light of exceptional technological progress, U.S. economic growth has surprisingly slowed down in recent decades (see Table 1). It has been argued that this observation, sometimes referred to as the "productivity paradox" or the "Solow paradox", could be due to productivity mismeasurements, to lags in technology adoption, or even to information technologies and social media distracting workers (see, e.g., Brynjolfsson, Benzell and Rock 2020).



(a) Transistors per microchip **(b)** Stored digital data **(c)** U.S. patents, scaled per capita

Figure 1

Technological growth. Panel (a) plots the exponential growth in computer processing power, as measured by the number of transistors included in various types of microchips (adapted from Roser and Ritchie 2013). Panel (b) plots the explosion in stored digital data (adapted from Durant 2020). Panel (c) plots the number of U.S. patents scaled per capita (adapted from Kelly et al. 2021).

Omitted from the discussion, however, is the impact of technological advancements on the rent-seeking behaviors of agents in the economy. In this paper, we model firms' optimal allocation of resources between surplus-creating (i.e., productive) and surplus-appropriating (i.e., rent-seeking)

Table 1
Real U.S. GDP growth per decade.

Decade	Avg. U.S. real GDP growth per year
1951-1960	3.64%
1961-1970	4.29%
1971-1980	3.19%
1981-1990	3.34%
1991-2000	3.45%
2001-2010	1.78%
2011-2020	1.64%

Data Source: Federal Reserve Economic Data website (https://fred.stlouisfed.org/series/GDPC1)

activities to uncover the impact of technological progress on firms' incentives to appropriate other firms' surpluses. We show that a technological innovation that improves productivity for an entire industry or economy generically induces a disproportionate and socially inefficient allocation of resources towards surplus-appropriating activities. While this prediction would be trivial if restricted to innovations that mainly facilitated surplus-appropriating tasks, it holds in our model even when the productivity gains induced are far larger for surplus-creating activities than for surplus-appropriating activities. In fact, as long as a technological innovation ameliorates *to some extent* firms' ability to appropriate their rivals' surplus, firms respond to it by shifting a larger share of their resources towards surplus appropriation.

Whereas industry-wide improvements in the technology used to appropriate others' surplus amplify the payoff of surplus-appropriating activities and reduce the payoff of surplus-creating activities, improvements in the technology used to create surplus amplify the payoffs of both activities in lockstep. Put simply, efforts to appropriate others' surpluses are more profitable when others have larger surpluses to appropriate. While we keep our analysis as transparent as possible by relying on the simplest set of assumptions, this fundamental insight generalizes to other specifications in which technology increases the surplus that can be appropriated.

As a result, industry-wide technological innovations that improve firms' abilities to create as

well as appropriate economic surplus, albeit to possibly different extents, cause these firms' incentives to appropriate others' surplus to increase disproportionately more than their incentives to create additional surplus. As technology keeps improving, the economy gradually moves from a *productive* economy to a *rent-seeking* economy, weakening the link between technological progress and economic progress so that any innovation translates less and less into higher output. Due to this overinvestment in surplus-appropriating activities, aggregate output is a concave, potentially non-monotone function of technology quality.

The disproportionate allocation of resources to non-productive activities may also raise the price of resources above what it would be in a benchmark economy without rent seeking. In this sense, the negative pressure of technological advancements on the economy does not only manifest itself in a higher share of the economy's resources being inefficiently allocated to surplus-appropriating activities, but also in a higher price paid for the resources needed to perform these activities (which often happen to be the same kind of resources that are used to create social surplus).

Although the expression "rent seeking" is sometimes used to specifically refer to lobbying activities and the interactions of private agents with a public authority, our analysis is more general and encompasses any activity aimed at appropriating the surplus of other agents, thereby generating a wedge between its private and social marginal values. As part of our analysis, we explore how our insights can be applied to various types of surplus-appropriating activities and shed light on their rising magnitude and compensation over the last few decades. Our model highlights how these activities become more attractive as the rest of the economy performs better and the surplus that can be appropriated expands. Central to our arguments is the recognition that recent technological advancements that made information gathering, transportation, and communication easier and more effective did not only help with the creation of surplus but also with its appropriation. Big data, machine learning, and artificial intelligence, for instance, affected both the creation and appropriation of surplus. Within a research and development context, these technologies could

be used to innovate, but also to reverse engineer and copy rivals' innovations. For legal and tax reporting services, they facilitated reporting processes, but also made it easier to sue others and take advantages of tax loopholes in multiple jurisdictions. In the finance industry, data and modeling innovations improved the allocation of credit and the monitoring of funded projects, which generate a more efficient use of capital, but they also facilitated various speculative activities, such as high-frequency trading in centralized stock markets. Our model predicts an overinvestment of resources in the latter type of activities and an inflated price for those resources.

Our model can also be extended to speak to firms' investments to protect their own surplus from rivals' appropriation efforts. It can also be modified to encompass activities aimed at appropriating consumers' surplus, as opposed to rival firms' profits. Our analysis suggests that technological advancements commonly expected to amplify the surplus created by an industry might instead result in an increase in the resources being used to create captive consumer demand through marketing, to collude with rivals, and/or to prevent entry into the industry, all to the detriment of consumers.

Moreover, our rationale for the disproportionate investments in activities aimed at appropriating others' surplus, even when technology facilitates surplus creation to a much greater extent, applies beyond the recent informational revolution. It sheds light on the impact of earlier technological improvements on economic progress: agricultural and farming technologies that led to better nutrition as well as wars and invasions, weapons that helped with hunting as well as stealing, and transportation technologies that facilitated trading of goods but also an expansion of speculative and stealing activities.[1] We identify an understudied, yet fundamental, dampening effect of surplus appropriation on the long-run relationship between technological progress and economic progress, which points toward the heightened relevance of identifying, regulating, taxing, and/or curbing rent-seeking activities as technology improves.

[1] See, e.g., Reames and Haverkost (2021) for a discussion of the relationship between agriculture and warfare in ancient Greece, Cook and van Ludwig (2003) for empirical evidence on the relationship between gun ownership and house burglaries, and Koudijs (2015) for empirical evidence on the prevalence of insider trading through official mail packet boats in 18th-century Amsterdam.

Literature review. Our paper contributes to the large literature connecting technological improvements with economic output. In the celebrated growth model of Solow (1957), long-term economic growth is purely driven along the balance-growth path by the growth rate of productivity, which is determined by technological improvements. Our work suggests that the connection between technological productivity and economic output becomes weaker over time due to the endogenously increased presence of rent-seeking activities. In this sense, rent seeking should be added to the forces commonly identified in the literature (e.g., Barro 1999) as being part of the Solow residual, such as spillovers, increasing returns, taxes, and various types of factor inputs. Further, the relevance of the "rent-seeking residual" increases with the technological progress and becomes more and more relevant over time.

Our paper thus helps rationalize the prevalence of surplus-appropriating activities in the economy. The seminal paper by Murphy, Shleifer, and Vishny (1991) studies the occupational choice of agents between productive and rent-seeking sectors, highlighting how this choice depends on the returns to ability and scale in each sector. When the returns from rent seeking are increasing in the intensity of rent-seeking efforts, multiple equilibria might exist and agents' occupational choices may lead to lower growth, a channel that is further highlighted in Murphy, Shleifer, and Vishny (1993). While these papers already make the case that rent seeking slows economic progress, our work expands our understanding of this relationship in several ways. First, we focus on technological progress and its effect on rent seeking, highlighting how the realistic possibility of increased productivity for surplus appropriation, concurrently with increased productivity for surplus creation, might significantly distort the mapping between technology and output. Second, instead of studying a worker's occupational choice as is done in these papers, we study a firm's choice of how to allocate resources at an intensive margin, not present in models of occupational choice: all agents in our model (i.e., firms) can both create and appropriate surplus from others.

Our analysis of the equilibrium price of resources also relates our paper to the literature on the compensation of superstars and other scarce resources, which identifies conditions under which

the prices of production factors may appear to be excessive (see, e.g., Rosen 1981). Although our model does not target a specific sector of the economy, it can be used to understand why Greenwood and Scharfstein (2013) observe positive trends in the relative economic importance of the financial sector, including activities that match our description of surplus appropriation, while Philippon and Reshef (2012) and Célérier and Vallée (2019) observe large increases in the prices paid for an essential resource in this sector: skilled workers.[2] Philippon (2010), Glode, Green, and Lowery (2012), Fishman and Parker (2015), Glode and Lowery (2016), Biais and Landier (2020), and Berk and van Binsbergen (2022) already propose models in which resources are invested in financial activities that do not benefit society, but our paper shows how the scale and compensation associated with these activities respond to waves of technological innovation.

Another related literature studies the optimal taxation of income produced by economic activities that generate negative externalities, like rent seeking in our model. Lockwood, Nathanson, and Weyl (2017) measure the negative externalities across several sectors, and conclude that rent-seeking behaviors are particularly prominent in the financial and legal sectors. Their evidence is cited by Rothschild and Scheuer (2016) to justify adjusting taxation schemes to account for rent-seeking externalities and thereby reduce the inefficient allocation of talent (see also Scheuer and Slemrod 2021, for a discussion specifically focused on the role played by a wealth tax). Our analysis highlights how technological innovation amplifies the negative impact of surplus-appropriating activities on economic productivity, thereby increasing the importance of designing policies that curb the inefficient allocation of talent and other scarce resources.

Finally, our paper relates to the burgeoning literature studying the effects of recent technological improvements in the collection, processing, and management of big data. Farboodi and Veldkamp (2020) highlight how improvements in information technology induce traders to focus on acquiring information about others' trades rather than about assets' fundamental values, while Farboodi and Veldkamp (2022) highlight the complementarity between data accumulation and firm

[2]See Zingales (2015) for arguments consistent with the idea that some (but not all) financial activities match our description of surplus appropriation, a.k.a., rent seeking.

size. Although our paper differs by linking technology and economic progress through the allocation of resources towards surplus appropriation, we share with this literature the call for a better understanding of the nuanced impact of new information technologies on the economy.

In the next section, we present a theoretical environment in which firms decide how to allocate their resources across surplus-creating and surplus-appropriating activities. We show how industry-wide technological progress impacts this allocation of resources, the price of resources, and the aggregate economic output in Section 3. We show that our main insights survive various extensions to our baseline model in Section 4 and relate these insights to prevalent forms of rent-seeking activities in Section 5. The last section concludes.

2 Model

Suppose a firm $i \in I$ has a positive supply of resources denoted b_i. The firm can choose to allocate a quantity $s_i \geq 0$ of these resources to *create* (social) surplus using a production function $\pi_i(s_i)$, and a quantity $x_i \geq 0$ of resources to *appropriate* a fraction $\alpha_i(x_i) \in [0,1]$ of a rival firm's surplus, such that $s_i + x_i \leq b_i$. (To fix ideas, it might help to think of these resources as labor, and each firm chooses how to allocate its workforce between the two types of activities.) For simplicity, assume for now that firm i has a single rival $j \neq i$ in the industry from which it can appropriate surplus, and vice-versa symmetrically. Firm i's payoff is then given by:

$$\pi_i(s_i) \cdot [1 - \alpha_j(x_j)] + \pi_j(s_j) \cdot \alpha_i(x_i). \tag{1}$$

The only restrictions we impose on the model is that, for all $i \in I$, $\pi_i(\cdot)$ and $\alpha_i(\cdot)$ are increasing, concave functions and $\alpha_i(\cdot) \in [0,1]$. By having $\alpha_i(x_i)$ multiplying $\pi_j(s_j)$ and vice-versa, the assumed payoff function aims to cleanly capture the simple, yet general idea that efforts to appropriate others' surpluses are more profitable when others have larger surpluses to appropriate.

This focus on surplus appropriation contrasts our environment from Hirshleifer's (1995), where rent-seeking efforts are modeled as resource-appropriation attempts.[3] In Section 5, we show how the payoff function (1), with $\alpha_i(x_i)$ multiplying $\pi_j(s_j)$ and vice-versa, can be micro-founded in various rent-seeking contexts, including those mentioned in the introduction. In Section 4, we also show how our results survive various modifications to this payoff function (while maintaining the aforementioned property). For instance, we extend the analysis to allow a firm's investment x_i to also help protect its surplus from the appropriation efforts of a rival firm. In that context, the relative importance of surplus appropriation vs. protection incentives is determined by the specific shape of $\alpha_i(\cdot)$, but the allocation of resources between these socially unproductive activities and surplus-creating activities remains determined by the forces highlighted in our baseline model below.

Given payoff function (1), firm i finds it optimal to allocate its resources to satisfy the first-order condition:

$$\pi_i'(s_i) \cdot [1 - \alpha_j(x_j)] = \pi_j(s_j) \cdot \alpha_i'(x_i),$$

where $s_i + x_i = b_i$. In order to capture technological progress, we assume for now that each firm's surplus-creation function $\pi_i(\cdot)$ and surplus-appropriation function $\alpha_i(\cdot)$ can be decomposed into an exogenous firm-specific technology parameter and a concave function of the resources the firm invests in that specific activity. That is, we let $\pi_i(s_i) \equiv \phi_{y,i} \cdot y(s_i)$ and $\alpha(x_i) \equiv \phi_{a,i} \cdot a(x_i)$. This parameterization assumes that increases in productivity come from technological changes improving *total factor productivity*, but we will show in Section 4 that our insights also apply to *factor-augmenting* technological changes within Cobb-Douglas production functions.

The firm's first-order condition then becomes:

$$\phi_{y,i} \cdot y'(s_i) \cdot [1 - \phi_{a,j} \cdot a(x_j)] = \phi_{y,j} \cdot y(s_j) \cdot \phi_{a,i} \cdot a'(x_i).$$

[3] See also Skaperdas (1992) who studies the equilibrium properties of various functional forms for rent-seeking payoffs, but does not consider technological progress and its economic implications, which are the focus of our paper.

This first-order condition delivers intuitive implications. Ceteris paribus (which includes keeping firm j's actions fixed), when firm i becomes individually more productive in creating surplus (i.e., $\phi_{y,i}$ increases), firm i finds it optimal to allocate more resources towards surplus-creating activities. When instead firm i becomes individually more productive in appropriating surplus from the other firm (i.e., $\phi_{a,i}$ increases), it finds it optimal to allocate more resources towards surplus-appropriating activities. Together, we get the natural implication that each firm responds to a firm-specific technological advancement by tilting its allocation of resources towards the activities whose productivity benefits most from the advancement. Again, this logic holds in partial equilibrium and in response to firm-specific improvements in technology. In the next section, we analyze what happens when firms are hit simultaneously by an industry-wide technological advancement, and highlight the consequences of technological progress in general equilibrium.

3 Industry-Wide Technological Progress

We now investigate how firms' resource allocation changes with technological progress that affects a firm and its rival(s) equally. In particular, we set $\phi_{a,i} = \phi_{a,j} \equiv \phi_a$ and $\phi_{y,i} = \phi_{y,j} \equiv \phi_y$. We assume that these industry-wide parameters, which capture broad technological improvements such as increased availability of data and more powerful computers, are exogenous to the firms' actions (we revisit the distinction between industry-wide and firm-specific innovations when applying our model to a research and development context as part of Section 5). In contrast to the previous section, we account for the fact that, in equilibrium, a firm has to react to the best response of its rival(s).

With industry-wide technology parameters, firm i's first-order condition becomes:

$$y'(s_i) \cdot [1 - \phi_a \cdot a(x_j)] = y(s_j) \cdot \phi_a \cdot a'(x_i). \tag{2}$$

The industry-wide technology parameter associated with surplus creation, ϕ_y, disappears from the first-order condition. The optimal allocation of resources is therefore unaffected by any industry-wide improvement in the productivity of firms' surplus-creating activities. The reason for this is that this type of technological progress boosts a firm's rewards to surplus creation in the same proportion it boosts the rewards from appropriating its rival's (now larger) surplus.

On the other hand, the industry-wide productivity of surplus-appropriating activities, ϕ_a, still enters the first-order condition. Ceteris paribus, a higher ϕ_a means that the left-hand side of (2) is lower while the right-hand side is higher. Firm i's optimal allocation of resources thus requires a smaller s_i and a larger x_i in response to an increase in ϕ_a. Altogether, these observations imply that any technological progress that increases the productivity of surplus-appropriating activities results in a larger share of the firm's resources being allocated to surplus appropriation, regardless of the extent to which the technological progress boosts the productivity of surplus-creating activities.

3.1 Allocation of resources

In our model, the term $\pi_j(s_j) \cdot \alpha_i(x_i)$ represents a transfer from firm j to firm i, which per se does not reduce the overall surplus in the economy. As previously discussed by Tullock (1967) with regards to activities such as theft, what ends up reducing the social surplus is that firm i invests a quantity $x_i > 0$ of resources in transferring surplus rather than in creating it. We now characterize the equilibrium allocation of resources between the two activities.

While predicting a firm's response to a change in industry-wide productivity levels is easy when holding its rival's allocation of resources fixed, what happens in equilibrium is not as immediate. Since firm i is expected to tilt its allocation of resources more towards surplus appropriation in response to technological progress that boosts ϕ_a, the marginal benefit firm j accrues from creating more surplus might decrease even if ϕ_y increases. Moreover, the effect of technological progress on the marginal benefit of appropriating firm i's surplus combines a decrease in resources invested by firm i in surplus creation with a higher productivity per unit invested.

To understand how all these effects combine in equilibrium, we characterize a symmetric equilibrium by considering any pair of symmetrically-impacted and behaving firms. Dispensing from the sub-indices i and j, equation (2) can then be re-written as:

$$y'(b-x^*)\cdot[1-\phi_a\cdot a(x^*)]-y(b-x^*)\cdot\phi_a\cdot a'(x^*)=0. \tag{3}$$

If we differentiate the left-hand side of the first-order condition in (3) by x^*, we get:

$$-y''(b-x^*)\cdot[1-\phi_a\cdot a(x^*)]-y(b-x^*)\cdot\phi_a\cdot a''(x^*),$$

which is strictly positive whenever either $a(\cdot)$ is strictly concave or $y(\cdot)$ is strictly concave and $\alpha(x^*)$ (i.e., $\phi_a\cdot a(x^*)$) remains a fraction smaller than 1. Thus, under fairly standard assumptions, the first-order condition in (3) can only be satisfied with one level of x^* and, as a result, there exists only one symmetric equilibrium.

As highlighted through firm i's first-order condition, any variation or cycle in the productivity of surplus creation ϕ_y that is not associated with a change in ϕ_a would have no impact on the optimal allocation of resources in the economy. The allocation of resources between surplus-creating and surplus-appropriating activities only depends on the absolute productivity of the latter (i.e., ϕ_a), regardless of the level of the former (i.e., ϕ_y). By applying the implicit function theorem to the first-order condition in (3), we can solve for how a marginal change in ϕ_a would affect the equilibrium investment in surplus appropriation x^*:

$$\frac{\partial x^*}{\partial \phi_a}=-\frac{y'(b-x^*)\cdot a(x^*)+y(b-x^*)\cdot a'(x^*)}{y''(b-x^*)\cdot[1-\phi_a\cdot a(x^*)]+y(b-x^*)\cdot\phi_a\cdot a''(x^*)}. \tag{4}$$

This expression is strictly positive whenever either $a(\cdot)$ is strictly concave or $y(\cdot)$ is strictly concave and $\alpha(x^*)$ remains a fraction smaller than 1. Thus, under the same fairly standard assumptions as above, technological progress is expected to lead to more (socially inefficient) investment of

resources in surplus appropriation. Yet, as we show below, the surplus created by each firm, i.e., $\pi(s^*) = \phi_y \cdot y(s^*)$, might still increase when technological progress significantly boosts the productivity of surplus-creating activities, ϕ_y.

3.2 Price of resources

We now consider the case in which firms have to compete for resources, that is, they are not endowed with a budget of resources b but instead have to pay for each unit of resources they acquire. We assume that the set of firms I competing for these resources is large enough such that each firm bids competitively for the same supply of resources.[4] In that case, the equilibrium price of resources, which we denote by w^*, is determined by the marginal benefit of investing more resources in either type of activities:

$$w^* \equiv \phi_y \cdot y'(b - x^*) \cdot [1 - \phi_a \cdot a(x^*)] = \phi_y \cdot y(b - x^*) \cdot \phi_a \cdot a'(x^*).$$

We can compare the equilibrium price of resources to what it would be in a benchmark economy that does not admit rent-seeking activities: $\phi_y \cdot y'(b)$. We refer to this quantity as the "marginal social value of resources", since it captures an alternative benchmark in which all resources are allocated efficiently to increase surplus, that is, without any diversion of resources to appropriate economic surplus already created. This benchmark also captures the standard practice in growth models of abstracting from rent-seeking activities.

If we focus our attention on how the resources allocated to surplus appropriation affect the marginal benefit of investing in surplus creation, we observe two forces going in opposite directions. First, the fact that a fraction $[1 - \phi_a \cdot a(x^*)]$ of the surplus a firm creates is appropriated

[4] If the number of firms competing for the same resources was small and these firms were all rivals within the same industry, the equilibrium price of resources could be inflated by what Glode and Lowery (2016) call a "defense premium": firm i would be willing to pay a premium to outbid rival firm j and prevent it from acquiring resources that could be used to steal firm i's surplus. We shut down this strategic bidding behavior from our model since it is superfluous to our paper's key insights.

by a rival firm lowers the marginal value of allocating resources to surplus creation. Second, the fact that a firm finds it optimal to allocate resources to surplus appropriation reduces the quantity of resources allocated to surplus creation and increases its marginal benefit, $\phi_y \cdot y'(b - x^*)$, when $y(\cdot)$ is strictly concave. Overall, the existence of rent-seeking opportunities leads resources to be "overpriced" in a symmetric equilibrium whenever:

$$y'(b - x^*) \cdot [1 - \phi_a \cdot a(x^*)] > y'(b).$$

This condition is most likely to be satisfied when $y(\cdot)$ is highly concave and the level of surplus appropriation remains low in equilibrium. Our prediction that within-firm misallocation of resources can inflate the price of these resources stands in contrast to the standard relationship between across-firm misallocation and prices (see a complete discussion in Restuccia and Rogerson 2017, Dou et al. 2022, and the references therein).

3.3 Firm output

We now analyze how industry-wide technological progress affects firm output. While most technological advancements should improve the productivity of surplus-creating activities, our analysis highlights that the benefits are mitigated by firms' overinvestment of resources in surplus-appropriating activities. Consider a technological progress that improves the productivity of each type of activities by $d\phi_y > 0$ and $d\phi_a > 0$, respectively. Then, equilibrium firm output, as measured by $\phi_y \cdot y(b - x^*)$, should increase by:

$$y(b - x^*) \cdot d\phi_y - \phi_y \cdot y'(b - x^*) \cdot \frac{\partial x^*}{\partial \phi_a} \cdot d\phi_a.$$

The first term in this expression captures the increase in surplus creation for a given equilibrium allocation of resources whereas the second term captures the impact of the reallocation of resources

in response to $d\phi_a$ (recall that $d\phi_y$ does not affect firms' resource allocation decisions).

The resulting increase in firm output is inferior to what it would be under the benchmark allocation without rent seeking, that is, if all resources were allocated to surplus creation: $y(b) \cdot d\phi_y$. Moreover, the wedge between the benchmark and equilibrium output levels is affected by the current technology parameters ϕ_y and ϕ_a in a non-linear way (recall the expression for $\frac{\partial x^*}{\partial \phi_a}$ derived in equation (4)). In what follows we parameterize the model to provide a numerical illustration in which the allocation of resources towards surplus appropriation becomes so relevant that the relationship between technological quality levels and equilibrium firm output is concave, and even negative in some cases.

3.4 Numerical Illustration

To further illustrate our insights, we parameterize the model by setting $a(x) = \frac{x}{1+x}$ and $y(s) = \frac{s}{1+s}$. The first-order condition that characterizes the optimal allocation of resources in a symmetric equilibrium becomes:

$$\frac{1}{(1+b-x^*)^2} \cdot \left[1 - \phi_a \cdot \frac{x^*}{1+x^*}\right] = \frac{b-x^*}{1+b-x^*} \cdot \phi_a \cdot \frac{1}{(1+x^*)^2},$$

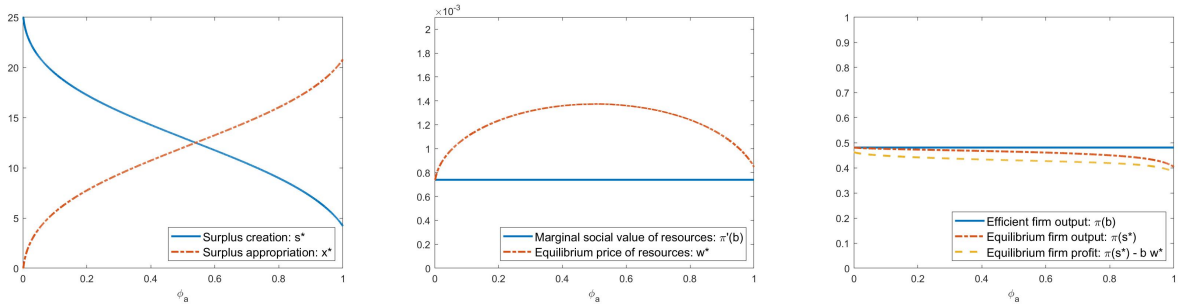
which pins down x^* as a function of the supply of resources, b, and the productivity of surplus-appropriating activities, ϕ_a, independently of the productivity of surplus-creating activities, ϕ_y. The equilibrium price of resources is given by:

$$w^* = \phi_y \cdot \frac{1}{(1+b-x^*)^2} \cdot \left[1 - \phi_a \cdot \frac{x^*}{1+x^*}\right] = \phi_y \cdot \frac{b-x^*}{1+b-x^*} \cdot \phi_a \cdot \frac{1}{(1+x^*)^2},$$

which depends on the productivity of surplus-creating activities, ϕ_y.

To highlight the impact of technological progress on the industry, we start with a simple scenario where technological progress is assumed to only improve the productivity of surplus-

appropriating activities. This scenario allows to emphasize the perverse effect of excessively allocating resources to surplus-appropriating activities in response to industry-wide technological progress. Later, we will extend our analysis by allowing technological progress to facilitate both surplus creation and appropriation and illustrate our main results.



(a) Allocation of resources **(b)** Price of resources **(c)** Firm output/profit

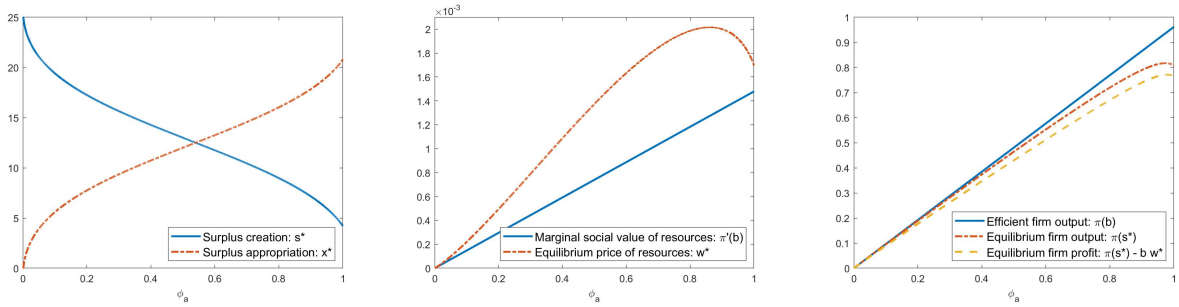
Figure 2

Impact of technological progress in surplus-appropriating activities only. The graphs illustrate how varying the productivity of surplus-appropriating activities (i.e., ϕ_a), while keeping the productivity of surplus-creating activities constant (i.e., $\phi_y = 0.5$), affects the optimal allocation of resources, the resulting price of resources, firm output and profit when each firm gains access to a supply $b = 25$ of resources.

Figure 2 plots, for a fixed level of ϕ_y and changing levels of ϕ_a, the optimal allocation of resources, the resulting price of resources, firm output and profit. Panel (a) shows that surplus appropriation is effectively shut down when $\phi_a = 0$. As in our alternative benchmark without rent seeking, all resources are then invested in surplus creation (i.e., $x^* = 0$ whereas $s^* = b$). However, as we increase ϕ_a, firms start to allocate more and more resources to surplus-appropriating activities. Due to the concavity of functions $y(\cdot)$ and $a(\cdot)$, the split of resources between surplus creation and appropriation inflates the price that firms are willing to pay for resources (i.e., w^*) above the marginal social value of these resources (i.e., $\pi'(b)$), as shown in Panel (b). Yet, once ϕ_a gets sufficiently large, firms invest so much of their resources into surplus appropriation that it starts reducing how much firms value additional resources in equilibrium. This behavior explains the hump shape of the price function, which reaches its maximum when the economy displays an intermediate mix of resources used to create as well as to appropriate surplus. Panel (c) shows

that this allocation of resources leads firm output $\pi(s^*)$ to decrease and get further away from the benchmark level of output $\pi(b)$ as we increase ϕ_a. Once we account for the high price of acquiring these resources in equilibrium, we observe that firm profit can also decrease with industry-wide technological progress that solely improves the productivity of surplus-appropriating activities.

We now explore a richer and arguably more plausible scenario in which technological progress improves the productivity of both types of activities: surplus creation and appropriation. In contrast with the previous scenario, this scenario allows for a positive effect of technology quality on economic output. Specifically, Figure 3 plots the equilibrium allocation of resources, the resulting price of resources, firm output and profit when the technological productivity levels of surplus creation and appropriation are assumed to move in parallel, i.e., $\phi_y = \phi_a$.



(a) Allocation of resources **(b)** Price of resources **(c)** Firm output/profit

Figure 3

Impact of equal technological progress in both types of activities. The graphs illustrate how varying the productivity levels of surplus-appropriating activities and surplus-creating activities in parallel (i.e., $\phi_y = \phi_a$) affects the optimal allocation of resources, the resulting price of resources, firm output and profit when each firm gains access to a supply $b = 25$ of resources.

Although ϕ_y and ϕ_a are now moving together and technological progress facilitates equally the creation and appropriation of surplus, Panel (a) shows that firms still find it optimal to allocate more of their resources to surplus appropriation in response to industry-wide technological progress. In fact, Panel (a) of Figure 3 is identical to Panel (a) of Figure 2. As was clear from equation (2), any industry-wide technological progress in surplus creation boosts a given firm's rewards from creating surplus in the same proportion that it boosts the rewards from appropriating its rival's

(now larger) surplus. Thus, the level of ϕ_y does not enter a firm's optimal allocation decision and any industry-wide technological progress to both types of activities directly results in further overinvestment in surplus appropriation. While the marginal social value of resources is increasing in ϕ_y, we see from Panel (b) that the equilibrium price of resources remains inflated due to the inefficient investment of resources in surplus-appropriating activities. Moreover, we can see from Panel (c) of Figure 3 that equilibrium firm output is concave in technology quality, unlike the socially efficient level of output. While industry-wide technological progress is treated in our model as an exogenous force that linearly induces higher economic output, its effect is dampened by firms' endogenous reallocation of resources towards rent-seeking activities. This countervailing force is the reason for the concavity of the equilibrium output function and can be so dramatic that technological progress may result in a drop in firms' output and profit when the technology parameters are large enough.

Finally, Figure 4, which zooms in on the region where $\phi_y = \phi_a \in [0.75, 1]$, emphasizes how strong the negative impact of firms' misallocation of resources can be. In this region, the negative impact of resource misallocation dominates the positive impact of higher technological productivity on firms' output and profit. Thus, improvements in technology are accompanied by reductions in aggregate output and profits.

4 Extensions

In the analysis above, we derived our main insights in what we considered to be the most natural theoretical setting — we focused on keeping our analysis as simple and transparent as possible. However, we now show that our main insights extend to a variety of alternative environments.

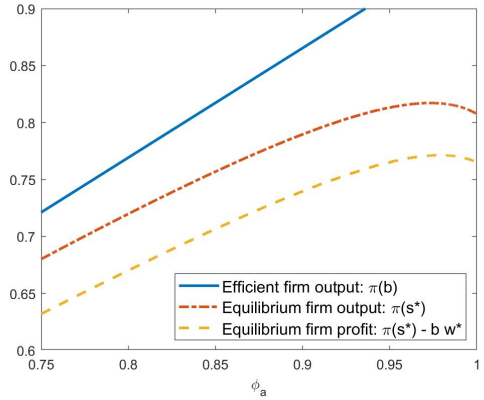


Figure 4

Non-monotonic impact of technological progress in both types of activities on firm output/profit. The graph illustrates how varying the productivity levels of surplus-appropriating activities and surplus-creating activities in parallel (i.e., $\phi_y = \phi_a$) affects firm output and profit for high productivity levels when each firm gains access to a supply $b = 25$ of resources.

4.1 Multiple rival firms

For tractability, our baseline analysis assumed that each firm i was appropriating the surplus of one rival firm (i.e., firm j) and vice-versa. However, our insights survive in an environment where firms have several rivals competing for their surplus. If firm i has N rivals, its payoff becomes:

$$\pi_i(s_i) \cdot \left[1 - \sum_{j=1}^{N} \alpha_j(x_j)\right] + \sum_{j=1}^{N} \pi_j(s_j) \cdot \alpha_i(x_i).$$

With industry-wide technology parameters, firm i's first-order condition becomes:

$$y'(s_i) \cdot \left[1 - \phi_a \cdot \sum_{j=1}^{N} a(x_j)\right] = \sum_{j=1}^{N} y(s_j) \cdot \phi_a \cdot a'(x_i).$$

A firm's optimal allocation of resources behaves similarly, from a qualitative standpoint, when $N > 1$ as it did in our baseline model (where $N = 1$). In particular, the productivity of surplus creation ϕ_y does not enter the first-order condition, which implies that technological advancements tilt the allocation of resources for all firms towards surplus appropriation whenever such advancements increase ϕ_a.

4.2 Surplus appropriation and protection

In our baseline analysis, we assumed that firm i could invest resources to appropriate firm j's surplus and vice-versa. In reality, firms might similarly use their resources to protect their own surplus from rivals' rent-seeking efforts, which still represents a socially wasteful allocation of scarce resources (see, e.g., Tullock 1967, for a discussion). A simple way to extend our model for this possibility is to assume that firm i's investments in surplus-appropriating activities have the added benefit of reducing rival firms' ability to appropriate firm i's surplus. For example, a technology firm can build a legal department aimed at finding loopholes in rival firms' patents *and* protecting the firm's own patents from infringement by rival firms (evidence of these practices has been recently provided by Argente et al. 2020).

In such instance, firm i's ability to appropriate firm j's surplus can be modeled as a function of firm i's investment in surplus-appropriating activities relative to that of firm j. Formally, using notation similar to our baseline analysis we can denote each firm's payoff as:

$$\pi_i(s_i) \cdot [1 - \alpha_j(x_j - x_i)] + \pi_j(s_j) \cdot \alpha_i(x_i - x_j). \tag{5}$$

With industry-wide technology parameters, the first-order condition becomes:

$$y'(s_i) \cdot [1 - \phi_a \cdot a(x_j - x_i)] = \phi_a[y(s_i) \cdot a'(x_j - x_i) + y(s_j) \cdot a'(x_i - x_j)].$$

As in the baseline model, the productivity of surplus-creating activities drops out of the first-order condition. Moreover, in a symmetric equilibrium, the first-order condition can be written as:

$$y'(b - x^*) \cdot [1 - \phi_a \cdot a(0)] - 2\phi_a \cdot y(b - x^*) \cdot a'(0) = 0.$$

By applying the implicit function theorem, we get:

$$\frac{\partial x^*}{\partial \phi_a} = \frac{y'(b-x^*)\cdot a(0) + 2y(b-x^*)\cdot a'(0)}{-y''(b-x^*)\cdot[1-\phi_a \cdot a(0)] + 2\phi_a \cdot y'(b-x^*)\cdot a'(0)} > 0.$$

As in the baseline model, a technological innovation associated with an increase in ϕ_a leads firms to tilt their allocation of resources towards surplus-appropriating/protecting activities (regardless of what happens to ϕ_y). Since these activities solely affect the transfer of surplus from one firm to another, investments in surplus appropriation and protection are socially wasteful in our environment. The main insights we derived in the baseline analysis, nonetheless, survive when it is the *relative* investment of resources in these activities that drives the share of its rival's surplus each firm can appropriate.

4.3 Rent-seeking affecting total surplus

In our baseline analysis, we assumed that rent-seeking efforts led to a redistribution of the economic surplus across firms. In other words, the symmetric equilibrium level of firm output was simply $\pi(s^*)$. While conceptually it is convenient to think of activities as being either surplus-creating or surplus-appropriating, firms often make investments that simultaneously affect both types of activities. For example, imitating a competitor might lead to a portfolio of offerings that better serves customers and enlarges total surplus (in addition to appropriating part of the competitor's surplus). Similarly, civil litigation efforts might lead to improved contracts that better enforce future property rights and promote socially valuable investments (in addition to eliciting a transfer from another party). Alternatively, it is reasonable to expect some rent-seeking activities to be associated with deadweight costs, which implies that firm i collects a smaller payoff than what firm j loses due to these activities.

To capture these possibilities, we denote firm i's payoff function as:

$$\pi_i(s_i) \cdot [1 - \tilde{\alpha}_j(x_j)] + \pi_j(s_j) \cdot \alpha_i(x_i),$$

where $\tilde{\alpha}_j(\cdot)$ is not necessarily equal to $\alpha_j(\cdot)$. Adapting our industry-wide technology parameterization for the addition of $\tilde{\alpha}_j(\cdot)$, the first-order condition becomes:

$$y'(s_i) \cdot \left[1 - \phi_{\tilde{a}} \cdot \tilde{a}(x_j)\right] = y(s_j) \cdot \phi_a \cdot a'(x_i).$$

As in our baseline analysis, the technology parameter associated with surplus creation, ϕ_y, disappears from the first-order condition and only the two technology parameters associated with surplus appropriation, ϕ_a and $\phi_{\tilde{a}}$, affect the optimal allocation of resources across activities. If technological progress boosts either ϕ_a or $\phi_{\tilde{a}}$, firm i's optimal allocation of resources requires a smaller s_i and a larger x_i, consistent with the main insights from our baseline analysis.

4.4 Factor-augmenting technological changes

In our baseline analysis, we considered technological advancements that improved total factor productivity (TFP), as surplus-creating and surplus-appropriating activities displayed production functions of the form $\phi_y \cdot y(s)$ and $\phi_a \cdot a(x)$, respectively. We now show that our main insights survive when considering factor-augmenting technological changes within the family of Cobb-Douglas production functions.

Before analyzing factor-augmenting technological changes, it helps to revisit our baseline derivations by imposing a Cobb-Douglas specification. Specifically, we set $\pi(s) = \phi_y \cdot y(s) = \phi_y \cdot s^{\eta}$ for surplus-creating activities and $\alpha(x) = \phi_a \cdot a(x) = \phi_a \cdot x^{\gamma}$ for surplus-appropriating activities.

With a budget constraint that is binding (i.e., $s = b - x$), we get the following expressions:

$$\pi'(b-x) = \phi_y \cdot y'(s) = \eta \frac{\pi(b-x)}{b-x} \qquad \text{and} \qquad \alpha'(x) = \phi_a \cdot a'(x) = \gamma \frac{\alpha(x)}{x}. \tag{6}$$

The first-order condition in a symmetric equilibrium can thus be rewritten as:

$$\eta \frac{\pi(b-x^*)}{b-x^*}\left[1-\alpha(x^*)\right] = \pi(b-x^*)\gamma\frac{\alpha(x^*)}{x^*} \qquad \Longrightarrow \qquad \frac{\alpha(x^*)}{1-\alpha(x^*)} = \frac{\eta x^*}{\gamma(b-x^*)}, \tag{7}$$

which replicates, for the case of Cobb-Douglas production functions, our previous result that the allocation of resources only depends on the productivity level of surplus-appropriating activities.

Now, consider an alternative specification that allows for factor-augmenting technological changes: $\pi(s) = y(\phi_y \cdot s) = (\phi_y \cdot s)^\eta$ for surplus-creating activities and $\alpha(x) = a(\phi_a \cdot x) = (\phi_a \cdot x)^\gamma$ for surplus-appropriating activities. In this case, the technological change does not directly increase the whole production, but it instead operates through a direct increase of the factor of production. Yet, taking derivatives with respect to the resources invested yields the same expressions as in (6), and as a result the first-order condition is also given by (7). Our model's main results thus hold whether we model technological progress as factor augmenting or as TFP augmenting.

5 Applications

In this section, we explore how our general theoretical framework applies to several of the most popular examples of surplus-appropriating activities: (i) civil litigation, (ii) product imitation, (iii) speculative trading, (iv) government lobbying, and (v) markups. We show that all of these settings generate micro-foundations for the payoff functions assumed throughout our analysis.

5.1 Civil litigation

While advances in telecommunications, data gathering and processing, and social media surely helped some firms to create more social surplus, they also made it easier for rent-seeking parties to collect evidence, put social pressure, and coordinate with other potential claimants with hopes of extracting surplus from targeted parties through civil litigation. Our setting can thus shed light on the extraordinary growth of the law profession over the last few decades (see Figure 5).

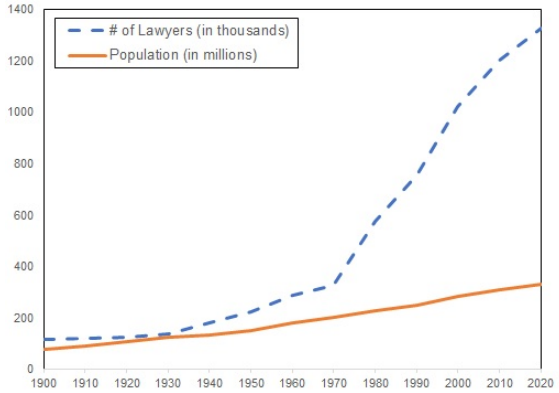


Figure 5

Growth of law profession. The figure plots the number of lawyers in the US (in thousands) and the overall US population (in millions) between 1900 and 2020. Data Sources: American Bar Association's 2020 Profile of the Legal Profession and 2020 US Census.

In particular, our model can be applied to capture firms' decisions to allocate resources between sustaining their core business and litigating rivals. Suppose that when firm j operates, it provides rival firm i with a probable cause to file a (socially wasteful) lawsuit with probability λ. In line with Guerra, Luppi, and Parisi (2018) and the references therein, we assume that the quantity of resources x_i that a plaintiff i invests in litigation (e.g., to hire the best lawyers and gather more evidence) increases the probability $\rho_i(x_i)$ that the plaintiff prevails (in or out of court) and becomes entitled to a compensation κ from the defendant j.[5] Yet, defendant j's ability to pay what it owes to

[5]Recall that in Section 4 we extended our analysis to allow a firm's investment in surplus-appropriating activities to lessen its rival firms' ability to appropriate this firm's surplus. If we imposed this assumption in the current context of civil litigation, it would be akin to allowing a firm to use its legal experts to defend itself better against rivals' lawsuits in addition to suing them with more success. The same insights would follow.

the plaintiff in this case depends on its core business profits $\pi_j(s_j)$, where s_j denotes the resources invested in the core business. Specifically, given the limited liability status of corporations, the payoff firm i collects from winning a lawsuit against firm j is: $min\{\kappa, \pi_j(s_j)\}$.

Since firm i is a threat to sue firm j and firm j is a threat to sue firm i, the expected payoff for firm i is given by:

$$\pi_i(s_i) - \lambda\rho_j(x_j) \cdot min\{\kappa, \pi_i(s_i)\} + \lambda\rho_i(x_i) \cdot min\{\kappa, \pi_j(s_j)\}.$$

When κ is large enough for firms' limited liability to bind, this expression simplifies to:

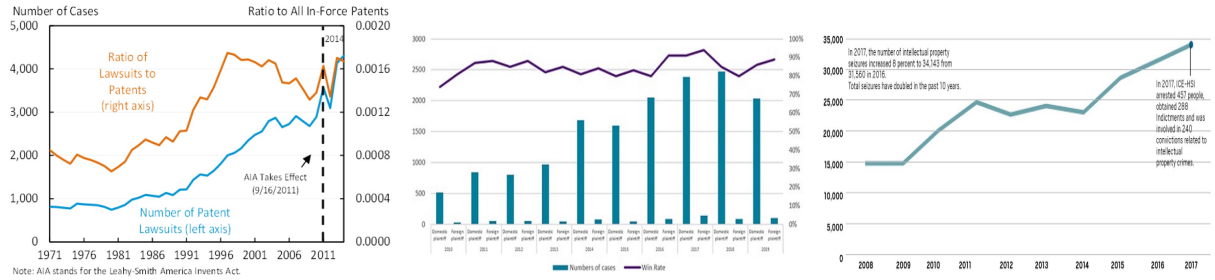
$$\pi_i(s_i) \cdot [1 - \lambda\rho_j(x_j)] + \pi_j(s_j) \cdot \lambda\rho_i(x_i),$$

and we are back to the profit expression (1) that we started with, now with $\alpha_i(x_i) = \lambda\rho_i(x_i)$. Due to the limited liability status of corporations, the surplus that firm i can appropriate from firm j by suing it is proportional to the surplus created by firm j whenever the maximum compensation κ is large. As in our baseline analysis, a firm's operating profit $\pi_i(s_i)$ contributes to the total surplus, but its civil litigation payoff $\lambda\rho_i(x_i) \cdot \pi_j(s_j)$ is solely a transfer from firm j. Thus, an industry-wide technological progress that boosts the marginal productivity of civil litigation (i.e., $\lambda\rho_i'(x_i)$) will result in a reallocation of firms' resources toward this activity, even when it also boosts the marginal productivity of firms' core business.

5.2 Product imitation

Another good example of surplus-appropriating activities is product imitation. Recent improvements in production speed, 3D printing, and telecommunications might have led firms to spend more resources on reverse engineering and corporate espionage with hopes of appropriating rents from innovative firms. Our setting can thus shed light on the recent growth in patent infringement

and product counterfeiting (see Figure 6).



(a) Patent infringement cases in US **(b)** Patent infringement cases in UK **(c)** Seizures of counterfeit products in US

Figure 6

Growth in imitation. Panel (a) plots the growth in the number of patent infringement cases in the US (adapted from Council of Economic Advisers 2016). Panel (b) plots the growth in the number of patent infringement cases in the United Kingdom (UK) (adapted from Zhang and Qiao 2020). Panel (c) plots the growth in the number of products seized by the US Government due to trademark and copyright violations (adapted from Snibbe 2019).

Assume firm j can spend resources s_j on researching and developing new technologies, which yields a probability of innovating of $\psi_i(s_i)$. Rival firm i can, however, spend resources x_i on corporate espionage or any other activity that helps reverse engineer firm j's innovations, which then yields a successful imitation of firm j's technology with probability $\rho_i(x_i)$. When its imitation attempts succeed, firm j captures a fraction λ of firm i's surplus associated with its innovation, denoted $\bar{V}$. If firm i is a threat to imitate firm j and firm j is a threat to imitate firm i, the expected payoff for firm i is given by:

$$\bar{V}\psi_i(s_i)\cdot\left[1-\lambda\rho_j(x_j)\right]+\bar{V}\psi_j(s_j)\cdot\lambda\rho_i(x_i).$$

Again, we recover the original profit expression (1), now with $\alpha_i(x_i)=\lambda\rho_i(x_i)$ and $\pi_i(s_i)=\bar{V}\psi_i(s_i)$. Since the benefit of imitating depends on the success of a rival's innovation, the surplus that firm i can appropriate from firm j is proportional to the expected surplus created by firm j's innovation efforts. As in our baseline analysis, a firm's innovation profit $\bar{V}\psi_i(s_i)$ contributes to the total surplus, but its imitation payoff $\bar{V}\psi_j(s_j)\cdot\lambda\rho_i(x_i)$ is solely a transfer from firm j (and vice-versa for firm j's imitation payoff). Thus, an industry-wide technological progress that boosts

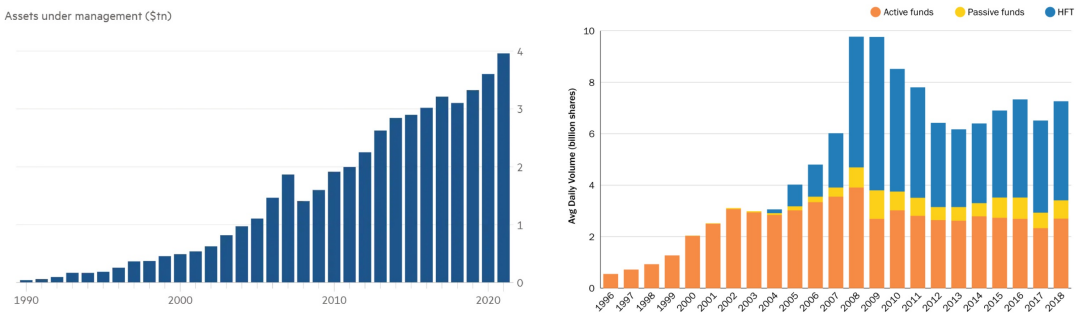
the marginal productivity of activities such as espionage, reverse-engineering, and imitation (i.e., $\lambda\rho_i'(x_i)$) will result in a reallocation of firms' resources toward these rent-seeking activities, even when the marginal productivity of firms' research and development also increases.

This application allows some technological progress to be a firm's choice in the spirit of endogenous growth models since the celebrated work of Romer (1990). More specifically, there are two types of technological advancements that can boost firms' surplus in this setting. First, as highlighted throughout the analysis, industry-wide parameters ϕ_a and ϕ_y capture broad technological improvements that are *exogenous* to the firms' actions, such as better computing power and increased availability of data. Second, the expected surplus $\bar{V}\psi_i(s_i)$ now embeds the possibility that firm-specific technological investments endogenously impact the surplus available to both firms i and j. Even absent any investment in surplus-appropriating activities, firm j captures a fraction $\lambda\rho_j(0)$ of the expected surplus created by firm i's innovations. If $\lambda\rho_j(0) > 0$, firm i's investment x_i captures any endogenous innovation effort by one firm that benefits both firms.

Moreover, when $\rho_j'(x_j) > 0$, this application entertains the possibility that rivals' efforts to imitate a firm's innovations impact its choice to spend on research and development. Indeed, imitation efforts have a feedback effect on the incentives to innovate. One of the best-known insights of the endogenous growth literature is that firms innovate when they can appropriate enough rents from their costly innovation investments (see the early survey by Griliches (1990)). But if the economy reallocates resources disproportionately towards imitation in response to technological progress, the incentives to innovate might weaken over time. In fact, in a dynamic environment where firms' current innovations drive future levels of ϕ_y, not only would surplus-appropriating efforts weaken the link between technology quality ϕ_y and output within a period, they would also slow down the growth in ϕ_y over time by weakening firms' current incentives to innovate.

5.3 Speculative trading

This application builds on the model of Glode and Lowery (2016) and highlights how advancements in financial modeling, data collection, and telecommunications may have contributed to a disproportionate reallocation of financial-sector resources towards surplus-appropriating activities such as speculative trading. In particular, our model's insights can shed light on the rising popularity of hedge funds and high-frequency trading, the rising relative wages collected by financial-sector workers, and the fact that the gradual arrival of skilled workers and their increased compensation have not been associated with an increased efficiency of financial intermediation (see Figures 7-8).



(a) Worldwide hedge fund AUM

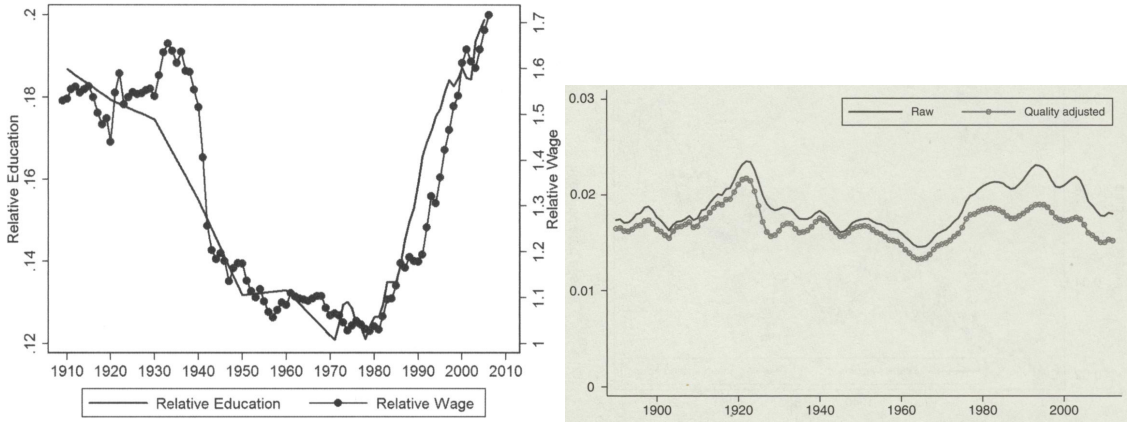
(b) US trading volume

Figure 7

Growth in speculative trading. Panel (a) plots the growth in assets under management (AUM) at hedge funds worldwide (adapted from Wigglesworth and Fletcher 2021). Panel (b) plots the growth and composition of average daily trading volume in the US (adapted from Klein 2020).

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Consider a setting with financial firms trying to identify entrepreneurs with credit-worthy projects (both from a private and social perspective). Each financial firm j can invest resources s_j to increase the probability $\mu_j(s_j)$ of finding such a profitable investment opportunity with an expected future payoff of $\bar{v}$. Conditional on making such investment, firm j is hit with probability ξ by a liquidity shock that drives the firm's private valuation of any future payoff down to zero. If that is the case, the firm contacts a counterparty i which was not hit by a similar liquidity shock, and tries to sell it a security backed by the (illiquid) investment in exchange for cash. For simplic-



(a) Relative wage of US finance workers

(b) Unit cost of financial intermediation

Figure 8

Financial-sector compensation and efficiency. Panel (a) plots the relative education and wage of US financial-sector workers (see Philippon and Reshef 2012). Panel (b) plots the unit cost of financial intermediation in the US (see Philippon 2015).

ity, we assume that the firm looking to sell its investment quotes a take-it-or-leave-it offer price p to its counterparty.

In preparation for this possibility, each counterparty can allocate some of its resources to acquire expertise (e.g., data, computers, human capital) that will help value any security that a firm in need of liquidity might offer. Specifically, we assume that a firm i can receive with probability $\theta_i(x_i)$ a private signal disclosing whether the security backed by firm j's investment is worth $2\bar{v}$ or zero (two equally likely outcomes). Thus, a firm hit by a liquidity shock might quote to its counterparty a price $p = \bar{v}$ for the security, which is accepted whenever the buyer does not receive a private signal that the security is worth zero, or it might quote a price $p = 2\bar{v}$ for the security, which is only accepted when the buyer receives a private signal that the security is worth $2\bar{v}$. Without knowing whether its counterparty i has received a private signal or not, firm j finds it optimal to quote a price $p = \bar{v}$ rather than $p = 2\bar{v}$ as long as $\left(1 - \frac{\theta_i(x_i)}{2}\right)\bar{v} \geq \frac{\theta_i(x_i)}{2}2\bar{v}$, which simplifies to $\theta_i(x_i) \leq \frac{2}{3}$. Assuming that this condition is satisfied for all firms, firm i makes a trading profit of $\bar{v}$ whenever it receives a private signal that the security is worth $2\bar{v}$ and only pays $p = \bar{v}$ for it. Considering that firm i is firm j's counterparty and vice-versa, the expected payoff for firm i, before knowing its

role as a buyer or seller, is:

$$(1-\xi)\mu_i(s_i)\bar{v}+\xi\mu_i(s_i)\left(1-\frac{\theta_j(x_j)}{2}\right)\bar{v}+\xi\mu_j(s_j)\frac{\theta_i(x_i)}{2}\bar{v},$$

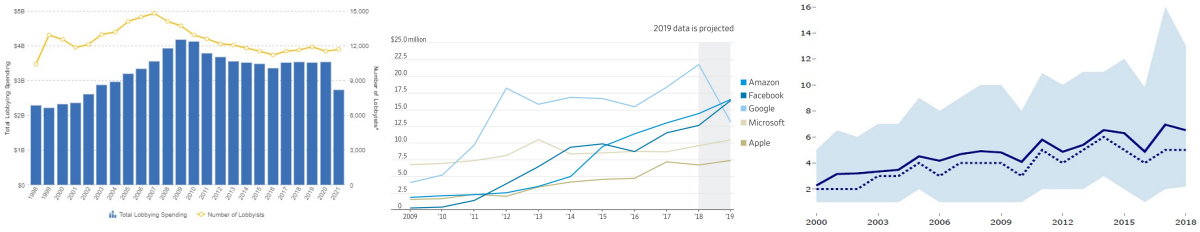
which simplifies to:

$$\mu_i(s_i)\bar{v}\cdot\left[1-\frac{\xi\theta_j(x_j)}{2}\right]+\mu_j(s_j)\bar{v}\cdot\frac{\xi\theta_i(x_i)}{2}.$$

We are then back to the profit expression (1) that we started with, now with $\pi_i(s_i)=\mu_i(s_i)\bar{v}$ and $\alpha_i(x_i)=\frac{\xi\theta_i(x_i)}{2}$. Since secondary-market trading involves claims on real projects, the surplus that firm i can appropriate from firm j through speculative trading is proportional to the surplus created by firm j through lending and investing. As in our baseline analysis, a firm's investment payoff $\mu_i(s_i)\bar{v}$ contributes to the total surplus, but its profit from informed trading $\mu_j(s_j)\bar{v}\cdot\frac{\xi\theta_i(x_i)}{2}$ is solely a transfer from firm j. Thus, an industry-wide technological progress that boosts the marginal productivity of speculative trading (i.e., $\frac{\xi\theta_i'(x_i)}{2}$) will result in a reallocation of firms' resources toward this rent-seeking activity, even when it also boosts the marginal productivity of firms' lending and investing activities. As a consequence of this reallocation, the sector's overall productivity will not feature a boost consistent with the improved technology quality, yet the price paid for the resources used to perform all financial activities will increase.

5.4 Government lobbying

Advancements in telecommunication and transportation technologies have facilitated government lobbying, which consists of investing resources to convince regulators and politicians to make decisions that favor a subset of the economy. Indeed, recent decades have featured impressive growth in the resources spent on government lobbying, especially coming from the technology sector and from foreign entities (see Figure 9).



(a)
US total lobbying spending (inflation-adjusted)

(b) Lobbying spending by large US tech firms

(c) Avg. number of foreign principals lobbying each US congress person

Figure 9

Growth in government lobbying. Panel (a) plots the growth in inflation-adjusted lobbying spending targeting US Congress and federal agencies (adapted from OpenSecrets 2021). Panel (b) plots the growth in lobbying spending by large US technology firms (adapted from Tracy 2019). Panel (c) plots the growth in the number of foreign principals (i.e., foreign organizations, associations, corporations, or governments) lobbying the average US congress person in a given year (adapted from Grotteria, Miller, and Naaraayanan 2022).

We now show that our analysis can be adapted to capture firms' decision to invest resources in lobbying the government. Suppose the government taxes the income of two firms that populate an industry, firms i and j, at a fixed rate τ. This inflow is then redistributed among these two firms through transfers such as non-taxable subsidies and grants, based on various governmental objectives. However, by investing resources on lobbying efforts, a firm can convince government officials to increase at an expected rate β the fraction of the total taxes collected that are transferred back to this specific firm. Without lobbying, each firm expects to collect half of the total taxes collected, that is, $\frac{1}{2}\tau[\pi_i(s_i)+\pi_j(s_j)]$, where $\pi_i(s_i)$ is the taxable income of firm i (similar notation for firm j). With lobbying spendings of x_i and x_j from the two firms, firm i expects to receive a subsidy of:

$$\left(\frac{1}{2}+\beta x_i-\beta x_j\right)\tau[\pi_i(s_i)+\pi_j(s_j)].$$

Thus, the payoff firm i expects to collect when investing s_i to increase the taxable income coming from its core business and investing x_i in lobbying activities is:

$$(1-\tau)\pi_i(s_i)+\left(\frac{1}{2}+\beta x_i-\beta x_j\right)\tau[\pi_i(s_i)+\pi_j(s_j)],$$

which simplifies to:

$$\pi_i(s_i) \cdot \left[1 - \tau\left(\frac{1}{2} + \beta(x_j - x_i)\right)\right] + \pi_j(s_j) \cdot \tau\left(\frac{1}{2} + \beta(x_i - x_j)\right).$$

We are then back to the profit expression (5) that we derived in the extension of Section 4 that featured relative investments in surplus appropriation, now with $\alpha_i(x_i - x_j) = \tau\left(\frac{1}{2} + \beta(x_i - x_j)\right)$. Since lobbying payoffs depend on the total amount of taxes collected, the surplus that firm i can appropriate from the government through lobbying efforts is proportional to the surplus created in the economy. As in our baseline analysis, a firm's investment payoff $\pi_i(s_i)$ contributes to the total surplus, but the additional transfer associated with lobbying $\pi_j(s_j) \cdot \tau\beta(x_i - x_j)$ is solely a transfer from firm j. Thus, an industry-wide technological progress that boosts the marginal productivity of government lobbying (i.e., β) will result in a reallocation of firms' resources toward this rent-seeking activity, even when also associated with an increase in the marginal productivity of firms' core businesses.

5.5 Markups

A recent literature has argued that observed technological improvements do not always translate into large improvements in economic productivity, but sometimes translate into the increased exercise of market power by firms (see, e.g., Philippon 2019, De Loecker, Eeckhout and Unger 2020, Nekarda and Ramey 2020). Figure 10 indeed shows the evolution of markups for US private businesses, as computed by Nekarda and Ramey (2020). To shed light on this trend, we analyze an application of our model that slightly deviates from the structure of our baseline analysis, yet produces similar implications.

Instead of having multiple firms appropriating each other's surplus as in our baseline model, we now consider a representative firm for the economy. Actual firms are atomistic of mass 1, and the surplus of each one of these firms, denoted π, is also its aggregate value added. These firms

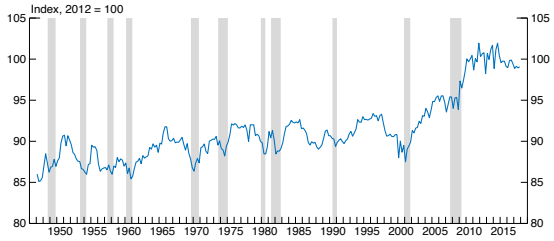


Figure 10

Growth of markups. This figure plots the growth in markups for U.S. private businesses, as computed by Nekarda and Ramey (2020) using the log of current dollar output divided by the wage bill for variable labor.

are homogenous but sell differentiated products, so they are all monopolists in their respective industries. We also assume that a representative household owns the "representative firm" and consumes its production. The representative firm can either allocate resources s to increase its surplus $\pi(s)$, or allocate resources x to increase its market power and extract a fraction $\alpha(x)$ of its consumers' wealth, which we denote $\pi(S)$ for reasons that will become clear shortly. In this setting, S should be interpreted, as is standard in macroeconomic models with a representative agent, as the aggregate spending in the economy, with the restriction that $S = s$ holds in equilibrium.

While surplus-creating activities are associated with standard production functions, surplus-appropriating activities can be thought of as anything that allows a firm to create a captive demand (e.g., through marketing activities that convince consumers of their need for certain products), reduce the demand elasticity for its products (e.g., by creating complementarities across product characteristics and add-ons), collude with rival firms (e.g., by forming cartels or acquiring potential competitors), or insulate its activities from competitors (e.g., through modern technological platforms with network effects that prevent competition and entry in the firm's major markets).

When the representative firm maximizes the surplus it collects, it does not internalize the effect of its own resources allocated to surplus-creating activities s on the aggregate value added and the resulting wealth of its consumers $\pi(S)$. The surplus the representative firm tries to maximize is thus given by:

$$\pi(s) + \alpha(x) \cdot \pi(S).$$

Even though this setting does not map directly into the profit expression (1), its implications are qualitatively consistent with those from our baseline analysis. In particular, the first-order condition with respect to x is simply:

$$-\pi'(b-x^*)+\pi(b-x^*)\alpha'(x^*)=0,$$

which assuming $\pi(s)=\phi_y\cdot y(s)$ and $\alpha(s)=\phi_a\cdot a(x)$ becomes:

$$y'(b-x^*)-y(b-x^*)\cdot\phi_a\cdot a'(x^*)=0.$$

Just as in the first-order condition (3), the technology parameter associated with surplus-creating activities, ϕ_y, does not enter the allocation decision, but any technological progress that facilities surplus-appropriating activities, through a higher ϕ_a, induces firms to channel resources towards extracting more surplus from their consumers.

In this setting, atomistic firms do not internalize their impact on the aggregate surplus of consumers (who are also their owners) when choosing their resource allocation. Yet, they take advantage of the fact that technological progress boosts consumers' wealth and they tilt their resource allocation towards activities aimed at extracting a larger share of this wealth. Intuitively, technological improvements increase wealth-maintaining resources allocated to production and a wealthier body of consumers increases the surplus that firms can appropriate when increasing their market power.

6 Conclusion

We show that technological innovations that improve productivity for an entire industry or economy generically induce a disproportionate and socially inefficient allocation of resources towards surplus-appropriating activities. Whereas industry-wide improvements in a technology used to

appropriate others' surplus amplify the payoff of surplus-appropriating activities and reduce the payoff of surplus-creating activities, improvements in a technology used to create surplus amplify the payoffs of both activities in lockstep. Over time, the economy evolves towards a rent-seeking economy in response to technological progress. This long-run reallocation of resources towards surplus appropriation has important implications for the relative price of resources that can serve as inputs for all types of activities as well as for the sensitivity of economic growth to technological innovations.

Our results shed light on the recent decoupling between information technology and economic progress, but also highlight more broadly how the historical evolution of rent seeking relates to technological improvements ranging from electricity to firearms, etc. Our results emphasize the importance of incorporating surplus-appropriation efforts as a fundamental and integral force within economic growth models and of improving how we empirically identify these types of activities for policymaking purposes.

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