TECHNOLOGICAL PROGRESS AND RENT SEEKING *

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Abstract

We model firms' allocation of resources between surplus-creating (i.e., productive) and surplus-appropriating (i.e., rent-seeking) activities. Our model predicts that industry-wide technological advancements, such as recent progress in data collection and processing, generically induce a disproportionate and socially inefficient reallocation of resources towards various types of 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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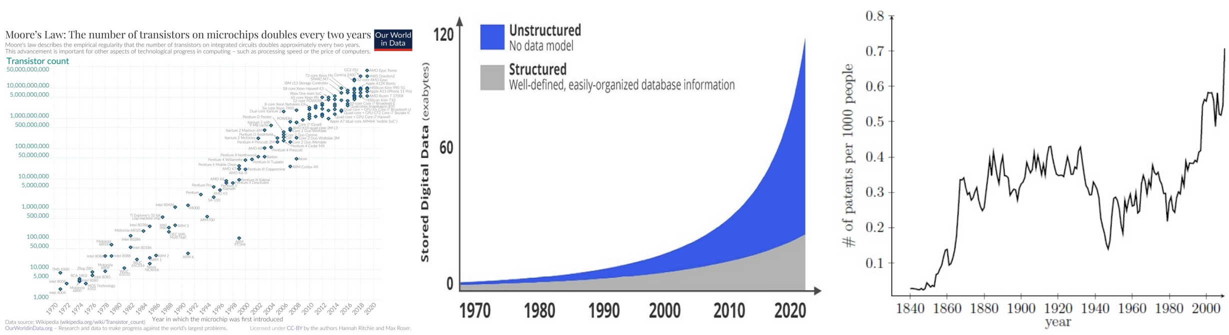
1 Introduction

The last few decades have featured exceptional technological progress, as evidenced for example by striking increases in computer processing power, data availability, and patented innovation (see Figure 1). Standard economic theories have highlighted the importance of technological progress that boosts firms' productivity (embodied in capital, in labor, in methods used to combine inputs, and in the creation of new varieties of intermediate goods) in generating long-term economic growth. Yet, in light of the observed technological progress, global economic growth has surprisingly slowed down in recent decades.[1] Some have argued that this phenomenon 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 progress on the rent-seeking behaviors of agents in the economy. Various economic activities are commonly thought of as instances of rent seeking, including lobbying/bribing government officials, suing wealthy defendants, imitating competing firms' innovations, taking advantage of financial counterparties' liquidity needs, and increasing the markups charged to unsophisticated customers. While all these activities might, at first, appear to be disparate in light of their different institutional settings, they all share the objective of appropriating wealth from other agents without creating much benefit for

[1] https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

society. Transferring wealth or economic surplus across agents is not by itself socially costly, but as clearly pointed out by Tullock (1980), investing scarce resources in activities aimed at influencing these transfers is “a negative-sum game” when these resources could have been allocated to more socially productive activities. Given the wide array of activities that fit this description, we study how rent-seeking activities impact the contribution that technological progress has on economic output through a stylized, yet flexible model focused on capturing the surplus-appropriation objective common to these activities.

Specifically, we model firms’ optimal allocation of resources between surplus-creating (i.e., productive) and surplus-appropriating (i.e., rent-seeking) activities. Our model’s key prediction is that firms disproportionately reallocate resources towards surplus-appropriating activities in response to industry-wide technological advancements, thereby mitigating the positive impact of technological progress on economic output that has been the focus of the literature so far. 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.

This stark prediction originates from two insights related to how firms’ profits are affected by technological productivity. First, industry-wide improvements in technologies used to appropriate others’ surplus amplify the payoff of investing in surplus-appropriating activities and reduce the payoff of investing in surplus-creating activities (since other firms are more productive in their surplus-appropriating efforts). Second, and more surprisingly, industry-wide improvements in technologies used to create surplus amplify the payoffs of both activities in lockstep since efforts to appropriate others’ surpluses become more profitable when others have larger surpluses to appropriate.

Altogether, these insights imply that industry-wide technological innovations that improve firms’ abilities to create as well as appropriate economic surplus, albeit to possibly different extents, cause 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, such as human capital).

We first illustrate our general economic insights using a transparent, yet flexible model. Then, we show how our insights survive tp a variety of extensions. We finally apply our insights to five seemingly disjoint cases of rent seeking to shed light on their empirical prevalence. First, we tackle a natural case of surplus appropriation: civil litigation between two parties. Second, we consider product imitation, which aims to appropriate part of the profits a competitor might create through its costly investments and innovations. Third, we study the case of speculative trading activities that are focused on securing a larger share of the gains from trade when interacting with trading counterparties. Fourth, we apply our insights to government lobbying efforts aimed at convincing regulators and politicians to make decisions that favor a subset of the economy. Fifth, we show how our baseline model can be adjusted to capture investments firms make to increase their market power and increase the rents they can extract from customers. These activities all share the common goal of appropriating other parties' surpluses (or defending a firm's surplus from its competitors' appropriation efforts). Moreover, for all these cases, we can think of recent technological advancements, whether it is big data, machine learning, artificial intelligence, communication and transportation improvements, that are likely to have facilitated both the creation and appropriation of surplus. Thus, besides applying our general insights to various contexts, and providing microfoundations that rationalize our stylized environment, our applications shed light on the observed rise in the prevalence of various rent-seeking activities.

Despite our focus on contemporaneous examples of surplus-appropriating activities, the disproportionate effect of technological improvements on rent seeking we highlight in this paper may have been operational well before the recent informational revolution. Many earlier technological improvements impacted both surplus creation and appropriation at the same time, albeit to different extents: improvements in agricultural and farming technologies led to better nutrition as well as wars and invasions, the proliferation of weapons helped with hunting as well as stealing, and more efficient transportation technologies facilitated trading of goods but also an expansion of speculative and stealing activities.[2] Our paper thus identifies an understudied, yet fundamen-

[2]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.

tal, 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. In fact, a salient implication of our analysis is that policies aimed at boosting the productivity of surplus-creating activities (e.g., by subsidizing related investments) will fail to tame the inefficient allocation of resources. Instead, policymakers must develop ways to identify surplus-appropriating efforts and reduce their productivity if they want to reduce firms' investments in surplus appropriation.[3]

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.[4] Our work studies firms' choice to allocate resources to rent-seeking activities and shows that the connection between technological productivity and economic output becomes weaker over time due to the endogenously increasing prevalence of those 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 technological progress and becomes more and more significant over time.

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 down economic progress through agents' occupational choices, we study firms' decision to allocate resources at an intensive margin, not present in models of occupational choices: all agents in our model (i.e., firms) can both create and appropriate surplus from others. Hence, we are able to apply our insight to several activities besides occupations. Moreover, unlike in those papers, our analysis investigates the impact of productivity improvements in both types of activities: surplus creation and appropriation.

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). Our insights

[3] See Del Rosal (2011) for a survey of the challenges linked with identifying rent-seeking activities and their social costs.

[4] In contrast to Solow (1957), Crouzet et al. (2022) show that idea transmission (i.e., the degree of non-rivalry) affects non-monotonically firms' incentives to innovate and compete, which determine long-run economic growth.

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.[5] Philippon (2010), Glode, Green, and Lowery (2012), Biais, Foucault, and Moinas (2015), Fishman and Parker (2015), Glode and Lowery (2016), Farboodi et al. (2019), 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). In an environment with heterogenous beliefs, Dávila (2023) studies the optimal taxation of transactions that may or may not improve the efficient allocation of financial assets. 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, Farboodi and Veldkamp (2022) highlight the complementarity between data accumulation and firm size whereas Gaballo and Ordonez (2022) highlight the trade-off between the benefits of information for production and the costs for risk sharing. 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.

In the next section, we present a theoretical environment in which firms decide how to di-

[5] 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.

vide their resources between 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 results survive various extensions to our baseline model in Section 4 and apply 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 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. Firm i's payoff is then given by:

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

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.[6] 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 in our environment is that firm i may invest a quantity $x_i > 0$ of resources in transferring surplus rather than in creating it.

We keep this setting as streamlined, simple, and flexible as possible with the dual objective of: (i) intuitively capturing the fundamental effects of technological advancements that affect surplus-creation and appropriation differentially on firms' resource allocation, and (ii) micro-founding the same payoff function (1) in various seemingly disparate rent-seeking contexts (section 5). The only restrictions we impose for now are that, for all $i \in I$, $\pi_i(\cdot)$ and $\alpha_i(\cdot)$ are increasing, concave functions and $\alpha_i(\cdot) \in [0,1]$.

[6] This focus on surplus appropriation contrasts our environment from Hirshleifer's (1995), where rent-seeking efforts are modeled as resource-appropriation attempts. 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.

In Section 4, we also show how our results survive various modifications to this payoff function. For instance, we extend the analysis to allow a firm's investment x_i to also help protect its surplus from appropriation efforts by 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 analysis.

Firm-specific technological progress. 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 main insights also apply to *factor-augmenting* technological changes within Cobb-Douglas production functions.

The firm's first-order condition then becomes:

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

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 allocations change with technological progress that affects all firms within an industry (e.g., increased availability of data, more powerful computers, improved communication and transportation capabilities). To keep our analysis of industry-wide technological progress tractable, we set $\phi_{a,i} = \phi_{a,j} \equiv \phi_a$ and $\phi_{y,i} = \phi_{y,j} \equiv \phi_y$. We also assume that these productivity parameters are exogenous to firms' actions.[7] In contrast to the previous section, we also account for the fact that, in equilibrium, each firm reacts to the best response of its rival(s).

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

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

This first-order condition reveals two insights about firms' optimal allocation of resources, one more surprising than the other. On the one hand, the industry-wide productivity of surplus-appropriating activities, ϕ_a, affects the first-order condition in two unsurprising ways. Ceteris paribus, a higher ϕ_a implies that firm i will be more successful in its attempts to appropriate any surplus that firm j creates and firm j will be more successful in its attempts to appropriate any surplus that firm i creates. Thus, the right-hand side of (2) is higher while the left-hand side is lower. As a result, firm i's optimal allocation of resources requires a smaller investment in surplus creation, s_i, and a larger investment in surplus appropriation, x_i, to respond to an industry-wide improvement in the productivity of firms' surplus-appropriating activities, ϕ_a.

On the other hand, the industry-wide productivity of surplus-creating activities, ϕ_y, disappears from the first-order condition and therefore does not impact the optimal allocation of resources. The intuition behind this more surprising insight 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. Indeed, improvements in surplus-creating technologies do not solely make surplus-creating efforts more productive for a firm, they also imply that its rival will be more productive in creating surplus that can be appropriated through rent-seeking efforts.

3.1 Allocation of resources

While predicting a firm's response to a change in industry-wide productivity levels is straightforward when holding its rival's allocation of resources fixed, what happens in equilibrium is not as

[7] We revisit the distinction between industry-wide and firm-specific innovations when applying our model to a research and development context in Section 5.

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 now characterize a symmetric equilibrium by considering any pair of symmetrically-impacted and behaving firms. Dispensing from the sub-indices i and j, the first-order condition in 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 (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 $\alpha(x^*)=\phi_a\cdot a(x^*)$ 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.

While technological progress that increases the productivity of surplus-creating activities at an industry level does not lead to a reallocation of resources towards surplus creation, technological progress that increases the productivity of surplus-appropriating activities at an industry level does lead to a reallocation of resources towards surplus appropriation. That is, technological progress has an asymmetric effect on optimal resources allocation, which generically leads in equilibrium to a disproportionate shift of resources towards surplus appropriation as technology improves. This is the central prediction of the paper.

These insights also imply that policies aimed at boosting the productivity of surplus-creating activities (e.g., by subsidizing related investments) will fail to tame the inefficient allocation of resources by firms. Just like with an increase of ϕ_y, interventions that expand the surplus a firm creates also boost rival firms' incentives to invest in appropriating this surplus. Instead, to reduce the relative incentives to inefficiently invest resources in surplus appropriation, policymakers must focus on identifying surplus-appropriating activities and reducing their productivity and profitability (e.g., by taxing their returns or imposing penalties). Promoting surplus creation is just not as effective at correcting resource misallocations as obstructing surplus appropriation is.

3.2 Price of resources

We now consider what happens when firms have to compete for resources. Instead of being endowed with a budget of resources b as considered above, we now assume that they have to pay for each unit of resources they acquire. We also 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.[8] 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 efficiently allocated to increase surplus, that is, without any diversion of resources to appropriate

[8] 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.

economic surplus already created. This benchmark also echoes 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 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. The 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 in equilibrium. While most technological advancements are likely to improve the productivity of surplus-creating activities, our analysis highlights that these benefits are mitigated by firms' optimal reallocation of resources towards 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 direct impact of increasing the productivity of surplus creation for a given equilibrium allocation of resources whereas the second term captures the indirect impact of the reallocation of resources in response to $d\phi_a$ (recall that 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:

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

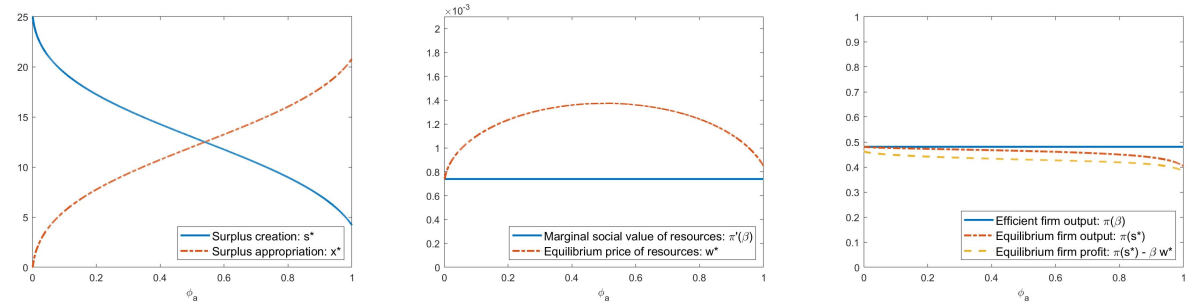
which pins down x^* as a function of the supply of resources, b, and the productivity of surplus-appropriating activities, ϕ_a, independently of the productivity of surplus-creating activities, ϕ_y. The equilibrium price of resources is given by:

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

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

To highlight the impact of technological progress on firms' behaviors, 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.

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



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

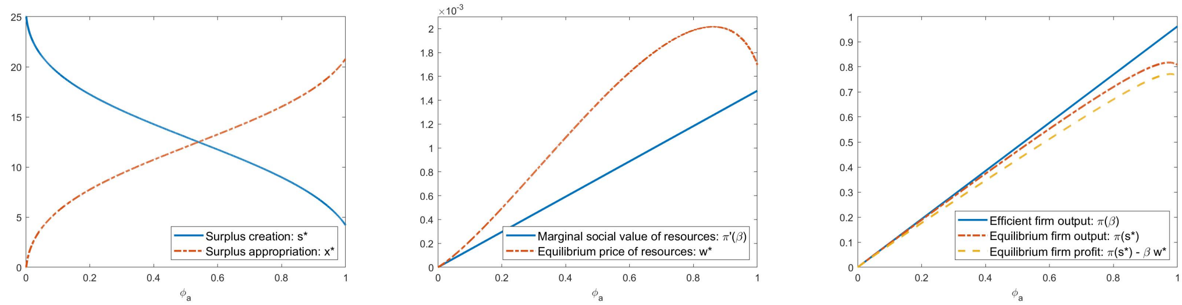
Figure 2

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.

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 technological progress to have a positive impact 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., $\phi_y = \phi_a$.

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 each firm's rewards from creating



(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.

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.

Indeed, 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.

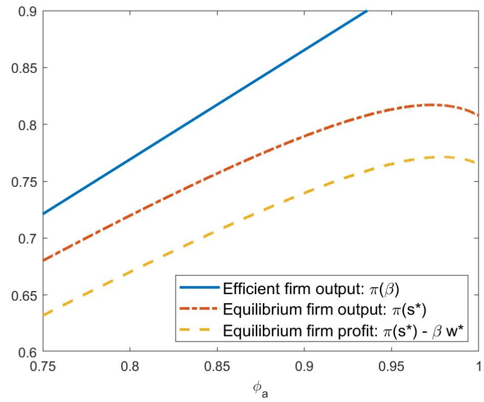


Figure 4

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 Extensions

So far, we have derived our main insights in a transparent theoretical setting. However, we show below that our main insights can extend to many alternative environments. Some of these extensions will also be useful when we study how our main insights apply to a wide variety of rent-seeking activities in the next section.

4.1 Asymmetric equilibria

For tractability, our baseline analysis focused on deriving the properties of the unique symmetric equilibrium in our model. However, asymmetric allocations of resources can also sustain an equilibrium in our environment. For example, we could have firm i allocating a larger share of its resources b to surplus appropriation than rival firm j does. Under intuitive parametric restrictions, such asymmetric allocation could possibly sustain an equilibrium since firm i would benefit more from attempting to appropriate the large surplus created by firm j than firm j would benefit from attempting to appropriate the small surplus created by firm j.

The first-order condition with industry-wide technological parameters (2) shows that the productivity of surplus creation ϕ_y does not enter a firm's first-order condition, regardless of whether we impose symmetric allocations or not. On the other hand, each firm's incentives to allocate more resources to surplus appropriation increase in ϕ_a as long as its rival either creates a positive level of surplus or appropriates a positive share of surplus. Thus, the prediction that technological improvements in the productivity levels of both types of activities tilt firms' allocations of resources towards surplus appropriation also holds in asymmetric equilibria where both firms participate (albeit unequally) to surplus creation and appropriation.

4.2 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.

4.3 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 a firm's investments in surplus-appropriating activities have the added benefit of reducing rival firms' ability to appropriate its 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 (see Argente et al. 2020, for related evidence).

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.

4.4 Rent-seeking affecting total surplus

In our baseline analysis, we assumed that rent-seeking efforts led to a redistribution of 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 involve 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.

4.5 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:

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

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, technological progress operates through direct increased in the factors 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 still given by (7). Our model's main results thus hold whether we model technological progress as factor augmenting or as TFP augmenting.

5 Applications

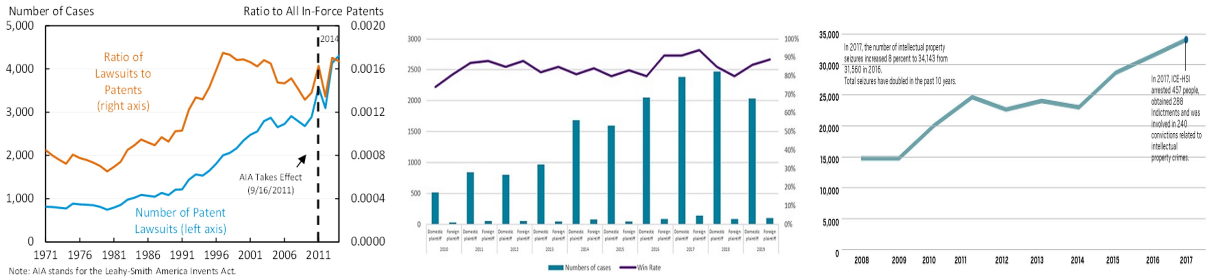
In this section, we explore how our general theoretical framework can be adapted to fit several of the most popular examples of surplus-appropriating activities: (i) product imitation, (ii) civil litigation, (iii) speculative trading, (iv) government lobbying, and (v) markups. Despite their institutional differences, these various contexts all embody our main theoretical insights and each provide micro-foundations for the general payoff functions that have been featured throughout our analysis.

5.1 Product imitation

A natural example of surplus-appropriating activities is product imitation. Recent improvements in production speed, 3D printing, and telecommunications facilitated product innovations that boost social surplus, but they may also have facilitated reverse engineering and corporate espionage efforts 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 5).

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:

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



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

Figure 5

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).

We then recover the original profit expression (1), 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 increases by a wider margin.

This application allows some of the technological progress in our model to be driven by firms' actions, in the spirit of endogenous growth models going back to 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 typical 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, e.g., Griliches 1990, Crouzet et al. 2022, and the references therein). 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.

5.2 Civil litigation

While advances in telecommunications, data gathering and processing, and social media surely helped firms 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 6).

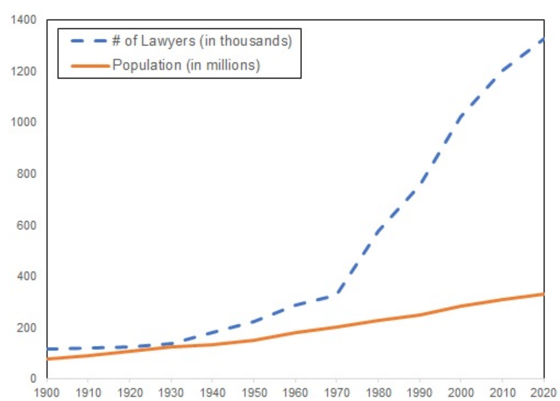


Figure 6

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), 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 a defendant j.[9] Yet, defendant j's ability to pay what it owes to 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: $min\{\kappa, \pi_j(s_j)\}$.

If 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:

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

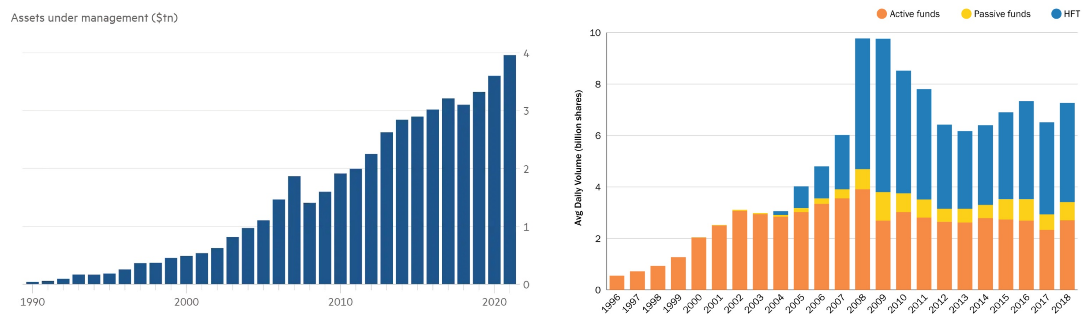
and we are back to the profit expression (1) that we started with, now with $\alpha_i(x_i) = \lambda\rho_i(x_i)$. Due to the limited liability status of corporations, the surplus that firm i can appropriate from firm j by suing it is proportional to the surplus created by firm j whenever the maximum 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 by a wider extent.

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 finding that the gradual arrival of skilled workers and their increased com-

[9] Recall that in Section 4 we extended our analysis to allow a firm's investment in surplus-appropriating activities to lessen its rivals' ability to appropriate its 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.

pensation 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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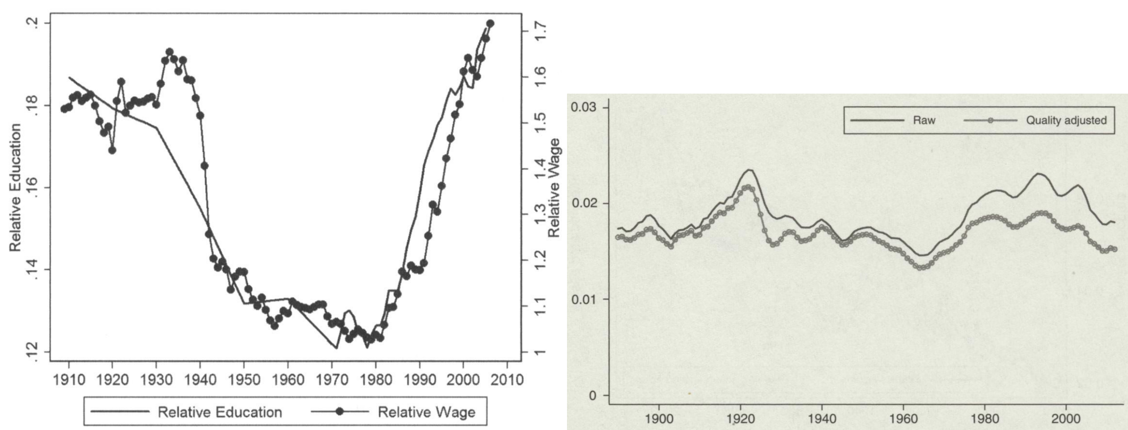


(a) Relative wage of US finance workers **(b)** Unit cost of financial intermediation

Figure 8

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

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 simplicity, 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:

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

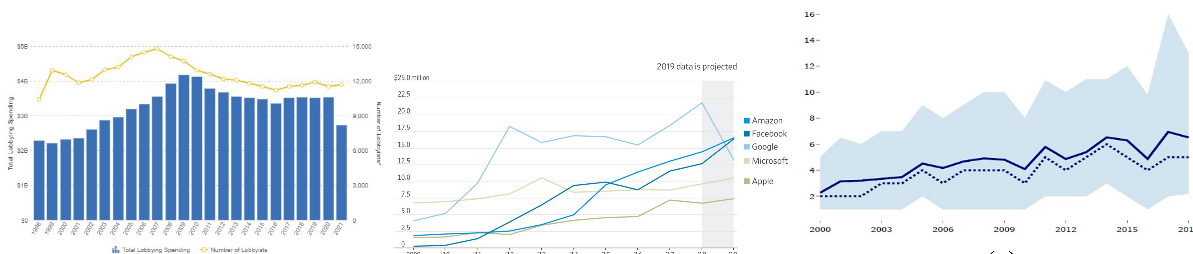
which simplifies to:

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

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 by a wider margin. 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). We now show that our analysis can be adapted to capture firms' increased investments in government lobbying.



(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).

Suppose the government taxes the income of two sectors of the economy, sectors i and j, at a fixed rate τ. This tax inflow is then redistributed among these two sectors through transfers such as non-taxable subsidies and grants, based on various governmental objectives. Without lobbying, each sector 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 sector i (similar notation for sector j). However, by investing resources on lobbying efforts, a sector 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 sector. Thus, with lobbying spendings of x_i and x_j from the two sectors, sector i expects to receive a subsidy of:

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

As a result, the payoff sector i expects to collect when investing s_i to increase the taxable income coming from its core production 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 sector i can appropriate from the government through lobbying efforts is proportional to the surplus created by the whole economy. As in our baseline analysis, a sector'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 sector j. Thus, an industry-wide technological progress that boosts the marginal productivity of government lobbying (i.e., β) will result in a reallocation of resources toward this rent-seeking activity, even when also associated with an increase in the marginal productivity of both sectors' core businesses.

5.5 Price markups

A recent literature has documented that observed technological improvements did not always translate into large improvements in economic productivity, but sometimes translated into increased market power for some firms (see, e.g., Philippon 2019, De Loecker, Eeckhout and Unger 2020, Nekarda and Ramey 2020). Figure 10 indeed shows the evolution of price markups for U.S. 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

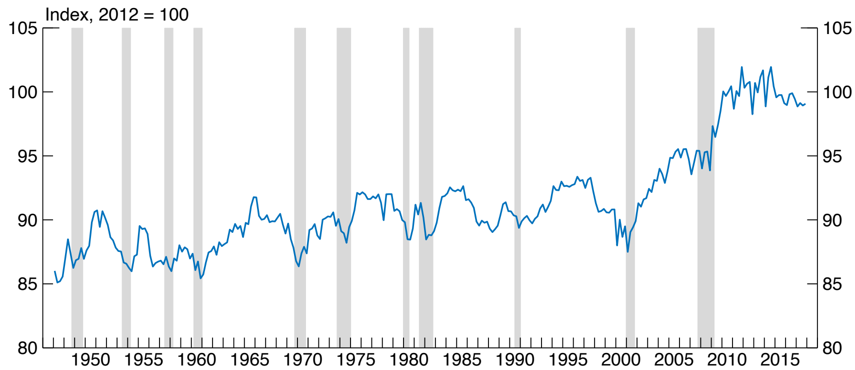


Figure 10

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.

the surplus of each one of these firms, denoted π, is also its aggregate value added. These firms 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:

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

which, when 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 facilitates surplus-appropriating activities, through a higher ϕ_a, induces firms to channel more resources towards extracting 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 make the whole economy wealthier and a wealthier body of consumers increases the surplus that firms can appropriate when exercising their market power.

6 Conclusion

We show that technological innovations that improve productivity for an entire industry or economy can 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 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. We emphasize the importance of incorporating surplus-appropriation as a fundamental and integral force within economic growth models and of improving its measurement for policymaking purposes.

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