Slowing Business Dynamism and Productivity Growth in the United States

Ufuk Akcigit and Sina T. Ates

Abstract

Business dynamism—the perpetual process of new firms forming, growing, shrinking, and dying—and the associated reallocation of factors toward more productive units is a fundamental source of aggregate productivity growth in a healthy economy. A variety of empirical regularities indicates that business dynamism in the United States has been slowing down since the 1980s, and even more strikingly, since the 2000s. We rationalize these regularities within a framework based on endogenous growth theory. Theoretical and quantitative investigations point to the role of factors that hamper the competition between the leaders and their competitors in U.S. industries as the key driver of the observed dynamics. In particular, a decline in knowledge diffusion, which allows laggard firms to learn from and implement the practices of the frontier firms, has potentially obstructed rivals from exerting enough competitive pressure on the frontier firms, leading dynamically to a decline in leaders' incentives to experiment and innovate. We present a set of empirical findings that are consistent with our theory and briefly review case studies from other countries.

I. Introduction

Aggregate productivity growth is the fundamental source of long-run economic growth and is driven to a large part by the reallocation of factors toward more productive units (Foster et al. 2000). What ensures this factor reallocation is a healthy business dynamism in an economy—the perpetual process of entry, growth, downsizing and exiting of firms. In the United States, an extensive set of empirical regularities suggests that business dynamism has been slowing down since early 1980s. The following list summarizes the characteristics of the slowdown in U.S. business dynamism (Akcigit and Ates 2020).

1. *Market concentration has risen.*
2. *Average markups have increased.*
3. *Average profits have increased.*
4. *The labor share of output has gone down.*
5. *The rise in market concentration and the fall in labor share are positively associated.*
6. *The labor productivity gap between frontier and laggard firms has widened.*
7. *Firm entry rate and the share of young firms in economic activity have declined.*
8. *Job reallocation has slowed down.*
9. *The dispersion of firm growth has decreased.*
10. *The productivity growth has fallen, except for a temporary burst between mid-1990s and mid-2000s.*

While the economics literature has more or less agreed on the broad weakening of business dynamism in the United States, there is less consensus on the underlying causes of these empirical trends, with most of them being analyzed in isolation. In this study, we strive to shed light on this discussion, delving deeper into the strategic aspect of competition and innovation. First, we introduce a unifying theoretical framework based on new growth theory, to make sense of the wide set of symptoms of declining business dynamism. We demonstrate analytically that a fairly stylized model of step-by-step innovations, with creative destruction and endogenous competition at its center, can account for salient features of declining business dynamism. We then use an extended version of this framework for quantitative analysis to determine the most important factors behind the slowdown in U.S. business dynamism over the past several decades. The results indicate that a decline in diffusion of knowledge from frontier firms to their competitors is a dominant factor behind the observed trends; a finding that is supported by an array of new empirical findings from micro-level data that focus on firms, ideas (patents), and inventors. As such, we trace the roots of lower productivity growth at the macro level in declining business dynamism and provide empirical evidence from the micro-level data to show how slower knowledge diffusion across firms could drive this decline. We complement our study with a brief discussion of two relevant country-specific case studies, which shed light on other factors that could disrupt business dynamism, considering also an emerging economy.

The key ingredient of our model is the strategic interaction between two competing firms in each market, with their decisions—in particular, research and development (R&D) efforts—depending on their own position relative to their rival.[1] The theoretical framework centers on an economy that consists of a measure of intermediate product lines. In each of these lines, two incumbent firms compete à la Bertrand for market leadership.[2] These firms produce the same good with different labor productivities; hence, the firm that has a better technology serves the market. Sectors are of two types. In leveled sectors, both firms have the same productivity, and therefore, both firms have the same market share and competition is strongest. In unleveled sectors, one of the two firms has a strictly higher productivity and serves the entire market; hence, market concentration is highest. Crucially, in this model, the markups are endogenous. More specifically, the markup that the leader firm can charge, and thus its profits, depends on the technological edge it has over its competitor. Firms invest in R&D to improve their productivity, hoping to obtain market leadership or increase their profits. The key benefit of this framework is that it explicitly models the relationship between product market competition and firms' endogenous innovation decisions. While the strength of competition affects firms' innovation efforts, the technological advantage of a firm determines its relative position to its rival and thus its markup and profits. Therefore, this framework allows us to explore different margins that could have distorted firm-level decisions and thus have led to endogenous changes in business dynamism.

We use a fairly standard version of the model, with no firm entry and a maximum of one unit of technology gap between competitors, to analytically characterize the predictions of the model as to the symptoms of slower business dynamism. A key margin that we explore is *knowledge diffusion* between frontier and laggard firms. In the model, we include an exogenous probability of catch-up, which makes the laggard close its technology difference with the leader.[3] Such a spillover benefits laggard firms, while it entails a cost for the leading firm in terms of higher competition. In the model, this cost is reflected by the fact that the frontier firm loses its technology advantage, and thus, the leadership of the market. We demonstrate theoretically that a *decline in knowledge diffusion* mimics most of the stylized facts. To start, it leads to a higher concentration with higher markups and profits (Facts 1, 2, and 3), and a decrease in the labor share of output (Fact 4). A crucial mechanism behind these results is the compositional shift in the economy to more unleveled and concentrated sectors where more productive firms pay less to their workers, consistent with Fact 5. As sectors become more concentrated, the productivity gap between the competing firms opens up, as in Fact 6.

Of course, the lack of free entry of firms leaves the standard model mute about the age-related trends (Fact 7). Similarly, the combined variation in both the composition and incentive margins (affecting firms' innovation efforts) yields ambiguous results for other incumbent-growth-related moments (Facts 8 and 9), calling for a quantitative investigation. Moreover, it is also important to understand the significance of decline in knowledge diffusion in comparison with other potential factors that could affect business dynamism. Therefore, in Section IV.v, we discuss the results from the quantitative investigation of a richer version of the model that features free entry and other potential channels in addition to knowledge diffusion, among other extensions. Importantly, we focus specifically on the implications of the model over the transition period that replicates the experience of the U.S. economy over the past several decades. The quantitative analysis corroborates our theoretical findings, underscoring the dominant role of a decline in knowledge diffusion in explaining the symptoms of the declining U.S. business dynamism.

Our theoretical and quantitative exercises point to a specific mechanism that rationalizes the slowdown in U.S. business dynamism, and our next step is to explore this mechanism in the data. In particular, we delve deeper into micro-level data on firms, patents—i.e., ideas—they generate, and inventors they hire. To preview some of the results, we first document the concurrent concentration of patenting activity among firms that already own the largest stock of patents or knowledge during the period of interest. We show that a higher patent concentration in an industry is positively associated with several symptoms of a declining business dynamism. Firms with larger patent arsenals may potentially use these to deter rivals from exerting competitive pressure, which is consistent with our findings using patent litigations. Similarly, we find that inventors are hoarded in larger firms. Interestingly, the innovative activity of these inventors and its quality deteriorate when they switch to large incumbent firms relative to those hired at young firms, although they earn much higher wages, suggesting a higher private return despite a lower public return.

Lastly, we end our study with a review of two recent country studies that analyze the relevant experiences of Italy and Turkey. While we focused on the changes in the knowledge diffusion margin in the study of U.S. business dynamism, a broader interpretation of our results is that the likely culprit behind the observed symptoms is a factor that hampers the competition between market leaders and their likely competitors. The studies of Italian and Turkish experiences highlight two such other factors: political connectedness of firms and differential access of firms to credit. These studies reveal how mechanisms that shield established firms from competitive pressures can cause a loss in overall business dynamism, with one of them providing a rare analysis of this phenomenon in the context of a developing economy.

While we explicitly focus on the declining U.S. business dynamism in this paper, we find it valuable to briefly discuss the model's implications for aggregate productivity growth. The balanced growth path of the model predicts an ambiguous effect of a decline in the intensity of knowledge diffusion on aggregate productivity growth, similar to Facts 8 and 9. Again, this result hinges on the combination of a positive incentive effect and a negative composition effect. However, the sequencing of these effects would matter if we consider the transition path of the economy adjusting to a decline in knowledge diffusion. While the initial stimulation of neck-and-neck firms to innovate would raise the growth rate, the subsequent shift of the economy toward unleveled sectors would cause a growth decline, creating a hump-shaped response in aggregate productivity growth. This insight can shed a light on the recent "fast/slow" cycle observed in U.S. productivity growth—in other words, faster growth between roughly the mid-1990s and mid-2000s, which many economists see as a byproduct of diffusion of information and communication technologies (ICT) in the economy, followed by a slower growth rate (Fernald 2014; Syverson 2017).

The rest of the paper is structured as follows. Section II presents the empirical evidence on declining business dynamism. Section III discusses potential causes of these trends proposed in the literature. Section IV introduces the theoretical model and its analytical implications and also presents the results obtained from an extended quantitative version of the model. Section V discusses the knowledge diffusion margin in light of new empirical evidence from micro-level data on firms, patents and inventors. Section VI presents the main findings of two relevant country studies that highlight other factors that could hamper business dynamism. Finally, Section VII concludes.

II. Trends in U.S. Business Dynamism

In this section, we briefly summarize the empirical trends documented in the literature on which we focus throughout our analysis. We list the figures in Appendix A.

Fact 1. Market Concentration Has Increased.

As documented by Autor et al. (2017a,b), Chart A.1 demonstrates this trend in terms of the fraction of sales captured by the largest four and 20 firms, respectively, in each industry, while concentration measured by the Herfindahl-Hirschman index exhibits similar results.[4] Grullon et al. (2017), analyzing Compustat data, arrive at a similar conclusion documenting the marked increase in market concentration in most U.S. industries in the post-2000 era.[5,6]

Fact 2. Markups Have Increased.

The level of markups has been on the rise in the United States, as illustrated in Chart A.2 (see Nekarda and Ramey 2013; De Loecker et al. 2017; Gutiérrez and Philippon 2017; Eggertsson et al. 2018; Hall 2018, among others; see De Loecker and Eeckhout (2018) for an international comparison). Using cross-country data, Calligaris et al. (2018) also find a global rise in markups (driven by firms in the top decile of the markup distribution). Using cross-country data, Calligaris et al. (2018) also find a global rise in markups (driven by firms in the top decile of the markup distribution) and a widening average markup gap between digitally-intensive and other sectors. The literature pays particular attention to the rise in markups as it serves as a proxy for market power and concentration.[7,8]

Fact 3. Profit Share of GDP Has Increased.

Similar to markups, the profit share of GDP has been on the rise, as shown in Chart A.3. Some recent papers investigate the implications of this trend. Gutiérrez and Philippon (2016) argue that higher within-industry concentration measured in terms of profitability is associated with weak investment. This result resonates with the findings of Eggertsson et al. (2018), who explore mechanisms that can give rise to higher profitability and lower investment-to-output ratio, along with several other changes.

Fact 4. The Labor Share Has Declined.

Chart A.4 demonstrates the steady decline in the labor share of output in the United States since the early 1980s (Karabarbounis and Neiman 2013; Elsby et al. 2013; Lawrence 2015). Kehrig and Vincent (2018) highlight an even stronger drop in the labor share in the U.S. manufacturing sector between the late 1960s and early 2010s. This trend has also an international nature, as highlighted by Karabarbounis and Neiman (2013) and Autor et al. (2017b).

Fact 5. Market Concentration and Labor Share Are Negatively Associated.

Chart A.5, reproducing the findings of Autor et al. (2017b), demonstrates the negative correlation between market concentration and the labor share across U.S. industries. Other recent works (e.g., Barkai 2017 and Eggertsson et al. 2018) corroborate this observation.

Fact 6. Labor Productivity Gap Between the Frontier and Laggard Firms Has Widened.

A key fact that is particularly informative about the culprit behind declining business dynamism is the labor productivity gap between frontier and laggard firms. Chart A.7 shows that this gap—measured in terms of real value added per worker—has been widening (Andrews et al. 2015, 2016).[9] Importantly, the authors also find that the aggregate productivity performance is weaker in industries where the divergence between frontier and laggard firms is stronger. This trend of a widening productivity gap between the frontier and laggard firms resonates with the finding of Decker et al. (2018), who show that the TFP dispersion across U.S. firms has risen, as shown in Chart A.7 in the appendix.

Fact 7. Firm Entry Rate and the Economic Share of Young Firms Have Declined.

A widely debated symptom of declining business dynamism in the United States is the fall in firm entry (see Decker et al. 2016a; Karahan et al. 2016; Gourio et al. 2014, among others). Chart A.8 illustrates this phenomenon using Business Dynamics Statistics data. This pattern is also common to individual industries.[10] Concurrently, the share of young firms in economic activity has been steadily declining since the early 1980s (Chart A.9).[11] Interestingly, several other advanced economies experience similar changes (Criscuolo et al. 2014; Bijnens and Konings 2018). This decline is particularly worrying given that surviving young firms contribute substantially to job creation (see Haltiwanger et al. 2013, in the context of the United States and Bravo-Biosca et al. 2013, for an international comparison).

Fact 8. Job Reallocation and Churn Have Gone Down.

Chart A.10 exhibits the secular decline in the gross job reallocation rate (defined as the sum of job creation and destruction rates) in the United States. For a thorough account of this phenomenon, see Decker et al. (2016a). The decline has been apparent in the retail trade and services sectors for several decades—due in large part to productivity–enhancing consolidation of activity in larger chains at the expense of mom and pop shops—whereas in the information sector a pronounced decline started in the early 2000s.

Fact 9. The Dispersion of Firm Growth Rates Has Gone Down.

As the activity by young (and high-growth) firms declined, the dispersion of firm growth (measured by standard deviation or skewness) decreased as well (Chart A.11)—an intriguing fact, particularly when considered in conjunction with the concurrent rise in the dispersion of productivity across firms. Using data from the U.S. Census Bureau, Decker et al. (2016a) show that the decline in growth dispersion accelerated in the post-2000 period.[12]

Fact 10. The Productivity Growth Has Fallen.

Finally, a heated debate on which our discussion of declining business dynamism could potentially shed some light concerns trends in U.S. aggregate productivity growth (labor or multifactor) in the last several decades. Except for a short period of increase between roughly the mid-1990s and mid-2000s, U.S. productivity growth appears to have slowed down notably (Gordon 2012; see Chart A.12).[13] Gordon (2016) concludes that broad-impact innovations have been depleted, which implies a structurally low aggregate growth in the foreseeable future, a prediction shared by Fernald (2014). Brynjolfsson and McAfee (2014) and Brynjolfsson et al. (2017) disagree, arguing that the diffusion of new technologies such as artificial intelligence will boost productivity growth going forward, whereas Nordhaus (2015) expects the opposite.[14]

While understanding the long-term future of aggregate productivity is very intriguing in itself and has far-reaching implications, resolving this debate is beyond the scope of this paper. Our priority here is to understand declining U.S. business dynamism in an all-encompassing manner, which is a daunting task by itself. Yet we will also examine the growth implications of the framework that we will use for this task, which we hope would help set the stage for future research to explore potential links between changes in business dynamism and aggregate productivity growth.

III. Potential Causes of Declining Business Dynamism

As discussed in the previous section, a large and growing body of work presents evidence of a slowdown in U.S. business dynamism and its manifestations through several potentially related dimensions. The question that naturally follows is, of course, "What is the driving force behind these developments?" The answer to this question is still being debated. The literature has proposed various candidates, albeit often focusing on specific aspects of business dynamics, including demographic shifts, sectoral changes, regulations, among others. In this section, we summarize these likely candidates.

As the culprit for the declining pace of startup creation, some researchers have focused on structural changes to the economy. Karahan et al. (2016) argue that "demographic" shifts were the main driver of declining U.S. entrepreneurship. In particular, they argue that the slowdown in the growth rate of the U.S. labor force with the end of the "baby-boomer" generation led to a rise in wages, and in turn, a decline in the firm entry rate.[15] Another structural-shift-based explanation for the fall in the firm entry rate relies on the Gordon (2016) argument that the economy has run out of low-hanging fruit innovations—i.e., ideas that are relatively easier to obtain and have far-reaching spin-off applications. Bloom et al. (2017) support this view, arguing that research efforts have been increasing, while their productivity has been falling, likely exacerbated by dead-end duplication of effort as described in Akcigit and Liu (2016). A decline in patent to R&D ratio was also observed by Kortum (1997). Through the lens of Gort and Klepper (1982), a lower arrival rate of impactful innovations would translate into lower rates of firm entry.

Focusing on job flows, Decker et al. (2018) argue that the culprit behind declining dynamism is the declining responsiveness of firms to shocks rather than a structural change in the nature of those idiosyncratic shocks. They argue that the declining responsiveness likely reflects difficulties in the employment adjustment margin, which may depend on a variety of factors (see Decker et al. 2016a for a succinct overview). For instance, Davis and Haltiwanger (2014) suggest that lower worker fluidity may be a reflection of widespread occupational licensing practices or the inhibitory effects of employment protection regulations.[16]

Analyzing the decreasing labor share in the economy, some recent studies focus on the role of "superstar" firms—very productive firms that dominate the industries in which they operate—and the concentration of economic activity in the hands of these firms. Kehrig and Vincent (2018) show that the product market concentration across U.S. industries has been increasing in the last several decades and that the industries with the highest concentration of sales are the ones with the largest declines in the labor share. The authors also provide evidence that the concentration dynamics due to superstar firms are more pronounced in "winner-takes-all" industries.[17] These findings are consistent with the analysis of Kehrig and Vincent (2018) who, using data from U.S. Census of Manufactures, document the shift of value added to hyperproductive low labor-share establishments. Using cross-country data, Diez et al. (2018) also find empirical support for the increasingly dominant role of superstar firms. The authors argue that the market power of superstar firms, manifesting itself in higher markups and profit margins, has been on the rise and is negatively associated with the labor share of output. Similarly, Barkai (2017) also finds a link between higher concentration and lower labor (and capital) share.[18,19]

One potential driver of rising market concentration may be the nature of new technologies and the increasing importance of the use of (often big and proprietary) data and tacit knowledge in production processes along with the rise of ICT-intensive sectors.[20] Digitalization, reliance on data, and the use of tacit knowledge can favor large and more productive firms in ways that hamper the diffusion of technology from frontier to laggard firms, as stressed by Andrews et al. (2016).[21] Calligaris et al. (2018) find that markups are higher in digitally intensive sectors relative to non-digitally intensive ones. Bessen (2017) finds that industry concentration measured by sales ratios is strongly associated with the industry-level intensity of ICT use. Autor et al. (2017b) find evidence that suggests a negative association between industry concentration and slower technology diffusion measured by the speed of patent citations. These findings may reflect that firms that better adapt to new technologies can gain a relatively more advantageous position compared to their competitors and can capture outsized market power. For instance, Grullon et al. (2017) find that in the post-2000 period, U.S. firms in more concentrated markets possess a larger number of patents as well as more valuable ones, which the authors interpret to be indicative of higher entry barriers in such sectors.

Regulations may be another driver of lower technology diffusion between firms, causing higher market concentration. Andrews et al. (2016) argue that lack of pro-competitive and extensive product market reforms exacerbated the widening productivity gap between frontier and laggard firms in retail services sectors across OECD economies in the post-2000 period. Grullon et al. (2017) find support for weaker antitrust law enforcement in the United States. This finding resonates with several legal studies that underscore a paradigm shift in the application of antitrust regulations toward the Chicago school, which emphasizes product market efficiency in the interpretation of laws (see Baker 2012; Khan 2016; Lynn 2010). Using U.S. data on lobbying and campaign spending activity, Bessen (2016) argues that political rent seeking played a disproportionate role in rising corporate profit margins in the United States in the post-2000 period. Using a cross-country approach, Haltiwanger et al. (2014) also stress the role of strict hiring and firing regulations in the reduced pace of job reallocation.[22]

IV. Basic Model to Rationalize the Observed Trends

In this section, we present a theoretical model of innovation and firm dynamics. The framework draws on step-by-step innovation models of endogenous growth (Aghion et al. 2001, 2005; Acemoglu and Akcigit 2012; Akcigit et al. 2018b) and is a simplified version of the model studied by Akcigit and Ates (2019). In our analysis, we will discuss the analytical implications of the model in light of the empirical regularities listed in Section II, focusing on the balanced growth path (BGP) equilibrium. For a quantitative analysis that also accounts for the transition path, we refer the interested reader to Akcigit and Ates (2019). A number of crucial features of the model are worth emphasizing: (i) Firms have strategic investment decisions—a key to understanding declining business dynamism, (ii) productivity enhancing innovation decisions are endogenous, (iii) thus, markups are endogenous, depending on the technology gap between competitors, and (iv) a reduced-form parameter governs the process of knowledge diffusion, keeping technology gaps within some limits.

In our model, a representative final good firm combines a continuum of intermediate goods to produce the final output. There is a unit measure of intermediate good product lines, and in each of them, two intermediate good firms compete to enjoy the monopoly power of production. Intermediate firms produce the same product but with different productivities. The firm with a higher productivity—the leader—is able to capture the market and reaps the monopoly rents. Firms invest in research and development activities to improve their productivity and take over the market ownership. Importantly, we assume that there is an exogenous flow of knowledge from the market leader to the follower that allows the follower to close the productivity gap with the leader, bringing them to a neck-and-neck position. The Poisson rate of this knowledge diffusion will be crucial in our analysis; in particular, we will show that a weakening in this margin can generate some of the observed changes in the economy.

IV.i. Basic Environment

Preferences We consider the following closed economy in continuous time. A unit measure of representative households consume the final good with log-utility preferences

$$U_t = \int_t^{\infty} \exp(-\rho(s-t)) \ln C_s ds,$$

where C_t represents consumption at time t, and $\rho > 0$ is the discount rate. The budget constraint of the representative consumer reads as

$$C_t + \dot{A}_t = w_t L_t + r_t A_t,$$

where A_t denotes total assets and L_t denotes labor (supplied inelastically). We normalize the total labor supply to one, such that $L_t = 1$. The relevant prices are the interest rate r_t, and the wage rate w_t. We normalize the price of the consumption good to one without loss of any generality. Households own the firms in the economy, and the asset market clearing condition implies that the total assets A_t equal the sum of firm values, $A_t = \int_{\mathcal{F}} V_{ft} df,$, where F is the set of firms in the economy.

Final Good The final good Y_t is produced in a perfectly competitive market according to the following production technology:

$$\ln Y_t = \int_0^1 \ln y_{jt} dj, \tag{1}$$

where y_{jt} denotes the amount of intermediate variety $j \in [0, 1]$ used at time t. The final good is used for consumption and R&D investment. Hence the resource constraint of the economy is simply

$$Y_t = C_t + R_t \tag{2}$$

with R_t denoting the aggregate R&D expenditure. Next, we describe the production of intermediate varieties.

Intermediate Goods and Innovation In each product line j, there are two incumbent firms $i \in \{1, 2\}$ that can produce a perfectly substitutable variety of good j. Total output of variety j is given by

$$y_j = y_{ijt} + y_{-ijt},$$

where $-i$ denotes the competitor of firm i, such that $-i \in \{1, 2\}$ and $-i \neq i$. Each firm produces according to the following linear production technology:

$$y_{ijt} = q_{ijt} l_{ijt}.$$

Here, l_{ijt} denotes the labor employed, and q_{ijt} is the associated labor productivity of firm *i*. These firms compete for market leadership à la Bertrand. The firm that has a higher labor productivity enjoys a cost advantage, which enables it to supply the entire market of good *j*. We call firm i the market leader and $-i$ the follower in *j* if $q_i >$ $q-i$. The two firms are neck-and-neck if $q_i = q_{-i}$.

Firms can improve their productivity by investing in innovation activity. If an innovation arrives in time $(t,\ t + \Delta t)$, it increases the innovating firm's productivity level proportionally by a factor $\lambda > 1$ such that

$$q_{ij(t+\Delta t)} = \lambda q_{ijt}.$$

Assuming an initial value of $q_{ij0} = 1$, we can summarize the productivity levels at time t by $q_{ijt} = \lambda^{nijt}$, where n_{ijt} captures the number of productivity improvements that took place by firm *i* since time *0*. The productivity difference between a leader and its follower reflects the difference between the total number of technology rungs these firms' productivities build on. In this simplified setting, we assume that this difference can be at most one step such that the economy consists of two types of product lines: leveled and unleveled. Then, the relative productivity level is given by

$$\frac{q_{ijt}}{q_{-ijt}} = \frac{\lambda^{n_{ijt}}}{\lambda^{n_{-ijt}}} = \lambda^{n_{ijt}-n_{-ijt}} \equiv \lambda^{m_{ijt}},$$

where $m_{ijt} \in \{-1, 0, 1\}$ defines the technology gap between the firm *i* and $-i$ in sector *j*. The technology gap between the two firms is a sufficient statistic to describe firm-specific payoffs, and, therefore, we will drop industry subscript j and use the notation mit $\in \{-1, 0, 1\}$ whenever m is specified to denote a firm-specific value. Likewise, we will use $m_{jt} \in \{0, 1\}$ to index sectors that are leveled or unleveled.

Firms invest in R&D to eventually take over the production by improving their productivity. When a firm invests R_{ijt} units of final good, it generates an innovation with the arrival rate of x_{ijt}. Following a large empirical literature that estimates the innovation cost function[23], we consider a quadratic cost of generating the arrival rate x_{ijt}, denoted by R_{ijt}, such that

$$R_{ijt} = \alpha \frac{x_{ijt}^2}{2} Y_t.$$

In this expression, α determines the scale of the cost function and Y_t ensures that the cost scales with the size of the economy.

In addition, we assume that knowledge may diffuse from the leader to the follower at an exogenous Poisson flow rate δ. Knowledge diffusion enables the follower to catch up with the leader's productivity level, bringing both firms to a neck-and-neck position. We interpret this exogenous catch-up probability to reflect the degree of *knowledge diffusion* or *intellectual property rights (IPR) protection*, as in Acemoglu and Akcigit (2012), with lower values of δ implying higher protection and lower catch-up. A leader's patent expires with the flow rate δ, allowing the follower to replicate the frontier technology and catch-up with the leader.

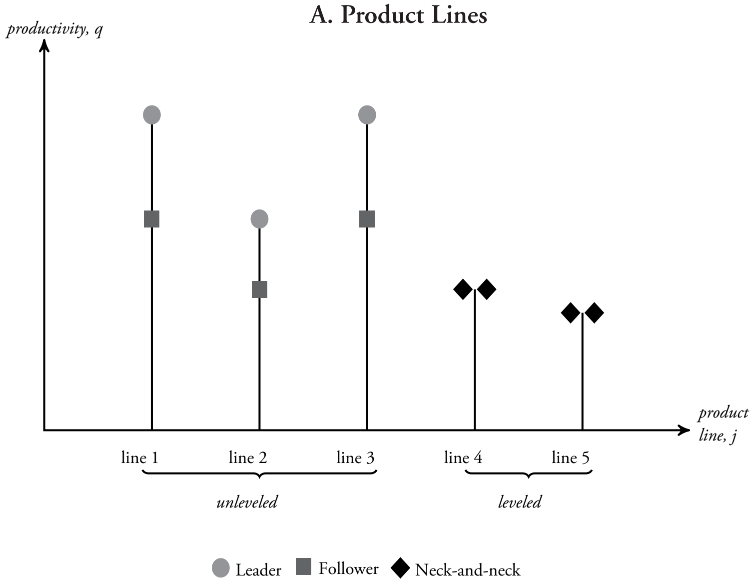
In Chart 1, we demonstrate how leadership positions in intermediate product lines evolve as a result of innovations. The left panel exhibits five product lines with different degrees of competition, with the first three lines being unleveled and the last two being leveled. Circles denote leaders, squares denote followers and diamonds denote neck-and-neck firms. If firm *i* leads in an unleveled line, then $q_i = \lambda q_{-i}$. The right panel shows the changes in leadership. In line 1, the follower catches up with the previous leader with help of an exogenous shock of knowledge diffusion, while in line 2, the follower catches up with an endogenous innovation. In line 4, a neck-and-neck firm innovates and escapes intense competition, capturing the market leadership. In lines 3 and 5, there is no change as no firm innovates (and as the follower in line 3 does not receive an exogenous shock).

In the remainder of our theoretical analysis, we focus on a balanced growth path equilibrium. For brevity, we present the definition of equilibrium relationships in Appendix B. However, it is worth it to define two variables that will be key in our analysis before proceeding. First, we define the share of unleveled sectors, which also acts as a proxy for the level of *market concentration*, as

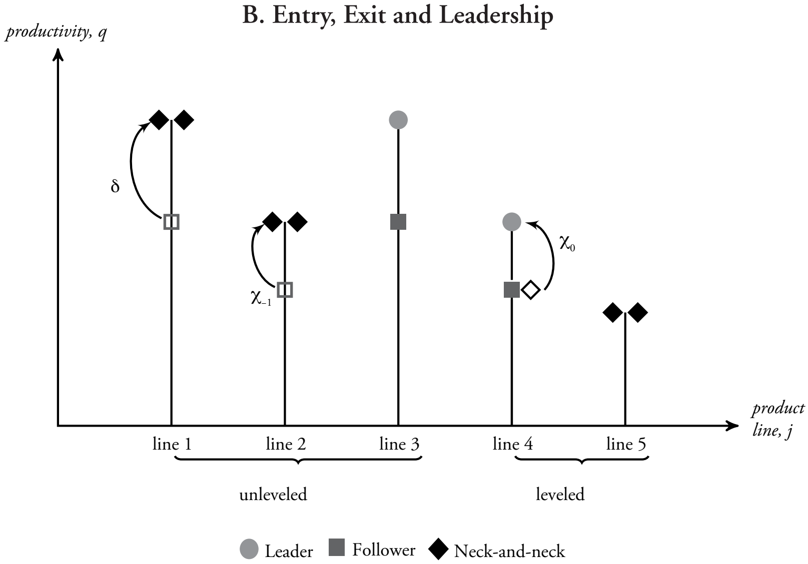
$$\mu \equiv \int_0^1 \mathbb{I}(q_{ij} \neq q_{-ij})dj.$$

Chart 1
Evolution of Product Lines

A. Product Lines



B. Entry, Exit and Leadership



Notes: Panel A exhibits the positions of competing incumbent firms in leveled and unleveled industries with heterogeneous productivity levels. If firm *i* leads in an unleveled line, then $qi = \lambda q_{-i}$. Panel B illustrates the effects incumbent innovation on industry leadership. Empty squares or circles denote the previous position of innovating firms.

In BGP, the value of this object becomes

$$\mu = \frac{2x_0}{2x_0 + x_{-1} + \delta}, \tag{3}$$

where x_0 and x_{-1} denote the innovation decisions of neck-and-neck and follower firms.

Finally, the equilibrium growth rate of this economy is given by

$$g = 2x_0(1 - \mu) \ln \lambda. \tag{4}$$

The growth rate of the economy is determined by innovations of neck-and-neck firms, which improve the productivity of workers employed in intermediate-good production. The surprising result here is that firms in unleveled sectors do not contribute to the BGP growth. This happens because while the leaders do not invest in innovation—as they could not open up their lead more than one step—the followers do not push the frontier forward but rather catch-up with the leader's technology level. Therefore market concentration (μ) has a negative impact on economic growth (g).[24]

IV.ii. Impact of Knowledge Diffusion, δ

In this section, we discuss some theoretical predictions of the framework introduced above, which shed light on several empirical trends discussed in Section II. Specifically, we focus on the effects of a decline in the intensity of knowledge diffusion on firms' innovation rates and their distributional consequences. These effects, in turn, generate changes in markups, profits and the labor share that are comparable to the observed trends. In the next section, we provide a discussion on why a decline in knowledge diffusion is a plausible explanation in light of the changes in the U.S. economy in recent decades.

We start with the following lemma that will form the basis of the main results.

Lemma 1 *The following results hold in a BGP equilibrium.*

Neck-and-neck firms have higher innovation intensity than laggard firms.

An increase in knowledge diffusion decreases innovation efforts. The decline is even more drastic for the neck-and-neck firms.

Proof. *See Akcigit and Ates (2020)*

The first point of Lemma 1 is a standard result of step-by-step innovation models driven by the escape-competition effect—the attempt of neck-and-neck firms to get ahead of their competitor by intensely investing in innovation. The second point implies that a decline in knowledge diffusion has a positive effect on the innovation rates of follower and neck-and-neck firms, but more so for neck-and-neck firms. The reason is that the value of being a leader increases disproportionately as the exogenous risk of losing the positions declines. These relationships lead to the following corollary.

Corollary 1 In a BGP equilibrium, a decrease in knowledge diffusion increases market concentration.

Proof. See Akcigit and Ates (2020)

Corollary 1 describes the main predictions of the model when two BGPs with different knowledge diffusion rates are compared. The relatively larger increase in neck-and-neck firms' innovation rates in response to a decline in the intensity of knowledge diffusion results in an associated increase in the measure of unleveled sectors. This compositional shift forms the backbone of the theoretical predictions that we discuss in Section IV.iii.

IV.iii. Reduction in Knowledge Diffusion and Empirical Facts 1-6

Using the theoretical results above, now we are ready to generate the empirical predictions of our model.

Fact 1. Market Concentration

In our model, market competition is toughest when firms are in a neck-and-neck position, i.e., when the industry is in state $m = 0$. Markups and profits vanish because of limit pricing and sales are equalized. As a result, the aggregate Herfindahl-Hirschman Index (HHI) can be summarized as follows:

$$HHI = \mu \times [(100\%)^2 + (0\%)^2] + (1 - \mu) \times [(50\%)^2 + (50\%)^2]$$
$$= 0.5 + 0.5\mu.$$

Our model implies that the HHI, the key measure of market concentration, increases in the measure of unleveled industries (μ). Recall that the BGP expression of the unleveled industries is

$$\mu = \frac{2x_0}{2x_0 + x_{-1} + \delta},$$

From Corollary 1, a decrease in knowledge diffusion increases market concentration through a direct and an indirect channel. First, a reduction in δ reduces the frequency at which followers learn from the leaders; hence, market concentration increases. Second, reduced knowledge diffusion increases the return to being the market leader. Neck-and-neck firms are much closer to becoming a leader than a follower who needs two innovations to become a leader. Therefore, an increase in the return to being a leader gives a bigger incentive to neck-and-neck firms, which in turn expands the share of unleveled industries; hence, the market concentration, i.e.,

$$\frac{d(HHI)}{d\delta} < 0.$$

Fact 2. Markups

In this model, markups are positive only when a firm has a strict advantage over its rival, i.e., $m_i = 1$. Therefore, the average markup in this economy is

$$Average\_markup = \mu \times (\lambda - 1) + (1 - \mu) \times 0$$
$$= \mu \times (\lambda - 1).$$

This expression shows that the average markup is proportional to the market concentration in the economy. Using Corollary 1, we conclude that the average markup increases when knowledge diffusion decreases, i.e.,

$$\frac{d(Average\_markup)}{d\delta} < 0.$$

Fact 3. Profit Share of GDP

Another empirical fact that the model can directly explain is the rise in the profit share of GDP. Recall that the profits in unleveled sectors are $(1 - \lambda^{-1})\, Y$ and in leveled industries they are 0. Therefore, the aggregate profit share is simply

$$Profit\,/\,GDP = \mu \times \left(1 - \frac{1}{\lambda}\right). \tag{5}$$

We again see that a rise in market concentration increases the share of GDP that is accrued by the business owners. Hence, a reduction in knowledge diffusion also causes a rise in the profit share of GDP, i.e.,

$$\frac{d(Profit\,/\,GDP)}{d\delta} < 0.$$

Fact 4. Labor Share

In our model, labor is the only input for production. When business owners generate some additional gains as a fraction of the output, it comes at the expense of reduced labor compensation. Therefore, markups and labor share go in opposite directions. More formally, the labor share in the above economy is

$$\begin{aligned} Labor\_share &= (1-\mu) \times 1 + \mu \times \frac{1}{\lambda} \\ &= 1 - \mu \times \left(1 - \frac{1}{\lambda}\right), \end{aligned}$$

which is again defined as ω as in equation (A.6). The labor share is 100% in leveled industries and $1/\lambda$ in unleveled industries. Therefore, this expression shows that the labor share decreases in market concentration and increases in the level of knowledge diffusion, as summarized by the following expression:

$$\frac{d(Labor\_share)}{d\delta} > 0.$$

Fact 5. Market Concentration and Labor Share

Our model has an interesting prediction on the relationship between productivity and labor share. In the same industry, firms' wage bill as share of sales decreases when they become more productive. Consider a leveled sector. When firms are neck-and-neck, the labor share is simply 100%, as they do not generate any profits. Yet once one of the firms innovates and becomes more productive, the labor share declines to $1/\lambda$. Therefore, market concentration and labor share are negatively correlated:

$$Labor\_share(m_j = 1) < Labor\_share(m_j = 0).$$

Fact 6. Productivity Gap between Leaders and Followers

Another interesting feature of our model is the link between relative productivities (q_i/q_{-i}) and knowledge diffusion (δ). The productivity of the market leader relative to the follower is 1 in leveled industries and λ in unleveled industries. Therefore, the average relative productivity can be expressed as

$$\begin{aligned} Average\_productivity\_gap &= \mu \times \lambda + (1 - \mu) \\ &= 1 + \mu \times (\lambda - 1). \end{aligned}$$

This expression, together with Corollary 1, implies that when knowledge diffusion slows down, the productivity gap between the leaders and followers open up. Therefore,

$$\frac{d(Average\_productivity\_gap)}{d\delta} < 0.$$

IV.iv. Remaining Empirical Facts 7-10

In the introduction of this paper, we listed four more empirical facts in the U.S. data. The first of those facts

> *Fact 7. Firm entry rate and the share of young firms in economic activity have declined.*

was related to entrants. Our model is silent on these closely tied observations, as we abstracted from free entry in order to keep the model analytically tractable and mostly focused on the competition between two incumbents. However, we can already develop some intuitions on the implications of free entry in this framework. Empirically, it is well known that new firms start small and some manage to grow over time. To capture this, we can think of a framework where entrants replace followers ($m_i = -1$) with probability μ or neck-and-neck firms ($m_i = 0$) with probability $1 - \mu$. Since entrants would be forward looking, they would directly be influenced by those forces that impact the market concentration. In particular, the implication of reduced knowledge diffusion (i.e., a decline in δ) would increase market concentration μ, which implies that a new entrant is much more likely to compete against a dominant market ($m_i = 1$), which would discourage new firm creation. This would also imply that the economic activity by young firms would also decrease.

The next two empirical facts

Fact 8. Job reallocation has slowed down.

Fact 9. The dispersion of firm growth has decreased.

concern the average growth rate of incumbents. Our model has the potential to explain these facts as well. Note that the change in the growth rate dynamics of firms is determined by two forces: (*i*) the composition of industries (μ) and (*ii*) the innovation incentives in each of those industries. In particular, a decrease in knowledge diffusion encourages both followers and neck-and-neck firms to invest more to innovate and become the market leader since the value of market leadership increases. This creates a *positive incentive effect*. However, reduction in knowledge diffusion implies that more sectors go into an unleveled state where firms invest less in innovation. This generates a *negative composition effect*. Hence, the overall response of firm growth and job reallocation depends on the quantitative magnitudes of each of these forces.

The final fact considers aggregate productivity growth:

Fact 10. The productivity growth has fallen.

Similar to the last two facts, aggregate productivity growth in this model would be determined by the combination of incentive and composition effects. A decline in the intensity of knowledge diffusion would exert both a positive force on aggregate growth by stimulating innovation of neck-and-neck firms and a negative force by causing the share of unleveled sectors to increase. In the BGP, the direction of the combined effect of the negative force through x0 and the positive force through μ would be ambiguous, as revealed by equation (4).

IV.v. Extending the Model and Quantitative Implications

As discussed in the previous section, the theoretical investigation has some limitations. First and foremost, we abstracted from the entry margin for the sake of analytical tractability. Second, the responses of some variables are not possible to characterize in a closed form and necessitate a numerical investigation. Third, the analysis was confined to the BGP. Last but not least, we focused on the particular channel of knowledge diffusion and did not discuss the effects of other potential channels that could have driven the observed trends in the data.

In Akcigit and Ates (2019), we extend our theoretical framework and resort to quantitative analysis to address all these concerns. Notably, we explicitly model the endogenous decision of a mass of entrant firms in addition to incumbent ones. In our quantitative investigation we focus on transition paths, mimicking the evolution of the U.S. economy in the decades after the 1980s. In addition, our extended structural model allows us to analyze various important margins that shape the competition dynamics including corporate taxes, R&D subsidies, entry costs, knowledge diffusion, a decline in the interest rates, a fall in research productivity and a decrease in workers' market power relative to employers/firms. Incidentally, the U.S. economy has observed significant changes along all of these margins in the past several decades (see Appendix C for a discussion). Changes in these margins have different implications as to how competition and business dynamism evolve over time in our model. Thus, our model allows us to run a horse race between these important channels and ascertain which one(s) among them has greater power in explaining the observed empirical trends in the U.S. economy.

Figure 1
Effects of Channels

	Data (1)	Lower corpo-rate tax (2)	Higher R&D subsi-dies (3)	Higher Entry Cost (4)	Lower Knowledge Diffusion (5)	Declining Interest Rate (5)	Ideas Getting Harder (7)	Weaker Power of Workers (8)
Concentration	↑	↔	↔	↔	↑	↔	↓	↔
Markups	↑	↔	↔	↔	↑	↔	↓	↑
Profit Share	↑	↔	↓	↔	↑	↓	↓	↑
Labor Share	↓	↔	↑	↔	↓	↑	↑	↓
Frontier vs. Laggard Gap	↑	↔	↔	↔	↑	↔	↔	↑
Entry	↓	↑	↔	↓	↓	↑	↓	↑
Young Frms' Empl. Share	↓	↔	↓	↓	↓	↔	↓	↔
Gross Job Reallocation	↓	↑	↑	↔	↓	↑	↓	↑
Dispersion of Firm Growth	↓	↓	↓	↑	↓	↓	↑	↓

Source: Akcigit and Ates (2019).

Our quantitative analysis proceeds as follows. We calibrate the model to pre-1980 targets in the data—which include firm entry, aggregate markups and output growth—as if the U.S. economy was in a steady state. Next, we focus on the transitional dynamics of the model economy and assess the ability of alternative channels mentioned earlier to generate observed trends in the model.[25] We introduce shocks to each channel one at a time (in a way disciplined by the data) and compare the model-generated responses of each variable over the transition path. Figure 1 compares the directions of model-based responses to changes in each mechanism with those of their empirical counterparts. The findings emphasize the differential ability of the knowledge diffusion channel for accounting for the observed trends. Another exercise, in which we decompose the contribution of alternative channels to the model-generated path of each variable, corroborates these findings. Both sets of exercises indicate that, even though each channel can have some effect at different levels, *reduction in knowledge diffusion* between 1980 and 2010 is the most powerful force in driving all of the observed trends simultaneously.[26]

Reduction in knowledge diffusion is able to account for these trends as follows. When knowledge diffusion slows down over time, as a direct effect, market leaders are shielded from being copied, which helps them establish stronger market power. When market leaders are shielded from being copied, which helps them establish stronger market power. When market leaders have a bigger lead over their rivals, the followers get discouraged; hence, they slow down. The productivity gap between leaders and followers opens up. The first implication of this widening is that market composition shifts to more concentrated sectors. Second, limit pricing allows stronger leaders (leaders further ahead) to charge higher markups, which also increases the profit share and decreases the labor share of gross domestic product (GDP). Since entrants are forward looking, they observe the strengthening of incumbents and get discouraged; therefore, entry goes down. Discouraged followers and entrants lower the competitive pressure on the market leader: When they face less threat, market leaders relax and they experiment less. Hence, overall dynamism and experimentation decrease in the economy. Consequently, with lower innovation investment, productivity growth slows over time, causing the equilibrium interest rate to fall. As such, the model provides an endogenous mechanism for declining interest rates over time—a widely discussed phenomenon in the United States (Summers 2014).

To sum up, our quantitative investigation underscores the importance of potential distortions in knowledge diffusion in explaining the declining U.S. business dynamism. The next section presents novel empirical evidence on the symptoms of a decline in the intensity of knowledge diffusion in the United States in line with the predictions of our analysis.

V. Symptoms of Declining Knowledge Diffusion and Potential Drivers

Our investigation of declining U.S. business dynamism emphasized the importance of a specific channel—namely the knowledge diffusion margin. The model-based responses of variables of interest to a decline in the intensity of knowledge diffusion strongly parallel their empirical counterparts, indicating that this margin is a very plausible candidate for the driving force behind the stylized facts. This finding raises the natural follow-up question: What could the decline in this reduced-form parameter represent? In order to have a more concrete understanding of this channel, in this section, we will look at empirical trends in the production and use of knowledge in the United States. Specifically, we will analyze the micro-level data on firms, patents, and inventors, among others, which provides novel evidence on (i) the potential anti-competitive (ab)use of intellectual property, (ii) concentration of inventors in large and established firms, and (iii) M&A and lobbying activity of firms.

To briefly summarize our findings, we observe that patents—the stock of knowledge—is increasingly accumulated in the hands of firms that already own the largest stock of patents, both via production of new patents or via purchases of existing ones. We find that this concentration of patents is positively associated with measures of market power at the industry level. Firms could potentially be using these large patent arsenals to deter subsequent competing inventions by other firms—as implied by patent thickets, which we discuss below—through legal action. Indeed, we find that an increase in the fraction of litigated patents in an industry correlates positively with increases in measures of market power. As a mirror image of this patent concentration, we observe that inventors are employed increasingly more by large and established firms instead of by small and young ones. Importantly, event studies suggest that such a shift induces a decline in inventors' productivity despite a rise in their wages. We conclude the section with additional evidence on the trends in M&A and lobbying activity by the U.S. firms.

V.i. Patent Concentration and Post-1980 Trends

A factor that could potentially limit the flow of knowledge from the frontier to the rest of the firms is the use (or abuse) of patents. A decline in imitators' ability to copy and learn from market leaders' technology (or to implement improvements on the existing technologies) due to heavier, and especially strategic, use of patents by the leaders would reduce the intensity of diffusion of knowledge and its efficient use among firms. Patent and reassignment data from the U.S. Patent and Trademark Office (USPTO) provide a fertile ground for investigating these patterns, as firms rely heavily on patent protection to shield themselves from imitators.

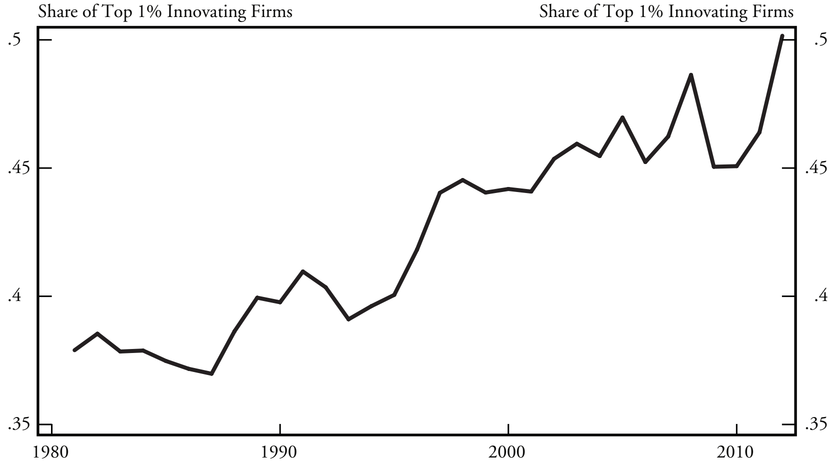
Many indicators of business dynamism suggest a declining trend since the 1980s along with rising market concentration. We first investigate if there has been a concomitant change in patenting concentration. To answer this question, Chart 2A looks at the share of patents registered by the top 1% of innovating firms with the largest patent stocks. The ratio exhibits a dramatic increase. While in the early 1980s about 35% of patents were registered by the top 1% of firms sitting on the largest patent stocks, this ratio reached almost 50% in three decades.[27] In addition, the share of patents registered by new entrants (firms that patent for the first time) exhibits the opposite trend: notwithstanding the small pickup in the early 1980s, there has been a dramatic secular decline in the entrants' share since then, with the ratio falling more than 50% in 25 years (Chart 2B).

A common practice that market leaders follow is to buy patents in the market to strengthen their intellectual property arsenals. This way, leaders can create a dense web of patents or "patent thickets" (Shapiro 2001), which makes it difficult for competitors to get close to the market leader's technology domain and potentially leapfrog. For instance, Argente et al. (2020) show in a recent paper that while market leaders introduce new products less frequently, they are more likely to patent these inventions, with their patenting being associated with a declining rate of product innovation by their competitors. Using a theoretical model, the authors demonstrate that as firm size increases, firms more likely use their patents to deter competition, with the protective value of their patents rising relative to their productive value, consistent with the data.

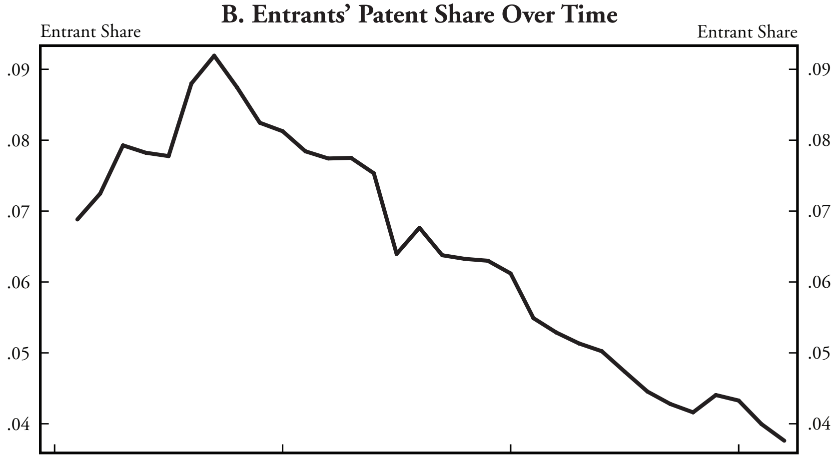
To investigate related patterns, we make use of patent reassignment data, which keep detailed records of all transactions of patents between entities. As in patent registries, we observe stark trends in patent reassignments since the 1980s. Chart 3A focuses on the purchasing trends of the top 1% of firms with the largest patent portfolios. The figure reveals that while 30% of the transacted patents were reassigned to the firms with the largest patent stocks in the 1980s, the share went up to 55% by 2010. This drastic increase has crowded out small players in the market, as illustrated in Chart 3B. The chart shows the likelihood of a patent to be assigned to a small firm, conditional on that patent being transacted from another small firm and

Chart 2
Registry of Patents

A. Share of Patents of the Top 1% Patenting Firms



B. Entrants' Patent Share Over Time



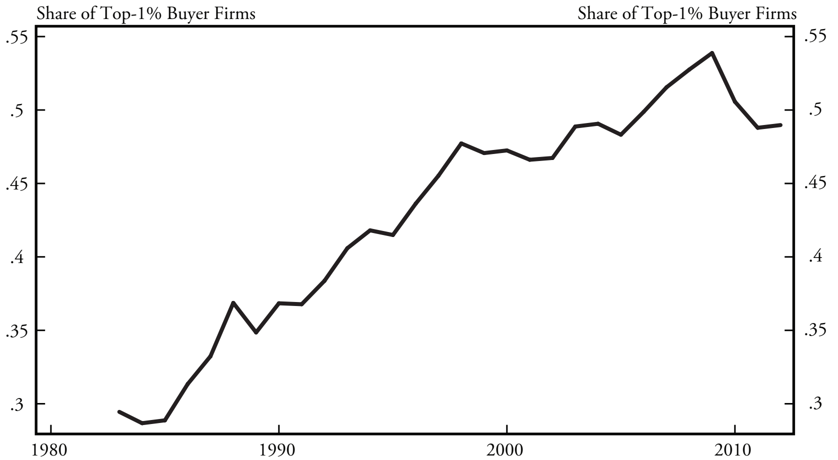
Source: Authors' calculations using U.S. Patent and Trademark Office data.

recorded.[28] In the past two decades, the fraction of transacted patents that are reassigned to small firms has dropped dramatically from 75% to almost 50%, implying a shift of ownership from the hands of small firms to large ones.

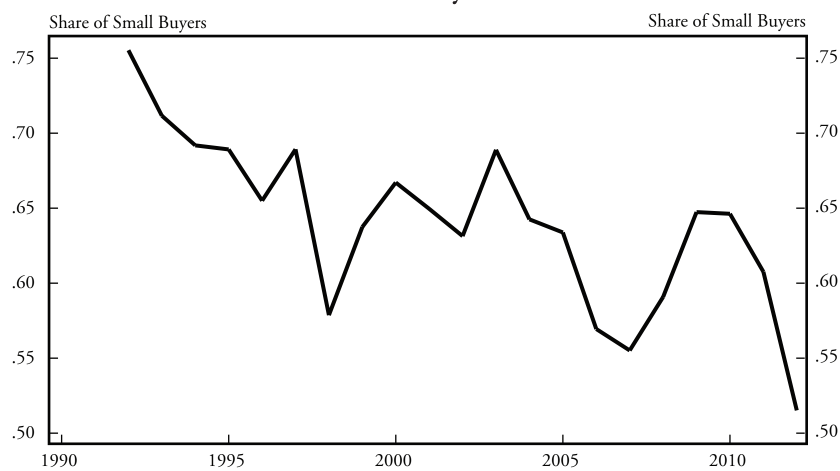
These figures reveal that concentration in patent production and reassignment has surged, and firms with the largest patent (knowledge) stock have further expanded their intellectual property arsenals. Next,

Chart 3
Reassignment of Patents

A. Share of Patents of the Top 1% Buyers Over Time



B. Share of Small Buyers Over Time



Source: Authors' calculations using U.S. Patent and Trademark Office data.

Table 1
Patent Concentration and Dynamism Indicators

	ΔHHI		ΔMarkups		ΔProfit Share	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ patent share of top 5% firms	0.243** (0.078)		0.054* (0.029)		0.046** (0.023)	
Δ share of litigated patents		0.005*** (0.002)		0.007*** (0.002)		0.027*** (0.009)
Observations	700	2,507	700	2,493	700	2,507
R-square	0.061	0.008	0.008	0.010	0.036	0.014

*** $p < 0.01$,
** $p < 0.05$,
* $p < 0.1$.
Notes: The regressions show the correlation between contemporaneous changes in patent concentration or patent litigation intensity and changes in indicators of market power. Dependent variable at the top of each column, and Δ refers to changes. The largest top 5% of firms are defined in terms of firm sales. Regressions are at the sector–period level (4-digit SIC sectors and five-year periods between 1980 and 2018, with the last period spanning 2015-20180 and control for the total number of patents in each sector. The share of litigated patents refer to the ratio of the number of patents subject to litigation in a given year to the total patent stock at the sector (4-digit NAICS) level. The period covered runs from 2003 to 2016, and the regression include year fixed effects. In all regressions, clustered standard errors at the sector level in parentheses.

we look at how higher patent concentration relates to business dynamism, and the regressions in the first row of Table 1 present the results of an initial attempt to understand this relationship. Using a match of patents to Compustat firms, standard OLS regressions suggest that the rise in patent concentration in the hands of the largest (in terms of sales) top 5% firms is positively correlated with higher concentration of sales, markups, and profit share at the industry level. Given that patents are exclusively used to prevent competitors from using the patent holders' technology, these trends can imply that the heavy use of patents by market leaders might have caused the decline in knowledge diffusion from the best to the rest. Indeed, the second row of Table 1 presents supporting evidence in this direction. Matching patent data with data on patent litigations, we show that a higher rate of patents that are subject to litigation in an industry is also positively correlated with higher levels of market power indicators in the post-2000 period (the period for which we have the available data on matched litigation cases). The post-2000 period is particularly interesting because evidence from Census Data compiled Decker et al. (2016b) indicates that the decline in business dynamism has accelerated after 2000, especially in some high-tech sectors. A closer look at the patent data reveals corroborating evidence on the potential strategic use of patents, which we discuss next.

Trends in the Post-2000 Period: Strategic Use of Patents

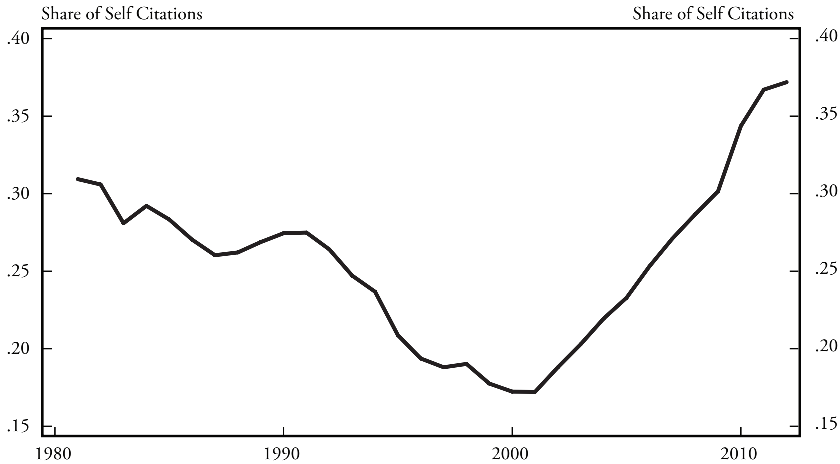
Patent records provide useful information for exploring whether firms produce strategic patents—patents firms can potentially use to build thickets around their core businesses and ensure that those core technologies are not easily adopted or challenged by others. Two key variables in this respect are citations and the text of claims. We explore the strategic aspects of patents by looking at how these two variables evolved over time.

Firms can either explore new areas of research to expand into new fields or they can focus on their existing technologies and try to build a protective wall around them. Akcigit and Kerr (2018) dub the former exploratory patents as "external" and the more exploitative ones as "internal" patents. If a firm's aim is mostly protecting its core technology, the new internal patent will cite many patents from the firm's existing portfolio. In contrast, if a firm's aim is expanding into new fields, more citations will be made in that case to patents that are not in the firm's portfolio. In this regard, the fraction of self-citations is informative about how internal a patent is and how likely it is that a patent serves to build a thicket. Chart 4A explores the self-citation dynamics over time. The striking observation is that while until 2000 patents were becoming more explorative in nature based on our earlier interpretation, this trend reverses completely around 2000, and patents become more exploitative and internal since then.

Another interesting piece of information on a patent file is the length of its claims. If a firm is introducing a novel technology that makes a broad contribution to the field, the relevant patent would be expected to have a relatively short claim, reflecting the broader scope. However, if a patent is making a marginal contribution to an already crowded area, then the claims are likely to be much longer with the details of the incremental contribution and also much narrower in scope. Therefore, the length of the claim could show us how broad or narrow the contributions are. Chart 4B shows the evolution of average patent claim length over time. Intriguingly, patent claims

Chart 4
Self Citation and Claim Length Patterns

A. Share of Self Citations Over Time



B. Average Claim Length Over Time

Source: Authors' calculations using U.S. Patent and Trademark Office data.

were getting shorter until 2000, suggesting that patents were becoming broader in scope, which completely reversed again around 2000. Since then, claim length has been increasing steadily, indicating that patents are getting narrower in scope and also less original.

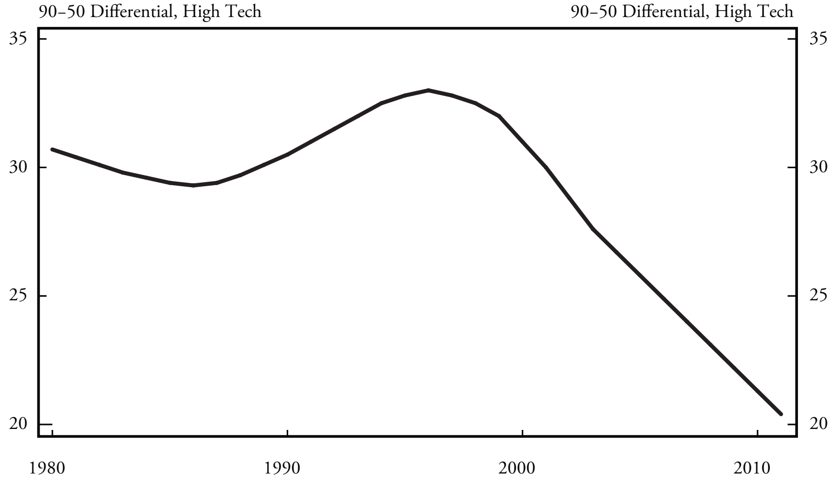
These post-2000 observations likely imply that patents have recently been used to crowd existing technology fields with incremental additional information, limiting the scope for spillovers to competitors. Intriguingly, the timing of these dramatic changes coincides with the period when business dynamism has slowed down even more. While several measures of business dynamism have indicated a slowdown in most sectors of the U.S. economy since the 1980s, the decline in the high-tech sector has become most visible in the 2000s (Decker et al., 2016b). As shown in Chart 5, the dispersion of firm growth in high-tech sectors started to decline steadily around 2000. Decker et al. (2016b) document that other measures of business dynamism, such as gross job reallocation, reverberate with this post-2000 pattern, again especially in high-tech sectors. In this regard, our post-2000 findings tell a coherent story with these empirical regularities, suggesting a concurrent slowdown in knowledge diffusion and business dynamism.

To sum up, these results constitute strong suggestive evidence that the concentration and use of patents, or intellectual property more broadly, have dramatically changed over time. Patent concentration has been trending up since the 1980s, and the nature of patents produced started to shift around 2000 toward more internal and narrower in scope, indicating a more strategic use of patents. These observations are broadly consistent with declining knowledge diffusion from the technology frontier to followers and have likely contributed to declining business dynamism through the lens of our model.

V.ii. Evidence from Data on Inventors

In the previous section, we documented trends in the generation and flow of ideas using data on patents in order to understand changes in the knowledge diffusion in the U.S. economy. In this section, we explore the reflection of these patterns on the employment dynamics of inventors who are the central agents for the generation and flow of

Chart 5
90-50 Differential in High-Tech Sector

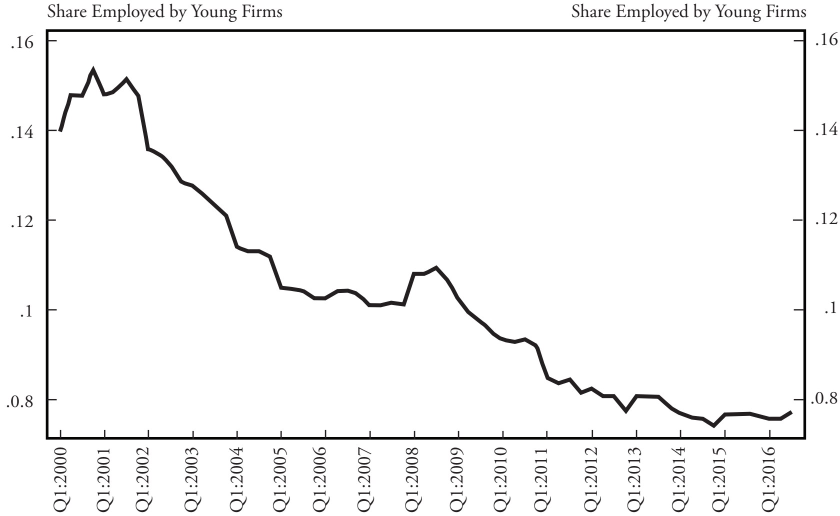


Notes: Taken from Decker et al. (2016b). Similar patterns are documented for the 50-10 differential, for the balanced sample of continuers, and gross job reallocation in the information sector.

ideas through the economy. In particular, we discuss some findings on inventor dynamics in a recent work by Akcigit and Goldschlag (2020), who build a novel data set that compiles detailed information on the population of inventors, linking patents to individuals, businesses, and employee-employer relationships. The results suggest a concentration of inventors in more mature firms, with their innovative output and its quality decreasing.[29]

To start, Chart 6 demonstrates the steady decline in the share of inventors working in young firms (firms that are 5 years old or younger) since the early 2000s, paralleled by a concentration of inventors in mature incumbent firms in parallel to our earlier results for patents. By itself, though, this observation is not worrying if inventors become more productive at more mature firms. However, event studies of inventor activity around the time they switch their jobs to work in more established firms show that this is not the case. Chart 7A shows that the number of patent applications by inventors drops after they join more established incumbents (relative to inventors with comparable characteristics who join young firms).[30] In addition, the citations to the patents for which inventors apply after switching to a mature

Chart 6
Share of Inventors Employed in Young Firms



Notes: Akcigit and Goldschlag (2020). Young firms are defined as being 5 years old or younger.

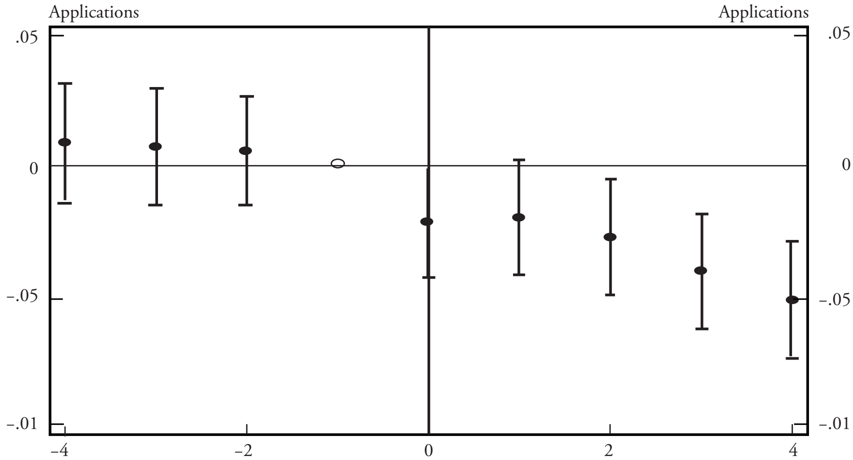
incumbent firm are also lower relative to inventors hired by young firms, suggesting a deterioration in the quality of innovative output among inventors at incumbent firms (Chart 7B). This result holds true also when the number of citations per applications is considered. In addition, unreported results suggest that the share of self-citations of inventors hired by mature incumbents increases relative to inventors hired by young firms. As we discussed in Chart 4A, higher self-citation of patents implies a more internal and exploitative content, consistent with the intuition that the patent plays a more protective role.

While the output of inventors deteriorates after they switch to more mature incumbents, they earn more in their new role, as Chart 8 demonstrates. This observation suggests that the private return to inventors' activity increases while the public return decreases. Clearly, this finding, together with the increasing share of inventors in more established incumbents, is concerning from the perspective of aggregate welfare.

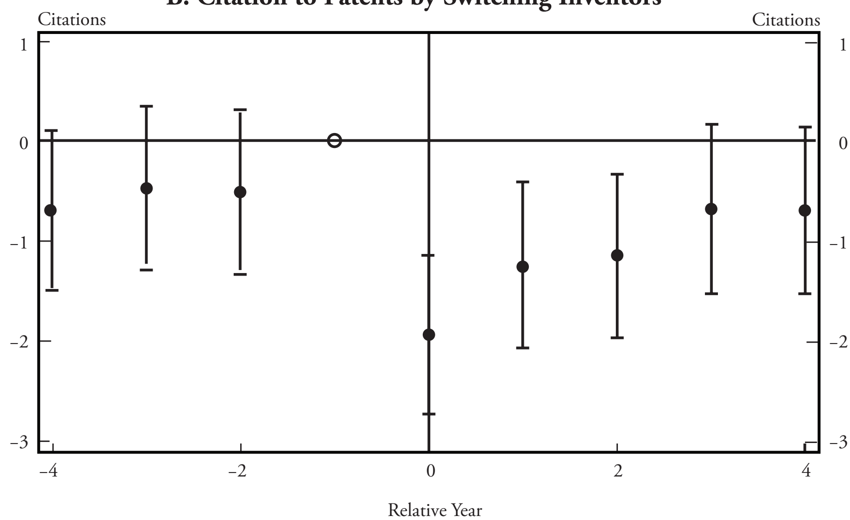
Turning back to Chart 6, the falling share of inventors in young firms may be an artifact of the falling share of activity by young firms

Chart 7
Event Studies Around Inventors' Switch to Incumbent Firms: Patenting and Citations

A. Patenting by Switching Inventors



B. Citation to Patents by Switching Inventors

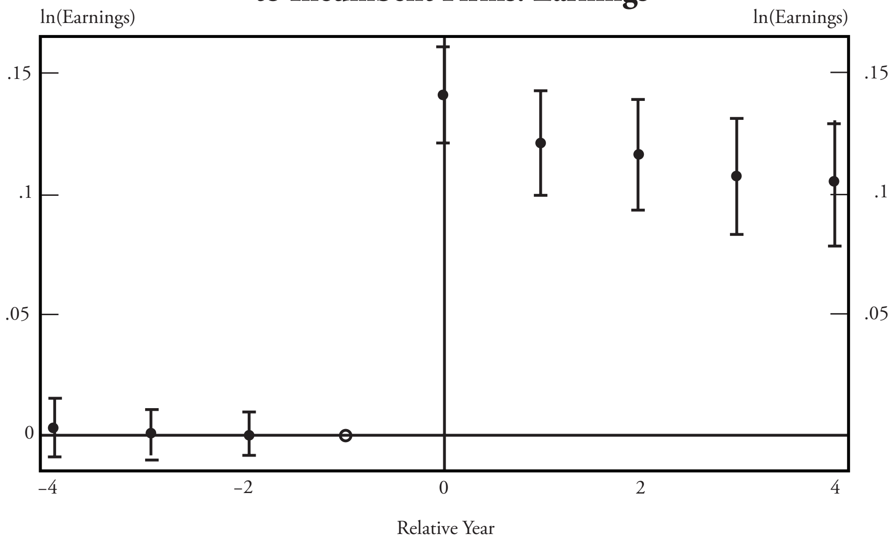


Notes: Akcigit and Goldschlag (2020). Estimates of η_j are obtained from the following regression equation:

$$Y_{i,t,e} = \alpha + \sum_{j=-4}^{4} \lambda_j d[j]_{i,t,e} + \beta_1 Incumbent_{i,e} + \sum_{j=-4}^{4} \eta_j d[j]_{i,t,e} \times Incumbent_{i,e} + \beta_4 Age_{i,t,e} + \delta_j + \gamma_k + \psi_i + \epsilon_{i,t,e},$$

for inventor *i*, relative year *t*, and hire event *e*. *t = 0* is the hire year (the quarter of hire and following three quarters). $Y_{i,t,e}$ is patent applications in Panel A and the number of citations in Panel B. *Incumbent* dummy takes 1 for firms with more than 1,000 employees and older than 20 years of age and 0 for hires by firms 5 years or younger. Excluded time dummy in estimation is *t−1*. δj are fixed effects for groupings of 2-digit NAICS sectors. γ_k are the year of the hire event fixed effects. ψi are inventor fixed effects. Standard errors clustered at the inventor level.

Chart 8
Event Studies around Inventors' Switch to Incumbent Firms: Earnings



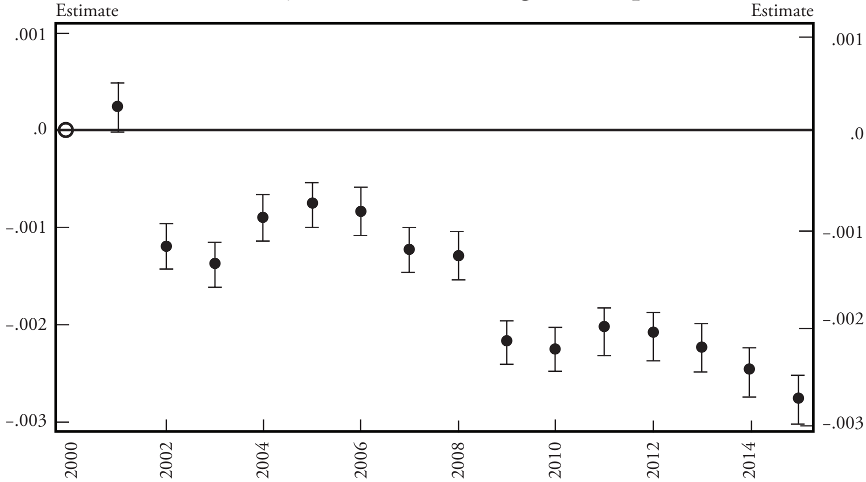
Notes: Akcigit and Goldschlag (2020). Estimates from a regression as described in Chart 7.

in the economy (Fact 7 discussed in Section II). However, when we focus on inventors' own entrepreneurial activities, the data reveal that inventors themselves have also become less entrepreneurial over time. Chart 9A demonstrates this fact, exhibiting that the probability of an inventor observed in the data being an entrepreneur herself in a given year declines over time. This observation is particularly worrying given that start-ups founded by inventors exhibit faster employment growth over the first decade of their lives than start-ups founded by non-inventor entrepreneurs, as shown in Chart 9B. As such, the lower frequency of inventor entrepreneurs in the post-2000 era has likely contributed to the declining prevalence of high-growth young firms and the concurrent decline in job reallocation rates.

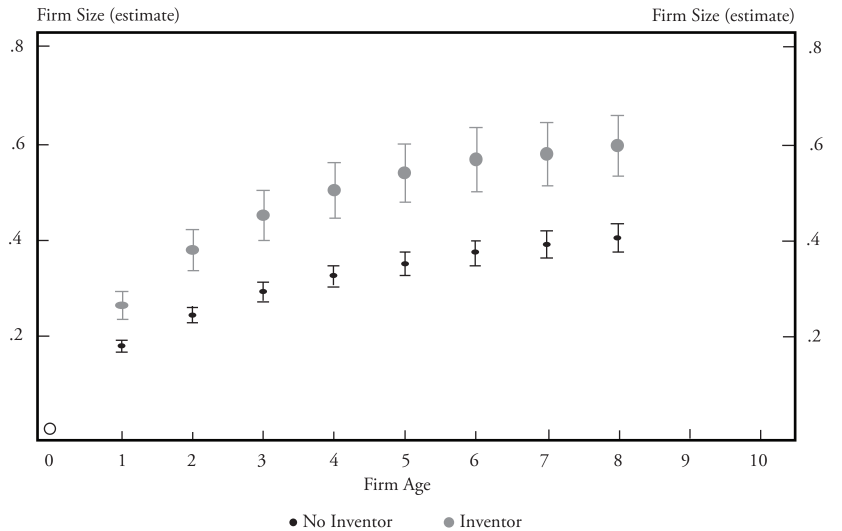
To summarize, the results imply that inventors are switching to larger mature firms; their innovation output and its quality decrease relative to similar inventors hired by young firms; and despite this, their earnings increase, suggesting a conflict between public and private returns from their innovative activity. In addition, inventors' entrepreneurial activity has slowed down. These observations are consistent with a decline in idea generation and the dissemination of

Chart 9
Entrepreneurship Activity by Inventors

A. Probability of an Inventor Being an Entrepreneur



B. Firm Growth, Inventor vs. Non-Inventor Start-ups



Notes: Akcigit and Goldschlag (2020). In Panel A, estimates of βk are obtained from the following regression equation: $Entrpreneur_{i,t} = \alpha + \sum_{k=2001}^{2015} \beta_k D_{i,t}^k + \psi_i + \epsilon_{i,t}$, with ψ_i denoting inventor fixed effects. Entrepreneur is defined as being among the top three earning workers within the founding team of a start-up. In Panel B, estimates of β_a are obtained from the following regression equation: $Firmsize_{f,t} = \alpha + \sum_{a=1}^{10} \beta_a FirmAge_{a,f,t} + \delta_j + \epsilon_{f,t}$, for start-up *f* in year *t*. δ_j are fixed effects for groupings of 2-digit NAICS sectors. This regression is estimated among startups with at least one inventor among the top earning founding team members and those without.

those ideas through the economy, suggesting a decline in knowledge diffusion and business dynamism.

V.iii. Other Relevant Trends

Up to now, our empirical investigation concentrated on variables that are directly related to the creation and diffusion of ideas in the economy. Yet, other decisions by firms that are not directly related to innovative activity and knowledge diffusion may have altered the degree of competition between firms as well. In this section, we present the results of initial analyses of two such activities: mergers and acquisitions (M&A) and lobbying.

One widely-discussed argument regarding the causes of higher market concentration emphasizes the changes in the enforcement of anti-trust laws and the associated rise in merger and acquisition (M&A) activity (Crane 2012; Harty et al., 2012; Grullon et al., 2017; and Wollman 2018). For instance, Cunningham et al. (2018) show the prevalence of “killer” acquisitions—acquisitions by large firms of innovative target firms, which have a high potential of posing competitive threat in the future—in the pharmaceutical industry. Importantly, Blonigen and Pierce (2016) argue that M&As in the U.S. manufacturing industry result in higher markups without generating any significant productivity gains (cf. David 2020).

Theoretically, M&A can affect business dynamism in non-trivial ways. For instance, if acquired by market leaders, M&A might increase market concentration by giving more market power to leaders. When leaders get more powerful, they could increase the mark-ups that they charge over their marginal cost of production. In market economies, firms compete among themselves strategically: intense competition among firms, especially when the competitors are in a neck-and-neck position in terms of their market share, induces more aggressive innovation investment and more business dynamism. Yet when the leaders open up their lead over their rival, say through M&A, followers could lose their hope of leapfrogging the leader and lower their innovation effort.

Table 2
M&A Concentration and Business Dynamism Indicators in the United States, 1985-2016

	HHI (1)	CR4 (2)	Markups (3)	Profits Share of Revenue (4)	Labor Share (5)	Sales Growth Dispersion (6)	Employer Growth Dispersion (7)
Share of Deals Top 5 percent (t-1)	0.194***	0.0812**	0.0726*	0.0192***	-0.136***	-0.0853**	-0.111**
	(0.0278)	(0.0361)	(0.0420)	(0.0071)	(0.0523)	(0.0405)	(0.0443)
Observations	7,085	7,085	7,053	7,084	4,865	7,012	6,984
R-Squared	0.734	0.326	0.627	0.783	0.224	0.311	0.252

*** $p < 0.01$,
** $p < 0.05$,
* $p < 0.1$.
Notes: The table reports standardized coefficients from regression in which the unit of observation is a 4-digit SIC sector-year. Dependent variable at the top of each column. In all the regressions we control for the total of M&A deals in the sector-year and sector and year fixed effects. Clustered standard errors at the 4-digit SIC level in parentheses.

We will test these theoretical predictions using Compustat data and information on M&As.[31] The key independent variable that we focus on is the "M&A concentration measure" defined as

$$x_{it} = \frac{\text{weighted total deals by top-5\% of firms in sector } i \text{ and year } t}{\text{weighted total deals in sector } i \text{ and year } t},$$

where the weights are based on firm sales. We are interested in the relationship between xit and several measures of market concentration and business dynamism, and Table 2 summarizes our preliminary results.[32] Columns 1 and 2 regress various market concentration measures on the share of M&A deals exercised by the largest 5% of the firms in every sector. While column 1 focuses on the usual HHI metric, column 2 uses the market share of top four firms. Both specifications show a positive association between the M&A concentration and market concentration. Column 3 focuses on markups and finds that M&A concentration is positively associated with higher markups. Column 4 shows that the same holds true for profit share of revenue. Column 5 suggests that this rise in profits occurs at the expense of the labor compensation. It shows that the M&A concentration is negatively associated with labor share. Finally, columns 6 and 7 show that both sales and employment growth rate dispersions are negatively associated with M&A concentration. As such, we observe a positive association between the M&A concentration in an industry and symptoms of a slowdown in business dynamism.

We finish this section with a preliminary analysis of lobbying firms. Lobbying activity can provide firms preferential treatment, putting them in an advantageous position against their competitors through means not related to their productive superiority. For instance, Arayavechkit et al. (2018) show that in the United States, lobbying firms are larger on average, enjoy lower capital-based effective tax rates, but have lower marginal product of capital than non-lobbying firms, which the authors argue is indicative of capital misallocation owing to lobbying activity. Consistent with Arayavechkit et al. (2018), we observe that larger and older firms are considerably more likely to lobby, as shown in Chart 10A. Moreover, total (real) lobbying spending had been rising during 2000s in the United States before leveling off in the aftermath of the Great Recession, as shown in Chart 10B. To the extent that firms that lobby and succeed in obtaining preferential treatment use this advantage to shield themselves against competition from their rivals, increased lobbying activity may be another factor that contributes to declining business dynamism in the United States. Indeed, Bessen (2016) underscores the role of increased political rent seeking in rising corporate profit margins in the United States in the post-2000 period.

VI. Case Studies in Other Countries

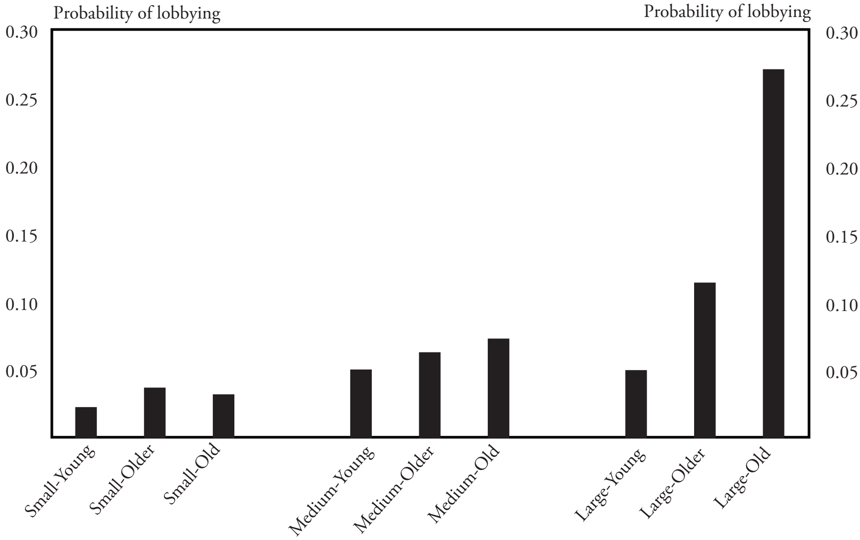
While our main interest is business dynamism in the U.S. economy, two recent studies that analyze Italian and Turkish firms highlight interesting factors that could strangle business dynamism in an economy. In particular, these studies show how access to credit and political connections can create wedges between firms distorting the extent to which rivals could exert competitive pressures on market leaders and thereby constrain business dynamism. In these section, we briefly overview the findings of these studies.

VI.i. Italy: Political Connections and Business Dynamism

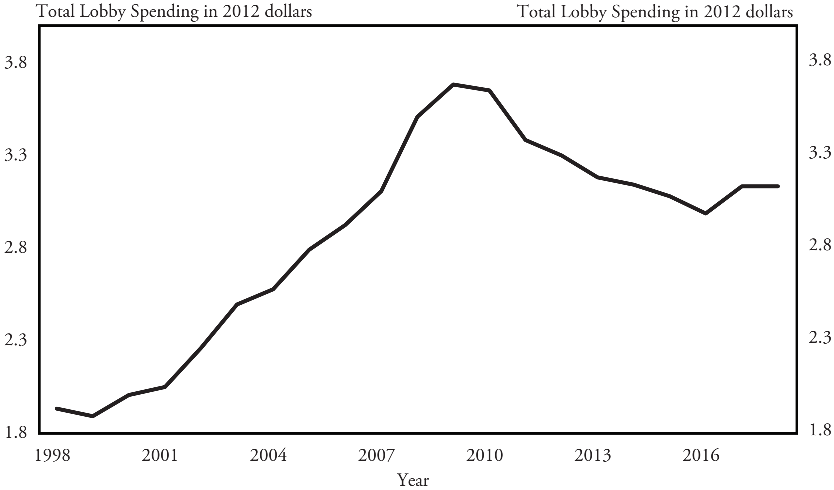
Business dynamism reflects a healthy economic environment, in which new firms emerge, innovate, grow, shrink and die, with a perpetual reallocation of factors toward more productive units. However, if some firms can have political connections to rig the rules in their favor, that power could definitely hamper these processes,

Chart 10
Lobbying Spending in the United States

A. Probability of Lobbying over Size and Age



B. Trend in Lobbying Spending



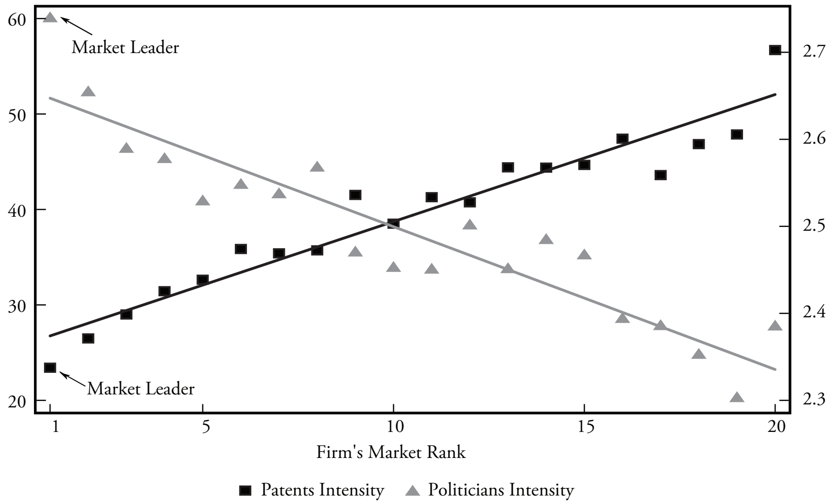
Notes: In Panel A, "young" refers to ages (0,5), "older" refers to (5,10), and "old" refers to 10+. By size, "small" refers to less than 100 workers, "medium" refers to 100-1,000 workers, and "large" refers to 1,000+ workers. In Panel B, total spending is in 2012 dollars.
Source: Authors' calculations.

preventing connected firms from competitive pressures exerted by more productive rivals. Akcigit et al. (2018a) explore this mechanism in the case of Italian economy, using an extensive novel dataset that provides information on firm balance sheets, social security records of the universe of workers, patent data from the European Patent Office, the national registry of local politicians, and local elections spanning two decades between 1993 and 2014. They document that in industries with more politically connected firms (firms that employ local politicians), there is less firm entry and a lower share of young firms, and those industries exhibit lower productivity growth. The survival probability of politically connected firms is higher and increasing in the political power of the employed politicians.

Perhaps most importantly, market leaders are the most politician-intensive (employing a higher share of local politicians in their white-collar workforce) relative to their immediate competitors but also relatively the least innovation-intensive. This finding is suggestive that political connections provide a protective shield to the connected firms, as they maintain their leadership and survive more despite being less innovative. To establish the causal effect of political connections on the firm and leadership outcomes, the authors exploit the results of marginally contested local elections within a quasi-random regression discontinuity framework. They observe that firms that happen to be connected to the marginally winning side grow much more in terms of size but not in productivity in the post-election period.

As the authors frame in a theoretical model, one could think about how political connections create a wedge between market leaders and the rest of the competitors as follows (Chart 11). Firms face regulatory burdens that distort production processes as in Restuccia and Rogerson (2008). Firms that are politically connected can alleviate this burden; however, establishing these connections is costly. Therefore, only large firms can afford this cost. Dynamically, this advantage discourages new firms to enter and rivals to compete, as the competition is not just in productivity but also at a political or bureaucratic level. In addition, this advantage of leaders incentivizes other incumbents to invest in establishing political connections instead of improving their productivity, which allows them to protect

Chart 11
Political Connections and Innovation Intensity at the Firm Level



Source: Akcigit et al. (2018a).

themselves against competition at the peril of business dynamism in the overall economy.

VI.ii. Turkey: Access to Credit and Business Dynamism

Applying a similar analysis presented in this paper, Akcigit et al. (2020) uncover the evolution of business dynamism in Turkey between 2006 and 2016 in a rare study of this phenomenon in the context of an emerging economy. The authors combine a wide range of administrative datasets on firm registries, firm balance sheets, social security information, and credit registries. With these data in hand, the authors document that after remaining relatively stable until 2012, business dynamism slowed down noticeably and market concentration went up thereafter. The authors argue that the culprit behind these trends was an exogenous shock to credit availability in the economy driven by the Taper Tantrum in 2013. As was the case in many emerging markets, domestic financial conditions tightened in Turkey after mid-2013, as the currency depreciated notably and interest rates climbed higher amid the risk-off sentiment among global investors.[33] The authors argue that the effects of this tightening in global liquidity conditions were heterogeneous across firms: the access to credit of larger firms, which are typically the leaders in their sectors, was relatively less affected, leading to a higher concentration of credit toward these firms. The bottom panel in Chart A.17 in the appendix highlights that this was especially true for cross-border foreign currency credits. The authors argue that this relative scarcity of credits for smaller firms increased the wedge between leaders and the rest of the firms in the economy benefiting the leaders, thereby weighing on competition between these firms and business dynamism. Consequently, the authors propose that policy should focus on decreasing financing costs (e.g., through R&D subsidies) of laggard competitors in the economy to foster competition and growth.

To summarize, the two examples discussed in this section highlight additional channels that can prevent firms from competing in a level playing field reducing the business dynamism. On the one hand, firms that are politically connected can use this power to preempt competition. Since larger and entrenched firms are relatively more capable to establish and maintain such connections, antitrust policies, discussed in Section III, may play an important role in curbing this unproductive advantage of firms. On the other hand, the case of Turkey emphasizes the cost of a lopsided distribution of credit toward larger firms. An important implication of this finding is that as financial institutions become more averse to provide credit to smaller or riskier firms—conversely, shifting available credit toward larger firms—such downturns can create persistent effects on business dynamism and aggregate productivity growth.[34]

VII. Conclusion and Policy Implications

A sustained growth in aggregate productivity necessitates a healthy degree of business dynamism, which has been losing its pace in the United States over the past several decades. In this study, we employ a holistic approach to understand the drivers of this phenomenon, presenting the results of theoretical and quantitative investigations and evidence from the micro-level data. Our investigations highlight the important role the slowing knowledge diffusion in the U.S. economy has played, which is corroborated by empirical evidence from a wide range of datasets covering information on firms, patents, and inventors.

A good understanding of the underlying causes of declining U.S. business dynamism is crucial to form the appropriate policy response. Is a shift in the technological nature of the economy behind the observed trends? Is there a change in policy (e.g., enforcement of antitrust policies) that has motivated firms to take actions that endogenously lead to higher concentration in product markets? These widely debated concerns call for a framework that enables a comparative study of alternative explanations, as we briefly discussed in Section IV.v. Moreover, public policy necessitates an evaluation of the implications of declining business dynamism on income and welfare—subjects that we analyze deeper in Akcigit and Ates (2019).

Slower business dynamism—economic agents having less incentives to invest in productive capacity and compete with each other—has far-reaching policy implications. For instance, higher average markups in the economy as a result can limit the effectiveness of monetary policy, reducing the pass through from changes in interest rates to firms' investment decisions (Van Reenen 2018b). In addition, the current global economic conditions could exacerbate the state of business dynamism, as the COVID-19-related disruptions weigh disproportionately on small and medium enterprises. Such asymmetric effects could lead to the consolidation of sectoral economic activity in a small number of large firms, impairing the competitive environment and thus business dynamism in the post-pandemic economies.

Then, the natural follow-up question is, what are the potential policies that could help spur competition and innovation in the U.S. economy and ultimately prop up business dynamism? The findings of this paper hint at the role of slower knowledge diffusion and the associated increase of the concentration of patents and inventors in the hands of larger, more established companies. As discussed in Section III, a contributing factor is likely the extent to which the antitrust law has been enforced; therefore, the effective use of antitrust policies could be one direction for action.[35] In addition, the dissemination of ideas—and, more broadly, firms' ability to build on other firms' technologies and introduce competing inventions—can be supported through secondary markets for patents and efficient licensing systems (Akcigit et al. 2016). Yet, the U.S. economy is not a closed one, and competitive pressures do not necessarily need to emerge from within the domestic economy. As such, policymakers can also seek support from openness to trade to bolster domestic business dynamism. Indeed, the competition from foreign rivals can potentially boost domestic productivity growth by incentivizing firms to invest in improving their products and processes in order to maintain or increase their market shares in the face of foreign competition (Bloom et al. 2016, Akcigit et al. 2018b). Uncovering the drivers of the knowledge diffusion in the U.S. economy, and thereby determining the direction for most effective policies, should be the goal of future research in this area.

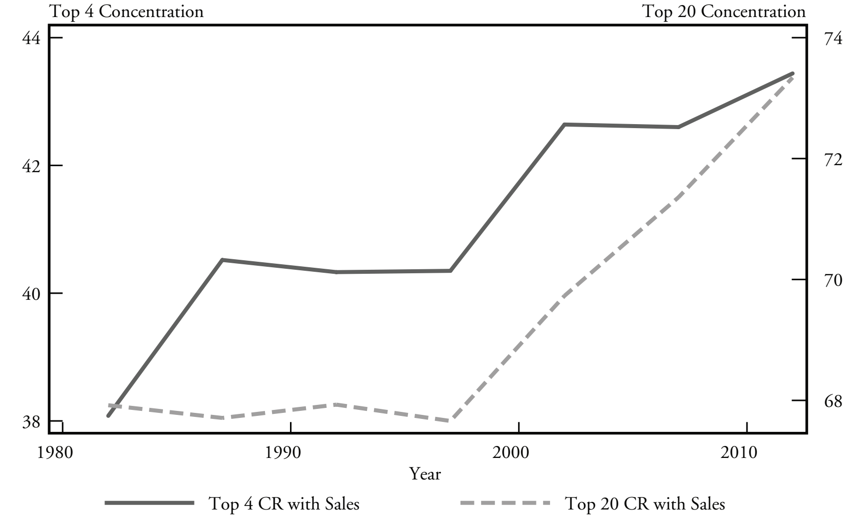
Finally, the overarching theme of our work is that what impedes business dynamism is a wedge between market leaders and their close competitors that favors the former while preventing the latter from competing effectively (rather than, say, barriers to entry; see Section IV.v). As such, policies should zero in on allocating resources in a way to ensure a level field for competition between market leaders and followers. Yet, as highlighted by the country studies discussed in Section VI, these wedges can stem from different sources, implying that effective policies to spur competition and business dynamism are not one size fits all. For instance, in the context of a developing economy, Turkey's experience emphasizes the role of relative deficiency of credit for smaller firms, while Italy's experience underlines the role of political influence. Therefore, policymakers are advised to be attentive to these differences when designing optimal policies to boost business dynamism and productivity growth.

Authors' Note: We thank Salome Baslandze, Santiago Franco and Daria Zelenina for their excellent contributions. The views and conclusions in this paper are solely the responsibility of the authors and should not be interpreted as the views of the U.S. Census Bureau or the Board of Governors of the Federal Reserve System or of any other person associated with the Census Bureau or the Federal Reserve System. The Census Bureau's Disclosure Review Board and Disclosure Avoidance Officers have reviewed this data product for unauthorized disclosure of confidential information and have approved the disclosure avoidance practices applied to this release (DRB Approval Numbers: CBDRB-FY20-CES007-004).

Appendices

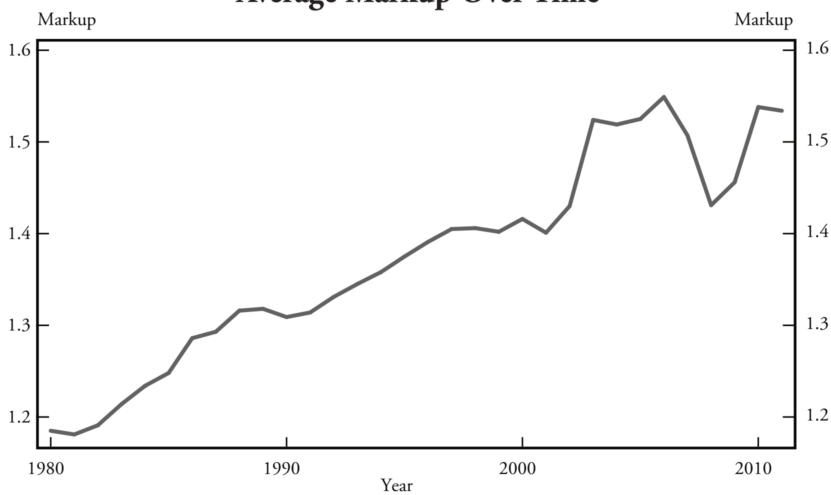
A. Empirical Trends

Chart A.1
Market Concentration



Notes: "Top4 CR with Sales" refers to the fraction of total sales accrued by four largest firms. "Top20 CR" is defined similarly.
Source: Autor et al. (2017b).

Chart A.2
Average Markup Over Time

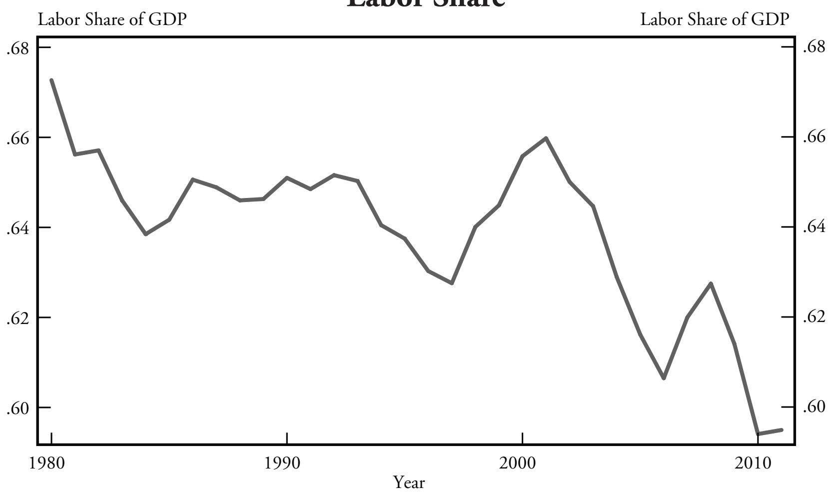


Source: De Loecker et al. (2017).

Chart A.3
Profits as a Fraction of GDP Over Time

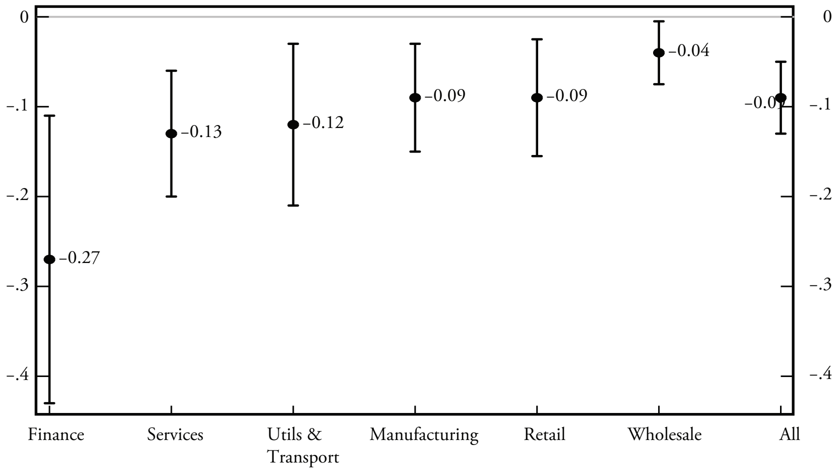
Note: The chart shows corporate profits of nonfinancial domestic U.S. firms adjusted for inventory valuation and capital consumption.
Source: Authors' own calculation using the BEA NIPA Table 1.15.

Chart A.4
Labor Share



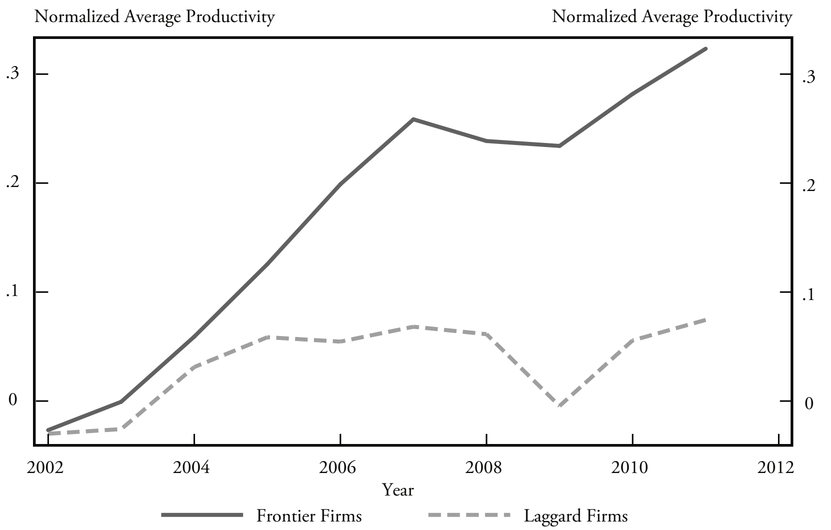
Source: Karabarbounis and Neiman (2013).

Chart A.5
Correlation Between Sector-Level Changes in Concentration and Labor Share



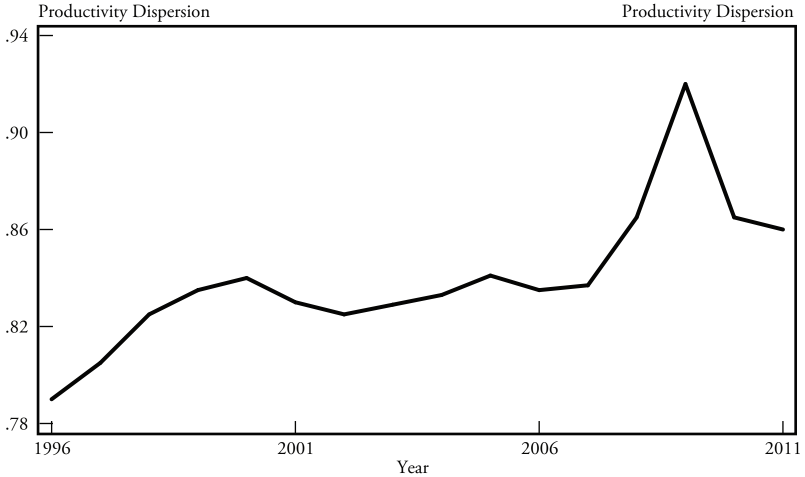
Source: Autor et al. (2017b).

Chart A.6
Labor Productivity of Frontier and Laggard Firms



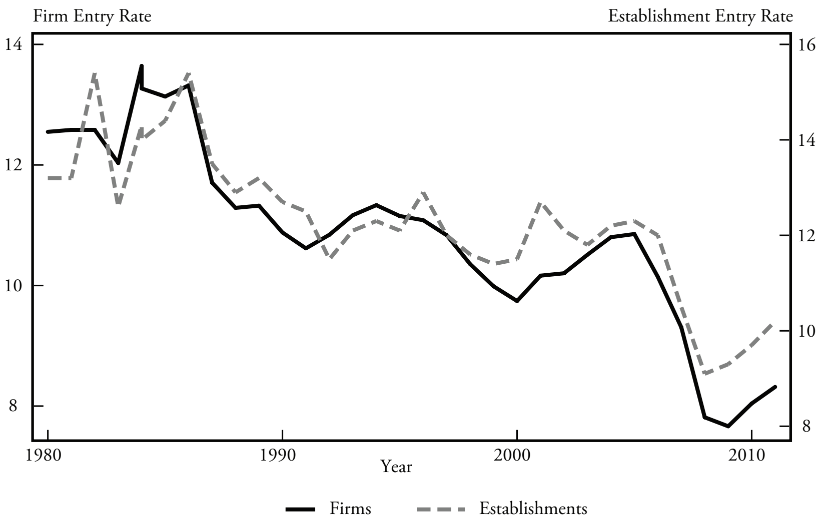
Note: Labor productivity is defined as real value added per worker.
Source: Andrews et al. (2016).

Chart A.7
Labor Productivity Dispersion in the United States



Source: The figure reproduces findings from Decker et al. (2018).

Chart A.8
Firm Entry and Exit Rates in the United States

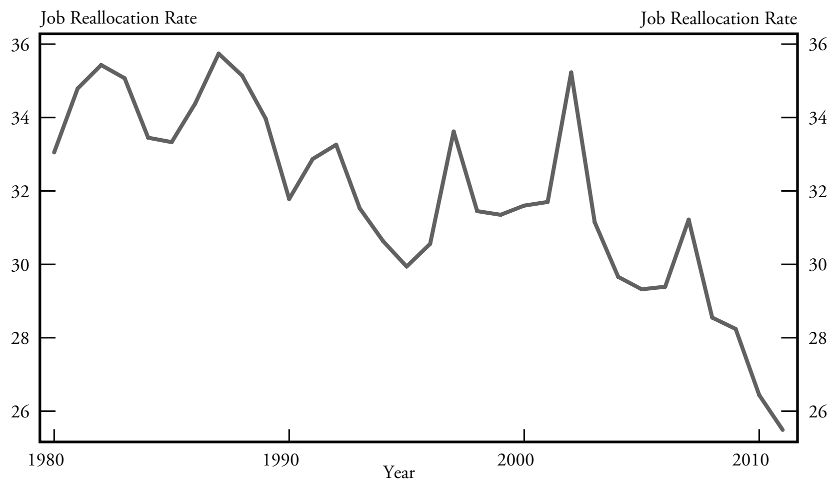


Source: Authors' calculations from BDS database (see also Decker et al. 2016a).

Chart A.9
Employment Share of <5-Year-Old Firms

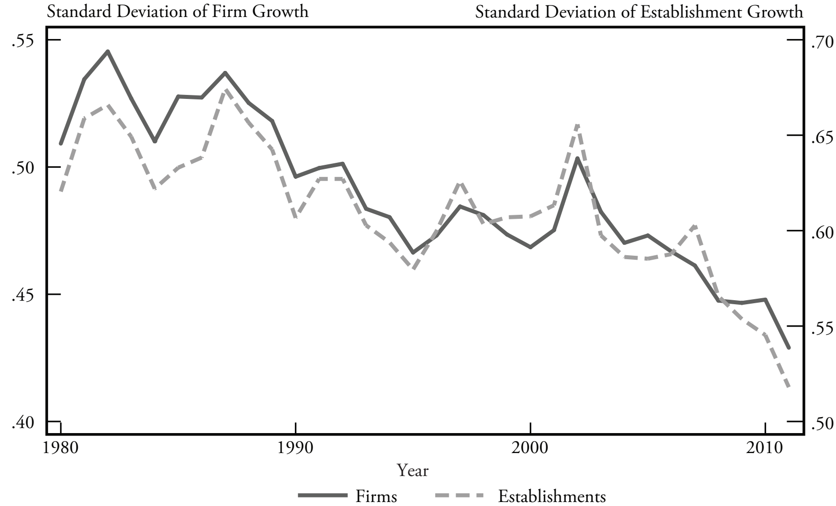
Source: Decker et al. (2016a).

Chart A.10
Gross Job Reallocation



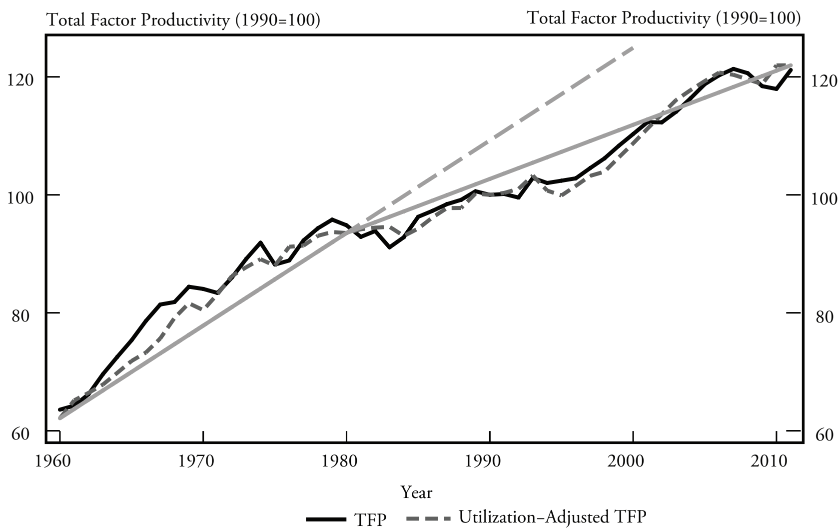
Source: Decker et al. (2016a).

Chart A.11
Growth Rate Dispersion has Shrunk



Source: Decker et al. (2016a).

Chart A.12
Average TFP Growth has Slowed Down



Notes: The thin solid gray line illustrates the pre-1980 (1960-80) and post-1980 (1980-2011) trends in utility-adjusted TFP growth. The average trend growth declines from 1.57% in the earlier period to 0.92% in the later. For comparison, the straight dashed line extends the pre-1980 trend into the late 1990s.
Source: Fernald and Jones (2014).

B. Equilibrium

We focus on the Balanced Growth Path (BGP) Markov perfect equilibrium, with equilibrium strategies depending only on the pay-off-relevant state variable $m \in \{-1, 0, 1\}$ and all aggregate variables growing at the same rate g while firms' innovation rates remain constant. Henceforth, we will drop the indices *i, j* and *t* when it causes no confusion and use only the pay-off relevant state variable *m*.

1. Equilibrium interest rate:

$$r = g + \rho \tag{A.1}$$

where g is the BGP growth rate of consumption.

2. Demand schedule for the intermediate good $j \in [0, 1]$:

$$y_{ij} = \frac{Y}{p_{ij}}, \tag{A.2}$$

where p_{ij} is the price of intermediate j charged by the producing monopolist i.

3. Intermediate producer's marginal cost:

$$MC_{ij} = \frac{w}{q_{ij}} \tag{A.3}$$

with w denoting the wage level.

4. Equilibrium intermediate good quantities:

$$y_{ij} = \frac{q_{-ij}}{\omega} \; for \; q_{ij} \geq q_{-ij} \tag{A.4}$$

and $y_{ij} = 0$ otherwise, with the normalized aggregate wage rate given as $\omega \equiv w/Y$.

5. Optimal production employment of the intermediate producer:

$$l_i = \frac{y_i}{q_i} = \frac{1}{\omega \lambda^{m_i}} \; form_i \in \{0, 1\}. \tag{A.5}$$

6. Operating profits of an intermediate firm (exclusive of its R&D expenditures):

$$\pi(m_i) = \begin{cases} \left(1-\frac{1}{\lambda}\right)Y \ if\, m_i=1 \\ 0 \ if \ m_i \in \{0,-1\} \end{cases} \tag{A.6}$$

7. Markups in leveled (mj = 0) and unleveled (mj = 1) sectors:

$$Markup_j = \frac{p_{ij}}{MC_{ij}} - 1 = \begin{cases} \lambda - 1 \ if \ m_j=1 \\ 0 \ if \ m_j=0\% \end{cases} \tag{A.7}$$

8. Aggregate labor share ω (equal to the normalized wage rate in the economy):

$$\omega = 1 - \mu\frac{(\lambda-1)}{\lambda}. \qquad \text{A.8}$$

9. Stock market value of firms that are in state $m_i \in \{-1, 0, 1\}$, which are denoted by v_{mi}:

$$\begin{aligned} \rho v_1 &= \max_{x_1}\left\{\left(1-\frac{1}{\lambda}\right) + x_1[v_1 - v_1] + (x_{-1}+\delta)[v_0 - v_1]\right\} \\ \rho v_{-1} &= \max_{x_{-1}}\left\{-\frac{x_{-1}^2}{\%}2 + (x_{-1}+\delta)[v_0 - v_{-1}]\right\} \\ \rho v_0 &= \max_{x_0}\left\{-\frac{x_0^2}{2}\% + x_0[v_1 - v_0] + x_0[v_{-1} - v_0]\right\}. \end{aligned} \tag{A.9}$$

10. Optimal innovation decisions of leaders, neck-and-neck firms and followers:

$$\begin{aligned} x_1 &= 0 \\ x_0 &= v_1 - v_0 \\ x_{-1} &= v_0 - v_{-1}. \end{aligned} \tag{A.10}$$

11. The law of motion for μ:

$$\dot{\mu} = -\mu(x_{-1}+\delta) + (1-\mu)2x_0. \tag{A.11}$$

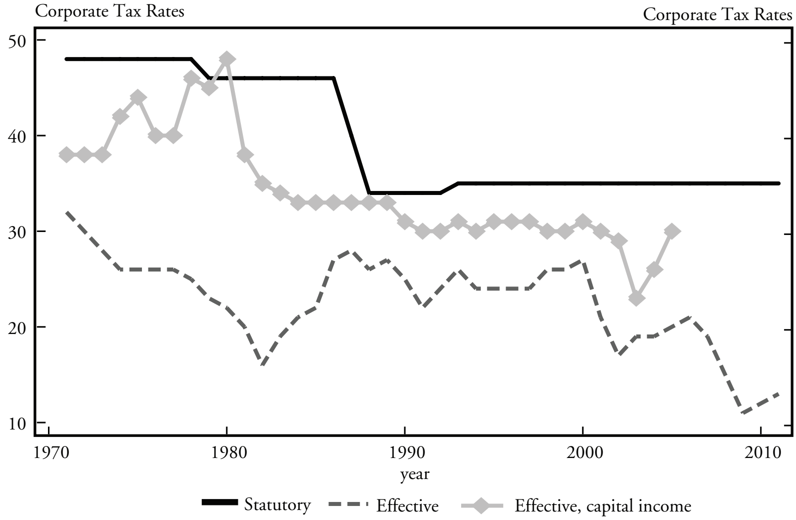
C. Potential Channels

In the past several decades, there have been some notable regulatory and structural changes in the United States that have shaped the channels, which we consider as potential drivers of declining business dynamism and rising market concentration. In this section, we briefly discuss these changes other than the shifts in the knowledge diffusion margin, which we discuss extensively in the main text.

Corporate Income Taxes. The U.S. tax system experienced two major overhauls in the 1980s with the passage of the Economic Recovery Act of 1981 and the Tax Reform Act of 1986. Although the United States has notoriously sustained the highest statutory corporate income tax rates among the developed countries until recently, the Tax Reform Act actually decreased this rate substantially in 1986, as shown by the solid black line in Chart A.13. Moreover, despite high statutory rates, the effective tax rates that determine the actual corporate tax bill paid by the firms are known to be much lower due to various tax benefits. According to the estimates of the CBO, the effective rate was about 19% in 2012, almost 20% below the statutory rate (Congressional Budget Office 2017).[36] Indeed, the average effective rates were lower in the period after 1980 than the previous two decades and have fallen further strongly after 2000 (dashed line). Finally, the effective corporate tax rate on capital income has declined as well, as depicted by the marked solid line.

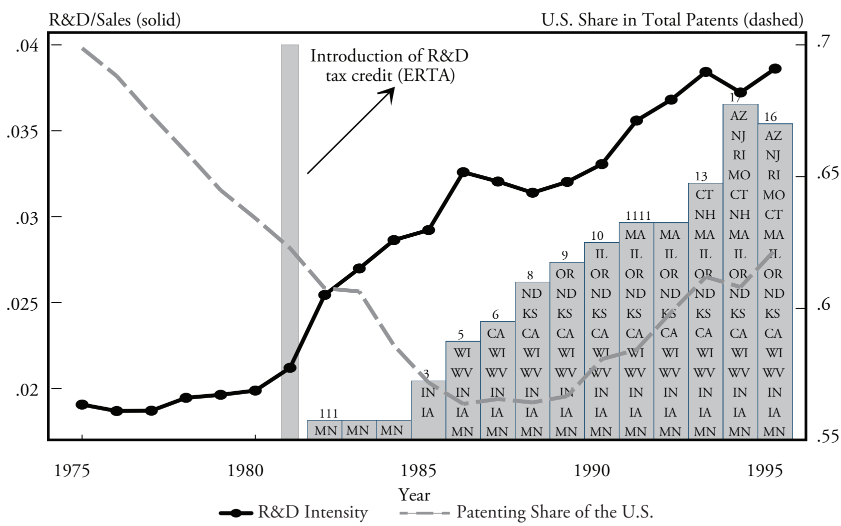
R&D Subsidies. Probably a less-known change has occurred in the R&D support provided by the U.S. government. In 1981, the government introduced a federal R&D tax credit for the first time. Starting in 1982 with Minnesota, several states followed suit by introducing their own state-level R&D tax credits. Chart A.14 summarizes these changes. The gray bar denotes the introduction of the federal tax credit, and the subsequent bars show the total number of U.S. states with a provision of R&D tax credits, along with their names. This substantial support for R&D boosted firms' investment in innovative activity (Akcigit et al. 2018b), which is especially true for large established incumbents—the recipients of the bulk of R&D tax credit claims (Tyson and Linden 2012)—given that firms need to generate taxable profits to claim the credit.[37] Chart A.14 also

Chart A.13
Effective Corporate Tax Rate in the United States



Notes: Statutory tax rates are obtained from Internal Revenue Service Statistics of Income Historical Table 24 and show the value for the top bracket. Statutory tax rates have been at least the level shown in the graph for corporate income brackets above $75,000. Effective corporate tax rate is calculated as Tax Receipts on Corporate Income/(Corporate Profits After Tax (without IVA and CCAdj)+Federal Government's Tax Receipts on Corporate Income) using Federal Reserve Economic Data (U.S. Bureau of Economic Analysis 2019). Effective corporate tax rates on capital income is taken from Congressional Research Service report RS21706 (Gravelle 2004).

Chart A.14
Federal and State-level R&D Tax Credit in the United States



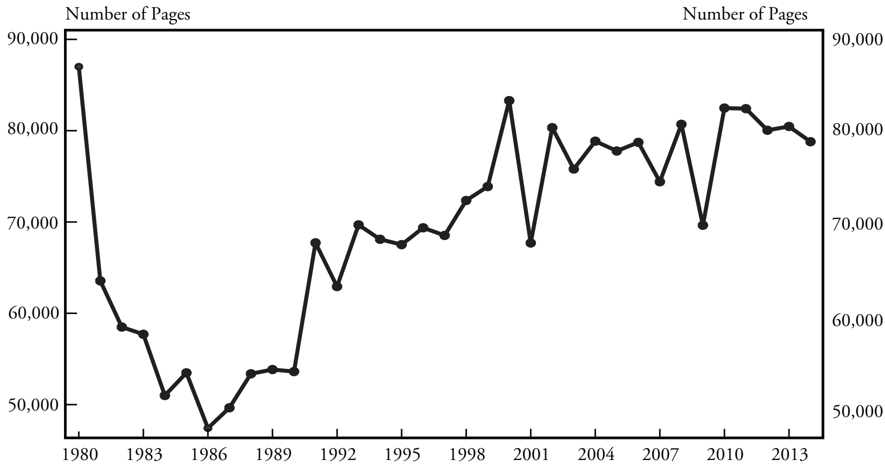
shows that there were significant changes in both R&D expenditure of firms and domestic innovative activity following these aggressive policy changes. Average R&D intensity of publicly traded U.S. firms showed a dramatic increase (solid line). Moreover, after an expected delay, the annual share of patents registered by U.S. residents in total patent applications increased as well (dashed line).

Regulatory Burden. Market economies are regulated to level the playing field for competing firms and encourage a more dynamic business environment. Yet too much regulation could slow the economy by simply distorting the incentives to invest and grow. "Overregulation" has become a growing concern among policy circles, especially with its potentially larger burden on small businesses (Crain and Crain 2010; U.S. Chamber of Commerce Foundation 2017), and the current U.S. administration is working hard to scale back the regulatory framework. The detrimental effect of higher entry barriers, and regulations in particular, on business entry has also been documented by the academic literature (Klapper et al. 2006; Klapper and Love 2010). In more recent work, Gutiérrez et al. (2019) stress the importance of higher entry costs in terms of the regulatory framework in driving the decline in business entry and competition.

The level of regulatory burden in the economy is hard to measure. However, the length of the Federal Register, where all new rules, executive orders, and other legal notices are published, gives a clue about how the regulatory burden has evolved in the United States. Chart A.15 plots the number of pages in the Federal Register over time. The increase in the amount of flow of new regulations lends some support to the argument that regulatory burden on U.S. businesses has grown, which could reasonably be expected to have weighed on entrants and small businesses. In this sense, this regulatory shift could have had some detrimental impact on the business dynamism. In light of this debate, we also investigate changes in the cost of entry in our quantitative analysis.

Declining Interest Rates. A stark trend observed in the U.S. economy since the 1980s has been a secular decline in interest rates, with short-term nominal interest rates even hitting a zero lower bound in the aftermath of the Great Recession (Summers 2014). This drastic

Chart A.15
Number of Pages in the Federal Register of the United States



Note: Data is obtained from Regulatory Studies Center.
Source: Akcigit et al. (2018b).

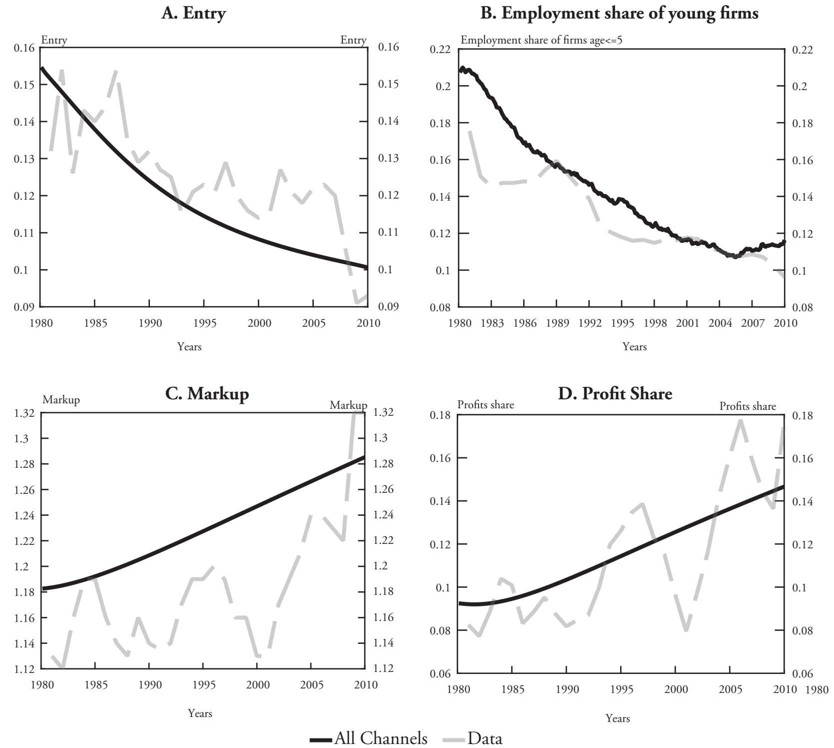
shift has, of course, drawn the attention of many researchers, who have built a large body of work looking at the causes and implications of a low interest rate environment. Closer to our work, Liu et al. (2019) argued more recently that a decline in interest rates could be the reason behind the increase in measured market power and a decline in productivity growth, which the authors hypothesize in a basic Schumpeterian step-by-step innovation model. As the argument goes, lower interest rates increase the return on investment, but more strongly for market leaders, because those firms are the ones that generate positive profits. In our exercises, we assess this argument by generating an exogenous fall in the interest rate through exogenously declining household discount rate, along the lines proposed by Liu et al. (2019).

Ideas Getting Harder. In an extensive work, Gordon (2016) argues that the U.S. economy has run out of low-hanging fruit ideas that are easier to obtain and yet have broad economic applications, implying a lower aggregate growth rate in the foreseeable future. In a similar vein, the intriguing work of Bloom et al. (2017) contends that novel and productivity-enhancing ideas have become harder to generate, which manifests itself in a declining research productivity. The authors document, using both macro and firm-level data, that the idea output (measured by variables such as TFP growth) per researchers employed has been steadily falling over most of the past century. To reflect on the potential effects of this shift, we consider an increase in the cost of R&D for both entrant and incumbent firms via higher scale parameters.

Weaker Market Power of Labor. The third alternative mechanism concerns a decline in workers' relative market power. Recent work (Bivens et al. 2014; Naidu et al. 2018) suggests that this decline could have depressed wage growth despite sizeable productivity gains, which would translate into a lower aggregate labor share.[38] We capture the potential effect of this change via an exogenous rise in the step size (λ), which translates into higher operational profits of firms and to a (statically) lower labor share.

D. Transition in the Extended Model

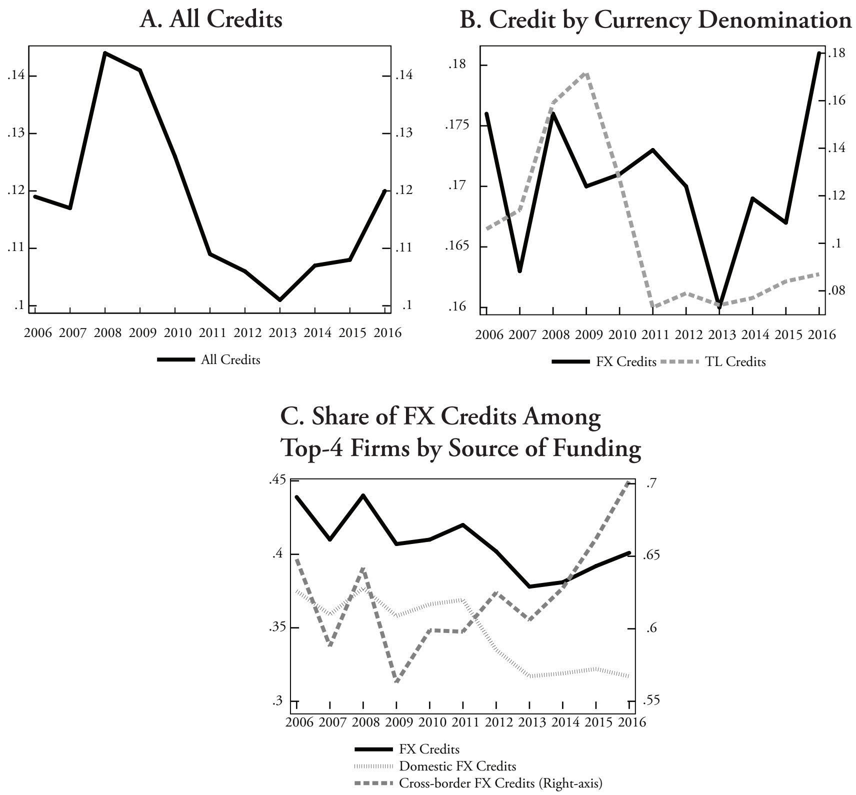
Chart A.16
Calibration Targets



Notes: The calibration procedure targets the terminal points in Panels A.16B, A.16C, A.16D and the decennial declines in entry in Panel A.16A. Solid black lines show the model-generated paths when all four channels are moving.

E. Country Studies

Chart A.17
Credit Concentration in Turkey



Notes: Authors' calculations using the Credit Registry and firm balance sheets. Panels A and B report annual averages of HH index weighted by the sum of industry credits. Panel C displays the credit share of the top-four firms, identified according to their sales ranking at the four-digit industry level. The four-digit industry annual averages are weighted by the sum of industry credits.
Source: Akcigit et al. (2020).

Endnotes

[1]For a set of prominent papers that feature a similar macro general equilibrium framework of endogenous growth with product market competition and strategic interaction between competing firms, please see Aghion et al. 1997, 2001, 2005; Acemoglu and Akcigit 2012; Akcigit et al. 2018b.

[2]This framework emphasizes the crux of competition between firms—their strategic behavior. Strategic firm behavior creates a complex state space of firm decisions, as each of these depend on the decisions of other firms. The model overcomes this complexity by summarizing the web of strategic actions by the decisions of only two firms—a leader and the follower. These two firms stand for the best firm versus the rest of the firms in an industry. Therefore, the structure should not be interpreted as reflective of competition between only two firms; rather, it summarizes the competition between a market leader and the rest of firms, which strategically invest in innovative activities with the aim of overtaking the leader.

[3]This feature can be considered as a reduced-form representation of any mechanism that makes followers learn from leaders and a reduction of it leads to slower knowledge diffusion (e.g., due to more intense use intellectual property protection or firm-specific customer data).

[4]See Council of Economic Advisors (2016) and OECD (2018a) for a thorough discussion. By contrast, notes by some participating delegations (see OECD (2018c) by the U.S. delegation and OECD (2018b) by Business at OECD (BIAC)) on the same subject doubt the notion of increased market concentration on the grounds of mismeasurement concerns and the lack of focus on relevant markets.

[5]For other studies on rising market concentration and its aggregate implications, see Barkai 2017; Gutiérrez and Philippon 2016, 2017; Eggertsson et al. 2018 among others. In a similar vein, Azar et al. (2017) document concentration in the U.S. labor market using disaggregated data at the geographical-occupational level.

[6]In his *Wall Street Journal* column, Larry Summers suggests that a rise in market power may be driving the symptoms of what he dubs "secular stagnation" (https://wapo.st/1UUF0sm?tid=ss_tw&utm_term=.4df9b0193380). In a recent speech, Stiglitz (2017) emphasizes the role of regulation in the rise of firms' market power across the U.S. economy and discusses the adverse economic and political consequences of this shift, especially in terms of higher inequality.

[7]Eggertsson et. al. (2018) argue that a rise in the market power and markups of firms along with a lower natural rate of interest are responsible for several macroeconomic and asset-pricing trends in the United States observed since the 1970s. Similarly, Farhi and Gourio (2018) also find a notable contribution from rising market power to several macro-finance trends. Barkai (2017) also focuses on the effect of declining competition and establishes a similar link between higher markups and lower capital and labor shares.

[8]Some recent work (e.g., Karabarbounis and Neiman 2018; Traina 2018) disagree with the evidence regarding the rise in markups on the grounds of measurement concerns, arguing that earlier work dismissed “selling, general and administrative expenses” from variable input costs when computing markups.

[9]This chart reproduces the findings of Andrews et al. (2016), who present a cross-country comparison of the top five percent of firms with the highest labor productivity level (frontier) to the rest of firms (laggard). Although the Orbis database used in their study has a rather limited coverage of U.S. firms, in a complementary work, the authors claim that the firms from advanced economies are well represented in the frontier group (Andrews et al. 2015).

[10]Gourio et al. (2014, 2016) find substantial losses in employment and output growth owing to the forgone “missing generations” of firms.

[11]Goldschlag and Miranda (2016) document that the decline has been especially pronounced in high-tech intensive sectors in the post-2000 period.

[12]The authors argue that the reason for this acceleration was the decline in young firm activity in high-tech sectors—the sectors that exhibited high growth dispersion in the earlier decades.

[13]Syverson (2017) and Ahmad et al. (2017) refute the argument that the measured slowdown in aggregate productivity growth may reflect measurement problems. The studies conclude that even if there was mismeasurement, it could only account for a small part of the decline.

[14]Fernald and Jones (2014) also point to a possible pickup in aggregate productivity growth due to the productivity-improving contribution of AI. They also mention potential spillovers from R&D conducted in developing countries such as South Korea and China, which are poised to provide vast resources for innovative activity.

[15]Similarly, Aksoy et al. (2019) analyze the effects of demographic trends in 21 OECD countries over the period between 1970 and 2014 using a panel VAR framework. The authors find that population aging reduce aggregate output growth and investment by dampening innovative activity.

[16]Furman and Giuliano (2016) document that about a quarter of U.S. workers hold occupational licenses, a dramatic increase since the 1950s. As to the effect of non-compete laws, see Marx et al. (2009). Using a seemingly exogenous variation in non-compete laws in Michigan, the authors show the attenuating effect of such policies on labor mobility. White House (2016) highlights that non-compete contracts bind a sizable fraction of workers even those without a four-year college degree and those earning less than $40,000, suggesting an abuse of the laws, possible in ways harmful to job reallocation. See Wessel (2018) for a brief non-technical account of regulatory concerns in light of competition.

[17]Andrews et al. (2016) show the prominence of ICT-intensive sectors, which are more likely to be of a "winner-takes-all" nature, in the differential productivity dynamics of frontier and non-frontier firms. In his Jackson Hole remarks, Van Reenen (2018a) contends that a growing part of the U.S. economy has gained winner-takes-most/all characteristics, possibly thanks to globalization and/or technological advances.

[18]As one of the manifestations of increasing market power of superstar firms, the literature has cited increasingly higher return on invested capital (ROIC) by superstar firms relative to others. A recent paper by Ayyagari et al. (2018) challenges this point. The authors argue that the increasingly unequal distribution of ROIC is driven by the mismeasurement of intangible capital. Still, the authors acknowledge that there may be other channels through which superstar firms exercise higher market dominance in ways that are harmful for the economic activity in the longer term. Pre-emptive mergers, in which large firms buy out smaller prospective competitors, is one such strategy (see Cunningham et al. 2018, *The Economist* 2018). Similarly, Blonigen and Pierce (2016) find that mergers and acquisitions in the U.S. manufacturing industry result in higher markups without generating any significant productivity gains.

[19]Other explanations for declining labor share proposed in the literature include offshoring (Elsby et al. 2013 and Boehm et al. 2017 in the context of U.S. manufacturing industry), declining corporate tax rates (Kaymak and Schott 2018), substitution of production workers by automated machinery (Acemoglu and Restrepo 2017), and a decline in population growth (Hopenhayn et al. 2018).

[20]In their Jackson Hole remarks, Crouzet and Eberly (2018) document the positive association between the intensity of intangible-capital use and concentration at both the industry and firm level. See also Furman and Seamans (2018) for the growing role that artificial intelligence (AI) plays in economic activity. The authors also discuss the case for a tailored regulatory framework in the face of economic implications specific to AI and the productive use of data more broadly.

[21]An article by *The Economist* (2017) also highlights the concern that large proprietary data bring an outsized market advantage to firms that possess them.

[22]Goldschlag and Tabarrok (2018) find no relationship between increasing federal regulations and declining U.S. entrepreneurship and challenge the notion that regulations might be behind secular trends in U.S. business dynamism.

[23]Among many others, see Griliches (1990), Blundell et al. (2002), Hall and Ziedonis (2001) and Akcigit and Kerr (2018). Another set of papers (e.g., Hall 1992; Bloom et al. 2002; Wilson 2009; and Hall and Van Reenen 2000) estimates the tax price elasticity of R&D spending and finds a value of unity, which corresponds to a quadratic cost function in our case.

[24]For the derivations of these objects, please see Akcigit and Ates (2020).

[25]Appendix D shows how the model-implied trends compare with the actual changes.

[26]These results do not mean that the decline in knowledge diffusion is the only driver of the observed trends. Indeed, each empirical trend considered here might have its own leading factors, and those factors may be different from the ones studied here. However, our analysis instead shows that among the mechanisms we consider, the decline in knowledge diffusion stands out as a powerful force when 10 empirical facts are considered together. Therefore, our results stress the importance of future research to understand the underlying reasons for slower knowledge diffusion. To this end, we conclude our study by discussing relevant empirical evidence in Section V.

[27]Notice that the increase in this ratio has been larger than the rise in market concentration (see Autor et al. 2017b).

[28]The designation as a "small business concern" derives from the USPTO's U.S. Patent Grant Maintenance Fee Events database, which records information on patent renewals.

[29]Mature incumbents refer to firms that employ more than 1,000 workers and are older than 20 years.

[30]The observation is consistent with the findings of Akcigit and Kerr (2018) that young firms are more R&D and innovation intensive than older firms.

[31]Our sample is an unbalanced panel from 1985 to 2016 that includes 414 SIC 4-digit sectors. Following Autor et al. (2017b), we only include sectors from sis main industries: manufacturing, retail trade, wholesale trade, services, utilities and transportation and finance. We also use Thomson Reuters' M&A data for the same years.

[32]In particular, we consider Hirsch Herfindal Index (HHI) and sales share of top four firms in an industry (CR4) (market concentration); the variable cost of goods sold as the variable input in the production function estimation (markups based on De Loecker et al. 2017); the operating income before depreciation over total revenue (profit share); payroll over total revenue (labor share); and, the dispersion of sales and employment growth rates following Davis et al. (1996), all defined at the sector-year level.

[33]Indeed, Yeldan and Ünüvar (2016) claim that the financing difficulty was particularly acute for Turkish nonfinancial corporates, whose net foreign exchange liabilities increased eight-fold between 2005 and 2013, from about 4% of GDP close to 20%.

[34]Shortage of credit during economic downturns can lead to permanent output losses. Ates and Saffie (2020) show that sudden stops can permanently depress the level of aggregate productivity and output as the limited availability of credit

constrains entry of young firms into the economy and their contribution to productivity growth.

[35]With the help of weaker antitrust law enforcement (Grullon et al. 2017), large conglomerates can consolidate economic activity in their hands and potentially find it easier to defend their turf, substantially decreasing the chances for small firms to learn from and catch up with them. The finding of Bessen (2016) on the increasing importance of lobbying and political rent-seeking speaks to this possibility.

[36]For instance, while trucking companies paid 30%, biotech companies paid less than 5% of their income as tax in 2009 (Appelbaum 2011). Even more, some companies such as General Electric not only did not pay any taxes, they even claimed positive tax benefits (Kocieniewski 2011).

[37]In fact, the nonrefundability feature of the U.S. R&D tax credits is subject to major criticism, along with the lack of preferential rates for small firms, which contrasts with schemes in other major economies such as France and the United Kingdom (Congressional Budget Office 2007; Tyson and Linden 2012). These features are especially important for the efficiency of tax credits in supporting the innovative activity of highly dynamic small and young firms, which are usually the firms that are constrained by the high cost of R&D capital.

[38]The findings of recent work by Bivens et al. (2017) and Farber et al. (2018) indicate that a decline in unionization could have suppressed a broad-based wage growth. Azar et al. (2017) document an increase in monopsony power in labor markets.

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