Market Power and Growth

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Abstract

I study the effects of market power on growth in a model with one large firm and a continuum of small firms in each industry. Firms can innovate by creatively destroying their competitors' goods, innovating on their own varieties, and developing new varieties. The key mechanism is that a large firm has a relative preference for creative destruction of its competitors' goods compared to small firms because creative destruction allows the large firm to take revenue disproportionately from its competitors, and avoid cannibalization. I show that on a balanced growth path, the growth rate in an industry as a function of the large firm's market share displays an inverted-U shape. I calibrate the model to US data and find that the recent rise in the average market share of the largest firm in each industry can explain almost half the fall in growth from the 1990s to the 2010s, as well as the burst in growth during the late 1990s and early 2000s. Large firms maintain their high market shares by creatively destroying their competitors' goods, which generates little growth but deters other firms from innovating. I find that substantial reductions in taxes on large firm acquisitions of their competitors' goods (with take-it-or-leave-it offers) increase growth and welfare. Intuitively, a large firm is harmful not because of its size, but because of the way in which it innovates to achieve its size. Acquisitions offer large firms an alternative to innovation, thus shifting innovation to small firms, who do so in a more socially optimal way.

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1 Introduction

What is the effect of market power on growth? The recent rise in the market shares of large firms has spurred research into the effects of this rise on the macroeconomy, as well as the policy implications.[1] In this paper, I develop a growth model to explore this question in the context of economic growth. The key features of the model are that firms can grow by creatively destroying other firms' goods, developing new goods, or improving their own goods, and that each industry consists of a single large firm and a continuum of small firms. I show that with particular parameter assumptions, without computing the full Markov Perfect equilibrium of the industry game, we can solve for the main macroeconomic outcomes as a function of large firms' market shares along a balanced growth path. Across *industries*, the rate of growth as a function of the large firm's market share displays an inverted-U shape, as observed in the data.[2] Across economies, each of which is on a different balanced growth path, the rate of growth is decreasing in the average large firm market share. I calibrate the model to the US economy in the early 1990s and find that, if the observed rise in industry concentration in the US since the 1990s is generated by a fall in the cost of innovation for large firms, then it can explain the burst in growth in the late 1990s, as well as 41% of the fall in the growth rate observed in the data from the early 1990s to the early 2010s. I use the calibrated model to analyze acquisition policies and find that a reduction in the tax on large firm acquisitions of small firms' goods, if big enough, *increases* growth and welfare.

The key mechanism driving the model's results is that compared to small firms, large firms have a relative preference for creatively destroying their competitors' goods over improving their own goods or developing new ones. A new good takes revenue from all other goods in an industry, which is costly for a large firm that produces many of those goods. On the other hand, if a large firm creatively destroys a small firm's good, then the revenue gained comes disproportionately from that small firm. A free entry condition at the aggregate level implies that on a balanced growth path, the sum of growth and the rate of creative destruction faced by small firms is pinned down by the cost of entry since each serves as a discount rate on small firm profits. As large firms' industry revenue shares grow, innovation shifts toward creative destruction of small firms' goods both because a bigger fraction of innovation is from large firms and because large firms focus their innovation even more on creative destruction as they grow. For the free entry condition to hold as creative destruction rises, growth must fall.

Across industries within a single economy, the sum of growth and creative destruction is no longer fixed since entry occurs at the aggregate level, which implies that each industry has the same measure of small firms. Instead, small firm innovation is a decreasing but continuous function of the total discount

[1] See Autor, Dorn, Katz, Patterson, and Van Reenen (2020), De Loecker, Eeckhout, and Unger (2020), Barkai (2020), and Weiss (2020).

[2] See Aghion, Bloom, Blundell, Griffith, and Howitt (2005) and Cavenaile, Celik, and Tian (2021).

rate on small firm profits. If heterogeneity across industries in large firm revenue shares is driven by heterogeneity in their costs of innovation, then more concentrated industries may see more growth due to higher rates of large firm innovation. Nonetheless, if a large firm has a sufficiently high market share, then so much of its innovation is creative destruction of small firms' goods that any further increase in its size implies a fall in growth.

The model thus provides a novel theory of the inverted-U relationship between market concentration and growth across industries. The theory is unrelated to the relative sizes of the "escape competition" and the Schumpeterian effects of competition, unlike previous work.[3] The magnitude of large firm innovation is driven by both effects, but the magnitude of small firm innovation depends only on the Schumpeterian effect: as the expected rate of innovation increases, small firms innovate less. The inverted-U relationship depends on the response of small firm innovation to an increase in large firm innovation. The relationship between concentration and growth is negative when the response is big enough to outweigh the increase in large firm innovation. The responsiveness of small firm innovation is increasing in industry concentration because larger firms choose types of innovation that are more harmful to their competitors. An important implication of this particular theory of the inverted-U relationship is that because the entry rate and innovation are more responsive to economy-wide changes, widespread higher concentration tends to be associated with lower growth at the aggregate level even if across industries or within an industry over time, higher concentration is associated with higher growth.

Testable empirical predictions of the model's main mechanism are that firms can direct creative destruction efforts toward particular goods, and smaller firms face higher discount rates on the profits from their innovations. The theory implies that this disparity increased as market concentration rose and growth fell in the US since the 1990s.

I use the calibrated model to explore the effects of acquisitions in which a large firm purchases a good from a small firm. Acquisitions increase concentration and shift large firms' innovation further toward creative destruction of their competitors, pushing down growth and welfare. However, if acquisitions are valuable to large firms, they discourage large firm innovation because the more a large firm innovates, the less market share remains for it to acquire. Thus, given an acquisition rate, reducing taxes on acquisitions shifts innovation to small firms who innovate in a more socially optimal way, increasing growth and welfare. I find that for large enough decreases in the acquisition tax rate, the second effect dominates, and growth and welfare are higher than in an economy without acquisitions.

Since acquisitions are made with take-it-or-leave-it offers, small firms face no incentive to innovate to be acquired, and the "entry for buyout" effect is not present.[4] Instead, acquisitions may be useful *because*

[3] See Aghion, Bloom, Blundell, Griffith, and Howitt (2005) and Cavenaile, Celik, and Tian (2021).

[4] See Rasmusen (1988) and more recently, Letina, Schmutzler, and Seibel (2021) and Fons-Rosen, Roldan-Blanco, and

they reduce large firm innovation, not in spite of it, and they are especially beneficial when concentration is particularly high.

These results highlight an important subtlety in optimal competition policy. Large firms are harmful in the model not because of their size, but because of how they *achieve their size*. Policies that encourage large firm innovation based on the notion that they under-produce backfire: such policies reduce growth because large firms over-innovate through creative destruction, deterring their competitors from generating growth. Policies that offer large firms a tempting alternative to innovation increase growth by shifting activity to smaller firms that innovate in a more socially optimal way.

Related Literature

The model builds on two different strands of the growth literature, one focused on models of creative destruction[5], and one on expanding varieties models[6]. Recent work combines the two, but without large firms with positive market shares.[7]

This paper is related to recent papers that study the effect of high productivity or superstar firms on growth.[8] Previous work has mostly considered models with only small firms, and so they focus on the effect of productivity dispersion across small firms, whereas I abstract from productivity dispersion and focus on the effect of large firms' market power. In particular, Aghion, Bergeaud, Boppart, Klenow, and Li (2022) and De Ridder (2021) focus on the channel that increased competition from high productivity competitors reduces less productive firms' markups, and therefore their incentive to grow. The channel I study in this paper is complementary in the sense that they focus on the flow profits a small firm receives from innovating, whereas I focus on the effective discount rate on small firm profits.

Liu, Mian, and Sufi (2022) study a growth model with two large firms in each industry, and find that a large firm can reduce growth by building a substantial productivity advantage over its competitor. The mechanism is that a bigger gap implies that the large firm will optimally cut its price by more in response to innovation by its competitor. On the other hand, as discussed, I focus on how a large firm's innovation decisions affect the rate at which its competitors discount their profits. An important difference is that my mechanism does not rely on a large firm responding directly to the actions of a single competitor. In that sense, my mechanism may be more relevant when thinking about the effect of a large firm on the innovation decisions of small firms. Finally, Cavenaile, Celik, and Tian (2021)

Schmitz (2022).

[5]See Grossman and Helpman (1991b), Aghion and Howitt (1992), Klette and Kortum (2004), and Aghion, Bergeaud, Boppart, Klenow, and Li (2022).

[6]See Romer (1990) and Grossman and Helpman (1991a).

[7]See Atkeson and Burstein (2019).

[8]See Aghion, Bergeaud, Boppart, Klenow, and Li (2022), De Ridder (2021), Cavenaile, Celik, and Tian (2021), and Liu, Mian, and Sufi (2022).

study a growth model with large firms, but the pressure those large firms place on small firms has no effect on growth because small firms always have zero profits.

Akcigit and Ates (2021) and Olmstead-Rumsey (2022) propose theories in which exogenous changes in the economy's innovation technology cause a decline in growth, as well as a rise in market concentration and markups. The theory I propose reverses the causality and suggests that changes in industry structure—a rise in concentration—drive a decline in growth. Moreover, it provides an alternative explanation for the fall in the effect of a patent on a firm's market value documented in Olmstead-Rumsey (2022): the innovation is more quickly creatively destroyed by a large firm.

The paper proceeds as follows. In section 2, I describe a simple illustrative model. In section 3, I describe the full quantitative model. In section 4, I solve the model and discuss optimal firm behavior. In section 5, I characterize analytical results, calibrate the model, and show quantitative results on the effects of a fall in large firms' innovation costs. In section 6, I analyze the effects of acquisition policies. In section 7, I confirm the robustness of the model's results to allowing large firm entry and exit. In section 8, I conclude.

2 A Simple Industry Model

I first describe a simple industry model of creative destruction with a large firm that does not creatively destroy its own goods. The model illustrates the key mechanism of the theory. If firms can target creative destruction toward their competitors' goods rather than their own, then large firms will generate less growth for a given rate at which they creatively destroy their competitors' goods. If small firm innovation is sufficiently responsive to the rate at which small firm goods are creatively destroyed, then an increase in innovation by large firms reduces overall growth. The simple model also demonstrates important empirical predictions of this mechanism. Firms can direct creative destruction efforts toward particular goods, and smaller firms face higher discount rates on the profits from their innovations.

Time is continuous and indexed by $t \in [0, \infty)$. There is a unit measure of goods, indexed by $j \in [0, 1]$, each of which always receives the same revenue. At each time t, there is a measure N_t of small firms, and a single large firm. Each good is produced by a single firm at each time t, with productivity $z_t(j)$. The producer of a good receives flow profits π. Firms innovate by creatively destroying each others' goods. When a firm creatively destroys a good, it becomes the sole producer of that good, and the good's productivity, $z_t(j)$, is multiplied by $\lambda > 1$.

Industry productivity is $Z_t = \int_0^1 z_t(j)dj$, and the industry growth rate is $g_t = \frac{1}{Z_t}\frac{\partial Z_t}{\partial t}$. Denote by $S_t \in [0, 1]$

the measure of goods the large firm produces at time t, which is also the large firm's share of industry revenue.

Each small firm chooses a Poisson arrival rate at which they creatively destroy each good, $\tilde{x}_{C,t}(j)$, subject to the flow cost function $\int_0^1 \tilde{x}_{C,t}(j)^2 dj$. Small firms choose innovation rates to maximize the expected present discounted value of profits, where they discount future payouts by the real interest rate r.

In this simple model, I take the large firm's innovation decisions as given. The large firm creatively destroys each good produced by a small firm at a flow rate rather than a Poisson arrival rate: in a finite interval of time, each small firm creatively destroys a finite *number* of goods, and the large firm creatively destroys a finite *measure* of goods. *The large firm does not creatively destroy its own goods.*

2.1 Long-Run Industry Concentration and Growth

I study balanced growth path Markov Perfect equilibria. All small firms creatively destroy all goods at the same rate, $x_{C,S}$, since each good yields the same flow profits. The large firm creatively destroys small firms' goods at rate $x_{C,L}$. The large firm's industry revenue share is constant over time at S. The industry productivity growth rate is constant at g. I consider two cases for determining the constant measure of small firms, N. In the first case, N is given by a free entry condition that fixes the value of being a small firm producing 0 goods. In the second case, N is exogenously given.

I analyze the effects of changes in the rate at which the large firm creatively destroys small firms' goods, $x_{C,L}$, on the large firm's industry revenue share, S, and growth, g, in the long-run. Since S is strictly increasing in $x_{C,L}$, we can write g as a function of S. On a balanced growth path, the large firm's industry revenue share and growth are

$$S = \frac{x_{C,L}}{N x_{C,S} + x_{C,L}}; \qquad g = (\lambda - 1)(N x_{C,S} + (1-S) x_{C,L}). \tag{1}$$

Small firms creatively destroy goods and generate growth at rate $N x_{C,S}$, and the large firm creatively destroys goods and generates growth at rate $(1-S)x_{C,L}$ since it does not creatively destroy its own goods. Small firm creative destruction is given by the First Order Condition:

$$x_{C,S} = \frac{\pi/2}{r + N x_{C,S} + x_{C,L}}.$$

If N is determined by the free entry condition, then since the value of being a small firm producing 0 goods is pinned down by the optimal small firm creative destruction rate, it follows that for any large firm creative destruction rate, $x_{C,L}$, the total rate at which a small firm's good is creatively destroyed,

$Nx_{C,S} + x_{C,L}$, is constant. From equation (1), the derivative of growth with respect to the large firm's industry revenue share is

$$g'(S) = \frac{-2S}{1+S}\frac{g}{1-S},$$

which is always negative. If N is exogenously given, then

$$g'(S) = \left(\frac{-2S}{1+S} + \frac{1+r_0}{2+r_0}\right)\frac{g}{1-S},$$

where r_0 is the interest rate relative to the total rate of creative destruction: $r_0 = r/(Nx_{C,S} + x_{C,L})$. Since r_0 is strictly decreasing in S, in this case the derivative of growth with respect to the large firm's industry revenue share is negative if and only if $S > S^*$ for some $S^* \in (0, 1)$.

The derivative in the free entry case, and the first term of the derivative in the exogenous N case, is the *composition effect*. Holding fixed the total rate at which small firm goods are creatively destroyed, total small firm creative destruction falls one-for-one with the rise in large firm creative destruction. Small firm creative destruction contributes to growth at rate $\lambda - 1$ and large firm creative destruction contributes to growth at rate $(1 - S)(\lambda - 1)$, so the effect of the fall in the former always outweighs the effect of the rise in the latter, leading to a decreasing relationship between growth and the large firm's industry revenue share. The second term of the derivative in the exogenous N case is the *total innovation effect*. Holding fixed the ratio of small firm creative destruction to large firm creative destruction, $Nx_{C,S}/x_{C,L}$, the total rate at which small firm goods are creatively destroyed, and thus growth, are increasing in large firm creative destruction. If the measure of small firms is exogenously given, then both the composition and total innovation effects are present because each small firm faces a convex innovation cost. If the large firm's revenue share is sufficiently small, then it makes little difference that the large firm does not creatively destroy its own goods, so the total innovation effect dominates the composition effect, which implies an increasing relationship between growth and the large firm's revenue share.

In the quantitative model I study in future sections, potential entrants pay entry costs not knowing into which industry they will enter. Thus, I interpret the exogenous N case as describing the relationship between concentration and growth across industries due to dispersion in large firm creative destruction, $x_{C,L}$, and the free entry case as describing the relationship between average concentration and growth over time due to widespread changes in $x_{C,L}$. Therefore, across industries growth as a function of the large firm's revenue share exhibits an inverted-U shape. On the other hand, widespread changes over time that increase large firms' revenue shares push down growth.

3 Quantitative Model

Time is continuous and indexed by $t \in [0, \infty)$. There is a unit measure of industries, indexed by $n \in [0, 1]$, each of which consists of firms producing differentiated goods. There is a representative household who consumes the numeraire final good and inelastically supplies $\bar{L}$ units of labor. The household's preferences are

$$\int_0^\infty e^{-\rho t} \ln(C_t) dt,$$

where C_t is consumption of the final good. Final good consumption is a Cobb-Douglas aggregate of industry consumption:

$$\ln(C_t) = \int_0^1 \ln(C_{n,t}) dn,$$

where industry consumption is an aggregate of the consumption of the differentiated goods within the industry. The household takes goods prices and the wage, W_t, as given and chooses the consumption of each good in each industry. The household can also buy and sell a risk-free real bond with net interest rate r_t (denominated in units of the final good). Going forward, I focus on a particular industry and drop industry subscripts to simplify notation.

3.1 Overview and Demand

Since final good consumption is a Cobb-Douglas aggregate of industry consumption, total revenue in an industry is exogenously given as R_t. The representative household's stochastic discount factor is characterized by the risk-free interest rate r_t. There is a measure M_t of goods indexed by $j \in [0, M_t]$. The representative consumer has CES preferences across goods with elasticity $\gamma \geq 1$: denote consumption of good j to be $c_t(j)$ and consumption of the industry good to be C_t, then

$$C_t = \left(\int_0^{M_t} c_t(j)^{\frac{\gamma-1}{\gamma}} dj \right)^{\frac{\gamma}{\gamma-1}}.$$

Denote the price of good j by $p_t(j)$. The price of the industry good is therefore P_t, where

$$P_t = \left(\int_0^{M_t} p_t(j)^{1-\gamma} dj \right)^{\frac{1}{1-\gamma}}. \tag{2}$$

The demand curve for good j is

$$c_t(j) = p_t(j)^{-\gamma} P_t^{\gamma-1} R_t. \tag{3}$$

3.2 Production and Competition

There is a large firm, denoted by subscript L, and a measure N_t of small firms, indexed by $i \in [0, N_t]$. The large firm can produce each good j with production function

$$q_{L,t}(j) = z_{L,t}(j) l_{L,t}(j), \tag{4}$$

where $q_{L,t}(j)$ is quantity and $l_{L,t}(j)$ is labor, which is purchased in a perfectly competitive market at wage W_t. Each small firm i can produce each good j with production function

$$q_{i,t}(j) = z_{i,t}(j) l_{i,t}(j). \tag{5}$$

All varieties of each good produced by different firms are perfect substitutes.

In each moment, firms simultaneously choose prices to maximize static profits. Let $\bar{z}_t(j)$ be the highest productivity for good j among all producers, i.e.,

$$\bar{z}_t(j) = \max\{\{z_{i,t}(j)\}_{i\in[0,N_t]}, z_{L,t}(j)\},$$

The evolution of productivity will be such that $\bar{z}_t(j)$ is always achieved by only a single firm. Given that firms compete in prices and that different varieties of each good are perfect substitutes, the most productive producer, with productivity $\bar{z}_t(j)$, is the sole producer of good j, and their price is constrained to be weakly less than the marginal cost of the second most productive producer of good j.

Let $\mu_t(j)$ be the gross markup of price over marginal cost for good j: $\mu_t(j) = \bar{z}_t(j)p_t(j)/W_t$.

Let Z_t be an aggregate of productivity in the industry:

$$Z_t \equiv \left(\int_0^{M_t} \bar{z}_t(j)^{\gamma-1} dj\right)^{\frac{1}{\gamma-1}},$$

and define the relative productivity of good j: $\tilde{z}_t(j) \equiv \bar{z}_t(j)/Z_t$. Going forward, I will usually characterize a good by its relative productivity rather than its productivity.

3.3 Innovation

In each moment, each firm chooses two types of innovation: a rate of creative destruction for each good j, and a rate of new good development. Conditional on creatively destroying a good j, a firm's relative productivity for that good becomes $\lambda\tilde{z}_t(j)$, where $\lambda > 1$. Conditional on developing a new good, a firm's relative productivity for that good, $\lambda\tilde{z}$, is drawn so that the expected value of $\tilde{z}^{\gamma-1}$ is equal to 1. Moreover, whenever a firm creatively destroys a good or develops a new good, so that the new relative productivity for that good is $\tilde{z}_t(j)$, all other firms are able to produce that good with relative productivity $\tilde{z}_t(j)/\kappa$, where $\kappa > 1$. Thus κ is the maximum possible gap between the productivities of the most productive and the second-most productive producers of a good. To ensure a balanced growth path, the costs of innovation depend on the relative productivity of the good (whether creatively destroyed or newly developed).

To be clear, a firm can creatively destroy a good that it already produces. For small firms, this possibility is irrelevant since each small firm produces finitely many goods, and creatively destroys each good at an infinitesimal rate. For the large firm, this possibility is meaningful, and implies that the innovative capacity of the economy is not mechanically reduced as the large firm's market share grows.

3.3.1 Small Firms

Each small firm i chooses a creative destruction rate $x_{C,i,t}(j)$ for each good j, where subscript C denotes *creative* destruction, and a new good development rate $x_{D,i,t}$, where subscript D denotes new good *development*. They creatively destroy good j at Poisson arrival rate $x_{C,i,t}(j)\Delta$, where Δ is very small so that at Poisson arrival rate $\int_0^{M_t} x_{C,i,t}(j)dj$, they creatively destroy a single good, and the relative probability of creatively destroying good j is proportional to $x_{C,i,t}(j)$. A small firm develops a new good at Poisson arrival rate $x_{D,i,t}$. The total flow cost in units of labor is

$$\chi_S \left(x_{D,i,t}^{\alpha} + \chi_C \int_0^{M_t} \tilde{z}_t(j)^{\gamma-1} x_{C,i,t}(j)^{\alpha} dj \right),$$

where $\chi_S > 0$ is the small firm innovation cost, $\chi_C > 0$ is the relative cost of creative destruction compared to new good development, and $\alpha > 1$ determines the curvature of cost in the innovation rate.

3.3.2 Large Firm

The large firm chooses a creative destruction rate $x_{C,L,t}(j)$ for each good j, and a new good development rate $x_{D,L,t}$. They creatively destroy good j at Poisson arrival rate $x_{C,L,t}(j)$, and develop new goods at rate $x_{D,L,t}$. The total flow cost in units of labor is

$$\chi_L \left(x_{D,L,t}^{\alpha} + \chi_C \int_0^{M_t} \tilde{z}_t(j)^{\gamma-1} x_{C,L,t}(j)^{\alpha} dj \right),$$

where $\chi_L > 0$ is the large firm's innovation cost, and the large firm faces the same relative cost of creative destruction as small firms, χ_C.

3.3.3 Small Firms vs. The Large Firm

For a small firm, at a Poisson arrival rate they creatively destroy a single good or develop a single new good. Hence, in finite time, a small firm gains control over a finite number of goods. On the other hand, the large firm creatively destroys goods and develops new goods at a continuous rate. Hence, in finite time, the large firm gains control over a finite *measure* of goods. We can think of the large firm as controlling jointly the innovation technologies of a continuum of small firms. Thus, all firms face the same relative cost of creative destruction compared to new good development, and the large firm's innovation cost, χ_L, depends on the measure of this continuum of small firms whose innovation technologies it controls.

3.3.4 Parameter Assumption and Discussion

To simplify analysis of the model, I make the following assumption:

Assumption 3.1. *The maximum productivity gap between the most productive and second-most productive producers of a good is weakly less than the creative destruction step size and the markup any firm would set if unconstrained, i.e.,* $\kappa \leq min\{\lambda, \gamma/(\gamma-1)\}$.

It follows that regardless of how a firm became the most productive producer of a good, the gap between that firm's productivity and the productivity of the second-most productive producer of the good is κ. I interpret this assumption as suggesting that firms can imitate each others' goods sufficiently well so that regardless of the gap between a firm's new innovation (creative destruction or new good development) and whatever came before it, the firm feels the same competitive pressure when pricing that good.

Assumption 3.1 implies that we can interpret new good development as firms innovating on their own goods. In either case, any gains enjoyed by a firm come from adding productivity to the industry, not from taking productivity from another firm, and in either case, the firm sets the same markup.

Since Assumption 3.1 implies that all firms set the same markup on all goods, I thus abstract from the effects of firms setting different markups on newly developed goods and on creatively destroyed goods, as well as the effects of large firms setting higher markups than small firms. Allowing for different markups substantially complicates the analysis. As large firms gain market share, they set higher markups, which reduces competition and encourages growth from small firms. This effect is mitigated or reversed if large firms are sufficiently more productive than small firms: they may set higher markups than small firms, but lower prices. Then, as large firms gain market share the industry price index falls, which decreases small firms' incentive to innovate.

3.4 Entry and Exit

Entry is undirected, so an entering firm draws an industry from the uniform distribution. At each moment in time, there is an infinite mass of potential entrants. If a potential entrant pays the cost of entry, then they draw an industry and enter as a single small firm. Otherwise, the potential entrant receives value 0. The total cost of entry is increasing in the entry rate and is E_t^ϵ units of labor, where E_t is the entry rate and $\epsilon \geq 1$ is the elasticity of total entry costs with respect to the entry rate. Thus, the marginal entrant faces an entry cost of $\epsilon E_t^{\epsilon-1}$. At the lower bound for the elasticity, $\epsilon = 1$, the marginal entry cost is constant and there is a free entry condition. At the upper bound for the elasticity, $\epsilon = \infty$, the marginal entry cost is 0 if $E_t < 1$ and infinite if $E_t > 1$. In that case, the entry rate is always 1.

Each small firm exits exogenously at Poisson arrival rate $\eta > 0$. When a firm exits, it sells each good for which it is the most productive producer to another small firm (not the small firm that is the second-most productive producer of that good).

3.5 Equilibrium

At each moment in time, the goods market must clear, i.e., the amount each firm supplies of each good is equal to the representative household's demand for that good, and the labor market must clear, i.e., the labor used in production, for entry costs, and for innovation costs, must equal the labor inelastically supplied by the representative household.

Given the parameter restriction made in Assumption 3.1, I characterize each good by its type $f \in \{S, L\}$, which denotes whether the good's current producer is a small firm (S) or the large firm (L). Let $T(j)$ be good j's type. For each type $f \in \{S, L\}$, define $\tilde{Z}_{f,t}$ to be an aggregate of the relative productivities of goods of type f at time t:

$$\tilde{Z}_{f,t} = \left(\int\limits_{j:T(j)=f} \tilde{z}_t(j)^{\gamma-1} dj \right)^{\frac{1}{\gamma-1}}.$$

It follows that $\tilde{Z}_{S,t}^{\gamma-1} + \tilde{Z}_{L,t}^{\gamma-1} = 1$.

The industry state is the fraction of industry relative productivity in goods produced by the large firm, $\tilde{Z}_{L,t}$, which implies the value of $\tilde{Z}_{S,t}$. The aggregate state is the measure of small firms in each industry, N_t, and the distribution of industry states across industries.

I study Markov Perfect Equilibria in which firms' markups are given by static optimization of profits and are a function only of $\tilde{Z}_{L,t}$. In particular, markups are not a function of the industry aggregate of productivity, Z_t, the measure of small firms, N_t, or of time t. Firms' innovation decisions are given by dynamic optimization of expected discounted profits and are functions only of the industry state, $\tilde{Z}_{L,t}$, and the aggregate state when converging to a balanced growth path. Innovation decisions do not depend on Z_t. Moreover, each firm creatively destroys all goods of each type f at the same rate. Potential entrants' decisions are given by dynamic optimization of expected discounted profits net of the marginal entry cost and are functions only of the distribution of industry states across industries, and the aggregate measure of small firms.

To be clear, firms can always observe all features of the economy when optimizing, but they suppose that other firms' actions depend only on the variables mentioned above. I show that it is then optimal for each firm also to condition their own actions only on the variables mentioned above.

I focus on balanced growth path equilibria and the convergence to a balanced growth path following unanticipated shocks. A balanced growth path is an equilibrium in which $\tilde{Z}_{L,t}$ is constant over time in each industry, the measure of small firms N_t is constant over time, Z_t grows at a constant rate, and each firm's innovation decisions are functions only of $\tilde{Z}_{L,t}$ in their industry.

3.6 Firm Problem

Before describing the firm problem, note that since small firms take industry aggregates as given, we can split their static profit maximization problem into a separate problem for each good they produce. Moreover, when innovating, a small firm's problem is the same regardless of the goods it produces.

3.6.1 Static Profit Maximization: Prices

At each moment in time, firms choose prices simultaneously to maximize static profits. A small firm that is the most productive producer of a good j with relative productivity $\tilde{z}_t(j) = \bar{z}_t(j)/Z_t$ takes as given the industry price index, the wage, and industry revenue, and chooses a markup to maximize static profits $\pi_{S,t}(\tilde{z}_t(j); \tilde{Z}_{L,t})$ subject to the demand curve (3), the production function (5), and competition from the second-best producer: $\mu_t(j) \leq \kappa$. A large firm takes as given small firms' prices, the wage, and industry revenue, and chooses markups for its goods to maximize static profits $\pi_{L,t}(\tilde{Z}_{L,t})$ subject to the demand curve (3), the production function (4), competition from the second-best producers of each of its goods, and aggregation (2), which determines the industry price index as a function of goods prices.

3.6.2 Dynamic Profit Maximization: Innovation

At each moment in time, firms simultaneously choose innovation rates: a creative destruction rate for each good, and a new good development rate. In the dynamic problem, a firm takes as given its profit function from static optimization.

All small firms choose the same innovation rates. Moreover, we will see that each small firm creatively destroys all goods at the same rate. Thus, let $x_{C,S,t}$ denote this rate of creative destruction, and let $x_{D,S,t}$ denote the rate at which small firms develop new goods. For large firms, let $x_{C,L,t}(f)$ denote the rate at which a large firm creatively destroys a good that is currently produced by a type $f \in \{S, L\}$ firm, and let $x_{D,L,t}$ denote the rate at which a large firm develops new goods.

Small Firms: For a small firm to choose their optimal innovation rate, they must know the expected present discounted value of being the most productive producer of a good. They take as given the static profit function at each moment in time, the aggregate state, and the innovation rates of other firms, which imply the evolution of the industry state and the growth rate of industry productivity. The expected present discounted value of producing good j is given by the HJB equation:

$$\begin{aligned} r_t \bar{\pi}_{S,t}(\tilde{z}_t(j); \tilde{Z}_{L,t}) =& \pi_{S,t}(\tilde{z}_t(j); \tilde{Z}_{L,t}) - (x_{C,S,t} + x_{C,L,t}(S))\bar{\pi}_{S,t}(\tilde{z}_t(j); \tilde{Z}_{L,t}) - g_t \tilde{z}_t(j) \frac{\partial \bar{\pi}_{S,t}(\tilde{z}_t(j); \tilde{Z}_{L,t})}{\partial \tilde{z}_t(j)} \\ &+ \dot{\tilde{Z}}_{L,t} \frac{\partial \bar{\pi}_{S,t}(\tilde{z}_t(j); \tilde{Z}_{L,t})}{\partial \tilde{Z}_{L,t}} + \frac{\partial \bar{\pi}_{S,t}(\tilde{z}_t(j); \tilde{Z}_{L,t})}{\partial t}, \end{aligned}$$

where g_t is the growth rate of industry productivity, i.e., $\dot{Z}_t / Z_t$, and a dot over a variable indicates its derivative with respect to time. The first term on the right-hand side of the first line is flow profits, the second term reflects the rate at which the good is creatively destroyed, and the third term reflects the rate at which the firm's relative productivity is depreciated by growth in industry productivity either due to creative destruction or new good development. The second line reflects changes in the expected present discounted value of profits over time due to changes in the industry state, or changes in the aggregate state when the economy is converging to a balanced growth path.

A small firm chooses innovation rates to maximize the expected present discounted value of profits using the household stochastic discount factor, i.e., the risk-free interest rate. As mentioned above, a small firm's innovation optimization problem is the same regardless of the goods they produce. The value function of a small firm with zero goods is given by the HJB equation:

$$\begin{aligned} r_t V_{S,t}(\tilde{Z}_{L,t}) =& \max_{x_{D,t}} \left\{ x_{D,t} \mathbf{E}[\bar{\pi}_{S,t}(\lambda \tilde{z}; \tilde{Z}_{L,t})] - W_t \chi_S x_{D,t}^{\alpha} \right\} \\ &+ \max_{\{x_{C,t}(j)\}} \left\{ \int_0^{M_t} x_{C,t}(j) \bar{\pi}_{S,t}(\lambda \tilde{z}_t(j); \tilde{Z}_{L,t}) dj - W_t \chi_S \chi_C \int_0^{M_t} \tilde{z}_t(j)^{\gamma-1} x_{C,t}(j)^{\alpha} dj \right\} \\ &- \eta V_{S,t}(\tilde{Z}_{L,t}) + \dot{\tilde{Z}}_{L,t} \frac{\partial V_{S,t}(\tilde{Z}_{L,t})}{\partial \tilde{Z}_{L,t}} + \frac{\partial V_{S,t}(\tilde{Z}_{L,t})}{\partial t}, \end{aligned}$$

where the first line is the optimization problem for the rate at which the small firm develops a new good, and the expected value is over realizations of $\tilde{z}$, which is distributed so that the mean of $\tilde{z}^{\gamma-1}$ is 1; the second line is the optimization problem for the rate at which the firm creatively destroys each good; the third line reflects the firm's exit rate as well as changes in the value function over time due to changes in the industry state, or change in the aggregate state when the economy is converging to a balanced growth path.

Large Firm: The large firm takes as given the aggregate state, the current industry state, as well as small firm behavior as a function of the industry state, and chooses innovation rates to maximize the expected present discounted value of profits, including innovation costs, discounting with the risk-free interest rate. The value function is given by the HJB equation:

$$\begin{aligned} r_t V_{L,t}(\tilde{Z}_{L,t}) =& \pi_{L,t}(\tilde{Z}_{L,t}) + \max_{\{x_{C,L,t}(j)\}, x_{D,L,t}} \Bigg\{ \dot{\tilde{Z}}_{L,t}(\{x_{C,L,t}(j)\}, x_{D,L,t}; \tilde{Z}_{L,t}) \frac{\partial V_{L,t}(\tilde{Z}_{L,t})}{\partial \tilde{Z}_{L,t}} \\ & - W_t \chi_L \chi_C \int_0^{M_t} \tilde{z}_t(j)^{\gamma-1} x_{C,L,t}(j)^{\alpha} dj - W_t \chi_L x_{D,L,t}^{\alpha} \Bigg\} \\ &+ \frac{\partial V_{L,t}(\tilde{Z}_{L,t})}{\partial t}. \end{aligned}$$

The first term on the right-hand side of the first line is the large firm's flow profits; the second term and the second line are the optimization problem of the large firm choosing innovation rates: the term on the first line is the benefit through changes in $\tilde{Z}_{L,t}$, and the second line is the flow cost of innovation. The final line reflects changes in the value function over time due to changes in the aggregate state when the economy is converging to a balanced growth path.

3.7 Aggregation and Welfare

Given Assumption 3.1, which implies that all firms set a markup κ on all goods, it follows that the industry price index is $P_t = \kappa W_t Z_t^{-1}$, and consumption of the industry good is $C_t = Z_t L_t^p$, where

$$L_t^p \equiv \int_0^{M_t} l_t(j) dj$$

is labor used in production, with $l_t(j)$ the labor used in production of good j.

Consider an economy in which all industries are identical. Since the final good is the numeraire, the final good price is always 1, and the wage is therefore $W_t = Z_t/\kappa$. The interest rate is the sum of the time discount rate and the growth rate of final good consumption: $r_t = \rho + g_t$. We can write the representative household's welfare as

$$\int_0^\infty e^{-\rho t} \left(\ln(Z_t) + \ln\left(L_t^p\right)\right) dt.$$

Along a balanced growth path with growth rate g and labor used in production L^p, the household's welfare at time t is

$$\frac{g}{\rho^2} + \frac{\ln\left(L^p\right)}{\rho} + \frac{\ln(Z_t)}{\rho}.$$

4 Firm Optimization

4.1 Static Optimization: Prices

For brevity, I omit the static optimization problem, and only note that all firms would set a markup weakly greater than $\gamma/(\gamma-1)$ if unconstrained by the second-most productive producer.[9] Thus, by Assumption 3.1, all firms set a markup of κ on all goods. The static profit function for a small firm producing a good with relative productivity $\tilde{z}$ is thus

$$\pi_{S,t}(\tilde{z}) = \tilde{z}^{\gamma-1}\frac{\kappa-1}{\kappa}R_t,$$

and for a large firm with relative productivity $\tilde{Z}_{L,t}$ is

$$\pi_{L,t}(\tilde{Z}_{L,t}) = \tilde{Z}_{L,t}^{\gamma-1}\frac{\kappa-1}{\kappa}R_t.$$

The industry revenue share of a large firm is $\tilde{Z}_{L,t}^{\gamma-1}$.

4.2 Evolution of the Industry State and Growth

To solve the dynamic firm problem, we must first understand how the evolution of the industry state and growth of industry productivity depend on the innovation decisions of firms.

[9] See Edmond, Midrigan, and Xu (2021) for a derivation of the optimal markup with oligopoly, nested CES demand, and Bertrand competition.

The industry state $\tilde{Z}_{L,t}$ evolves according to

$$\begin{aligned}\frac{\partial \tilde{Z}_{L,t}^{\gamma-1}}{\partial t} =& \lambda^{\gamma-1}\left(x_{D,L,t} + \left(1-\tilde{Z}_{L,t}^{\gamma-1}\right)x_{C,L,t}(S) + \tilde{Z}_{L,t}^{\gamma-1}x_{C,L,t}(L)\right) \\ &- \tilde{Z}_{L,t}^{\gamma-1}(N_t x_{C,S,t} + x_{C,L,t}(L)) - (\gamma-1)\tilde{Z}_{L,t}^{\gamma-1}g_t,\end{aligned} \tag{6}$$

where g_t is the growth rate of industry productivity, Z_t:

$$\begin{aligned}(\gamma-1)g_t \equiv \frac{\partial Z_t^{\gamma-1}/\partial t}{Z_t^{\gamma-1}} =& (\lambda^{\gamma-1}-1)\left(N_t x_{C,S,t} + \left(1-\tilde{Z}_{L,t}^{\gamma-1}\right)x_{C,L,t}(S) + \tilde{Z}_{L,t}^{\gamma-1}x_{C,L,t}(L)\right) \\ &+ \lambda^{\gamma-1}(N_t x_{D,S,t} + x_{D,L,t}).\end{aligned}$$

In the evolution of $\tilde{Z}_{L,t}$ over time, the first line is the inflow due to new good development, creative destruction of small firms' goods, and creative destruction of the large firm's own goods. The first term on the second line is the outflow due to creative destruction of the large firm's goods by small firms and the large firm, and the last term is the outflow due to growth in Z_t, which reduces relative productivity. In the expression for growth, g_t, the first line is growth from creative destruction: the -1 in $\lambda^{\gamma-1}-1$ reflects the destroyed productivity of the old good; and the second line is growth from new good development in which all the productivity of new goods is novel.

4.3 Dynamic Optimization: Innovation

4.3.1 Small Firms

We can write the expected present discounted value of small firm profits from producing a good with relative productivity $\tilde{z}_t$ as

$$\bar{\pi}_{S,t}(\tilde{z}_t;\tilde{Z}_{L,t}) = \tilde{z}_t^{\gamma-1}\bar{\pi}_{S,t}(\tilde{Z}_{L,t}),$$

where the new definition of $\bar{\pi}$ is the old definition with $\tilde{z}_t = 1$. The First Order Condition for the small firm new good development optimization problem then yields

$$x_{D,S,t}(\tilde{Z}_{L,t}) = \left(\frac{\lambda^{\gamma-1}\bar{\pi}_{S,t}(\tilde{Z}_{L,t})}{\alpha\chi_S}\right)^{\frac{1}{\alpha-1}}. \tag{7}$$

The First Order Condition for the small firm creative destruction optimization problem yields

$$x_{C,S,t}(\tilde{Z}_{L,t}) = \left(\frac{\lambda^{\gamma-1}\bar{\pi}_{S,t}(\tilde{Z}_{L,t})}{\alpha\chi_S\chi_C}\right)^{\frac{1}{\alpha-1}}, \tag{8}$$

where $x_{C,S,t}(\tilde{Z}_{L,t})$ is the common rate at which a small firm creatively destroys all goods, and so $M_t x_{C,S,t}(\tilde{Z}_{L,t})$ is the Poisson arrival rate at which a small firm creatively destroys a single good. A small firm creatively destroys all goods at the same rate since the cost and benefit each scale with the relative productivity of the good, and since a small firm does not internalize the different effects that creatively destroying different types of goods will have on the industry.

4.3.2 Large Firm

Using the evolution of the industry state as a function of the large firm's innovation decisions, the First Order Condition for the large firm's new good development rate yields

$$x_{D,L,t}(\tilde{Z}_{L,t}) = \left(\frac{\lambda^{\gamma-1}\left(1 - \tilde{Z}_{L,t}^{\gamma-1}\right)}{\chi_L \alpha} \frac{\partial V_{L,t}(\tilde{Z}_{L,t})}{\partial \tilde{Z}_{L,t}^{\gamma-1}} \right)^{\frac{1}{\alpha-1}}. \tag{9}$$

The term $1 - \tilde{Z}_{L,t}^{\gamma-1}$ reflects the two ways in which new good development affects the industry state: it increases the productivity of goods produced by the large firm, but it also increases the total productivity in the industry, Z_t, which depreciates relative productivities. The significance of the second effect scales with the large firm's relative productivity share, $\tilde{Z}_{L,t}^{\gamma-1}$.

The First Order Condition for the rate at which the large firm creatively destroys small firms' goods yields

$$x_{C,L,t}(S; \tilde{Z}_{L,t}) = \left(\frac{1 + (\lambda^{\gamma-1} - 1)\left(1 - \tilde{Z}_{L,t}^{\gamma-1}\right)}{\chi_L \chi_C \alpha} \frac{\partial V_{L,t}(\tilde{Z}_{L,t})}{\partial \tilde{Z}_{L,t}^{\gamma-1}} \right)^{\frac{1}{\alpha-1}}, \tag{10}$$

and for the rate at which the large firm creatively destroys its own goods yields

$$x_{C,L,t}(L; \tilde{Z}_{L,t}) = \left(\frac{(\lambda^{\gamma-1} - 1)\left(1 - \tilde{Z}_{L,t}^{\gamma-1}\right)}{\chi_L \chi_C \alpha} \frac{\partial V_{L,t}(\tilde{Z}_{L,t})}{\partial \tilde{Z}_{L,t}^{\gamma-1}} \right)^{\frac{1}{\alpha-1}}. \tag{11}$$

When the large firm creatively destroys a small firm's good, we can decompose the effect on the industry state into two components. First, the small firm's good is essentially transferred to the large firm, generating the 1 in the numerator. Second, the relative productivity of the good is increased, which has the same effect as when the large firm creatively destroys its own good. When the large firm creatively destroys its own good it is equivalent to developing a new good, except that the quantity of novel productivity is $\lambda^{\gamma-1} - 1$ rather than $\lambda^{\gamma-1}$.

New Good Development vs. Creative Destruction: The key mechanism in the model is that, compared to small firms, the large firm has a relative preference for creatively destroying its competitors' goods over other types of innovation. Small firm creative destruction relative to new good development is

$$\frac{x_{C,S,t}(\tilde{Z}_{L,t})}{x_{D,S,t}(\tilde{Z}_{L,t})} = \chi_C^{\frac{-1}{\alpha-1}}, \tag{12}$$

which depends only on the cost of creative destruction relative to new good development. The rate at which the large firm creatively destroys its competitors' goods relative to the rate at which it develops new goods is

$$\frac{x_{C,L,t}(S;\tilde{Z}_{L,t})}{x_{D,L,t}(\tilde{Z}_{L,t})} = \chi_C^{\frac{-1}{\alpha-1}} \left(\frac{1 + (\lambda^{\gamma-1} - 1)\left(1 - \tilde{Z}_{L,t}^{\gamma-1}\right)}{\lambda^{\gamma-1}\left(1 - \tilde{Z}_{L,t}^{\gamma-1}\right)} \right)^{\frac{1}{\alpha-1}}, \tag{13}$$

which is strictly increasing in its relative productivity share, $\tilde{Z}_{L,t}$, and strictly greater than the relative rate for small firms as long as $\tilde{Z}_{L,t} > 0$. The rate at which the large firm creatively destroys its competitors' goods relative to the rate at which it creatively destroys its own goods is

$$\frac{x_{C,L,t}(S;\tilde{Z}_{L,t})}{x_{C,L,t}(L;\tilde{Z}_{L,t})} = \left(\frac{1 + (\lambda^{\gamma-1} - 1)\left(1 - \tilde{Z}_{L,t}^{\gamma-1}\right)}{(\lambda^{\gamma-1} - 1)\left(1 - \tilde{Z}_{L,t}^{\gamma-1}\right)} \right)^{\frac{1}{\alpha-1}}, \tag{14}$$

which is also strictly increasing in $\tilde{Z}_{L,t}$, and strictly greater than 1. Comparing equations (12) and (13), we can see that compared to small firms, the large firm has a relative preference for creatively destroying its competitors' goods over new good development. In both cases, a small firm does not internalize the effect on other firms' relative productivities. On the other hand, the large firm prefers creative destruction of its competitors' goods because then the relative productivity of its new good comes disproportionately from small firms' goods rather than from its own goods. Similarly, whereas small firms creatively destroy other small firms' goods and the large firm's goods at the same rate, equation (14) shows that the large firm has a relative preference for creatively destroying its competitors' goods over creatively destroying its own goods.

5 Results

5.1 Growth and Concentration Along a Balanced Growth Path

I focus first on the distribution of growth across industries and across economies along a balanced growth path, in which each industry is in a steady state equilibrium with a constant $\tilde{Z}_L$ over time. These results also provide intuition for the quantitative exercises that follow. Without solving for a Markov Perfect Equilibrium of the dynamic game, we can compute the growth rate of an industry or the economy as a function of the market share of the large firm. I omit the time t subscript.

The following theorem shows that across industries in a single balanced growth path, growth as a function of the large firm's market share exhibits an inverted-U shape.

Theorem 5.1. *Suppose $\alpha \geq 2$ and the economy is on a balanced growth path. Suppose the only heterogeneity across industry parameters is in the large firm's cost of innovation, χ_L. The long-run growth rate in an industry is a function of the long-run market share of the large firm, $g(\tilde{Z}_L)$. There exists a threshold market share Z^* such that $g(\tilde{Z}_L)$ is strictly increasing if $\tilde{Z}_L < Z^*$ and strictly decreasing if $\tilde{Z}_L > Z^*$.*

To gain intuition for the theorem, note that along a balanced growth path, and in the steady state equilibrium of an industry, the expected present discounted value of profits from a good produced by a small firm with relative productivity 1 is

$$\bar{\pi}_S = \frac{(1-\kappa^{-1})R}{r + Nx_{C,S} + x_{C,L}(S) + (\gamma-1)g}, \tag{15}$$

where heterogeneity across industries, driven by heterogeneity in χ_L, is in the equilibrium innovation rates, $x_{C,S}$, $x_{C,L}(S)$, and g. The effect of the large firm's market share on growth operates through the effective discount rate on small firm profits, the denominator on the right-hand side of equation (15).

As the large firm's market share increases, there are two effects analogous to the composition and total innovation effects from Section 2, the first of which pushes growth down and the second of which pushes growth up. The first effect is due to a shift in the composition of the effective discount rate on small firm profits. We can decompose the non-interest component of the effective discount rate as

$$Nx_{C,S} + x_{C,L}(S) + (\gamma-1)g = Nx_{C,S} + (\gamma-1)g_S + x_{C,L}(S) + (\gamma-1)g_L, \tag{16}$$

where g_S and g_L are growth from small and large firm innovation, respectively. In the steady state equilibrium of an industry, the terms in the decomposition are related by

$$\tilde{Z}_L^{\gamma-1}(Nx_{C,S} + (\gamma-1)g_S) = \left(1 - \tilde{Z}_L^{\gamma-1}\right)(x_{C,L}(S) + (\gamma-1)g_L), \tag{17}$$

where the left-hand side is the rate at which relative productivity flows from the large firm to small firms, and the right-hand side is the rate at which relative productivity flows from small firms to the large firm. Holding fixed the effective discount rate on small firm profits, equation (17) shows that as the large firm's market share increases, innovation shifts away from small firms (the first two terms on the right-hand side of equation (16)) and toward the large firm (the last two terms). Recalling the relative innovation rates of small and large firms, equations (12), (13), and (14), the large firm's ratio of growth to creative destruction of small firms' goods, $g_L/x_{C,L}(S)$, is lower than the ratio for small firms, $g_S/x_{C,S}$. Thus, the effective discount rate on small firm profits shifts away from growth and toward creative destruction.

The second effect of the large firm's market share on growth is due to an increase in the effective discount rate on small firm profits. The First Order Conditions for small firm innovation imply that small firm innovation is

$$Nx_{C,S} + (\gamma - 1)g_S = \lambda^{\gamma-1} N \left(\frac{\lambda^{\gamma-1}\bar{\pi}_S}{\alpha \chi_S} \right)^{\frac{1}{\alpha-1}} \left(1 + \chi_C^{\frac{-1}{\alpha-1}} \right). \tag{18}$$

As the large firm's market share increases and innovation shifts away from small firms, the left-hand side of equation (18) falls. For the right-hand side to fall as well, $\bar{\pi}_S$ must fall, so the effective discount rate on small firm profits must rise. Thus, holding fixed the composition of the effective discount rate, growth increases.

When the large firm's market share is sufficiently low, the composition effect is small and the second effect dominates; the large firm's innovation is not so tilted toward creative destruction of its competitors, and the composition of its innovation does not change much in its market share. When the large firm's market share is sufficiently high, the opposite holds and the composition effect dominates.

From this intuition, we also have the following Theorem that compares balanced growth paths across economies.

Theorem 5.2. *Suppose $\alpha \geq 2$ and a free entry condition holds, i.e., $\epsilon = 1$. Suppose there is no heterogeneity across industries. Index the balanced growth path of the economy by the large firm's cost of innovation, χ_L, and let labor supply, $\bar{L}$, adjust so that final good output, C_t, relative to productivity, Z_t, is constant across economies. The long-run growth rate is a strictly decreasing function of the long-run market share of the large firm, $g(\tilde{Z}_L)$.*

A free entry condition at the aggregate level, along with holding fixed output relative to productivity, implies that the non-interest component of the effective discount rate on small firm profits is constant across economies indexed by the large firm's cost of innovation. All that remains is the composition effect, which implies that growth falls as the large firm's market share increases. In the quantitative exercise in Section 5.3, I allow output relative to productivity to adjust, but the effect of changes in output relative to productivity on long-run growth is small relative to the composition effect of the rise in the large firm's market share.

Figure 1 shows growth as a function of the large firm's revenue share both across industries on a balanced growth path, and across balanced growth paths. Figure 2 shows the two channels described above through which the large firm's market share affects growth. In the left panel, we see that the small firm effective discount rate is higher in industries with bigger large firm revenue shares. In the right panel, we see that the rate at which a large firm generates growth relative to the rate at which it creatively destroys its competitors' goods is decreasing in its revenue share. The analogous value for small firms is the value for the large firm when its revenue share is 0. Equations (16) and (18) show that the large firm's share of the non-interest component of the effective discount rate is $\tilde{Z}_L^{\gamma-1}$. Along with

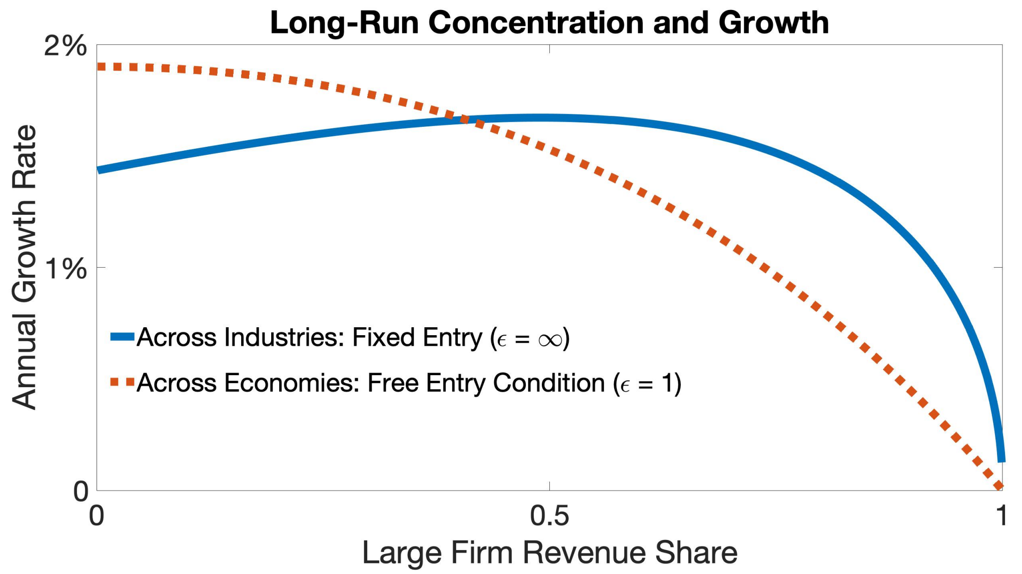

Figure 1: The lines depict growth on a balanced growth path at various levels of the large firm's market share. The solid blue line shows the growth rate across industries on a single balanced growth path, and the dotted orange line shows the growth rate across balanced growth paths in different economies, each with constant large firm market shares across industries. The figure is based on the calibration described in Section 5.2.

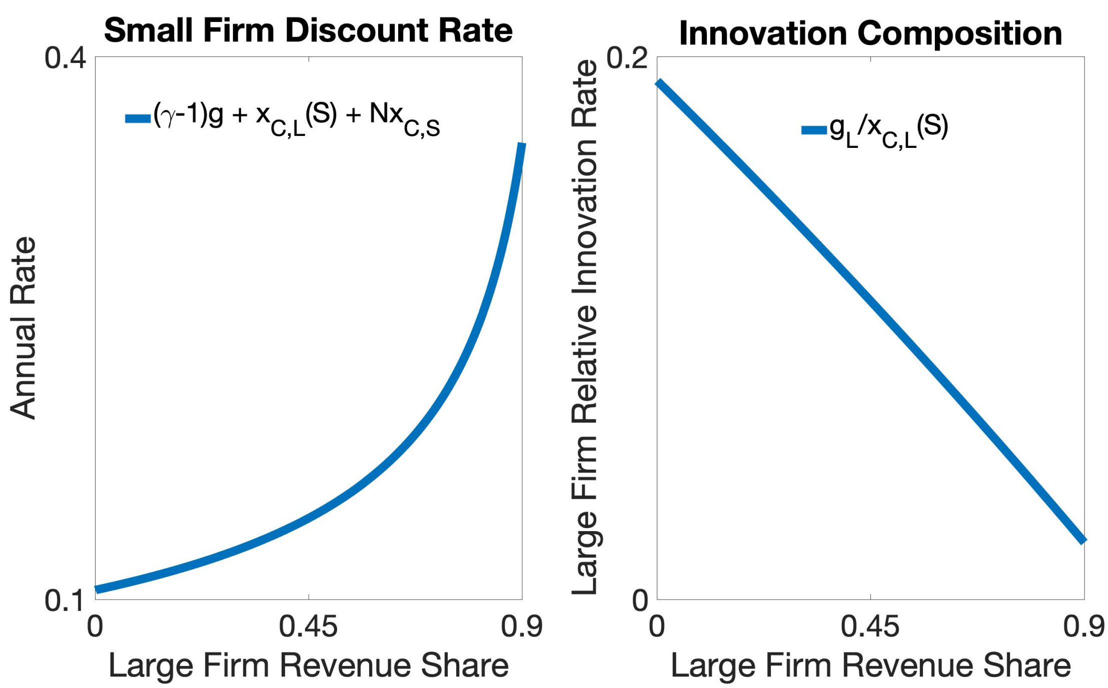

Figure 2: The left panel depicts the effective discount rate on small firm profits minus the interest rate in the steady state equilibrium of an industry as a function of the large firm's revenue share. The right panel depicts the rate at which a large firm generates growth relative to the rate at which it creatively destroys small firms' goods, as a function of its revenue share. The figure is based on the calibration described in Section 5.2.

the right panel of Figure 2, we can thus see that the composition effect implies a decreasing relationship between the large firm's revenue share and growth.

5.2 Calibration

I calibrate the model and solve it computationally to yield more results. I first calibrate the model to an initial balanced growth path in which all industries are identical. I set some parameters externally, and internally calibrate the rest to jointly match a set of moments in the data. The externally calibrated parameters as well as their sources are listed in Table 1. The internally calibrated parameters are listed in Table 2. The data moments used to calibrate the internally calibrated parameters as well as their sources are listed in Table 3. I set the minimum productivity gap, κ, equal to the innovation step size, λ, which is the largest possible value given Assumption 3.1. I normalize the final good price to 1 in all periods, and set the household's labor supply, $\bar{L}$, so that output in the initial balanced growth path relative to productivity, $C_t/Z_t = R_t/Z_t$, is 1. The units of time are years.

Table 1: Externally Calibrated Parameters

Parameter	Description	Value
η	Exit Rate	0.04
γ	Demand Elasticity	3.1
α	Innovation Cost Elasticity	2
ϵ	Entry Cost Elasticity	1

The exit rate is from Boar and Midrigan (2022). The demand elasticity is from Broda and Weinstein (2006), using their median estimate from 1990-2001 at the most disaggregated level. The innovation cost elasticity is from Acemoglu, Akcigit, Alp, Bloom, and Kerr (2018). The entry cost elasticity is chosen so that there is a free entry condition at the aggregate level.

The innovation cost elasticity, α, which I calibrate externally to 2, is particularly important because it determines how a large firm's innovation composition responds to its market share. I assume that creative destruction and new good development costs are independent, and that each innovation rate responds to the expenditures on that type of innovation as in the studies described in Acemoglu, Akcigit, Alp, Bloom, and Kerr (2018).

The innovation step size, λ, which I calibrate internally to 1.05, is important because it determines the fraction of a creative destruction innovation that improves on the replaced good and is novel,

Table 2: Internally Calibrated Parameters

Parameter	Description	Value
λ	Innovation Step Size	1.05
χ_C	Relative Creative Destruction Cost	0.265
χ_S	Small Firm Innovation Cost	2.22
χ_L	Large Firm Innovation Cost	15.14
ρ	Time Discount Rate	0.0194

Table 3: Calibration Targets

Moment Description	Data Average from 1983-1993	Model
R&D Relative to GDP	1.81%	1.81%
Creative Destruction Growth Share	26.51%	26.53%
TFP Growth Rate	1.66%	1.66%
Large Firm Market Share	40.68%	40.74%
Real Interest Rate	3.6%	3.6%

The ratio of R&D expenditures on GDP is the Business Enterprise Expenditure on R&D (BERD) relative to GDP from the OECD MSTI database. The creative destruction growth share is the fraction of growth from creative destruction from Garcia-Macia, Hsieh, and Klenow (2019). I compute this value in the model excluding innovation when large firms creatively destroy their own goods because this will appear as innovating on their own goods in the data. The TFP growth rate is from the BLS measure in Garcia-Macia, Hsieh, and Klenow (2019). The large firm market share is the sales-weighted average across 4-digit industries of the largest firm's revenue share in Compustat from Olmstead-Rumsey (2022). The real interest rate is the 1-year real interest rate from FRED.

$(\lambda^{\gamma-1}-1)/\lambda^{\gamma-1}=0.1$. As λ increases and the fraction that is novel goes to 1, the difference between creative destruction and new good development disappears. Moreover, if a larger fraction of creative destruction innovations are novel and generate growth, calibrating the model to match the fraction of growth due to creative destruction requires a lower rate of creative destruction relative to new good development. The calibrated value is consistent with more direct evidence in Garcia-Macia, Hsieh, and Klenow (2019) using data on labor flows, in which the average innovation step size from creative destruction in 1983-1993 is 1.07.

I calibrate the market share of large firms, as well as the shock in Section 5.3, to the average market share of the largest firm in 4-digit industries in Compustat. This measure likely overstates the size of the largest firm since Compustat does not include all firms. An alternative measure is the Census data on industry concentration measures, which show a smaller level of industry concentration, but a similar rise over the same time period. One downside of the Census data is that it only lists the market share of the top 4 firms in each industry, not the top firm. Moreover, while the Census data is in a sense more accurate because it includes more firms, it may include too many small firms that are not relevant to the mechanism in the model. In the model, if there are many small firms that do not innovate but simply imitate the innovations of others, then the effect may just be to lower the price index by a fixed factor, without any further impact on the decisions of the innovative firms.

5.3 The Rise in Concentration and the Fall in Growth

I show that a rise in concentration driven by a fall in the cost of innovation for large firms can explain a portion of the changes in US data since the mid-1990s. In line with the interpretation of the large firm's innovation cost discussed in Section 3.3.3, we can interpret the fall in the cost of innovation as an increase in the concentration of innovative capacity within large firms. The economy begins in the balanced growth path from the calibration in Section 5.2. There is an unanticipated permanent change in χ_L in all industries so that the average market share of large firms in the new balanced growth path is 0.51, the sales-weighted average across 4-digit industries of the largest firm's revenue share in 2018 in Compustat from Olmstead-Rumsey (2022) (the large firm innovation cost falls to $\chi_L = 12.04$). I track the transition path of the economy as it converges to a new balanced growth path. Figure 3 shows the average market share of large firms along the transition path. The market share converges over a similar time interval as the gap between the years in the initial calibration, 1983-1993, and the target year for the shock, 2018.

Table 4 compares the main results concerning growth in the model to the data. The model can explain all of the increase in the short-run growth rate in the data if we include growth in output due to changes in output relative to productivity, C_t/Z_t, as well as changes in productivity. However, the burst in growth does not last as long in the model as in the data: the peak difference in output along the transition path from the original balanced growth path occurs after 4 years and is 42% of the difference in the data after 4 years. The model can explain 41% of the long-run fall in growth, which in the model is due entirely to a change in the growth rate of productivity, Z_t, since output relative to productivity is constant along a balanced growth path.

Figure 4 shows annual growth, in real output and in productivity, following the shock. As seen in Table

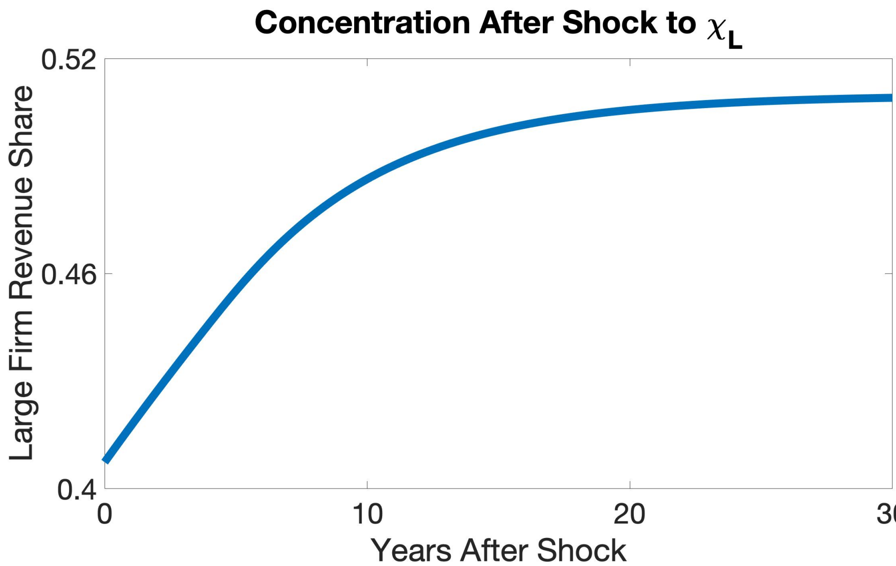

Figure 3: The line depicts the revenue share of the large firm in each industry in the economy over time following a shock to χ_L.

Table 4: Growth After Shock to χ_L

Moment Description	Data	Model
Growth Rate Burst	+0.64 ppt (38.6%) (1993-2003)	Output: +0.87 ppt (52.4%) (first year) TFP: +0.1 ppt (6.0%) (first year)
Cumulative Burst	+6.4 ppt (38.6%) (1993-2003)	Output: +1.07 ppt (16.1%) (4 years) TFP: +0.18 ppt (2.7%) (3 years)
Growth Rate Fall	-0.34 ppt (-20.5%) (2003-2013)	-0.14 ppt (-8.4%) (New BGP)

For each value, ppt is the percentage point rise, and the number in parentheses is the percent rise relative to the initial value. The data are taken from Garcia-Macia, Hsieh, and Klenow (2019). The growth rate burst in the model is the peak growth rate in the short-run following the shock. The output growth rate reflects changes in output relative to productivity, C_t/Z_t, as well as changes in Z_t. The cumulative burst is the sum of growth rates, i.e., the peak difference between the new output or productivity path and the old path.

4, there is a burst in growth immediately following the shock, particularly in output growth but in productivity growth as well, ultimately followed by a decline in the long-run growth rate. Figures 5 and 6 provide a deeper look at the underlying forces. Based on the discussion in Section 5.1 on the small firm effective discount rate, the dashed blue line in Figure 5 shows that the composition effect drives down growth as the large firm's market share grows and innovation shifts toward creative destruction of small firms' goods. The dotted orange line shows that in the first few years after the shock, the effective

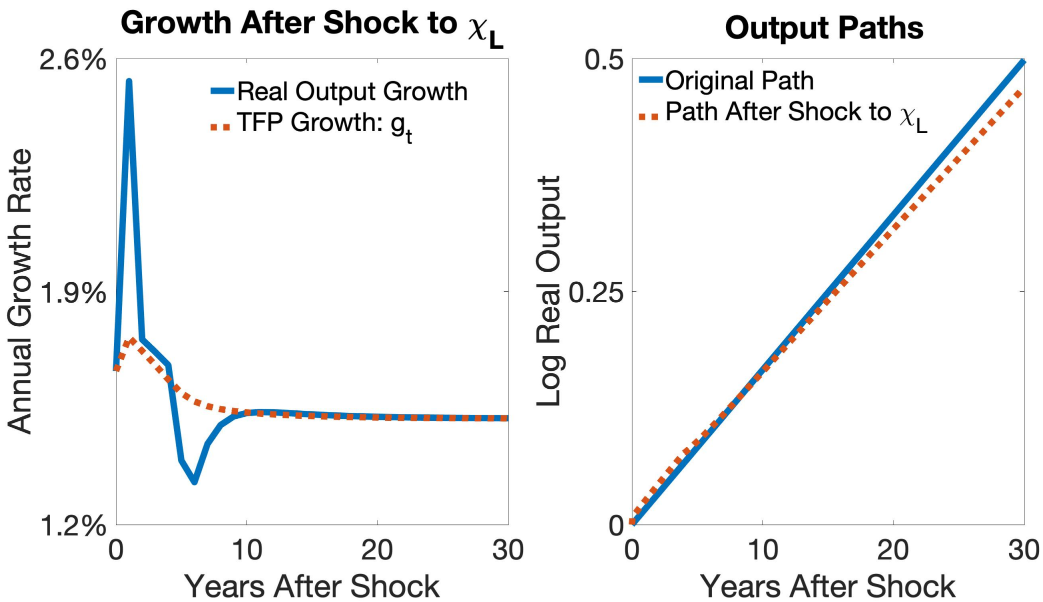

Figure 4: The left panel shows annual growth rates following the shock. The dotted orange line is the growth rate of productivity, g_t, and the solid blue line includes changes in output relative to productivity, C_t/Z_t, which is constant along a balanced growth path. The right panel shows paths of real output over time. The solid blue line is the original path the economy would have followed had it not been hit by a shock. The dotted orange line is the realized path following the shock.

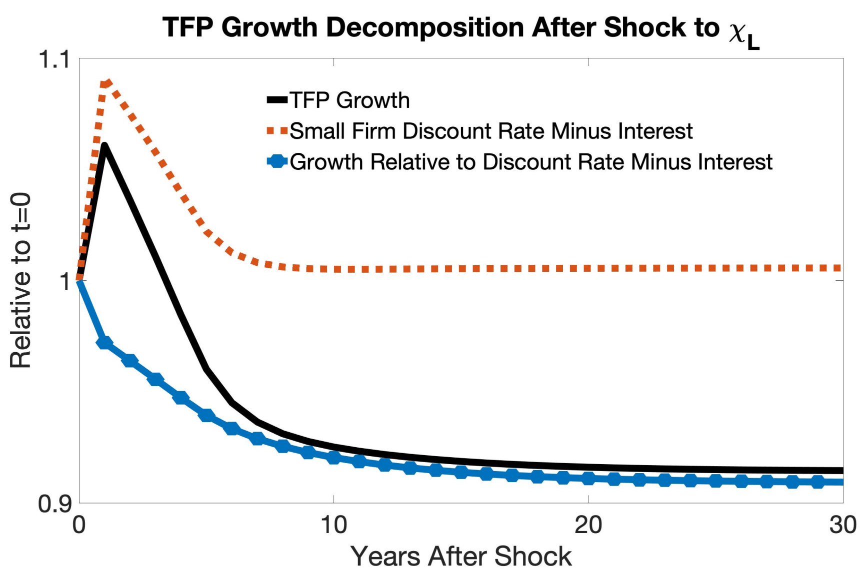

Figure 5: The solid black line depicts the annual productivity growth rate relative to in the original balanced growth path before the shock. The dotted orange line and the textured blue line decompose the black line into the non-interest component of the effective discount rate on small firm profits and growth over the non-interest component of the effective discount rate, respectively, relative to before the shock.

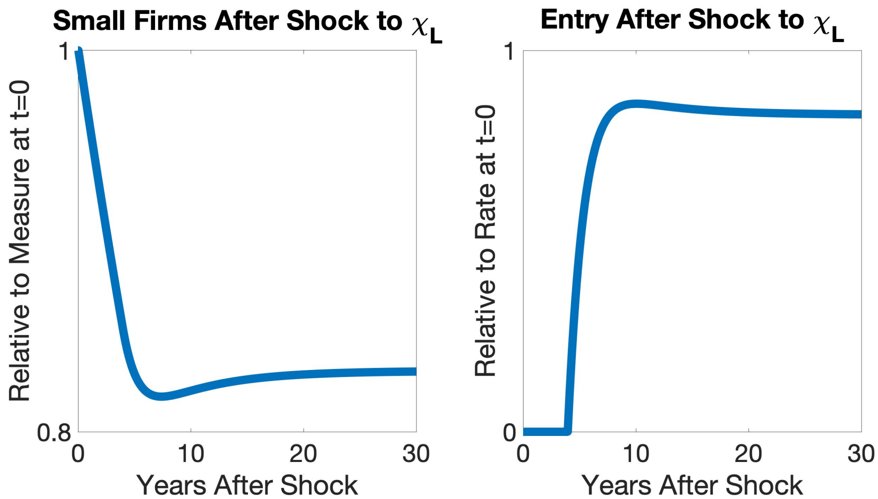

Figure 6: The left panel is the measure of small firms over time relative to the measure before the shock. The right panel is the entry rate over time relative to the entry rate before the shock.

discount rate on small firm profits rises, outweighing the composition effect, and leading to a higher growth rate. However, in the long-run, the effective discount rate is only slightly higher due a small increase in real output relative to productivity, and the composition effect dominates. Figure 6 shows that the large increase in the short-run in the effective discount rate on small firm profits is possible because the entry rate hits its lower bound of 0; the expected discounted profits of entering become negative, but the measure of small firms can only fall over time as firms exogenously exit. Thus, growth increases because large firms innovate more, and total small firm innovation is slow to fall due to an overhang of small firms. The small increase in the long-run in real output relative to productivity is driven by the fall in long-run entry costs (as well as a fall in innovation costs), which implies an increase in labor used in production.

The large fall in entry in the short-run and the smaller fall in the long-run match the data in Decker, Haltiwanger, Jarmin, and Miranda (2016), which show that the entry rate declined sharply in the mid-to-late 1990s followed by a partial recovery before a large drop during the Great Recession.

5.3.1 Creative Destruction

Figure 7 shows that the share of growth due to creative destruction falls following the shock, as in the long-run in Garcia-Macia, Hsieh, and Klenow (2019), although by a smaller magnitude. More generally, we can see that a *smaller* share of large firms' growth is due to creative destruction than of small firms' growth. This is not at odds with Figure 2 or with the relative innovation rates in equations (12), (13), and (14) because a large firm only creatively destroys small firms' goods, whereas small firms creatively destroy all firms' goods. Although large firms focus their innovation particularly toward creative destruction of small firm goods, their innovation is less focused on creative destruction overall.

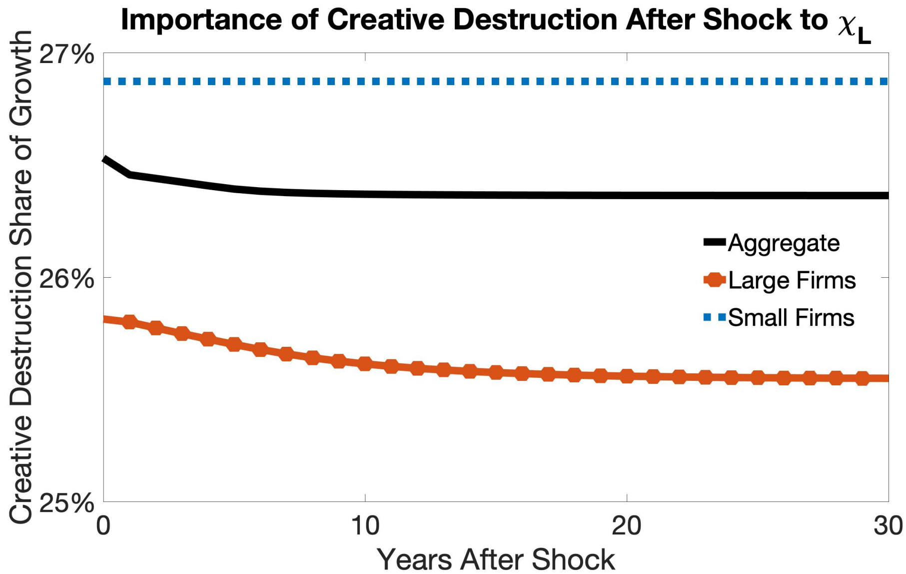

Figure 7: Each line depicts, over time following the shock, the rate at which a type of firm generates growth through creative destruction relative to the total rate at which that type of firm generates growth.

5.3.2 Welfare and Size-Dependent Taxes

Taking into account the transition path, welfare defined as the utility of the representative household falls by the equivalent of a permanent 5.8% drop in final good consumption. The decline in the long-run growth rate from the original balanced growth path to the new balanced growth path is ultimately the dominant effect. This suggests that on the margin, contrary to the result in Edmond, Midrigan, and Xu (2021), a tax on firms increasing in their size will improve growth and welfare. For a small tax, large firm prices are unaffected since they are already setting their markups at the constraint implied by the second-best producer. Large firms will respond to the tax by reducing innovation, leading to more small firms and growth and in the long-run. Even if large firms ultimately respond by investing less in their innovative capacity, the effect on growth and welfare is positive: large firms over-invest in innovative capacity because as their innovation cost, χ_L, falls, their profits rise yet welfare falls.

6 Antitrust Policy: Acquisitions

I use the calibrated model to explore the effects of two different types of acquisition policies. First, for each good produced by small firms, at an exogenous Poisson arrival rate the large firm in the same industry can make a take-it-or-leave-it offer to purchase the good from the small firm. I consider the effects of a tax, τ, on these transactions so that if the relative productivity of the good is $\tilde{z}$, then the small firm receives payment $\tilde{z}^{\gamma-1}\bar{\pi}_{S,t}\left(\tilde{Z}_{L,t}\right)$, and the large firm pays $(1+\tau)\tilde{z}^{\gamma-1}\bar{\pi}_{S,t}\left(\tilde{Z}_{L,t}\right)$. If a large firm acquires goods at rate A_t with relative productivities $\tilde{z}$ so that the average value of $\tilde{z}^{\gamma-1}$ is $\tilde{z}_{A,t}^{\gamma-1}$, then the evolution of $\tilde{Z}_{L,t}^{\gamma-1}$ is as before in equation (6) with the additional term $A_t\tilde{z}_{A,t}^{\gamma-1}$.

Second, for each small firm, at an exogenous Poisson arrival rate the large firm in the same industry can make a take-it-or-leave-it offer to purchase the small firm's innovation capacity. I again consider the effects of a tax, τ, on these transactions so that the small firm receives payment $V_{S,t}\left(\tilde{Z}_{L,t}\right)$, and the large firm pays $(1+\tau)V_{S,t}\left(\tilde{Z}_{L,t}\right)$. If a large firm acquires small firms' innovative capacities at rate A_t, then the measure of small firms declines at rate A_t beyond the baseline effects of entry and exit. The large firm's innovation capacity changes at rate

$$\frac{\partial \chi_{L,t}^{\frac{1}{1-\alpha}}}{\partial t} = A_t \chi_S^{\frac{1}{1-\alpha}} - \eta\left(\chi_{L,t}^{\frac{1}{1-\alpha}} - \bar{\chi}_L^{\frac{1}{1-\alpha}}\right),$$

where $\chi_{L,t}$ is the large firm's innovation cost at time t, and $\bar{\chi}_L$ is the large firm's exogenously given innovation cost absent any acquisitions, so the second term on the right-hand side reflects the rate at which the large firm's acquisitions exit.

In each case, any taxes collected are dispersed to the representative household. If the tax is negative, then it is funded by a lump sum tax on the representative household.

6.1 Acquisitions of Small Firm Goods

The economy begins on a balanced growth path in the calibrated model either before the shock to χ_L or after. Each good produced by a small firm can be acquired by the large firm in the same industry at rate 0.05. Put another way, each large firm can acquire 5% of the goods produced by small firms in its industry per year. The initial tax rate on acquisitions is $\tau = 0.2$, which is sufficiently high so that large firms do not purchase small firms' goods. Thus, the economy is indistinguishable from the case without any acquisitions. There is an unanticipated permanent change in the tax rate τ. I track the transition path as the economy converges to a new balanced growth path.

Figure 8 shows the fraction of small firm goods that large firms acquire in the long-run as a function of the acquisition tax rate, τ, both under the initial calibration before the shock to the large firm innovation cost and the new calibration following the shock to the large firm innovation cost. Once the tax rate is sufficiently low, although still positive, large firms switch from never acquiring to always acquiring small firm goods when given the opportunity. Large firms acquire small firms' goods when the tax rate is 0 because the face a lower creative destruction rate.

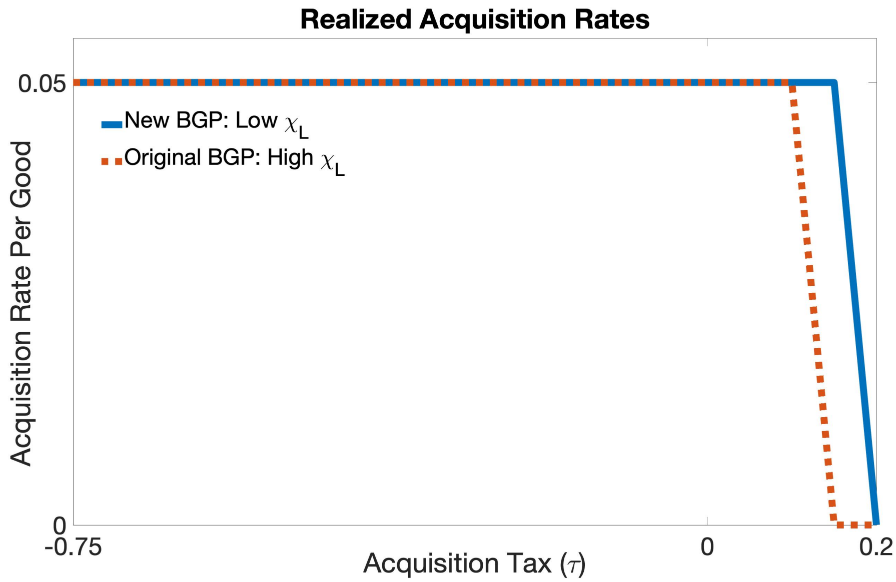

Figure 8: Each line depicts the fraction of small firm goods that large firms acquire per year in the balanced growth path as a function of the acquisition tax rate.

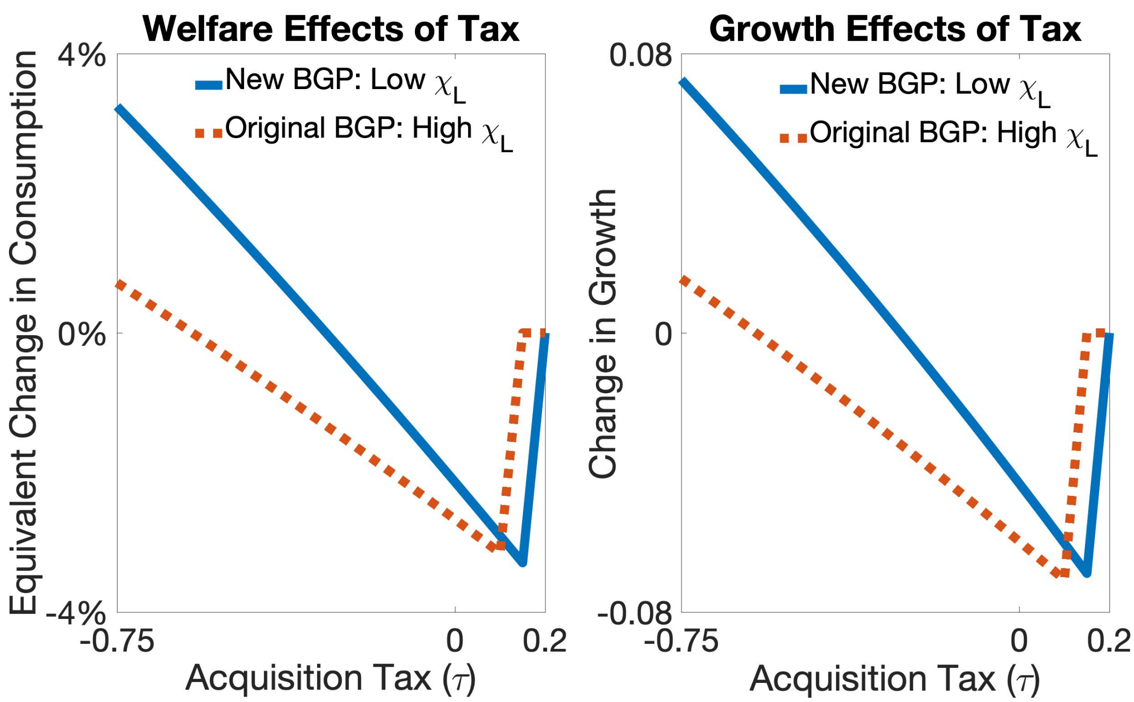

Figure 9: The left panel depicts, starting from either the original balanced growth path before the shock to χ_L or the new balanced growth path after the shock, the welfare effects of an unanticipated permanent change in the acquisition tax rate, taking into account the transition path. Welfare is computed as the equivalent permanent percentage change in final good consumption. The right panel depicts the percentage point change in the long-run growth rate as a function of the acquisition tax rate.

Figure 9 shows that when the tax rate falls just enough so that the acquisition rate rises above 0, there is a large negative effect on growth and welfare. As the tax rate falls further and ultimately becomes a subsidy, the acquisition rate does not change, but growth and welfare rise, eventually exceeding their values in the balanced growth path without acquisitions.

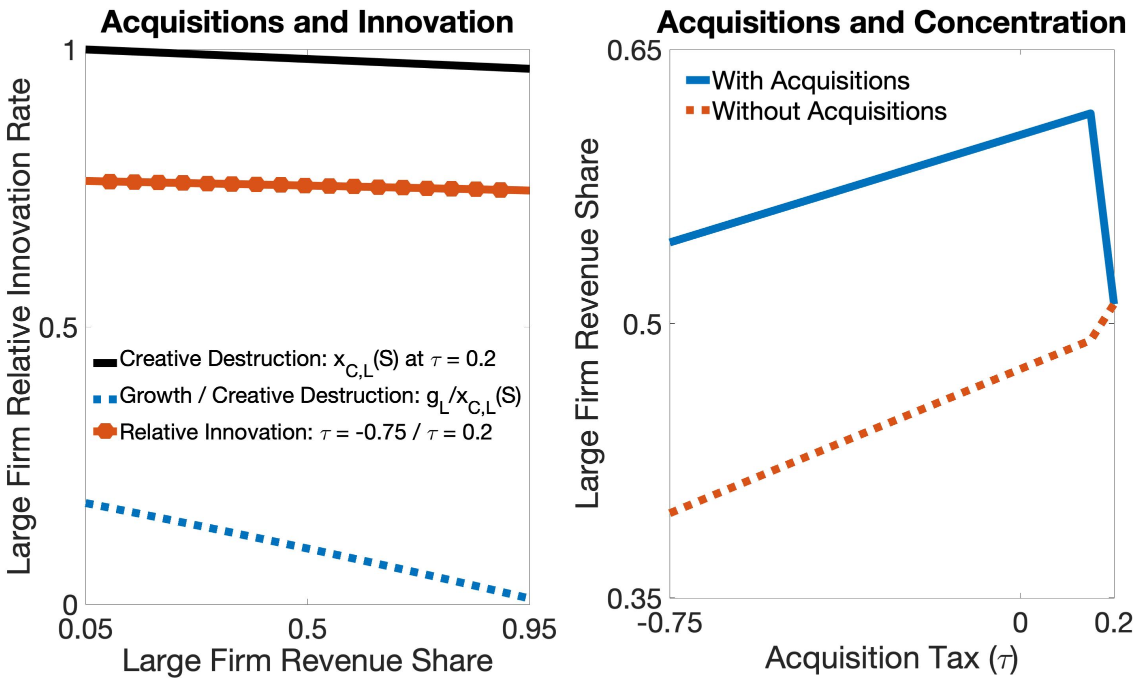

Figure 10: In the left panel, the solid black line is the rate at which the large firm creatively destroys small firms' goods as a function of its current revenue sharer relative to when its revenue share is 0.05. The dotted blue line is the rate at which the large firm generates growth relative to the rate at which it creatively destroys small firms' goods (the same line as in the right panel of Figure 2). The textured orange line is the rate at which the large firm performs each type of innovation when the acquisition tax is -0.75 relative to the same rate when the tax is 0.2. In the right panel, the solid blue and dotted orange lines depict each large firm's long-run revenue share as a function of the acquisition tax, with and without the effects of acquisitions on the distribution, respectively. The figure uses the calibration of the model following the shock to χ_L.

To understand the growth and welfare results, Figure 10 shows how acquisitions and the acquisition tax rate affect large firm innovation. The main takeaway is that changes in the *rate of acquisitions* and changes in the *value of acquisitions* to the large firm have opposing effects. The rise in the acquisition rate increases large firm revenue shares, reducing their incentive to generate growth relative to their incentive to creatively destroy small firm goods (the solid black and dotted blue lines in the left panel). On the other hand, the opportunity to acquire small firms' goods reduces the incentive to perform all types of innovation (the textured orange line in the left panel) because the more a large firm innovates, the less relative productivity remains for them to acquire. Since large firm innovation ultimately reduces growth and welfare, as we saw in Section 5.3, increasing the *value of acquisitions* to the large firm, conditional on the *rate of acquisitions*, improves growth and welfare.

The benefits of reducing the acquisition tax or subsidizing acquisitions are larger starting from the balanced growth path with more industry concentration. Small firms have less relative productivity for large firms to acquire, mitigating the effect of the rise in the acquisition rate, and large firms innovate more, increasing the effect of a proportional fall in large firm innovation.

6.2 Acquisitions of Small Firm Innovative Capacity

The economy begins on the balanced growth path in the calibrated model following the shock to χ_L from Section 5.3. Each small firm's innovative capacity can be acquired by the large firm in the same industry at rate 0.01. The initial tax rate on acquisitions is sufficiently high so that large firms do not purchase small firms. Thus, the economy is indistinguishable from the case without any acquisitions. There is an unanticipated permanent decrease in the tax rate so that large firms acquire small firms whenever given the opportunity. I track the transition path as the economy converges to a new balanced growth path.

The effect is largely the same as a fall in the large firm innovation cost, detailed in Section 5.3, except that the increase in large firm innovative capacity comes at the expense of small firm innovative capacity rather than for free. Growth falls in the long-run by 0.19 percentage points and welfare, taking into account the transition path, falls by the equivalent of a permanent 6.18% drop in final good consumption. The particular choice of the acquisition tax rate does not matter as long as it is sufficiently low for large firms to acquire small firms because the value large firms receive from acquisitions does not affect their other decisions.

7 Extension: Large Firm Entry and Exit

Following the shock to the innovation cost of large firms, χ_L, in Section 5.3, there is a rise in large firm profits. Since potential entrants face no possibility of becoming a large firm, these profits have no impact on entry. Thus, in this section, I alter the model so that large firms exit at exogenous rate η, the same rate as for small firms, and potential entrants face the possibility of entering as a large firm in an industry that did not otherwise have one. Since large firms exit and then enter with zero relative productivity, even if exogenous parameters are the same in each industry, the distribution of industry states across the economy is no longer a single mass point. Instead, for each $n \in [0,1]$, $\tilde{Z}_{L,t}(n)$ is the relative effective productivity of the large firm in industry n. When there is no large firm in industry n and when a new large firm enters industry n, then $\tilde{Z}_{L,t}(n) = 0$. To isolate the effects of this dispersion from the other effects of endogenizing large firm entry, I develop another version of the model in which large firms exit at exogenous rate η, and are immediately replaced by a new large firm with zero relative productivity. I call this model the *exogenous* large firm entry model, and call the model in which potential entrants may enter as small or large firms the *endogenous* large firm entry model. In both cases, when a large firm exits, they receive value 0.

Given an entry rate E_t, in the endogenous large firm entry model, large firms enter the economy at rate $E_L E_t$, where E_L is exogenously given. I hold fixed the innovative capacity per unit of entry, $\chi_S^{\frac{1}{1-\alpha}}$. Since a large firm has the innovative capacity of a measure $(\chi_L/\chi_S)^{\frac{1}{1-\alpha}}$ of small firms, it follows that the entry rate of small firms into each industry is $E_S E_t$, where

$$E_S = 1 - \left(\frac{\chi_L}{\chi_S}\right)^{\frac{1}{1-\alpha}} E_L.$$

To maintain that there is at most one large firm per industry, I suppose that large firm entry is directed to industries without a large firm. If the measure of industries without a large firm is $\Gamma_{0,t}$, then the Poisson arrival rate of a large firm into such an industry is $E_L E_t/\Gamma_{0,t}$. Thus, if a potential entrant pays the entry cost, they receive expected value

$$E_L V_{L,t}(0) + E_S \int_0^1 V_{S,t}\left(\tilde{Z}_{L,t}(n)\right) dn.$$

I calibrate the endogenous and exogenous large firm entry models to the same initial balanced growth path as in Table 3. The changed parameter values are listed in Table 5. As before, each industry has the same parameters. I also calibrate E_L so that, in both the initial balanced growth path and the new balanced growth following the shock, there is a large firm in almost every industry: 93.63% and 96.96% of industries have a large firm in the pre- and post-shock balanced growth paths, respectively.

Table 5: Re-Calibrated Parameters For Models with Large Firm Entry

Parameter	Description	Endogenous Entry	Exogenous Entry
λ	Innovation Step Size	1.059	1.057
χ_C	Relative Creative Destruction Cost	0.305	0.295
χ_S	Small Firm Innovation Cost	2.9	3.0
χ_L	Large Firm Innovation Cost	10.4	11.5
E_L	Per Unit Large Firm Entry Rate	2.12	N/A

As in Section 5.3, I conduct the following experiment. The economy begins on an initial balanced growth path. There is an unanticipated permanent change in χ_L in all industries so that the average market share of large firms in the new balanced growth path is 0.51 (χ_L falls to 8.74 in the endogenous entry case and 9.05 in the exogenous entry case). In the endogenous large firm entry case, the innovative capacity per unit of entry and the entry rate of large firms per unit of entry are held fixed, so the entry rate of small firms per unit of entry, E_S, falls with χ_L from 0.41 to 0.30. I track the transition path of the economy as it converges to the new balanced growth path. Table 6 compares the main results in these models with the results from Section 5.3.

Table 6: Different Model Results After Shock to χ_L

Moment	Baseline	Endogenous Large Entry	Exogenous Large Entry
Concentration	+10.14 ppt (24.9%)	+10.44 ppt (25.7%)	+10.37 ppt (25.5%)
Growth	-0.14 ppt (-8.4%)	-0.16 ppt (-9.6%)	-0.18 ppt (-11.1%)
Small Firms	-16.5%	-24.0%	-25.9%
Welfare	-5.8%	-6.7%	-12.5%

Concentration is the sales-weighted average large firm industry revenue share across industries. Small firms is the measure of small firms. The changes in concentration, growth, and the measure of small firms are from the initial to the new balanced growth paths, and are computed both in percentage points (ppt) and as a percentage of the initial value. The change in welfare is from the initial balanced growth path to immediately after the shock (taking into account the transition path to the new balanced growth path), and is computed as the welfare equivalent permanent percent change in final good consumption.

The results are similar in the models with and without large firm entry and exit. There are two main differences between the baseline model and the model with endogenous large firm entry that have opposite effects on growth and thus welfare. The first difference, which is the only difference between the baseline model and the exogenous large firm entry model, is that the models with large firm entry exhibit dispersion in large firm revenue shares across industries. Since the negative effects of large firms on growth and welfare are increasing and convex in large firms' revenue shares, this dispersion implies a greater cost of a rise in the average large firm revenue share. The second difference between the baseline model and the endogenous large firm entry model is that an entrant's innovation capacity is split between the possibility of being a small firm and of being a large firm. When χ_L falls, the value of entering as a large firm per unit of innovative capacity, $V_L(0)/\chi_L^{\frac{1}{1-\alpha}}$, rises relative to the expected value of entering as a small firm per unit of innovative capacity, $\int_0^1 V_S\left(\tilde{Z}_L(n)\right) dn/\chi_S^{\frac{1}{1-\alpha}}$. Thus, although the value of entering as a small firm is held fixed across balanced growth paths by the free entry condition in the baseline model, it falls by 2% in the endogenous large firm entry model. An increase in the difference between the discount rates on large and small firms' innovations allows for a rise in the small firm discount rate, which implies a higher growth rate. Nonetheless, this effect is not large enough to overwhelm the conclusion that more large firm innovation reduces growth.

I interpret the particular way of modeling the large firm entry process as implying that the shock to the large firm innovation cost is an increase in the concentration of innovative capacity within larger firms, rather than an increase in the ease of generating new innovative capacity. Alternatively, I can model large firm entry by allowing the innovative capacity per unit of entry or the entry rate of large firms per unit of entry to change with the shock. For example, if I hold fixed the entry rates of small and large firms per unit of entry, E_S and E_L, respectively, then a fall in χ_L implies a rise in the innovative capacity per unit of entry, which has the effects of the shock already studied in addition to a fall in the entry cost. In that case, the fall in the entry cost overwhelms the other effects, and growth and welfare rise. On the other hand, allowing the entry rate of large firms per unit of entry to change so that the innovative capacity per unit of entry and the entry rate of small firms per unit of entry are fixed gives difficult to interpret results because large firms become bigger, but there are fewer industries with a large firm.

8 Conclusion

To understand the effects of market power on growth and the policy implications, I study a model with one large firm and a continuum of small firms in each industry. Firms can innovate through creative destruction, developing new goods, and improving on their own goods. Large firms, to avoid cannibalization, have a strong relative preference for creatively destroying their competitors' goods. As a result, when large firms innovate more, small firms' innovations are discounted heavily relative to the overall innovation and growth rate. A widespread fall in large firm innovation costs reduces small firm entry, long-run growth, and taking into account the transition path, welfare. Small firm innovation is less responsive to differences across industries than to widespread changes, so more concentrated industries only have lower growth if they have particularly big large firms that target their innovation strongly toward creative destruction of their competitors' goods. Thus, across industries, growth as a function of the large firm's revenue share exhibits an inverted-U shape.

Large firm acquisitions of their competitors' goods have direct and indirect effects with opposite implications for concentration, growth, and welfare. Acquisitions directly shift market share to large firms, strengthening their relative preference for creative destruction of their competitors' goods, and leading to a fall in growth. The indirect effect is that since acquisitions are valuable to large firms, each large firm innovates less so that more market share remains for it to acquire. As large firm innovation falls, it is replaced by small firm innovation, which is more geared toward growth rather than creative destruction of small firms' goods, ultimately facilitating more innovation and growth. If acquisitions are sufficiently valuable to large firms, then growth and welfare are higher in an economy with acquisitions than without. Unlike when acquisitions may be beneficial by encouraging small firms to innovate and sell (an entry for buyout effect), here acquisitions may be desirable because they encourage large firms to innovate less. Thus, the positive effect is strongest when acquisitions are valuable for large firms and when industry concentration is particularly high.

The theory and results highlight a novel way to think about the effects of market power and optimal competition policy. Large firms are harmful not because of their size, but because of how they achieve their size through innovation. Large firms do not under-produce as in static models of oligopolistic competition, but instead innovate in a destructive way. Policies that increase concentration may be beneficial as long as they reduce large firm innovation. Facilitating acquisitions is a particularly useful policy because, unlike taxing large firms, it does not require knowing firms' relevant industries or their market shares in those industries.

Bibliography

Acemoglu, Daron, Ufuk Akcigit, Harun Alp, Nicholas Bloom, and William Kerr. 2018. "Innovation, Reallocation, and Growth." *American Economic Review*, 108(11): 3450-3491.

Aghion, Philippe, Antonin Bergeaud, Timo Boppart, Peter J. Klenow, and Huiyu Li. 2022. "A Theory of Falling Growth and Rising Rents." Working paper.

Aghion, Philippe, Nick Bloom, Richard Blundell, Rachel Griffith, and Peter Howitt. 2005. "Competition and Innovation: An Inverted-U Relationship." *The Quarterly Journal of Economics*, 120(2): 701-728.

Aghion, Philippe and Peter Howitt. 1992. "A Model of Growth Through Creative Destruction." *Econometrica*, 60(2): 323-351.

Akcigit, Ufuk and Sina T. Ates. 2021. "Ten Facts on Declining Business Dynamism and Lessons from Endogenous Growth Theory." *American Economic Journal: Macroeconomics*, 13(1): 257-298.

Atkeson, Andrew and Ariel Burstein. 2019. "Aggregate Implications of Innovation Policy." *Journal of Political Economy*, 127(6): 2625-2683.

Autor, David, David Dorn, Lawrence F. Katz, Christina Patterson, and John Van Reenen. 2020. "The Fall of the Labor Share and the Rise of Superstar Firms." *The Quarterly Journal of Economics*, 135(2): 645–709.

Barkai, Simcha. 2020. "Declining Labor and Capital Shares." *The Journal of Finance*, 75(5): 2421-2463.

Boar, Corina and Virgiliu Midrigan. 2022. "Markups and Inequality." Working paper.

Broda, Christian and David E. Weinstein. 2006. "Globalization and the Gains from Variety." *The Quarterly Journal of Economics*, 121(2): 541-585.

Cavenaile, Laurent, Murat Alp Celik, and Xu Tian. 2021. "Are Markups Too High? Competition, Strategic Innovation, and Industry Dynamics." Working paper.

De Loecker, Jan, Jan Eeckhout, and Gabriel Unger. 2020. "The Rise of Market Power and the Macroeconomic Implications." *The Quarterly Journal of Economics*, 135(2): 561-644.

De Ridder, Maarten. 2021. "Market Power and Innovation in the Intangible Economy." Working paper.

Decker, Ryan A., John Haltiwanger, Ron S. Jarmin, and Javier Miranda. 2016. "Where Has All the Skewness Gone? The Decline in High-growth (Young) Firms in the U.S." *European Economic Review*, 86: 4-23.

Edmond, Chris, Virgiliu Midrigan, and Daniel Yi Xu. 2021. "How Costly Are Markups?" Working paper.

Fons-Rosen, Christian, Pau Roldan-Blanco, and Tom Schmitz. 2022. "The Aggregate Effects of Acquisitions on Innovation and Economic Growth." Working paper.

Garcia-Macia, Daniel, Chang-Tai Hsieh, and Peter J. Klenow. 2019. "How Destruction is Innovation?" *Econometrica*, 87(5): 1507-1541.

Grossman, Gene M. and Elhanan Helpman. 1991(a). "Innovation and Growth in the Global Economy." *MIT Press*.

Grossman, Gene M. and Elhanan Helpman. 1991(b). "Quality Ladders in the Theory of Growth." *Review of Economic Studies*, 58(1): 43-61.

Klette, Tor Jakob and Samuel Kortum. 2004. "Innovating Firms and Aggregate Innovation." *Journal of Political Economy*, 112(5): 986-1018.

Letina, Igor, Armin Schmutzler, and Regina Seibel. 2021. "Killer Acquisitions and Beyond: Policy Effects on Innovation Strategies." Working paper.

Liu, Ernest, Atif Mian, and Amir Sufi. 2022. "Low Interest Rates, Market Power, and Productivity Growth." *Econometrica*, 90(1): 193-221.

Olmstead-Rumsey, Jane. 2022. "Market Concentration and the Productivity Slowdown." Working paper.

Rasmusen, Eric. 1988. "Entry for Buyout." *The Journal of Industrial Economics*, 36(3): 281-299.

Romer, Paul M. 1990. "Endogenous Technological Change." *Journal of Political Economy*, 98(5): S71-S102.

Weiss, Joshua. 2020. "Intangible Investment and Market Concentration." Working paper.