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Antitrust Law and Business Dynamism

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Abstract

In this paper, I study firms' strategic and anticompetitive behaviour, and the consequent role of antitrust law as a macroeconomic policy in promoting business dynamism. Over the past few decades, business dynamism has been declining in the US: firm entry has fallen, accompanied by a slowdown in the rate of productivity growth. Additionally, enforcement of antitrust law has been at historically low levels. Using firm-level and sector-level data from the US, I find that stronger antitrust enforcement is associated with higher entry and higher productivity growth but lower R&D investments. Next, I develop and structurally estimate a dynamic general equilibrium model with innovation and oligopolistic product market competition. The dynamic structure of the model allows firms to eliminate competition through strategic decision-making. The model is calibrated to the recent US experience and quantitative exercises show that strengthening antitrust policies results in: (1) a higher firm entry rate, (2) a higher rate of productivity growth, (3) a larger labour share of GDP, and (4) a decline in the innovation rate. Overall, the model indicates that stronger antitrust policies are effective at restoring business dynamism and can deliver up to 16% higher welfare in consumption-equivalent terms. The improvement in welfare is mainly driven by an increase in the welfare of workers, without affecting the capitalists, suggesting that antitrust law has distributional implications, and therefore, has a potential role in reducing inequality.

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Antitrust Law and Business Dynamism

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1. Introduction

Over the past few decades, business dynamism has been slowing down, both in the US and globally. Rates of business formation and new firm entry have been falling persistently across a broad range of sectors. Simultaneously, there has been an increase in both market concentration and the profit-share of market leaders, as well as a decline in firms' investment rates (Akcigit and Ates, 2021). A recent literature has studied these trends and considers various explanations for them, spanning from a demographic change to shifts in the structure of production. Nevertheless, in the continued absence of strong antitrust policies,[1] anticompetitive practices by firms are a potentially important contributor to the observed decline in business dynamism, and one that is relatively understudied.

Enforcement of antitrust law is at historically low levels in the US, with the Department of Justice filing substantially fewer antitrust cases in recent years. For example, the average number of investigations conducted by the antitrust division of the Department of Justice in the previous decade is less than 10% of the number of conducted investigations in the 1970s.[2] The fact that this reduction in investigations occurs contemporaneously with an increase in market power suggests that there is an increasingly lax enforcement of antitrust policies.

Little is known about antitrust law as a macroeconomic policy. The common approach in studying the effects of antitrust and firms' anticompetitive practices, both in the academic literature and in public policy, is to focus on *specific* actions by individual companies in a *well-defined* market, and to analyse the implications of such actions for competition in a narrow industry. This approach has provided valuable insights into a wide range of strategic actions that firms undertake, and into their consequent impact on competition. Yet with the increasing trends in market concentration across the majority of US industries, the existence of anticompetitive practices may not be limited to a few sectors, and therefore, will have consequences for the wider economy.

This paper studies the macroeconomic consequences of firms' anticompetitive behaviour, and of lax antitrust policies. In this regard, it departs from the common partial equilibrium approach that focuses on a narrow market and develops a general equilibrium model that analyses the implications of lax antitrust policies on macroeconomic outcomes such as productivity growth, firm entry rate, innovation, and labour share of total income. Further, a general equilibrium framework allows us to study the short run effects of antitrust law, the long run trade-offs it generates, and its relation to business dynamism. Additionally, we can compute welfare losses from lax antitrust and of gains from stricter enforcement. In particular, estimates from the model indicate that stronger

[1] Throughout this paper, I will use antitrust policy and competition policy interchangeably.
[2] See figure 1 for more details.

antitrust policies can generate up to 16% higher welfare in consumption-equivalent terms.

To this end, I first provide empirical evidence, for both the US and Europe, that as concentration levels increase, strengthening antitrust policies is associated with a higher rate of entry, higher growth, and lower investment in innovation. I then build a dynamic model with oligopolistic competition and endogenous entry and exit to explain these mechanisms. The dynamic nature of the model, combined with the incumbents' market power, gives rise to strategic decisions in which incumbents choose to block the entry of new firms in equilibrium. Such actions have consequences for entry and productivity growth, especially when incumbents target efficient potential entrants.

In the model, incumbents take costly actions to create entry deterrents and increase the costs faced by entrants,[3] thereby discouraging them from joining the market. Prior to entry, entrants and incumbents receive a signal that yields information on entrants' relative productivity. If entrants are expected to be very efficient, they will be able to capture a larger share of the market, thus posing a more significant challenge to incumbents' positions. In a dynamic setup, incumbents may find it optimal to respond to the threat of entry by bearing an immediate cost to prevent the entry of new firms. Optimality of these strategic decisions depends on the size of costs and potential benefits and is determined by incumbents' incentive compatibility constraints.

To increase their lifetime value, besides deterring competitors from entry, incumbents can innovate and improve their productivity over time. An incumbent that invests more in innovation is more likely to be successful in its efforts, and to move up on the productivity ladder. The optimality condition implies that firms invest to the level at which the marginal cost of innovation equals its marginal return. The marginal return depends on the stream of future profits and is therefore correlated with possible market share gains as a firm becomes more productive. The gains from innovation interact with incumbents' decisions to deter entry of new firms. On the one hand, aggressive strategies increase the lifetime value of the incumbent at all productivity levels. In turn, these higher values *encourage* incumbents' innovation efforts. On the other hand, aggressive strategies offer protection against the external competition posed by entrants. This protection *lowers* incumbents' incentives to invest in innovation. Both forces are present in the framework of this model, and their relative size differs across firms in the distribution. Thus, the overall effect on innovation in the economy depends on the distribution of firms, which itself is an endogenous object and depends on the calibrated parameters.

In this framework, innovation may be considered a productive approach in increasing profits, while deterring entry to eliminate competition is an aggressive method. The aggressive strategies are modelled in the form of a short term cost, but can have various

[3] The model can equivalently be defined as lowering the value of potential entrants.

interpretations, including (but not limited to) aggressive pricing, killer acquisitions, lobbying, and excessive patenting. To regulate the behaviour of firms, the model includes an antitrust authority, which constrains the extent to which firms can engage in aggressive strategies. More specifically, the antitrust authority dictates the maximum amount of firms' current profit sacrifices on aggressive strategies and creating entry barriers. While this is a simplification of real-world antitrust policies, it reflects the fact that the antitrust authority's reviews of firms' anticompetitive practices include an investigation of firms' profitability.[4]

The model is structurally estimated to fit the data on productivity growth, entry rate, profit share, innovation, and other facts of business dynamism for the US in 2000-2010. I use the estimated model to analyse counterfactual scenarios in which antitrust law is strengthened until all anticompetitive strategies are ruled out. The model predicts that strengthening antitrust is an effective policy for increasing business dynamism. In particular, counterfactual exercises show that productivity growth can increase by up to 0.8 percentage points, entry rate by up to 8 percentage points and the employment share of entrants by up to 4.4 percentage points. At the same time, profit share of total income and average R&D expenditure can fall by up to 8.1 and 2.9 percentage points. The higher rate of productivity growth, despite the fall in average R&D expenditure under stronger antitrust laws, is a result of higher entry of more efficient firms.

It is worth noting that, in the counterfactual scenarios, the increase in rates of entry and productivity growth is driven by eliminating the dynamic distortions generated by firms' anticompetitive strategies, and the static distortions in form of high markups remain intact. Therefore, the results suggest that, when concentration levels are high and firms have a greater market power, antitrust law can deliver higher growth even before reducing firms' markups.

One of the main insights of this paper is related to the welfare and distributional implications of antitrust policies. I find that strengthening antitrust policies can lead to welfare gains of up to 16% in consumption equivalent terms. This gain is driven primarily by an increase in the rate of productivity growth. Decomposition of welfare gains for workers and capitalists indicates that, while both parties benefit in the long run, workers experience a relatively larger improvement in their welfare. The welfare analysis also indicates that there are short vs long run trade-offs, owing to the reallocation of labour from production to the setting-up of new businesses.

A recent literature has been studying the welfare costs of markups. With oligopolistic

[4]This is especially the case in reviewing exclusionary acts under the section 2 of the Sherman Act and is discussed in more details in Section 3 of this paper. For mergers and acquisitions, a first round investigation happens based on the value of the deal, and clearing the merger depends mainly on the resulting concentration in response to the M&A.

competition, and in the presence of firms with high markups, there is a welfare loss due to static distortions associated with moving away from perfect competition and resource misallocation in the market. Edmond et al. (2018) and De Loecker et al. (2021) estimate the cost of these markups to be 7.5% and 9% in consumption equivalent terms. The welfare losses estimated in this paper are solely based on firms' anticompetitive strategies, and do not correct for static distortions caused by markups. Altogether, the true cost of firms' market power is a combination of the two channels, which suggests that the true welfare loss is higher than the values presented by the literature and in this paper.

The paper is organised as follows. Section 2 contains a brief review of the literature. Section 3 provides an overview of antitrust law and its developments over time. Section 4 presents empirical evidence on the relationship of antitrust law and business dynamism. Section 5 describes the model set-up. Section 6 includes the baseline calibration, and Section 7 discusses the quantitative results and welfare analysis. Section 8 concludes.

2. Literature Review

Recent papers have documented trends in falling business dynamism. There has been a decline in the firm entry rate and the growth rate of young firms (Decker et al., 2016; Karahan et al., 2019). Coinciding with lower entry, there is evidence of rising concentration and markups both in the US and globally (Gutiérrez et al., 2018; Grullon et al., 2019; Philippon, 2019; Bajgar et al., 2019; De Loecker et al., 2020; Eeckhout, 2021). Additionally, there has been a decline in capital investment (Gutiérrez and Philippon, 2017; Crouzet and Eberly, 2019), a decline in labour's share of GDP (Karabarbounis and Neiman, 2014; Barkai, 2016) and an increase in profit share[5] (Eggertsson et al., 2018).

A follow up literature has explained these trends through changes in the fundamentals of the economy such as changes in demographics (Karahan et al., 2019), shifts in production structure towards technologies with more scalability (Autor et al., 2020), and changes in the structure of competition. The proponents of the increase in scalability and intangibles argue that the increase in the concentration is efficient owing to a reallocation of resources towards highly productive "superstar firms". Aghion et al. (2019) and De Ridder (2019) find that shifts towards technologies with increasing returns to scale lead to higher concentration. Others support arguments suggesting that the decline in competition has led to rising barriers to entry (Crouzet and Eberly, 2019; Grullon et al., 2019; Covarrubias et al., 2020). Gutiérrez and Philippon (2019) find that the weakening of competition and the falling entry rate can be explained by increased lobbying and regulation, showing that this trend is most pronounced in industries with high lobbying

[5]For a detailed discussion of trends in falling business dynamism in the US please refer to Akcigit and Ates (2019).

expenditure. In this paper, I highlight the role of weak competition, lax enforcement of antitrust law and firms' anticompetitive practices in eliminating entrants in generating lower dynamism and growth in the economy.

To analyse macroeconomic implications of firms' anticompetitive behaviour, this paper builds on a large body of literature studying market power and its consequences in the macroeconomy (Atkeson and Burstein, 2008; Grassi, 2017; Edmond et al., 2018; Baqaee and Farhi, 2020; Burstein et al., 2020; De Loecker et al., 2021). In this regard, the paper takes a model-based approach and extends an oligopolistic competition and CES demand as in Atkeson and Burstein (2008) to allow for dynamic trade-offs and firms' strategic decisions. Additionally, the model includes innovation as a source of growth following the endogenous growth literature (Aghion et al., 1997, 2001; Acemoglu and Akcigit, 2012; Akcigit and Ates, 2019). With respect to this literature, the framework of this paper allows for endogenous entry of firms, therefore moving from a duopolistic competition to an oligopolistic setup.

The closest to this paper is the study by Cavenaile et al. (2021) who also take a structural and general equilibrium approach to antitrust policies. They develop an oligopolistic model with innovation and examine the effect of antitrust policies on mergers and acquisitions and similar to the findings of this paper, they show that there are considerable welfare gains from strengthening antitrust policies. However, the mechanism through which they get this result is considerably different from mine as their findings suggest that strong competition policies, captured by a higher threshold of HHI for mergers, hurts smaller firms (by lowering the probability of them getting acquired) and benefits larger firms. In this regard my paper is complementary to Cavenaile et al. (2021) in that I find that strong antitrust policies protect and benefit the highly productive young firms and subsequently increase the competition for the existing market leaders.

These results can be reconciled by examining the nature of the antitrust law and firms' anticompetitive actions as well as firms' innovation incentives. In markets where the main goal of the entrant is to get acquired by an existing market leader, antitrust policies that are solely based on concentration measures would hurt small firms through the channel described by Cavenaile et al. (2021). However, in markets where there is a possibility that the entrants' productivity is higher than the incumbents, strong antitrust policies protect young efficient firms, allowing them to grow and even replace the existing market leaders. Compared to Cavenaile et al. (2021) this paper does not constrain the productivity of entrants with respect to incumbents, and therefore generates different welfare implications. Additionally, the focus of this paper are strategies that attempt to monopolise the market (rather than M&As which are sometimes efficient), thus pointing to another aspect of antitrust policies in protecting competition. Other papers studying macroeconomic and welfare implications of antitrust policies, include Moreau and Panon

(2022) studying the effect of cartels in France, and Ederer and Pellegrino (2022) looking at the impact of common ownership in the US.

This paper also relates to studies investigating the role of institutions and antitrust policy in protecting competition. Grullon et al. (2019) study the US, and find that there has been a decline in enforcement of antitrust law by the Department of Justice and the Federal Trade Commission, thus allowing for mergers with greater market-power and higher profit margins. Besley et al. (2020) explore the impact of antitrust law on preserving competition especially in the non-tradable sector across 90 different countries. Their findings suggest that a stronger antitrust law significantly lowers profit margins in the non-tradable sector. In another empirical study, Affeldt et al. (2021) find strong evidence that barriers to entry are positively related to concentration while past merger enforcement negatively correlates with concentration. The empirical section of this paper complements these results, by studying the response of entry, innovation and growth to changes in antitrust policy in the US and Europe.

Antitrust law and its implications have been widely studied in the Industrial Organisation (IO) literature, in a partial equilibrium framework focusing on narrow and well-defined markets. The focus of this area of research has often been on rationalising the existence of aggressive strategies by incumbents and finding evidence of these actions in the data in carefully defined markets. In this paper I seek to quantify the aggregate losses associated with such aggressive strategies, and therefore, I do not take a stance on the nature of firms' anticompetitive practices.[6] Below I provide a short review of the findings of the IO literature on firms' strategic actions in deterring entry.

Studies focusing on strategic entry barriers were pioneered by Bain (1956). Predation is one of the most widely discussed topics with regards to strategic entry barriers and it has been explained by incumbents seeking to establish a reputation (Milgrom and Roberts, 1982; Kreps and Wilson, 1982) or incumbents forcing a financially constrained entrant out of the market (Telser, 1966; Benoit, 1984; Poitevin, 1989).[7] Other strategies firms undertake to deter entry and monopolise the market include exclusive dealings, coordinated effects and killer acquisitions.[8] An exclusive contract limits the access of a competitor to certain suppliers or customers, thereby increasing the costs of competitors and under certain conditions, deterring entry (Segal and Whinston, 2000; Fumagalli and

[6] While the model is set in a generalised framework, in the appendix, I show that the framework of this paper is better suited for studying strategies such as aggressive pricing, lobbying and killer acquisitions.

[7] More recent models of limit and predatory pricing combine the dynamic nature of such frameworks with various informational asymmetries scenarios to study the equilibrium outcome. For example refer to Toxvaerd (2017) and Kaya (2009).

[8] Horizontal and vertical mergers and common ownership are other strategies which may be considered anticompetitive, however they have less relevance for deterring entry. For an overview of these topics refer to Morton (2019).

Motta, 2006).[9] Coordinated effects include tacit or explicit collusion among firms often without a formal contract and are more common when there is multi-market contact - situations in which firms compete with the same competitors across different markets- (Bamberger et al., 2004; Schmitt, 2018). Finally, killer acquisitions occur when incumbents of an industry acquire the start-ups and discontinue their productive innovation lines in order to eliminate future competition (Cunningham et al., 2018; Fumagalli et al., 2020).

The empirical IO literature investigates the existence of such strategic interactions in the data. In particular studying aggressive pricing, exclusive dealings, collusion and killer acquisitions empirically, shows that as predicted by the theory, such actions lead to lower entry rates and a fewer number of competitors in a given industry (Goolsbee and Syverson, 2008; Ellison and Ellison, 2011; Nurski and Verboven, 2016; Aryal et al., 2018; Cunningham et al., 2018; Burgdorf, 2019; Sweeting et al., 2020; Eliason et al., 2020).

All these strategies described by the literature are different in nature. However, a common feature among them is the notion that incumbents have an advantage over the potential entrants or young firms, and would benefit from removing the entrants from the market. The remainder of this paper builds on the notion that such aggressive strategies exist when firms have high market power. In abstracting from modelling specific forms of aggressive strategies, this paper is able to study the implication of such actions for the wider economy.

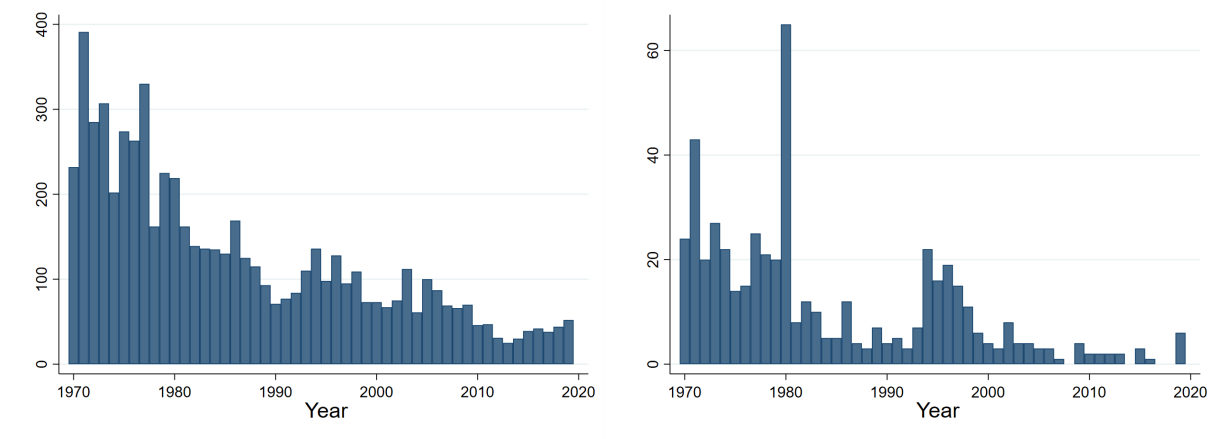
3. Overview of Antitrust Law

The first US antitrust law, the Sherman Act, was passed in the 1890, with the intention of creating more robust competition.[10] Since then, there have been many developments in the US antitrust law, most notably the passing of the Clayton Act in 1914.[11] The modern practices, however, can be traced back to the discussions of Robert Bork in the late 1970s (Baker, 2019; Sawyer, 2019; Kovacic, 2020). In his book, Bork (1978) proposed consumer welfare as the appropriate standard for evaluating cases of antitrust policy. His arguments in choosing consumer welfare as the appropriate measure shifted the legal practice towards a shorter term analysis of firms' anticompetitive behaviour, and narrowed

[9] Theoretical research points out that exclusive contracts can have an opposite effect by promoting investment in the downstream market by removing uncertainty. Therefore, the overall impact of such contracts is ultimately an empirical question.

[10] Early drafts indicate that legislators had distributional concerns when preparing the Sherman Act (Baker, 2017; Klobuchar, 2021).

[11] The Clayton Act supplements the Sherman act by explicitly discussing certain anticompetitive practices in more details. Additionally, it declares certain anticompetitive practices illegal where the existing laws were not sufficiently clear on them or the language was vague. For a detailed discussion on development of antitrust law in the US see Sawyer (2019).



(a) Restraint of Trade

(b) Monopoly

Figure 1: Total number of investigations

Source: Antitrust division of Department of Justice, workload statistics 1970-2019. Panel (a) refers to section 1 of the Sherman Act that prohibits agreements that unreasonably restrain trade. Panel (b) refers to section 2 of the Sherman Act that considers actions to monopolise or attempt to monopolise the market illegal.

the interpretation of antitrust policies (Stucke, 2012; Orbach, 2012; Khan, 2016).[12]

As a result, since the early 1980s, the courts have become more lenient towards corporations and the enforcement of antitrust has become lax (Kovacic, 1989). Figure 1 illustrates these changes by plotting the total number of investigations initiated under section 1 and section 2 of the Sherman Act.[13] According to the workload statistics, this number has significantly declined since the 1980s under both sections. Figure 2 shows the number of investigated cases under section 7 of the Clayton act for merger enforcement.[14]

As suggested by Figure 1 and 2 and discussed by Stucke (2012), since the 1980s and the adoption of Bork's views on antitrust, the influence of antitrust law in the US has declined. Baker (2017) argues that antitrust policies today are not sufficient to deter collusions, anticompetitive mergers, exclusions and vertical agreements. He further argues that with the increase in concentration among US industries, antitrust agencies and policy makers can do more to deter anticompetitive conduct. Other legal scholars share similar concerns on the development and practice on antitrust law. Edlin (2002) discusses in details the difficult conditions currently required to prove predation in courts

[12] Many antitrust scholars argue that Bork used the term consumer welfare and efficiency interchangeably. In the sense that consumer welfare did not only refer to the consumers (in terms of price paid), rather considering corporations and monopolies themselves as consumers, arguing higher prices are only a transfer of wealth ((Klobuchar, 2021), pages 134-135).

[13] Source: Antitrust division, workload statistics 1970-2019. The graphs only reflect the primary type of conduct under investigation at the outset of the investigation. For further information please refer to the workload statistics. Workloads downloaded on August 2021.

[14] Source:Antitrust division, workload statistics 1970-2019. In addition to the department of Justice, Competition Enforcement Database provides data on cases pursued by the FTC under 2 general category of merger and non-merger since 1996. During this time span, there is no obvious overall trend in enforcement by the FTC.

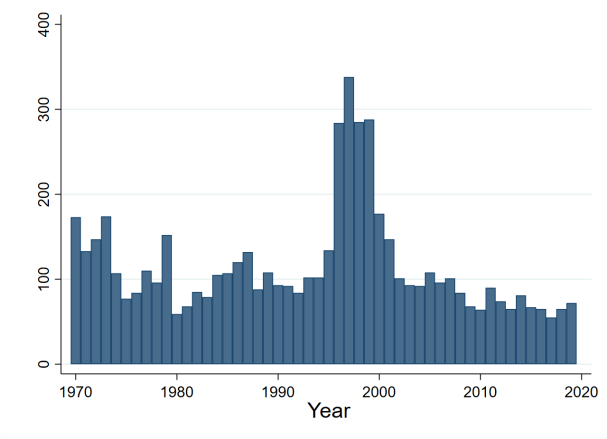


Figure 2: Total investigation - Merger

Source: Antitrust division of Department of Justice, workload statistics 1970-2019. The figure refers to investigations of potential violations of Clayton Act.

and claims that predatory pricing cases are more common than perceived. Crane (2005) shows that despite the difficult conditions required to prove predation, many cases were filed that resulted in settlements.[15] Shapiro (2019) calls for the restoration of antitrust laws with a focus on stronger merger enforcement and Steinbaum and Stucke (2020) provide alternative measures to the consumer welfare standard.

Importantly, for the modelling of antitrust authority, I use the guidelines of the Department of Justice, and the tests they propose in assessing firms' anticompetitive conduct. In particular, two of these tests "the profit-sacrifice test" and "the no-economic sense test" investigate if firms' practices have led to sacrifice of profits in the short run in an exclusionary scheme, only to be recouped in the future.[16] While the wording of these tests considers any deviations from the optimal short run profits anticompetitive, courts under the landmark case of Brooke Group have required showing evidence of a loss.[17] Within the narrow confines of the model, the Brooke Group case provides the most clear-cut measure of profit sacrifices for an exclusionary action to be considered anticompetitive in courts. A list of cases that were assessed under the profit-sacrifice test are provided in the Department of Justice publications.[18]

Finally, in contrast to the US, the main objective of antitrust law in the European Union is integrating and creating a Single Market (Fox, 1997). Despite their differences

[15] Crane (2005) provides details of federal antitrust lawsuits alleging predatory pricing between 1993-2004. He states there are more unreported federal cases filed as well.

[16] In total, the department of Justice proposes 5 tests for investigation of exclusionary conduct. Exclusionary conduct relates to actions under section 2 of the Sherman Act.
Source: https://www.justice.gov/atr/competition-and-monopoly-single-firm-conduct-under-section-2-sherman-act-chapter-3

[17] Brooke Group is a case of predatory pricing and Edlin (2002) argues requirements of the court were influenced by the arguments of Bork.

[18] The source is as indicated in footnote 16.

in the main objective, policies in both the US and the EU are centred around cartel enforcement, monopoly regulations and treatment of mergers and acquisitions (Bartalevich, 2017), and the general trend of antitrust policy has been similar between the two jurisdictions (Kovacic, 2008).

4. Empirical Motivation

The literature has widely documented a decline in business dynamism particularly for the US, but also globally. Firm entry rates have been falling, there has been a decrease in productivity growth, while the profit share of GDP has increased and the labour share of output has dropped (Akcigit and Ates, 2021). In line with these facts, I also show that the turnover rate among top firms has gone down. Figure 8 in the appendix plots the turnover rate and discusses this fact in more details. The objective of this section is to understand the interaction of antitrust law with macroeconomic outcomes such as growth, entry, and R&D expenditure.

Effective antitrust policies can regulate markets and prevent powerful firms from engaging in anticompetitive practices. In turn, protecting the competitiveness of the markets fosters growth through facilitating entry of new and more efficient firms. Additionally, antitrust policies may alter the incentive of market leaders to invest in innovation: On the one hand, a more competitive market encourages innovation as firms try to maintain their leading position (the Arrow (1962) replacement effect). On the other hand, with a more competitive market the net present value of profits is lower, therefore discouraging innovation (the Schumpeter (1942) effect). To understand which channel dominates in size and its implications for productivity growth, this question needs to be investigated empirically. Finally, one would expect the role of antitrust law to become more important as market concentration increases and fewer firms dictate the outcome of their respective industries. Below, I list the empirical findings in form of three stylised facts:

(1) In more concentrated markets relative to less concentrated ones, strengthening antitrust policies is associated with an increase in productivity growth.

(2) In more concentrated markets relative to less concentrated ones, strengthening antitrust policies is associated with higher share of entrants.

(3) In more concentrated markets relative to less concentrated ones, strengthening antitrust policies is associated with lower investment in R&D.

In the remainder of this section, I describe the data and provide evidence of the stylised facts listed above.

4.1. Data

US- The analysis for the firm level and sectoral outcomes (growth, entry and R&D expenditures) relies on Compustat, the Business Dynamics Statistics (BDS) database and the US Bureau of Labor Statistics (BLS) database. Compustat is a firm-level dataset that contains balance sheet information of all US publicly listed firms. This dataset is used to get information on firms' R&D expenditures as a measure of investment in innovation and is the source I use to create a measure of concentration for 4-digit and 3-digit NAICS sectors.[19] To get information on firm entry, I use the BDS database, which provides information on firm age for 4-digit and 3-digit NAICS sectors and is used to generate the share of entrant firms at the sectoral level. Finally, the BLS database serves as the source for information on multi-factor productivity of the manufacturing sector aggregated at 4-digit NAICS level. The main period of study for the US is between 1978 to 2018.

The measure used for US antitrust policies is the budget allocated to the Antitrust Division as a share of GDP.[20] The appropriation figures for the antitrust division are obtained from the Department of Justice (DoJ) reports. Figure 9 in the appendix illustrates the changes in enforcement budget over GDP from 1990 to 2015. I consider the enforcement budget to be an appropriate proxy for antitrust policies in the US, as the antitrust law itself has not been subject to any substantial developments[21] since 1976 when the mandatory merger notification was adopted.[22] Therefore, given that the antitrust laws in the US have not changed significantly over the period of study, the resources available for this purpose can capture changes in the stringency of antitrust law over time.

Figure 9 shows that antitrust enforcement budget as a share of GDP was increasing in the 1990s, but has been falling since the early 2000s. In line with this observation, Grullon et al. (2019) find that antitrust agencies were more lenient since the early 2000s. Historically, the resources allocated to the enforcement of antitrust have been political decisions, reflecting the preferences and the ideology of the elected president with these preferences often going beyond the political affiliation of the president. Klobuchar (2021) provides

[19] In the appendix, I show that results are robust to using concentration measures from Census.

[20] To ensure the results are not driven by business cycles and fluctuations in the GDP, the antitrust budget is divided by GDP trend rather than the realised GDP. GDP trend is estimated by regressing GDP on a linear and quadratic term.

[21] Using the Comparative Competition Law Dataset developed by Bradford et al. (2019), it can be observed that the Competition Law Index has remained constant since 1976.

[22] Hart-Scott-Rodino Antitrust Improvements Act of 1976 requires large companies to file notifications with the Federal Trade Commission and the Antitrust division of Department of Justice prior to certain mergers and acquisitions.

a detailed historical discussion on the perspective of all US administrations towards the enforcement of antitrust law.

Europe- The analysis for the sectoral outcomes for Europe relies on the Orbis database and the CompNet firm-level dataset. Orbis is a cross-country firm level database provided by Bureau van Dijk. It contains information on firms' characteristics and their balance sheets. The variables of interest are measures of concentration and the share of entrants, which are formed by aggregating firm level data at the 4-digit industry level. The main measure of concentration that I use, is the Herfindahl-Hirschman Index (HHI) which is constructed using sales share of firms at a 4-digit sector level, and entry rates are constructed using information on the date of incorporation. One limitation of Orbis is coverage and representativeness. In order to address such issues, I follow steps of Bajgar et al. (2020). The list of countries and summary statistics are provided in Table 8 in the appendix.

I use the 7th Vintage of CompNet dataset[23] which is an unbalanced panel with indicators over various categories based on firm-level information, aggregated at a two-digit industry level with 57 sectors in total. The variables of interest for the purposes of this paper are measures of productivity and concentration. I use the "all sample" data set from CompNet which includes all firms in the target population. The first available date that the data becomes available is 1999 for Finland, though for most countries the starting date is 2003-2004. The final period of study in 2010, which coincides with the final year that the Competition Law Data, discussed below, is available. Summary statistics are provided in Table 7 in the appendix.

The main measure used for the intensity of competition policy in Europe is the Competition Law Index, provided by Bradford and Chilton (2018) and Bradford et al. (2019). They introduce two different datasets, the Comparative Competition Law Dataset and the Comparative Competition Enforcement Dataset. First, the Comparative Competition Law Dataset is comprised of longitudinal data for 131 jurisdictions from 1889 to 2010. Their dataset encodes more than 700 competition laws for these jurisdictions to construct an overall index called the Competition Law Index. Second, the Comparative Competition Enforcement Dataset has information on competition agencies' resources for 100 jurisdictions between 1990 and 2010. As Bradford et al. (2019) explain, their datasets offer the most comprehensive coverage of competition laws with respect to laws, countries and the period of study.

The Competition Law Index (CLI) is constructed such that it remains comparable across time and countries. It takes values between zero and one, where higher values indicate stronger policies.[24] The frequency of the data is annual, and a distinct index is

[23] CompNet 2020, User Guide for the 7th Vintage CompNet Dataset

[24] These values are constructed using existing competition policies and therefore in case of introduction

assigned to each jurisdiction. Bradford and Chilton (2018) construct the CLI by aggregating elements of the "authority" granted to enforce competition and the "substance" of the regulations.[25]

4.2. US: Results

In this subsection, I outline the approach and provide evidence for the main results discussed in the beginning of this section for both the US and Europe.

Empirical Approach- This section aims to understand how growth, entry and investments in innovation correspond to changes in antitrust policies and resources. To get a sense of the dynamic relationship of outcome variables with the antitrust measure, I run a sequence of regressions and shift the dependent variable one period forward each time. The estimated coefficients on the variable of interest are then collected, where each estimate captures the response to a change in antitrust policies at horizon h. The main specification for the US is outlined below:

$$y_{s,t+h} = \delta_t + \delta_s + \beta_1 budget_t \times cr_{s,t} + \beta_2 cr_{s,t} + \beta_3 budget_t + \epsilon_{s,t}$$

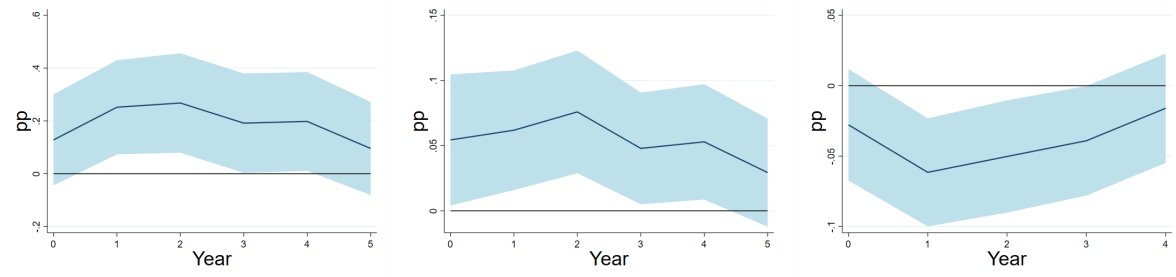
Where δ_t are year fixed effects and δ_s are sector fixed effects. Inclusion of time fixed effects implies that coefficient β_3 cannot be estimated. y is the outcome of interest showing productivity growth, share of entrants or R&D expenditure over sales. The intensity of antitrust law is proxied by the enforcement budget as a share of GDP (trend) for the US.

The Relation between Antitrust Policy and Productivity Growth- I now analyse the relation between antitrust policies and productivity growth. The source for productivity data is the BLS, which includes estimates for multifactor productivity at 4-digit NAICS levels for all firms in the manufacturing industry. The concentration measure is the HHI, and the coefficient of interest is β_1.

A test of my hypothesis is $\beta_1 > 0$, i.e. in sectors with a higher level of concentration, an increase in the antitrust budget as a share of GDP, corresponds to higher productivity growth. Figure 3a presents the results and as expected the correlation is positive and

of new antitrust laws (currently absent from all jurisdictions) the measure might change.

[25] First, authority refers to the provisions of the agency with the power to enforce the law and the remedies that can be imposed in case of violation of the law. Second, substance aggregates information on regulations on three set of policies: merger control, abuse of dominance, and anticompetitive practices. The CLI gives equal weights to authority and substance. Within substance, each category takes an equal weight of one-third. Figure 10 shows the development of these laws across European countries from 1995 to 2010. Bradford and Chilton (2018) discuss their methodology in constructing the index extensively.



(a) Productivity Growth (b) Share of Entrants (c) R&D Expenditure

Figure 3: Dynamic responses
Shaded areas are 90% confidence intervals.

significant. It can be observed that a 10% increase in the enforcement budget as a share of GDP, evaluated at the sample average of the explanatory variables[26] is associated with roughly 0.25 percentage points improvement in the growth rate one period after impact. The peak is reached between year 1 and year 2, before declining and losing significance. Table 9 relates to results of Figure 3a. Productivity growth is the result of interaction between the innovation of incumbents and entry of new and more efficient firms. The response of each channel is discussed below in details.

The Relation between Antitrust Policy and Entry- In this specification, I use the BDS data to get the share of entrants Ent_{st} in sector s and year t, and Compustat to form the concentration measure. The analysis is run for a 4-digit NAICS level and the concentration measure is the HHI. The goal is to understand how enforcement budget correlates with share of entrants accounting for concentration level. The parameter of interest, therefore, is β_1 and a test of my hypothesis is $\beta_1 > 0$, i.e. the antitrust measure (budget over GDP) matters more for entry as concentration increases.

Figure 3b captures the impulse response function of a 10% increase in the enforcement budget as a share of GDP, evaluated at the sample average of the explanatory variables. Figure 3b shows the correlation between share of entrants and antitrust policies is positive as expected and reaches its peak after 2 years. More specifically, evaluated contemporaneously, the figure shows that a 10% increase in the enforcement budget as a share of GDP is associated with roughly 7 basis points increase in the share of entrants one year after implementation. Table 10 in the appendix reports the results. Restricting the sample to years after 1985 leads to a larger response for entry equal to roughly 0.15 percentage points after one year.

The Relation between Antitrust Policy and R&D Expenditures- To understand

[26] The values are 9.87e-06 and 0.40 for the average enforcement budget as a share of GDP and average HHI at a 4-digit NAICS level respectively.

the relationship between antitrust policy and investment in innovation, I use the Compustat data for R&D Expenditures and measure of concentration at a 4-digit NAICS level. The dependent variable $RD_{i,t+h}$ shows the expenditures of firm i in Research and Development as a share of its sales at time $t+h$. As a robustness check, and to make results comparable to the results of productivity growth and entry, I run another specifications using the weighted average of expenditures on research and development over sales in sector s and time $t+h$ as reported in Table 13 and Figure 14. The specification for innovation is presented below:

$$y_{i,t+h} = \delta_i + \delta_t + \beta_1 budget_t \times HHI_{s,t} + \beta_2 HHI_{s,t} + \beta_3 budget_t + \epsilon_{i,s,t}$$

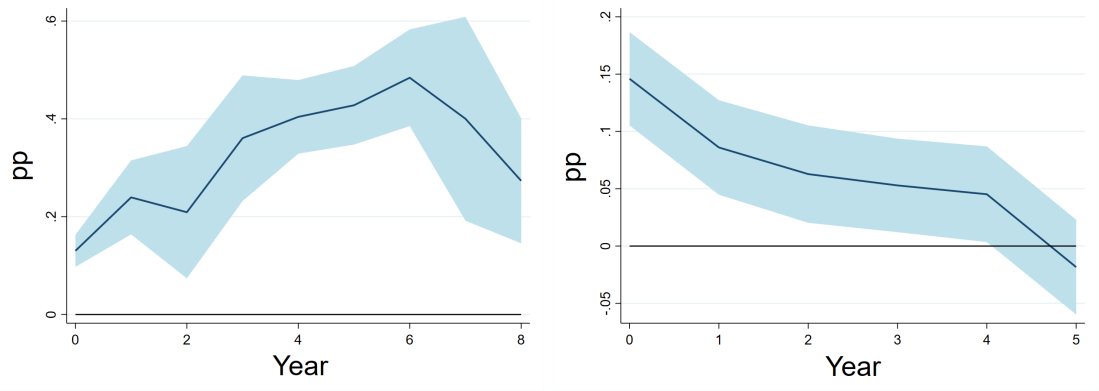
Where i is a firm specific index, as before s shows sector and t is year. I include firm and year fixed effects. Similar to previous parts, the concentration measure is the HHI and the parameter of interest is β_1. A test of my hypothesis is $\beta_1 < 0$, i.e. in sectors with a higher level of concentration, an increase in the antitrust budget as a share of GDP, corresponds to lower levels of R&D Expenditures. Figure 3c shows the results for the specification described above. Results show that a 10% increase in the enforcement budget as a share of GDP, evaluated at the sample average of the explanatory variables is associated with roughly .07 percentage point drop in R&D expenditure over sales after one year. This is equivalent to approximately a 3% drop in ratio of R&D expenditure over sales.

Robustness Checks- To make sure the results are robust, I run various tests. One possible source of concern could be using concentration measures from Compustat. For the years that information is available I use the data from census, while this leads to considerably fewer observations results remain robust. Another concern could be if HHI is able to capture market power. To address this issue, I use profit ratios, as firms with higher market power are expected to make higher profits. Finally, I account for the effect of foreign competition, by focusing on the non-tradable sector and correcting for share share of imports in each sector. Results remain robust in all these cases.

4.3. Europe: Results

The empirical approach for Europe is similar to the US as in the previous subsection and the main specification is outlined below:

$$y_{c,s,t+h} = \delta_{c,t} + \delta_{c,s} + \beta_1 CL_{c,t} \times cr_{c,s,t} + \beta_2 cr_{c,s,t} + \beta_3 CL_{c,t} + \epsilon_{c,s,t}$$



(a) Productivity Growth (b) Share of Entrants

Figure 4: Dynamic responses
Shaded areas are 90% confidence intervals.

c is country, s sector and t year. Country-year $\delta_{c,t}$ and country-sector $\delta_{c,s}$ fixed effects are included. The specification is as the previous section, however, here, the measure for intensity of competition policy is the competition law index (CLI) as discussed before.

The Relation between Antitrust Policy and Productivity Growth- Next, I investigate the correlation between antitrust policy and productivity growth in Europe. CompNet provides various measures for total factor productivity corresponding to the dependent variable.[27] Figure 4a shows the response to a 10% improvement in the index, when all variables are evaluated at their mean.[28] The contemporaneous outcome of growth in response to a 10% increase in the index is roughly 0.18 percentage point improvement in the growth rate of productivity. This correlation increases after one year and seems to be persistent at least for up to 8 years.

The Relation between Antitrust Policy and Entry- In this specification, I use the Orbis database to get the share of entrants $Ent_{c,s,t}$ in country c, sector s and year t, and to form the concentration measure $cr_{c,s,t}$. The analysis is done for 4-digit industry levels and the concentration measure is HHI. The intensity of competition law is measured by the CLI and the parameter of interest is β_1. Figure 4b represents the results and suggest that a 10% improvement in the index, when all variables are evaluated at their mean,[29] is associated with 0.15 percentage point increase in rate of entry upon impact. As in the Orbis database small and young firms are under-represented, this value corresponds to a 4% increase over the sample average. Table 25 presents the results.

[27] There are multiple measure for productivity in the CompNet database. I use all the available measures at sectoral level and present the results in the appendix in Figure 15 as a robustness check.
[28] The average CLI and HHI (2 digit sector) are 0.6 and 0.057 respectively.
[29] The average CLI and HHI (4 digit sector) are 0.6 and 0.34 respectively.

This section investigated the response of productivity growth, entry rate, and innovation to stronger enforcement of antitrust policies in the US and Europe. Next, building up on the empirical findings, I will develop and estimate a structural model to quantify the effect of stronger antitrust policies on various macroeconomic outcomes relating to business dynamism.

5. Model

In this section, I present a dynamic general equilibrium model of oligopolistic competition with step-by-step innovation and entry and exit. The dynamic nature of the model allows for strategies with short term costs, but long term returns such as investment in innovation. Additionally, combining a dynamic set up with oligopolistic competition creates an environment in which firms strategically decide to undertake a costly action today in order to eliminate the competition and increase their value in the future. This paper restricts the analysis to strategic decisions that are directed to entry of new and possibly more efficient firms. To regulate firms' behaviour and ensure competition is preserved, the model includes an antitrust authority which constraints the extent to which the incumbents can engage in creating strategic entry deterrents.

5.1. Preferences

The utility of the representative consumer is standard and is given by $U(C_t) = C_t$, where C_t indicates final consumption, which is a composition of the output of a continuum of sectors Q_{jt}, $j \in [0, 1]$ as specified below:

$$C_t = \int_0^1 lnQ_{jt}dj \tag{1}$$

Within each sector j, output is denoted by Q_{jt}. Output of each sector itself is composed of N_j distinct goods as in Atkeson and Burstein (2008), using a CES aggregator where N_j is determined endogenously:[30]

$$Q_{jt} = N_{jt}^{\frac{1}{1-\epsilon}}[\sum_{i=1}^{N_{jt}} q_{ijt}^{\frac{\epsilon-1}{\epsilon}}]^{\frac{\epsilon}{\epsilon-1}} \tag{2}$$

where q_{ij} denotes quantity produced in sector j by firm i and $\epsilon > 1$ is the elasticity of

[30]Similar to Jaimovich and Floetotto (2008) the term $N_{jt}^{\frac{1}{1-\epsilon}}$ corrects for the variety effect.

substitution across firms. The price index of output of sector j is:

$$P_{jt} = N_{jt}^{\frac{1}{\epsilon-1}}[\sum_{i=1}^{N} p_{ijt}^{1-\epsilon}]^{\frac{1}{1-\epsilon}} \tag{3}$$

The log-preference assumption of equation (1) implies that consumers will optimally allocate a constant proportion of their income to each sector j and this constant share is denoted by I_t. Thus prices are defined at each time period and the maximisation problem is subject to $\sum_{i=1}^{N_{jt}} q_{ijt}p_{ijt} = I_t$.

Solving the problem yields the demand for each variety as a function of its price:

$$q_{ijt} = (\frac{p_{ijt}}{P_{jt}})^{-\epsilon} \times \frac{I_t}{N_{jt}P_{jt}} \tag{4}$$

It is worth noting that as there is no disutility of labour, which is supplied inelastically. I further assume that there is no labour growth over time. Therefore, the total income of the household is also equal to the sum of labour income and the profits households receive from firms.

5.2. Firms

Production technology- Within each sector, there are a finite number of firms with idiosyncratic productivity levels, producing differentiated goods. Upon paying the sunk cost of entry, firms observe their productivity level and if entry is successful, they get access to an increasing returns to scale technology to produce using labour as the only input. Firms of a given productivity behave symmetrically and they have the option to invest in research and development to improve their productivity. There are fixed costs of production at each time period and the production technology is defined as in Melitz (2003):

$$l_{ijt} = f + q_{ijt} \times \lambda_{ijt} \tag{5}$$

Similar to before i is indexing the type of the firm defined in terms of its productivity level, j indicates the sector and t is the time index. f denotes the fixed cost of production, and $\lambda = 1/\phi$ is the marginal cost of production defined as the inverse of the productivity of the firm. Firms compete a la Bertrand in the product market.

State Variables- There are three state variables that are relevant for a firm's decisions. First, the idiosyncratic state of the firm ϕ is given by its productivity level which

is initially drawn from a given distribution $G(\phi)$ when the firm enters, and later can be improved by investing in innovation.

The next state variable is the sectoral state and is composed of two parts: The first part of μ_{jt} is a vector of size K, where K shows the number of distinct productivity levels of firms active in production at time t in sector j. Each elements of vector μ_{jt} presents the number of firms with a given productivity level in sector j and it can be shown as $\{\phi_1, \phi_2, ..., \phi_{k-1}, \phi_k, ...\}$. I assume that the elements of this set are ordered such that $\phi_1 < \phi_2 <, ..., < \phi_{k-1} < \phi_k <, ...$ and $\phi_k/\phi_{k-1} = \gamma$ for all $k \in \mathbb{N}$. Therefore, $\gamma > 1$ reflects the productivity step and firms with a higher index i have a higher productivity level. For example, a sectoral state defined as $[a_1\ a_2\ a_3\ a_4\ a_5]$ suggests that $K = 5$ and there are 5 types of firms (denoted by their productivities) in sector j. Additionally, it suggests that there are a_1 firms with productivity level γ^1, a_2 firms with productivity level γ^2 and so on.

The second part of the sectoral state includes the signal for potential entrants at sector j denoted by $\phi^{j,t}$. The signal varies across time and sectors and is discussed in more details in the next part.

Finally, the aggregate state $\mu_{agg,t}$ is an aggregation of the sectoral states and it pins down the equilibrium wage in the economy. As the aggregate state combines a continuum of sectors, it implies that despite the idiosyncratic shocks at the sectoral level, there is no uncertainty over the aggregate.

Entry- At every time period, there is a sufficiently large number of potential entrants at each sector j. Prior to entry, potential entrants in each sector receive a sector specific signal of their expected productivity ϕ^q_{jt} from distribution $\mathcal{H}(\phi)$, and based on the signal, they can decide to enter or not. If they decide to enter, they have to pay a one-time sunk cost of entry S. After paying this cost, they observe their individual productivity level and can decide to whether to produce at time $t+1$ or exit.

More precisely, potential entrants of sector j with signal ϕ^q_{jt} will be distributed according to $G(\phi)$ with mean $\phi^q_{jt} + \bar{\phi}_{jt}$, where $\bar{\phi}_{jt}$ is the average productivity of sector j (incumbent firms) at time t. Introducing $\bar{\phi}_{jt}$ accounts for productivity growth in the economy and implies there are spillovers from the incumbents to the pool of entrants, thus as incumbents become more productive, the pool of entrants becomes proportionally more productive too. On the other hand, term ϕ^q_{jt} suggests that the expected productivity level of entrants (with respect to the incumbents) changes over time, and in some periods the entrants may be relatively more productive on average. Distribution $\mathcal{H}(\phi)$ pins down the frequency of entrants having a higher average productivity with respect to incumbents while $G(\phi)$ indicates the general shape and other properties of entrants distribution.

Therefore, with a high signal, while the potential entrants' distribution with respect to each other $G(\phi)$ remains the same, their relative productivity with respect to incumbents is higher and therefore they will have a higher expected value of entry. Note that all entrants of industry j receive the same signal but the signals are different for the prospective entrants across industries. In order to solve for the equilibrium, I assume that entry happens sequentially in each sector and conditional on the signal until the free entry condition is satisfied:[31]

$$E[V_{ent}(\phi, \mu_j, \mu_{agg})|\phi^q_{jt}] > S \tag{6}$$

Sequential entry suggests that the number of successful entrants will depend on the sectoral state and therefore is denoted by M_j. Given that there is a continuum of industries, it means that a constant share of industries will always receive signal ϕ^q and therefore on aggregate there is no uncertainty regarding the economy-wide level of entry.

Additionally, note that signal ϕ^q_{jt} to sector j is observed by the incumbents of that sector as well. This means from the perspective of incumbents at time t there is no uncertainty over the state of the sector and aggregate sectoral productivity with respect to entrants, even before the sunk cost is paid. However, from the perspective of entrants there is uncertainty, as for them the individual draw for productivity combined with the sectoral state determines their value. Similar to the incumbents, they know with certainty the state of the sector, but, as they do not yet have information on their idiosyncratic state prior to paying S, they will base their entry decision on their expectations of profits given the signal ϕ^j.

Finally, in order to endogenise N, the number of active firms in each sector, I use the sequential entry assumption and allow firms to enter one by one according to distribution G and taking the sectoral steady state distribution as given. Firms continue to enter until the free entry condition as defined in (6) is satisfied.[32] Another interpretation of this assumption is that, at the equilibrium level of N and conditional on having the steady state distribution of firms, new firms will not find entry optimal.

Incumbents- The state of firm i at sector j at time t can be described by the idiosyncratic state productivity ϕ_{ijt}, the sectoral state μ_{jt} as discussed above and $\mu_{agg,t}$ which shows

[31] Potential entrants are placed in a queue and they know their position in the queue but do not have information on the productivity draw of firms that are in front of them. Therefore, each firm decides to pay conditional on the productivity signal of entry and its relative position. This also implies that if the potential entrant in position $\mathcal{P}$ does not find it optimal to enter, all remaining entrants in the queue will not find it optimal either.

[32] Since this is an oligopolistic competition and there are discrete number of firms, the condition will not be satisfied with equality and N is found when adding an additional firm reverses the sign of the condition.

the aggregate state of the economy. The aggregate state is deterministic, ensures the existence of a balanced growth path and pins down the equilibrium level of wage.

Firms compete under Bertrand and their optimisation problem involves choosing prices, investment in innovation and whether to create strategic entry barriers (deterring strategies are a binary choice). The timing of their decisions is described below. In the beginning of the time period incumbents observe the outcome of their innovations at time $t-1$ and realise whether it has been successful or not. Successful innovation implies that firms go up one step on the productivity ladder and as a result become more efficient in their production. Next, incumbents and entrants of industry j observe the signal for entry ϕ^q_{jt}. Upon observing the signal, incumbents commit to prices, amount of strategic entry barriers and investment in innovation. Potential entrants observe the decision of incumbents and can decide to pay the sunk cost of entry in order to enter at time $t+1$. All firms produce and incumbents can decide to exit and potential entrants (who paid the sunk cost of entry) join the pool of incumbents.

Given the timing, the value function of the incumbents is defined below. Firms' idiosyncratic state is described by $\tilde{\phi}_{ij}$ which shows the number of steps between firm i and the leader firm in industry j and is a direct mapping from the firm's productivity ϕ_{ij}. The sectoral state is denoted by μ_j and the aggregate state of the economy is shown by μ_{agg}. Therefore, an incumbent firm i in industry j chooses innovation rate, prices and deterring strategies to maximise its value given by:

$$\begin{aligned} V(\tilde{\phi}_{ij}, \mu_j, \mu_{agg}) = \max_{x,D} & \underbrace{\pi^*(\tilde{\phi}_{ij}, \mu_j, \mu_{agg})}_{\text{Profit flow}} - \underbrace{w(\mu_{agg})c(x)}_{\text{Innovation cost}} - \underbrace{D \times \mathcal{K}(\tilde{\phi}_{ij}, \phi^q_{jt})}_{\text{Cost of entry deterrents}} \\ & + \underbrace{max\Big\{0, \beta EV(\tilde{\phi}'_{ij}, \mu'_j, \mu'_{agg})\Big\}}_{\text{Continuation value}} \end{aligned} \tag{7}$$

where β is the discount factor and $c(x)$ is the cost innovation paid in units of labour and implies a firm spending $c(x)$ on innovation will move up one step on the productivity ladder with probability $h(x)$. $D \in \{0, 1\}$ is a binary variable taking value 1 if the firm engages in creating strategic entry barriers. Thus, the law of motion for the idiosyncratic state can be presented as:[33]

$$E[\tilde{\phi}'_{ij}] = \underbrace{\tilde{\phi}_{ij}}_{\text{Position at time } t} + \underbrace{(1-D) \times \phi^q_{jt}}_{\text{Change in position due to entry}} - \underbrace{h(x)}_{\text{Innovation}} \tag{8}$$

which states that the expected future idiosyncratic state of the firm, depends on its

[33]The law of motion characterises the evolution of firm idiosyncratic state along the equilibrium path.

current state, entry of new firms and the outcome of innovation. When more efficient firms enter, while the productivity of any given incumbent is not directly affected, its relative position worsens as the firm is now further away from the market leader, and thus firm loses competitiveness. As it will be discussed in the later sections, this paper focuses on deterrence strategies that either all incumbents find it optimal to prevent entry or none do. Therefore, considering the decision of each given firm will capture the outcome of the industry. Next, successful innovation directly affects the productivity level of the firm and consequently improves its relative position in its respective industry. Later in this section, I will discuss in details the firm's decision to deter entry D, the costs $\mathcal{K}$ associated with it and the firm's innovation strategy.

Finally note that productivity, innovation and firms' position on the productivity ladder are distinct in this model. The relationship between productivity and the position of firms is discussed above in detail. In short, the productivity level determines the marginal cost of production but does not provide any details on where the firm stands with respect to the other competitors. The position of the firm on the productivity ladder includes this information and combined with a moment of the distribution can get translated into the productivity level. Innovation, in this model, shows the effort of firms to move up the productivity ladder, improve their position and lower their marginal cost.

Continuation value- Firms' continuation value as defined in equation (7) depends on the developments of the sectoral state. The future sectoral state itself, depends on the outcome of entry and the result of innovation by individual firms. As the outcome of innovation is not deterministic, this implies at every time period there will be deviations from the steady state firm distribution over the productivity level. Additionally, as the number of incumbents increases it becomes computationally infeasible to track the realised distribution and the exact probability associated with the event. To overcome this problem, I assume firms have bounded rationality, and they solve their value maximisation problem assuming that future sectoral state μ_j' is at its steady state value.[34]

Profit maximisation and optimal price- Firms use production technology defined by equation (5) and labour as the only input of production to maximise their profits at each time period:

$$\pi^*(\phi_{ij}, \mu_j, \mu_{agg}) = \max_{p_{ij}, q_{ij}} \left\{ p_{ij} q_{ij} - w(f + q_{ij} \times \lambda_{ij}) \right\}$$

[34] The nature of this assumption is similar to the oblivious equilibrium described by Weintraub et al. (2008) with many firms. An alternative assumption is considering dynamic firms' models with strategic decisions and few firms in each industry, and often the literature considers a duopolistic set up in analysing such strategies. An exception from the duopolistic set up is Cavenaile et al. (2021) in which they consider a setup with maximum 4 incumbents competing in the oligopolistic setup.

subject to demand (4). Where λ_{ij} presents the marginal cost of production and is the inverse of productivity level. Therefore, the static profit maximisation[35] yields the pricing rule as in Atkeson and Burstein (2008) and Grassi (2017):

$$p_{ij} = (\frac{\epsilon}{\epsilon - 1} + \frac{s_{ij}}{(\epsilon - 1)(1 - s_{ij})}) \times \lambda_{ij} w \tag{9}$$

where s_{ij} is the sales share of firm i in sector j and the term in parentheses denotes the firm's markup which is increasing in the sales share of firm. s_{ij} is defined as:

$$s_{ij} = (\frac{p_{ij}}{P_j})^{1-\epsilon} \times \frac{1}{N_j}$$

ϵ is the elasticity of substitution and P_j shows the sectoral price. Similar to before N_j is the total number of firms in that sector. All time subscripts have been dropped here.

Optimal investment in innovation- Incumbents choose x to improve their productivity and move up the productivity ladder. Moving up on the productivity ladder improves the firm's relative position in the sector and consequently increases the firms market share. Innovation is costly and firms pay $c(x)$ in units of labour to move up one step on the productivity ladder with probability $h(x)$. In the remainder of this paper, I define the cost of innovation by:

$$c(x) = b\frac{x^2}{2} \tag{10}$$

The probability of having a successful innovation $h(x)$ is given by:

$$h(x) = 1 - e^{-x} \tag{11}$$

Therefore, higher investment in innovation leads to a higher probability of climbing up the ladder, but there are decreasing returns to the investment.

Using the cost function defined as (10) and the innovation success probability function (11), the optimal amount of innovation can be derived as:

$$x = W\left(\frac{\beta E[\Delta V]}{wb}\right) \tag{12}$$

where $W(.)$ is the Lambert W-function, defined as the inverse function of $f(W) = We^W$.

[35] An alternative way of solving the problem is to include the profits in the value function and decide over the prices in that problem. Under this characterisation prices can be used as a strategy to deter entry of new firms, similar to limit pricing literature. See for example Fudenberg and Tirole (1983). The aggressive pricing characterisation of the problem, with dynamic profit maximisation and decision over prices is discussed in the appendix. The conditions for the equivalence between the two problems are also discussed. The main characterisation of this paper allows for wider interpretations beyond limit pricing.

ΔV is the expected value gain if innovation is successful and w is wage. Equation (12) suggests that the higher the expected value gain in response to successful innovation, the higher the optimal innovation would be. Similarly, higher costs to investment imply a lower level of innovation as the optimal strategy. Derivations of the result are provided in the appendix.

Aggressive strategies and creation of barriers to entry- Firms' aggressive behaviour aimed at deterring the entry of new and more efficient firms is the mechanism central to this paper, offering a possible source for the decline in business dynamism. Firms act aggressively in order to eliminate the competition and consequently increase their market share. This is an additional channel, on top of innovation, for firms to improve their position in the market. However, while innovation is considered a productive approach to increasing firms' market share, creating barriers to entry may affect the sectoral productivity negatively, as some efficient entrants are now eliminated.

Additionally, while aggressive strategies towards entrants are costly in the short run, they increase the incumbents' value in the long run. It is worth noting that this paper focuses on aggressive strategies of incumbents towards entrants and does not study the equilibria in which incumbents undertake actions against each other. Formally, firms have to satisfy their incentive compatibility constraint in order to find it optimal to act aggressively towards entrants:

$$\pi_{D=1}(\tilde{\phi}_{ij}, \mu_j, \mu_{agg}) + \beta E[V(\tilde{\phi'}_{ij}, \mu'_j, \mu_{agg})] \geq \pi_{D=0}(\tilde{\phi}_{ij}, \mu_j, \mu_{agg}) + \beta E[V(\tilde{\phi''}_{ij}, \mu''_j, \mu_{agg})] \quad (13)$$

where $D = 1$ indicates that firm is creating entry deterrents and $D = 0$ shows the opposite. μ_j shows the sectoral state, and μ'_j and μ''_j show that the development of sectoral state will depend on the incumbents' aggressive strategies. Overall, this condition states that if the gains of creating strategic entry deterrents compensate the immediate cost, the incentive compatibility constraint would be satisfied and incumbent i optimally decides to act aggressively by setting $D = 1$. Deterrence take the form of raising entry costs[36] in the free entry condition as described by (15). Additionally, note that a given firm is willing to pay the cost of entry deterrence only if it can successfully put entrants of sector j on their participation constraints:

$$E[V_{ent}(\phi, \mu_j, \mu_{agg})|\phi^q_{jt}] \leq S + \mathcal{K}_{tot,jt}(\phi^q_{jt}) \quad (14)$$

where $\mathcal{K}_{tot,jt}$ presents the total amount of entry barriers created by incumbents at sector

[36] This is equivalent to assuming that entry deterrence lowers the value of entrants.

j and is an aggregation of firm level entry deterrents:

$$\mathcal{K}_{tot,jt}(\phi^q_{jt}) = N_j^{-\frac{1}{\alpha_d}}(\sum_{i=1}^{N}\mathcal{K}^{\alpha_d}_{ijt}(\phi^q_{jt}))^{\frac{1}{\alpha_d}} \tag{15}$$

N denotes the number of incumbents in sector j, α_d is the elasticity parameter and $\mathcal{K}_{ijt}$ shows the amount of strategic barriers to entry created by firm i at sector j. Below I describe how individual firms create barriers to entry, $\mathcal{K}_{ijt}$ for new firms.

Assumption: To create entry barriers, $\mathcal{K}_{ijt}$, firm i in sector j and time t sacrifices a fraction of its profits according to:

$$\mathcal{K}_{ijt}(\phi^q_{jt}) = \psi(\phi^q_{jt}) \times \pi^*_{ijt} \tag{16}$$

where $\psi(.)$ is a parameter indicating a fraction which depends on the signal of entry at sector j and time t, and therefore, is common among all incumbents of the sector at every time period, but changes over time based on observations for the signal of entry ϕ^q_{jt}.

The assumption states that to deter entry, incumbents forgo a fraction of their profits, therefore, incurring a short term cost. The profit sacrifice, $\mathcal{K}_{ijt}$, then translates into an extra cost imposed on the entrants. Note that this fraction depends on the signal of entry, as the expected value of entry itself would be a function of signal. Higher entry signals, imply higher expected value of entry and therefore, incumbents have to create more entry deterrents in order to successfully prevent entry.

To solve for the optimal value of $\psi(\phi^q_{jt})$ required to successfully deter entry, and subsequently understand the value of $\mathcal{K}_{ijt}$, firms use backward induction to find $\mathcal{K}_{tot,jt}$ the amount required to put the potential entrants on their participation constraint. Substituting for $\mathcal{K}_{tot,jt}$ from equation (15), and then substituting for firm level entry deterrents from equation (16) yields the fraction $\psi(\phi^q_{jt})$.

Equation (15) states that there are potentially multiple combinations of firm level entry deterrents, $\mathcal{K}_{ijt}$, by firms of sector j that can put the entrants on their participation constraint. The existence of various combinations, point out to the possibility of multiple equilibria. The assumption above overcomes the multiplicity problem by focusing on the equilibrium that take the above form. Further it ensures that the firms' value remains increasing in their productivity.[37]

[37] The set of equilibria that impose disproportional costs on firms, may result in non-monotonicity in the value of firms as a function of idiosyncratic productivity level. For example, a deterrence rule which requires the most productive firm to incur a high share of cost of barriers, lowers the value of market leader $\mathcal{K}_{tot,jt}$ (given its ICC being satisfied), with limited cost on the remaining firms. As long as $V_1 - V_2 < \mathcal{K}_{tot,jt}$ this creates non-monotonicity in the value function, in turn altering the incentive of firms to innovate, as now there is a penalty in becoming the market leader. This assumption further

5.3. Antitrust Regulator

There is a regulator who monitors the actions of incumbents and constrains the extent to which they can engage in aggressive strategies. In the previous sections, firms' aggressive strategies were modelled as foregoing a fraction of their profits, implying incumbent firms incur a cost to create barriers to entry for the new firms. The role of the antitrust regulator is to obstruct such strategic actions, when incumbents find it optimal and profitable to engage in them and act aggressively. In this framework, antitrust policy is summarised by the following equation indicating that antitrust policy sets a limit on the level of profit sacrifices by firms:

$$\psi(\phi^q) \leq \psi_{cl} \tag{17}$$

The condition states that the profit sacrifices of firms cannot be higher than the antitrust (competition law) parameter ψ_{cl}. Note that higher ψ_{cl} implies that firms can sacrifice a larger fraction of their profits and, therefore, they can create more barriers to entry, thus pointing to a more lax antitrust policy. On the other hand, a lower value of ψ_{cl} denotes a more stringent antitrust policy in which aggressive strategies by firms are not permitted. In the case where $\psi_{cl} = 0$, aggressive strategies are completely ruled out by the antitrust authority, and in the absence of innovation, the problem becomes fully static and equivalent to Atkeson and Burstein (2008).

While this is a reduced-form presentation of antitrust law and abstracts from various complexities of such policies, it is still able to capture the focus of antitrust law on profit margins and profit sacrifices. For example as discussed in Section 3 of this paper in more details, in cases of monopolisation or attempted monopolisation (Section 2 of the Sherman Act) possible assessments of firms' anticompetitive conduct are the profit sacrifice test and the no economic sense test.

Finally, while each firm i may individually have the incentive to deter entry of new firms according to (13), the antitrust policy sets an upper bound on the aggressive strategies. Consequently, the maximum amount of barriers to entry jointly created by firms of sector j is:

$$N^{-\frac{1}{\alpha_d}}(\sum_{1}^{N} \mathcal{K}_{max,i}^{\alpha_d})^{\frac{1}{\alpha_d}} \geq EV[\bar{\phi}^q] - S \tag{18}$$

Where $\mathcal{K}_{max,i} = \psi_{cl} \times \pi_i^*$ is the maximum amount of deterrent that firm i has the *ability* to create within the law. The condition therefore pins down the cutoff for signal of entry, $\bar{\phi}^q$, as above a certain entry signal, entrants are expected to have a very high

rules out cases of free riding, in which a few firms create a lot of barriers and other firms free ride.

productivity and consequently high values.

5.4. Equilibrium

The dynamic equilibrium is characterised by a steady state distribution (along a trend) over all sectors. Firms compete in a Bertrand setting maximise their lifetime value as defined in (7) with respect to prices, innovation and aggressive strategies subject to demand for their products, as in equation (4), the law of motion for the sectoral state, defined in equation (8), the antitrust constraint (17), and their incentive compatibility constraint (13). The maximisation problem is further subject to production technology, cost of innovation, and the probability of successful innovation. The optimal price is defined as equation (9), and the optimal innovation is as described in equation (12). The grim trigger aggressive strategy is discussed in the appendix. Further, in the equilibrium there is an entry cutoff $\bar{\phi}_{entry}(\mu_t)$ derived from the free entry condition as in equation (14), and a cutoff for exit $\bar{\phi}_{exit}(\mu_t)$ derived from equation (5). Once detrended, the cutoffs become independent of time. Further, households maximise their utility as in equation (1) subject to their budget constraint, and there is market clearing for the the goods and the labour market.

6. Calibration

In this section, the model is estimated numerically to match the firm-level and sector-level data of the US between 2000 and 2010. The parameters that need to be determined are: ϵ, S, f, ψ_{cl}, β, L_s, γ, b, α_d, H_e and $\mathcal{G}_e$. The description of parameters is provided in Table 1. Four of these parameters are exogenously calibrated. The elasticity of substitution is set to 4 as in Costantini and Melitz (2009), β the discount factor is set to 0.96 and labour supply is normalised to 1. Modelling of antitrust authority is motivated by the "profit-sacrifice" test and the "no economic sense" test for assessing firms' anticompetitive conduct by the Department of Justice. ψ_{cl} the antitrust parameter is set to 1 implying that the profit-sacrifice test does not allow an aggressive strategy leading to a net loss, consistent with the court rulings under the US antitrust policies as discussed in details in section 3 of this paper.[38] The remaining parameters are structurally estimated using a

[38] The wording of the guideline: "Generally, a profit-sacrifice test asks whether the scrutinized conduct is more profitable in the short run than any other conduct the firm could have engaged in that did not have the same (or greater) exclusionary effects. If the conduct is not more profitable, the firm sacrificed short-run profits and might have been investing in an exclusionary scheme, seeking to secure monopoly power and recoup the foregone profits later." Source: Antitrust Division of Department of Justice - Chapter 3, General Standards for Exclusionary Conduct. Further, as discussed in section 3 the case of Brooke Group required showing evidence of a loss (along with other factors) for exclusionary behaviour (Edlin, 2002).

simulated method of moments approach and their values are reported in Table 1.

Table 1: Parameters of the theoretical model

Internally calibrated		
Parameter	Value	Description
S	0.030	Sunk cost of entry
f	0.008	Fixed cost of production
γ	1.056	Productivity step
$\mathcal{H}_e$	1.050	Parameter of entry signal distribution $\mathcal{H}$ (truncated pareto)
b	0.098	Cost of innovation
α_d	2.001	Deterrent aggregator parameter (elasticity)
$\mathcal{G}_e$	2.570	Parameter of entry distribution g_{ent} (truncated pareto)
Externally calibrated		
ϵ	4	Elasticity of substitution
β	0.96	Discount factor
ψ_{cl}	1	Competition law parameter
L_s	1	Labour supply

The estimated moments, their data counterparts and the data source are reported in Table 2 and discussed further below. The data for rate of entry of firms is obtained from the Business Dynamics Statistics (BDS), which provides various measures of business dynamics for the economy aggregated at the sectoral level. The BDS data is created from Longitudinal Business Database (LBD) of the US census and thus covering the population of entrant firms. The distribution of entrants in the model is assumed to be pareto (truncated over the productivity space) and the parameter of the distribution is estimated to match the entry rate of firms in the BDS data. Additionally, the BDS database provides information over employment of firms at different age groups, which is used to get the employment share of entrants.

Research and Development expenditure proxies the intensity of innovation in the model. The data counterpart is obtained from the Compustat dataset and is the weighted average of Research and Development expenses over sales for each year. The weights are sales share of firms in their respective industries and when averaging over the years, all years have equal weights.[39] The same moment is formed in the model and is used to estimate parameter b, denoting marginal cost of innovation. The data moment in Table 2 shows the concentration ratio averaged across all 4-digit sectors in year 2010.

The data source for the remaining moments are the values reported in the literature. Average markups are targeted to values in De Loecker et al. (2020). Profit share of GDP

[39]The respective variables in Compustat are xrd and sale.

Table 2: Targeted Moments

Moment	Estimated	Data	Source
Entry rate	0.08	0.08	BDS
Fixed cost over total cost	0.21	0.20	Compustat
RD Expenditure over total sales	0.040	0.043	Compustat
Average Markup	1.37	1.45	De Loecker et al. (2020)
Entrants employment share	0.046	0.044	BDS
Productivity growth	0.012	0.013	BLS
Profit share of total income	0.13	0.12	Akcigit and Ates (2021)

is obtained from Akcigit and Ates (2021) and is also similar to values reported in Barkai (2016). The estimate for growth rate of productivity is from the BLS website and is the average of annual growth rate between years 2005-2018.

Table 3 reports the untargeted moments of the data. The second column shows the estimated values from the model, and the third and forth column are the data counterparts reported for corporations with more than one hundred and one thousand employees respectively. The final column provides the source of the data.

The concentration measure is CR4 indicating the sum of sales share of top four firms in each industry and is taken from Akcigit and Ates (2019). Profit over sales of the market leader is obtained from Compustat. The market leaders are the top 5% of firms based on their sales in their respective 4-digit sectors. The moment reported in Table 3 is the average ratio of gross profits over sales averaged over all sectors.[40] The next two moments are measures of firm size distribution and show the sales' ratio of 25 and 75 percentile to the median firm, and there is a better match with the sample of the data that considers firms with over a thousand employees. The final moment presented in Table 3 is the interquartile range of R&D expenditure where the quartiles are defined based on sales. The information is obtained from Compustat and reported conditional on firms having above one hundred or one thousand employees.

7. Quantitative Results

This section uses the calibrated quantitative model to investigate the properties of the equilibrium. I first discuss the firms' policy functions and then explore the implications of antitrust law for business dynamism. In particular, I run counterfactual exercises changing the stringency of antitrust law from the baseline "lax" scenario to cases that put a higher

[40] The relevant variables in Compustat are gp and sale.

Table 3: Untargeted Moments

Moment	Estimated	Data emp>100	Data emp>1000	Source
Concentration measure CR4	0.29	0.42	-	Akcigit and Ates (2021)
Profit over sales of market leaders	0.28	0.32	0.33	Compustat
P25 to median sales	0.61	0.26	0.41	Compustat
P75 to median sales	2.59	3.71	2.84	Compustat
IQR of R&D expenditure (sales quartiles)	3.71	3.30	2.92	Compustat

constraint on the extent of anticompetitive practices. In particular, in the limiting case, the antitrust authority is able to prevent all anticompetitive practices, thus providing an upper bound estimate on the effect of strengthening antitrust policies. Next, I show how changes in the stringency of antitrust law affect business dynamism by looking at its impact on entry rate, productivity growth, labour share of GDP and profit share of GDP. In the final subsection, I assess the welfare effects of antitrust law and discuss the possible distributional consequences.

7.1. Policy Functions

Figure 5 depicts the optimal policy function of the firm in the equilibrium under the benchmark calibration of the previous section. Firms choose prices, investment in innovation and deterrence strategies.

The first panel of Figure 5 displays the markups of firm. The relevant idiosyncratic state variable here is the rank of the firm in the distribution or equivalently their distance from the market leader of that industry. Since firms are competing in an oligopolistic setup they internalise the effect of the markup they set on the sector level price as in Atkeson and Burstein (2008) and Grassi (2017). Firms higher on the productivity ladder, have higher sales share and this translates into having higher markups as in equation (9). The second panel shows the prices defined over a given productivity space. Unlike the markups, the position of the firm on the productivity ladder is not enough to pin down prices and the marginal cost itself matters. Marginal cost falls over time (through entry and innovation) and prices are accordingly affected.

The third panel of Figure 5 plots the expected innovation decision of firms.[41] Firms closer to the market leader invest more in innovation compared to firms that are lagged behind. Below, in subsection 7.2, I discuss in more details how innovation incentives of

[41] Decision over innovation happens after the signal for entry is observed, therefore it is also a function of entry signal. To simplify the presentation, the graph shows the expected value of innovation over all signals.

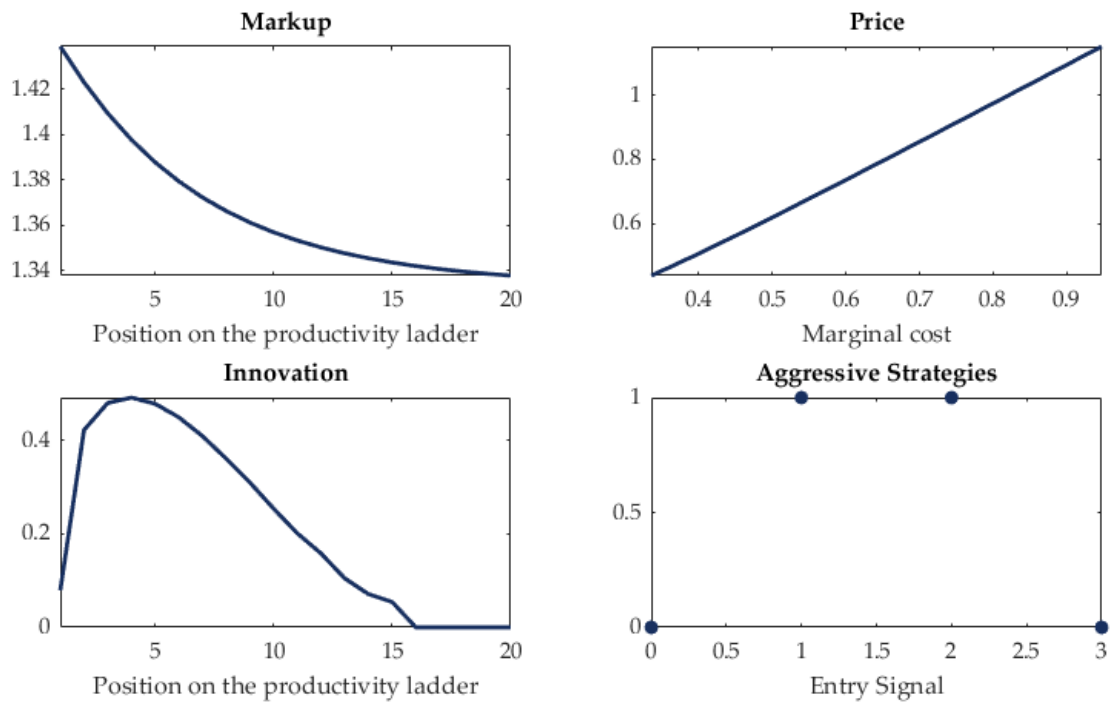


Figure 5: Policy Functions

Position on the productivity ladder indicates the rank of the firm, therefore, 1 refers to the market leader and higher values are the followers.

firms interact with aggressive strategies. The fourth panel of Figure 5 shows incumbents' aggressive strategies in response to given signals for entry. The x-axis depicts the signal for entry and is an indication of the relative productivity of entrants with respect to incumbent. For example, value 2 on the x-axis suggests that entrants attach a non-zero probability to receiving signals which are (at most) two steps above the leader of the industry. Therefore, higher signals for the productivity of the entrant increase the expected value of entrants. The y-axis shows whether firms decide to act aggressively towards entrants in response to the entry signal. Aggressive strategies take values $\{0, 1\}$, where 1 indicates firms deciding to deter entry and 0 suggests that firms do not find it optimal to react. If firms decide to act aggressively, they have to forego a fraction of their profits as equation (16).

As in can be observed from Figure 5 aggressive strategies happen in response to signal 2 and 3 while incumbents do not react to other entry signals. Choosing $D = 0$ can happen for two distinct reasons. First, if there is a low draw for the entrants, incumbents do not perceive entrants to be a threat and will optimally decide not to react. Second, if entrants have a very high draw for their productivity signal, to prevent entry, incumbents have to part with a larger share of their profits in order to create sufficient amount of barriers. However, sacrificing such a large fraction may either be too costly for the firm itself, such that it does not satisfy the incentive compatibility constraint, or not allowed within the antitrust policy, therefore not satisfying the antitrust condition as 17.

Table 4: Counterfactual analysis: Moments

	Baseline estimation	**Counterfactual**	**Counterfactual**
	$\psi_{cl} = 1$	$\psi_{cl} = 0.6$	$\psi_{cl} = 0$
Entry rate	0.08	0.13	0.16
Fixed cost over total cost	0.21	0.25	0.27
RD Expenditure over sales	0.039	0.015	0.01
Average Markup	1.37	1.36	1.35
Entrants employment share	0.046	0.08	0.09
Productivity growth	0.012	0.017	0.02
Profit share of total income	0.13	0.09	0.049

7.2. Counterfactual Scenario: Strengthening Antitrust Law

In this section, using the parameter values from the baseline calibration, I vary the antitrust policy parameter to reflect stricter antitrust policy regimes. Recall that under the baseline scenario, the "profit-sacrifice test" of the antitrust authority required firms to make a loss for the conduct to be considered anticompetitive. In the counterfactual scenarios, I consider an intermediate case, and an extreme case in which any profit sacrifice and deviation from the short run profits is considered anticompetitive and illegal. Table 4 presents the results of the counterfactual scenarios, with the second column including the baseline calibration under lax policies, the third column showing the intermediate case, and the final column reporting the results under very strict antitrust policies.

In both counterfactual exercises firms' ability to engage in strategic and aggressive actions decreases as the antitrust authority takes a tougher stance on the profit-sacrifice test. In response to antitrust law becoming stronger, entry rate increases from 8 percent to 13 and 16 percent under the intermediate and extreme case respectively.

Next, it can be observed that the measure of innovation captured by the weighted average of R&D expenditure over sales falls from 3.9 percentage points under the baseline scenario to 1.5 and 1 percentage points. To offer a breakdown of the contribution of each firm to the aggregate measure of innovation, the first panel of Figure 6 plots the expected innovation[42] of firms as a function of their position on the productivity ladder. It can be observed that firms do not act uniformly in response to strengthening of antitrust policies, as some increase their investment in innovations while others do the opposite.

In particular, in determining the response of incumbents' investment in innovation

[42]Firms decide on investment in innovation after observing the signal for entry, this graphs takes the expected value of innovation under all signals.

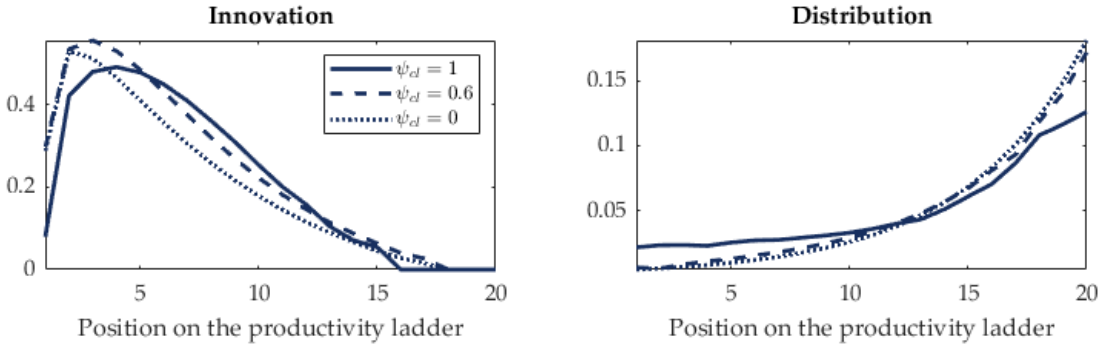


Figure 6: Innovation and Distribution

Position on the productivity ladder indicates the rank of the firm, therefore, 1 refers to the market leader and higher values are the followers.

to the changes in antitrust policy, there are two opposing forces at play. First, under lax policies, incumbents are able to act more strategically and aggressively, in turn increasing their lifetime value. Higher lifetime value encourages incumbents to increase their investment in innovation. Second, more aggressive strategies under lax policies protect incumbents against external competition from entrants, thus lowering incumbents' incentive to innovate. These two forces are similar to the Arrow replacement effect and the Schumpeter effect discussed by the literature.[43]

As illustrated in the first panel of Figure 6 the dominating force in determining innovation is different among incumbents, and some incumbents increase their innovation efforts while others do the opposite. Further, based on the innovation decision of incumbents alone on the first panel of Figure 6 it is not clear that the aggregate innovation would decline in response to strengthening antitrust policies. The aggregate innovation measure, therefore, depends on the share of incumbents increasing their innovation in equilibrium. The second panel of Figure 6 illustrates the firms' distribution under each antitrust regime and shows that there are fewer high innovation incumbents under strong antitrust policies. The endogenous distribution of firms in the equilibrium is one contributing factor for the lower aggregate innovation under stronger antitrust policies. In fact, if the firms' distribution under lax antitrust is applied to the innovation policy function under intermediate antitrust, the measure of aggregate innovation becomes 4.2 percentage point, more than the estimated value under the baseline calibration. Further, in this set up it would not be possible to discuss the inverted U shape relationship of concentration and innovation of Aghion et al. (2001), as concentration remains high under all antitrust regimes.

Another outcome of interest is the response of productivity growth to changes in

[43] The Arrow replacement effect argues that more competition fosters innovation, and the Schumpeter effect argues that high monopolistic profits incentivise more innovation. In this model, similar to the replacement effect, higher entry creates more competition, not by lowering concentration levels, but by increasing turnover, replacing market leaders and pushing less productive firms out of the market. Similar to the Schumpeter effect, less competition from lower entry, increases lifetime value of the firms (by increasing their probability of survival), thus encouraging more innovation.

antitrust law. As shown in Table 4, productivity growth increases from 1.2 percentage points in the baseline model to 1.7 and 2 percentage points in the intermediate and extreme case respectively. The results in the final column of Table 4 require the antitrust authority to detect all aggressive strategies and profit sacrifices, and thus should be interpreted as an upper bound on the effect of antitrust law. Note that productivity growth itself, is a combination of innovation efforts of firms and the contribution of net entry. Therefore, while innovation falls with stronger antitrust policies, net entry is able to drive a higher growth rate because entrants may be more productive than incumbents.

In addition to higher entry rate and productivity growth, Table 4 suggests that stronger antitrust policies lead to a more dynamic economy along other dimensions. It can be observed that the share of employment of young firms (entrants) increases in response to limiting the extend of aggressive strategies, while the profit share of total income falls. Since the only factor of production in the model is labour, the results point to a higher share of labour in national income. It is worth noting that markups remain relatively high under the strict antitrust law case. Therefore, antitrust policies can be used to promote business dynamism by limiting firm anticompetitive conduct, even before applying policies directly aimed at lowering firms' markups.

7.3. Welfare Implications of Antitrust Law

This section presents the welfare costs of lax antitrust policies and its distributional implications. Total welfare is measured in terms of present value of consumption where $U(C_t) = C_t$, and is then decomposed into the welfare of worker and the welfare of the capitalist. To decompose, I assume workers take home the wage part of the total income, while the capitalists consume the earnings from capital and profits. Since the model features only one factor of production (labour), I adjust the wage income by factor $\alpha = 2/3$ to correct for the share of capital. Welfare of worker is defined as: $V_w = \sum_{t=0}^{\infty} \beta^t \frac{\alpha w}{P_t}$ where w is the wage and P_t is the aggregate price at time t. Welfare of capitalist is defined as $V_c = \sum_{t=0}^{\infty} \beta^t \frac{(1-\alpha)w + \pi}{P_t}$ with π denoting profits.

Table 5 shows the welfare gains in response to strengthening antitrust policies. In Panel A a shift from the baseline model to the case with no anticompetitive conduct, leads to 16% improvement in total welfare. As Panel A rules out all aggressive strategies, the numbers should be taken as an upper bound on the effect of antitrust policies. The remaining parts of the panel indicate that workers benefit more from strengthening antitrust policies with their lifetime value of consumption increasing by 28%. Capitalists, on the other hand, remain unaffected. In Panel B there is a strengthening of antitrust law to an intermediate level and firm are still able to act strategically though to a lesser extent compared to the baseline scenario. The gains are smaller compared to the previous

Table 5: The Change in Relative Welfare in Response to Strengthening Antitrust Policies

	Welfare Present value of Consumption	Consumption (immediate)	Consumption (after 50 years)	Break even year
Panel A				
Total	0.16	-0.15	0.25	23
Workers	0.28	-0.06	0.37	10
Capitalists	0.00	-0.27	0.07	41
Panel B				
Total	0.06	-0.12	0.12	28
Workers	0.12	-0.06	0.19	16
Capitalists	-0.03	-0.20	0.02	46

Panel A indicates change in welfare in consumption equivalent terms as a result of moving from the baseline model to the case where no anticompetitive practices are allowed. Panel B indicates an intermediate level, with strengthening antitrust policies relative to the baseline model.

exercise with total welfare increasing by 6%.

The increase in welfare under both cases is due to higher growth under more stringent antitrust policies. The distributional differences can be explained by the increase in wage and fall in profit rates as competition policies become stronger.

Table 5 contains the welfare results, and the response of consumption decomposed for the workers and capitalists and Figure 7 plots the response of consumption over time. In particular, these functions depict relative changes in consumption under a strict(er) antitrust regime relative to consumption under the benchmark case:

$$\mathcal{C}_T = \frac{C_{strict}}{C_{lax}}$$

Additionally Figure 7 plots changes in consumption of workers and capitalists as antitrust regime changes. More specifically these functions are presented as:

$$\mathcal{C}_w = \frac{C_{w,strict}}{C_{w,lax}}, \qquad \mathcal{C}_c = \frac{C_{c,strict}}{C_{c,lax}}$$

where C shows consumption, subscript w and c indicates workers and capitalists respectively. Given the above definitions, any value greater than one presents an improvement in consumption. As it can be observed from Figure 7 there is an immediate drop in all three measures in response to strengthening antitrust policies, indicating a short- and medium- run decline in consumption. This trend, however, is reversed in the long run, showing significant improvements in total consumption and the consumption of worker.

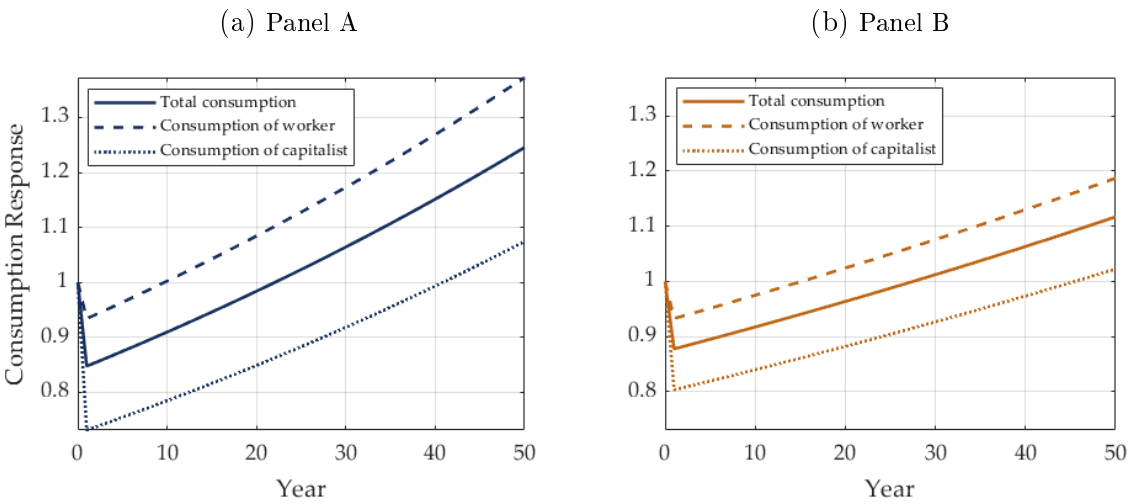


Figure 7: Consumption

Panel A indicates change in consumption as a result of moving from the baseline model to the case where no anticompetitive practices are allowed. Panel B indicates an intermediate level, with strengthening antitrust policies relative to the baseline model.

The initial drop in consumption in response to strengthening antitrust policies is due to reallocation of labour from production to the setting up of new firms. Recall from section 5 that labour is supplied inelastically and is used for setting up a new firm, innovation, and production. Under lax antitrust law, aggressive strategies mean entry rate is lower, and thus the fraction of labour allocated to setting up a new firm is instead used for production and innovation. Despite the higher rate of productivity growth, in the short run, the reallocation of labour leads to a fall in total output.

Similar reasoning exists for $\mathcal{C}_w$, but now the higher rate of growth is combined with higher wage, thus leading to a weaker immediate decline and higher rate of consumption growth. As for capitalists, the immediate drop in their share of total income is large enough to require a much longer horizon for consumption to return to its previous levels. Figure 23 depicts development of consumption in a longer horizon.

The results of this section suggest that when analysing the effect of antitrust policies, besides the dynamic considerations of consumer welfare standards, there are distributional and general equilibrium effects, captured by wages and prices, that should be considered. While the overall improvements to welfare are due to increase in the rate of productivity growth, strengthening antitrust policies would have unequal effect on workers vs. capital owners.

A short discussion on inequality- The relationship between market power, antitrust law and inequality has been widely discussed in the past few years (Baker and Salop, 2015; Stiglitz, 2017; Zingales, 2017). In the context of this paper, higher market power leads to more barriers to entry, thereby increasing the value of incumbents at the expense of

(potential) entrants. Further, greater barriers to entry lead to the concentration of profits in the hands of a few firms, reducing the share of the population that can enjoy such high gains. In this section, I provide some rough calculations, to illustrate the effectiveness of stronger antitrust policies in addressing inequality.

The measure of inequality used for the analysis is P90-P10 ratio, indicating the relative real income of the 90th percentile to the 10th percentile of wealth distribution. Based on Cagetti and De Nardi (2006), Lee (2019) roughly 10% of population in the US are entrepreneurs and 90% are dependent on wage income. To get an estimate of the P90-P10 ratio, I assume that the bottom 90% of wealth distribution are all workers and the source of their income is from wage, while the top 10% are all entrepreneurs. I then calculate the present discounted value of consumption of workers and capitalists under the three antitrust regimes and correct for their relative shares in the population to get consumption per worker and consumption per capitalist. The value of consumption per worker under the benchmark case is normalised to one, and the results are reported in Table 6.

Under the benchmark case, P90-P10 ratio is 6.69, indicating that the capitalists or equivalently the 90th percentile, consume roughly 6.7 times more than the workers.[44] The actual value estimated by the OECD for the US population is 6.2.[45] The estimated value from the model, therefore, appears to be sufficiently close to its data counterpart.

These simple calculations show that strengthening antitrust policies to an intermediate and a very strict case lowers the measure of inequality by 14% and 22% respectively. In both cases the effect on the consumption per capitalist seems to be marginal (or non-existent) and the improvement in the inequality measure happens through an increase in consumption per worker.

Table 6: The effect of antitrust law on inequality

	Benchmark	Intermediate	Strict
	$\psi_{cl} = 1$	$\psi_{cl} = 0.6$	$\psi_{cl} = 0$
Consumption per worker	1	1.12	1.28
Consumption per capitalist	6.69	6.45	6.69
P90-P10 ratio	6.69	5.76	5.23

The objective of this exercise is to illustrate that antitrust policies, whether lax or strong, can have implications for inequality in the economy. Otherwise, it would be premature to draw conclusions solely based on the estimates of this section.

[44] A more conservative estimate, assuming 14% of population are entrepreneurs is provided in Table 30 in the appendix. 14% is the highest share of entrepreneurs in the US based on Lee (2019).

[45] See https://data.oecd.org/inequality/income-inequality.htm

8. Conclusion

A recent literature has documented a decline in business dynamism in the past few decades. At the same time enforcement of antitrust in the US has been at historically low levels. This paper develops a structural model and studies the role of antitrust law as a macroeconomic policy in improving business dynamism and its impact on welfare.

The first part of the paper finds empirical evidence on the relationship between antitrust enforcement and business dynamism. Using Compustat database combined with the BDS and the BLS datasets for the US, I find that strengthening antitrust policies is associated with an increase in rates of productivity growth and entry in sectors with a higher level of concentration. However, the results for investment in innovation move in the opposite direction. Similar results are found for Europe using the CompNet and Orbis database.

The paper then develops a dynamic general equilibrium model with oligopolistic competition in each sector, in which firms can invest in innovation and act anticompetitively towards entrants in order to increase their lifetime value. The model features an antitrust authority monitoring the decision of firms and constraining the extent to which firms can eliminate their competitors. The model is structurally estimated to match the US data on various dimensions of business dynamism such as entry rate, markups, share of young firms in employment, among other moments between 2000-2010. In this regard, the framework takes a different approach from the literature that focused on analysing firms' anticompetitive behaviour and antitrust law in partial equilibrium and narrow markets, and instead investigates the macroeconomic and distributional implications of firms' strategic behaviour.

Using the estimated model, the paper considers counterfactual scenarios in which antitrust law becomes stronger. The results point out to a significant increase in the rate of productivity growth through higher entry in response to a tightening of antitrust policies. In particular, under the strictest case of antitrust with no tolerance for aggressive strategies, productivity growth increases by 0.8 percentage points relative to the benchmark calibration. Further, there is an increase in the labour share of total income and employment share of young firms (entrants). It is worth noting that the change in antitrust policies in this framework and under the baseline calibration has a limited impact on firms' market power. Therefore, there is scope for antitrust policies in generating a more dynamic economy even when high concentration and high market power are inherent to the structure of the market.

An important insight of this paper is to study the welfare implications of stronger antitrust policies. An antitrust law that is able to rule out all anticompetitive practices

improve welfare by 16% in the model, where welfare is defined in terms of net present value of consumption. This number should be interpreted as an upper bound to the effectiveness of antitrust policies as it relies on the ability of antitrust authority to rule out all anticompetitive practices. Further, this paper takes a first look at the distributional implications of strengthening antitrust policies and finds that those dependent on the labour income benefit relatively more from strengthening antitrust law. The literature has been debating the effect of monopolies on income inequality and their interaction with antitrust law (Baker and Salop, 2015; Stiglitz, 2017; Zingales, 2017). The findings of this paper suggest that antitrust policies will have a distributional impact and can potentially be used in addressing inequality. More studies with frameworks suited in answering such questions are required to shed light on the role of antitrust in reducing inequality.

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Appendix

In this section, I provide description of the data, regression tables and robustness checks.

Data Sources and Sample Description

This section discusses data sources used in the main part of the paper for the US and Europe.

US

The main data sources used for the US are Compustat database, Business Dynamic Statistics, Bureau of Labour Statistics, data from the US Census website, and the DoJ website. In the main analysis where I use Compustat, I exclude firms with negative sales, cost of goods sold and total assets from the calculations. I exclude unclassified sectors, utilities, finance and real estates. As mentioned in the data section, the sample for the U.S is from 1978-2018 (inclusive) for the explanatory variables where data on these years is available. While looking into the dynamic responses, where possible I use future values of dependent variables to get better estimates. Share of entrants and growth rates for manufacturing are trimmed at top/bottom 5%. For R&D expenditure I do both a firm-level regression and a sector-level regression in which firm-level R&D expenditure share is aggregated to a 4-digit sector level weighted by firms' sale share. In all analysis, standard errors are clustered at sector-year level unless otherwise stated.

Turnover of Market Leaders

To investigate turnover rate, using Compustat data, I rank firms in each 4-digit NAICS sector based on their sales share. Figure 8 shows the average number of years a given firm has been among the top 8 firms over the next 10 years. Therefore if a given firm is always ranked above 8[46], the value recorded for years at the top will be zero. This means results reported in Figure 8 will depend on the composition of firms, as an increase in the number of publicly traded firms would affect the average. To correct for the size of the market, I consider only the sample of firms that have been among the top 8 firms of their respective sector for at least one year and report the results in Figure 8. Both figures point to an increase in the average number of years firms remain in the leading position since the 1990s, and thus they show lower turnover among top firms.

[46]The analysis is robust to other cutoffs. Top 8 firms capture concentration ratio CR8.

(a) Turnover, all firms

(b) Turnover, top 8 firms

Figure 8: Turnover rates

Antitrust Enforcement Budget USA

The measure of strictness of antitrust for the US is the relative share of enforcement budget allocated to the Antitrust Division of the Department of Justice (DoJ) is obtained from the DoJ website as discussed before. The budget is then divided by GDP trend to become a stationary variable. I consider GDP trend rather than GDP to ensure cyclicalities that exist in GDP are not driving the result.

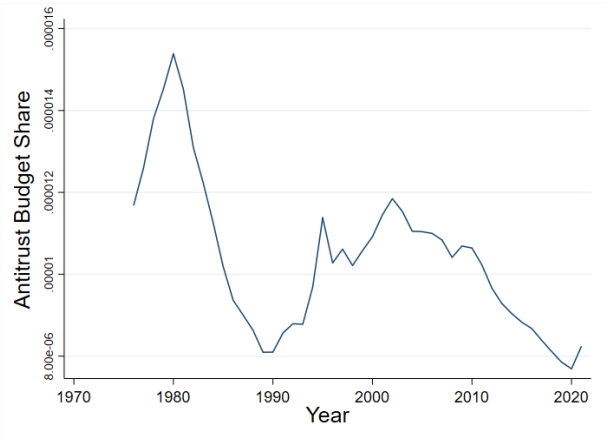


Figure 9: Antitrust Enforcement Budget over GDP Trend

Europe

The main sources of data for Europe are the Comparative Competition Law database, CompNet database and Orbis. More details are provided below.

Competition Law Index- This part contains information on development of the Competition Law index across European countries, as well as maps visualising the budget available for each country.

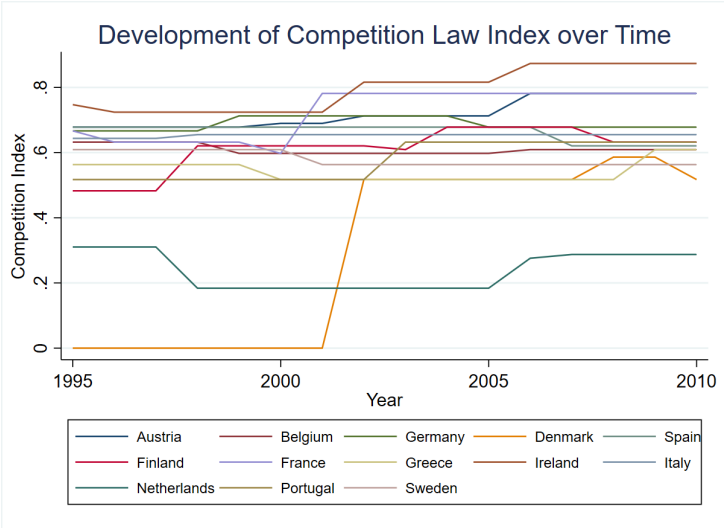


Figure 10: Source: Comparative Competition Law Dataset

Figures 20 and 21 and 22 depict the Competition Law Index for year 2010 for the world and for Europe respectively. Figure 22 shows the Enforcement budget for Europe in 2010, the final year the data is provided.

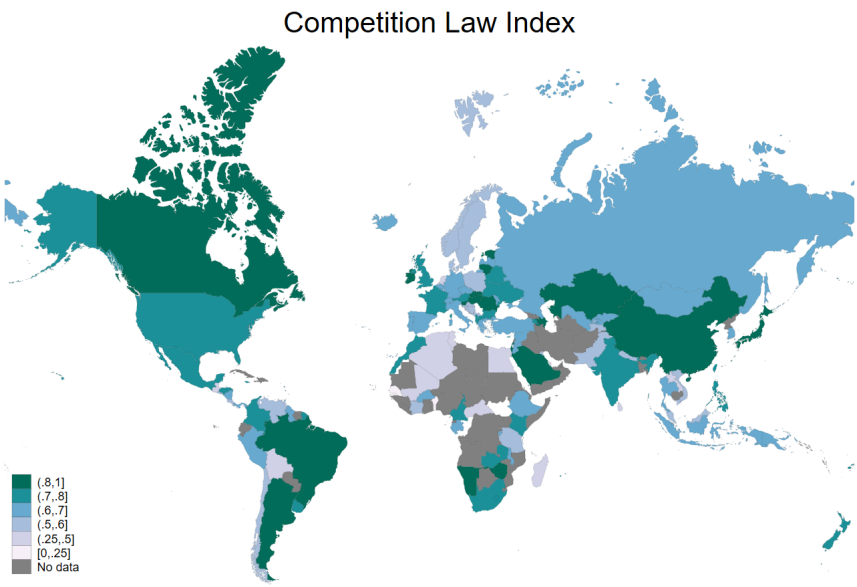


Figure 11: Competition Law Index for all countries in 2010

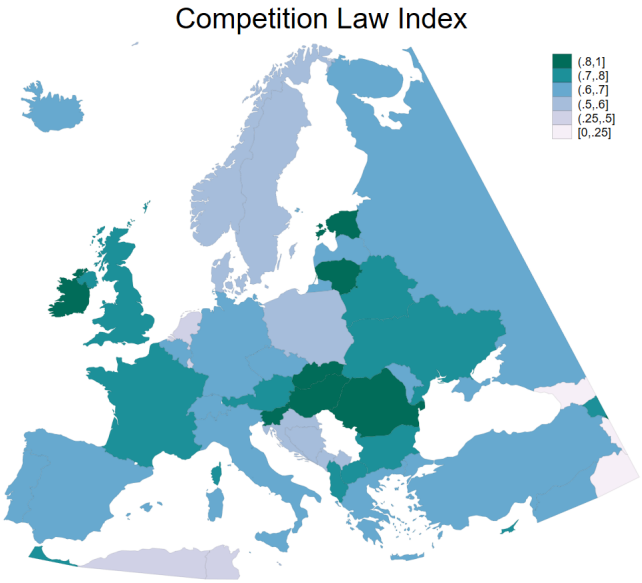


Figure 12: Competition Law Index for European countries in 2010

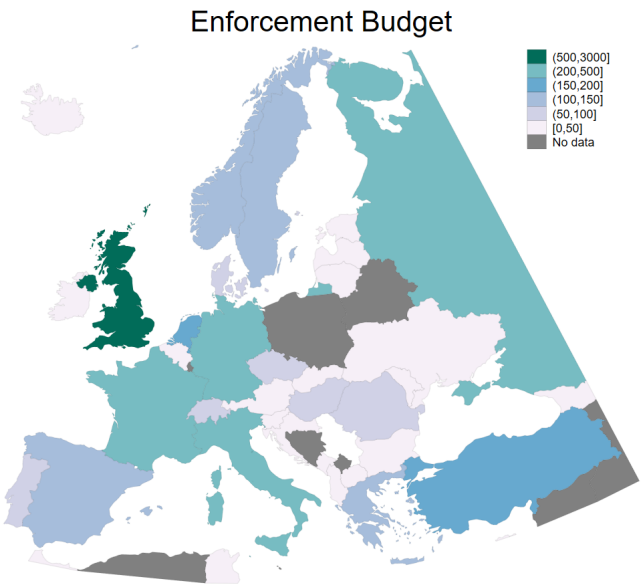


Figure 13: Enforcement Budget for European countries in 2010

CompNet- I use the 7th vintage of CompNet database. Countries included are listed in table 7. The TFP variables used are:

- PE21_lntfp_rcd_in_ols_S_mn: Logarithm of the total factor productivity, derived from OLS estimation of revenue-based Cobb-Douglas production function with

intangibles

- PE23_lntfp_rcd_ols_S_mn: Logarithm of the total factor productivity, derived from OLS estimation of revenue-based Cobb-Douglas production function
- PE25_lntfp_rcd_wd_S_mn: Logarithm of the total factor productivity, derived from Wooldridge estimation of revenue-based Cobb-Douglas production function
- PE27_lntfp_rtl_ols_S_mn: Logarithm of the total factor productivity, derived from OLS estimation of revenue-based translog production function
- PE29_lntfp_rtl_vi_ols_S_mn: Logarithm of the total factor productivity, derived from OLS estimation of revenue-based translog production function with variable inputs
- PE31_lntfp_rtl_vi_wd_S_mn: Logarithm of the total factor productivity, derived from Wooldridge estimation of revenue-based translog production function with variable inputs
- PE33_lntfp_rtl_wd_S_mn: Logarithm of the total factor productivity, derived from Wooldridge estimation of revenue-based translog production function
- PE35_lntfp_vcd_ols_S_mn: Logarithm of the total factor productivity, derived from OLS estimation of value-added based Cobb-Douglas production function
- PE37_lntfp_vcd_wd_S_mn: Logarithm of the total factor productivity, derived from Wooldridge estimation of value-added based Cobb-Douglas production function. All estimations are at the sectoral level

Measure of concentration used is:

- CV07_hhi_rev_sam_S_tot: Hirschman-Herfindahl index of market concentration at the sector level based on the firm sample
- CV03_hhi_rev_pop_S_tot: Hirschman-Herfindahl index of market concentration at the sector level based on the firm population

For robustness check I also use the second measure, but I decide the former variable for the main analysis as it has better coverage. Results are robust to dropping one country at a time, and trimming the growth variable at top/bottom 5%. The Competition Law Index is available only up to 2010, however the growth variables are available until 2018. I use the values beyond 2010 for the dynamic responses when available.

Orbis- List of countries and years of coverage are included in table 8. Share of entrants are trimmed at top/bottom 5%. Industries where sale information is missing for more than 60% of firms are excluded. Results are robust to making this cutoff stricter. Results are robust to dropping one country at a time. Robust standard errors are used. Analysis

Table 7: Summary Statistics: CompNet

Country	Coverage	Average HHI
Belgium	2003-2017	.10
Denmark	2000-2016	.07
Finland	1999-2017	.08
France	2004-2016	.03
Germany	2001-2017	.06
Italy	2006-2016	.04
Netherlands	2007-2017	.08
Portugal	2004-2017	.06
Spain	2008-2017	.06
Sweden	2003-2016	.07

in done from 2000-2016, where available future values of entrants are used when iterating forward to understand the dynamic responses. Note that the competition law index is available only until 2010 and therefore the averages presented in table 8 reflect this period. As literature has discussed Orbis has better coverage of large firms and small and young firms are under-represented. For the analysis of this paper, the results remain valid as long as they are not driven by changes in the coverage. This is ensured by following Bajgar et al. (2020).

Table 8: Summary Statistics: Orbis and CLI

Country	Coverage	Average HHI	Average share of entrant	Average CL index
Austria	2000-2016	.38	.059	.70
Belgium	2000-2016	.31	.021	.61
Finland	2000-2016	.31	.040	.62
France	2000-2016	.20	.023	.72
Germany	2000-2016	.32	.041	.70
Greece	2000-2016	.32	.046	.54
Italy	2000-2016	.18	.046	.65
Netherlands	2000-2016	.47	.064	.23
Portugal	2000-2016	.25	.062	.59
Spain	2000-2016	.16	.035	.66
Sweden	2000-2016	.29	.023	.57

Detailed Specifications and Regression Tables

Similar to before, I discuss the case of the US and Europe.

US

This section provides more details on the specification used for the US. For productivity growth the regression is defined as below:

$$\frac{mfp_{s,t+h} - mfp_{s,t+h-1}}{mfp_{s,t+h-1}} = \delta_t + \delta_s + \beta_1 budget_t \times HHI_{s,t} + \beta_2 HHI_{s,t} + \beta_3 budget_t + \epsilon_{s,t} \quad (19)$$

$mfp_{s,t+h}$ shows multifactor productivity in sector s and time $t+h$. Data comes from BLS for the manufacturing sector at 4-digit industry level from 1987-2018.

For Entry data comes from the BDS database for all industries at a 4-digit level between 1978-2018. Data from BDS are also available for 3-digit industry level. The results are robust to using both values.

$$Ent_{s,t+h} = \delta_t + \delta_s + \beta_1 budget_t \times HHI_{s,t} + \beta_2 HHI_{s,t} + \beta_3 budget_t + \epsilon_{s,t} \quad (20)$$

Measure of investment in innovation is relative share of R&D expenditure to the sales of the firm. The analysis is done at two levels. The main specification uses firm level values for the relative share of R&D expenditure in the analysis and the standard errors are clustered at firm and year level. The main analysis is written as:

$$RD_{i,t+h} = \delta_t + \delta_i + \beta_1 budget_t \times HHI_{i,t} + \beta_2 HHI_{i,t} + \beta_3 budget_t + \epsilon_{i,t} \quad (21)$$

Result Tables: US

To make results comparable to other regressions, I also aggregate the measure of innovation to 4-digit sector level. For the aggregation I use two robustness checks. 1) A weighted average of R&D expenditure to the sales weighted by each firms' sale share. 2) Average of R&D expenditure to the sales of market leaders:

$$RD_{s,t+h} = \delta_t + \delta_s + \beta_1 budget_t \times HHI_{s,t} + \beta_2 HHI_{s,t} + \beta_3 budget_t + \epsilon_{s,t} \quad (22)$$

Table 9: Growth Rates

Productivity Growth - Manufacturing - USA						
	(0)	(1)	(2)	(3)	(4)	(5)
HHI × budget	3416.78	6717.44**	7144.04**	5111.25*	5283.95*	2553.77
	(2799.19)	(2897.01)	(3061.17)	(3057.28)	(3039.12)	(2866.20)
budget						
HHI	-0.03	-0.07**	-0.07**	-0.05*	-0.06*	-0.03
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
cons	0.01***	0.01***	0.00***	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	2165	2177	2180	2184	2198	2201

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
HHI is the Herfindahl index, budget is share of budget in GDP trend.
Column h is the response of dependent variable at $t + h$.

Table 10: Entry - USA

Share of Entrants						
	(0)	(1)	(2)	(3)	(4)	(5)
HHI × budget	1377.80*	1566.18**	1824.03**	1150.05*	1282.75*	667.27
	(776.81)	(708.25)	(719.19)	(654.64)	(676.52)	(634.59)
budget						
HHI	-0.00	-0.01	-0.01	-0.00	-0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
cons	0.09***	0.09***	0.09***	0.09***	0.09***	0.08***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	7765	7748	7727	7545	7363	7175

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
HHI is the Herfindahl index, budget is share of budget in GDP trend.
Column h is the response of dependent variable at $t + h$.

Europe

The specification for productivity growth for Europe uses information from the CompNet data base:

$$y_{c,s,t+h} - y_{c,s,t-1} = \delta_{c,t} + \delta_{c,s} + \beta_1 CL_{c,t} \times HHI_{c,s,t} + \beta_2 HHI_{c,s,t} + \beta_3 CL_{c,t} + \epsilon_{c,s,t} \quad (23)$$

Table 11: Entry - USA - Sample from 1985 to 2018

Share of Entrants						
	(0)	(1)	(2)	(3)	(4)	(5)
HHI × budget	2530.00**	3589.13***	2019.86*	2056.22*	2188.99**	1505.60
	(1002.38)	(1223.16)	(1126.07)	(1078.96)	(1057.87)	(1081.37)
budget						
HHI	-0.02**	-0.03***	-0.02	-0.02	-0.02*	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
cons	0.08***	0.08***	0.08***	0.08***	0.08***	0.08***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	6558	6384	6210	6028	5846	5658

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

HHI is the Herfindahl index, budget is share of budget in GDP trend.

Column h is the response of dependent variable at $t + h$.

Table 12: R&D Expenditure - All Firms

R&D Expenditure - All Firms					
	(0)	(1)	(2)	(3)	(4)
HHI × budget	-740.04	-1639.76**	-1339.31*	-1041.84	-426.58
	(643.70)	(623.68)	(648.02)	(632.28)	(630.58)
budget					
HHI	0.01	0.02**	0.02*	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
cons	0.07***	0.07***	0.07***	0.07***	0.07***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
N	117952	109919	102435	95014	86840

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

HHI is the Herfindahl index, budget is share of budget in GDP trend.

Column h is the response of dependent variable at $t + h$.

Table 13: R&D Expenditure - All Firms

R&D Expenditure - All Firms Aggregated to NAICS-4 Level					
	(0)	(1)	(2)	(3)	(4)
HHI × budget	-3793.48**	-3074.07*	-2635.67	-840.97	-283.56
	(1386.20)	(1458.37)	(1628.61)	(1481.78)	(1496.27)
budget					
HHI	0.06***	0.05**	0.04*	0.02	0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
cons	0.02***	0.02***	0.02***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Industry FE	Yes	Yes	Yes	Yes	Yes
Sector-Year FE	Yes	Yes	Yes	Yes	Yes
N	8507	8425	8206	7993	7775

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
HHI is the Herfindahl index, budget is share of budget in GDP trend.
Column h is the response of dependent variable at $t + h$.

Table 14: R&D Expenditure - All Firms

R&D Expenditure - Average of Top 8 Firms Aggregated to NAICS-4 Level					
	(0)	(1)	(2)	(3)	(4)
HHI × budget	-5698.91***	-4765.04**	-4149.63*	-2076.16	-1253.83
	(1476.44)	(1560.50)	(1704.40)	(1573.27)	(1557.96)
budget					
HHI	0.08***	0.07***	0.06**	0.03*	0.03
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
cons	0.02***	0.02***	0.02***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Industry FE	Yes	Yes	Yes	Yes	Yes
Sector-Year FE	Yes	Yes	Yes	Yes	Yes
N	8101	8019	7805	7600	7384

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
HHI is the Herfindahl index, budget is share of budget in GDP trend.
Column h is the response of dependent variable at $t + h$.

Variables are defined in the first part of this appendix. Tables 15 to 23 respond to the results of this section. Figure 15 corresponds to a 10% improvement in the index, when all variables are evaluated at their mean.[47] The contemporaneous outcome of growth in response to a 10% increase in the index is roughly 0.2 to 0.4 percentage point improve-

[47] The average CLI and HHI are 0.6 and 0.057 respectively.

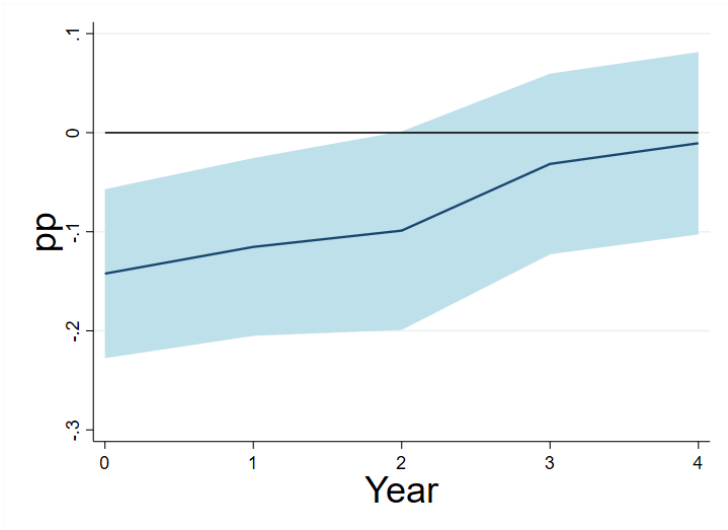


Figure 14: Average industry R&D expenditure share response

ment in the growth rate of productivity, depending on the specification for the production technology. In most specifications, this correlation increases after one year and becomes relatively stable from year three. This relationship seems to be persistent at least for up to 5 years.

Data for entry is obtained from the Orbis database:

$$Ent_{c,s,t+h} = \delta_{c,t} + \delta_{c,s} + \beta_1 CL_{c,t} \times HHI_{c,s,t} + \beta_2 HHI_{c,s,t} + \beta_3 CL_{c,t} + \epsilon_{c,s,t} \tag{24}$$

The main results use the HHI index, however as robustness check, sales share of top 8 firms is used as another measure of concentration. Results remain robust.

Result Tables: EU

This section includes the regression tables for the analysis of Europe. CompNet database provides nine different measure of productivity based on assuming different production functions and estimating them. I use all measures available and investigate the implications of improving the measure of antitrust (competition policy). Next, to investigate the response of entry, I use the Orbis database and tables 24 and 25 refer to these results.

The result presented here are different from the analysis on the US, where the correlation while positive and significant, was temporary. To investigate whether this more persistent correlation is due to differences between Europe and the US or differences between budget and law, I run the same regression for Europe while including the interaction between concentration and budget as a share of GDP. The results are shown in Figure 16 and Figure 17, presenting the coefficient on the interaction of concentration with law

Table 15: Growth (1)

Log of the TFP, from OLS estimation of revenue-based Cobb-Douglas production function with intangibles									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
HHI × CLI	0.38***	0.70***	0.61**	1.05***	1.18***	1.25***	1.42***	1.17**	0.80***
	(0.06)	(0.13)	(0.24)	(0.23)	(0.13)	(0.14)	(0.18)	(0.37)	(0.23)
CLI									
HHI	-0.12***	-0.31***	-0.21***	-0.58***	-0.64***	-0.73***	-0.70***	-0.56*	-0.35**
	(0.03)	(0.08)	(0.06)	(0.08)	(0.14)	(0.15)	(0.12)	(0.30)	(0.12)
cons	-0.01***	-0.00	-0.00	0.01	0.01	0.01*	0.01*	0.02	0.02
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Country year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	2096	2092	2091	2089	2088	2087	2090	1882	1511

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

HHI is the Herfindahl index, CLI is the competition law index. Column h is the response of dependent variable at $t + h$.

Table 16: Growth (2)

Log of the TFP, from OLS estimation of revenue-based Cobb-Douglas production function									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
HHI × CLI	0.62**	1.00***	0.99***	1.26***	1.19***	1.32***	1.02***	0.98***	0.73***
	(0.22)	(0.24)	(0.22)	(0.16)	(0.20)	(0.15)	(0.23)	(0.25)	(0.11)
CLI									
HHI	-0.20	-0.40*	-0.51***	-0.67***	-0.64***	-0.75***	-0.62***	-0.56***	-0.48***
	(0.18)	(0.18)	(0.10)	(0.08)	(0.10)	(0.11)	(0.13)	(0.15)	(0.11)
cons	-0.01	-0.01	0.00	0.01	0.01	0.01	0.02**	0.02	0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Country year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	2794	2792	2791	2786	2787	2785	2784	2540	2054

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

HHI is the Herfindahl index, CLI is the competition law index. Column h is the response of dependent variable at $t + h$.

Table 17: Growth (3)

Log of the TFP, from Wooldridge estimation of revenue-based Cobb-Douglas production function									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
HHI × CLI	0.53**	0.80**	0.37***	0.94***	0.77***	1.27***	0.76***	0.76***	0.47***
	(0.18)	(0.33)	(0.09)	(0.21)	(0.14)	(0.15)	(0.13)	(0.18)	(0.11)
CLI									
HHI	-0.25	-0.37	-0.33*	-0.69***	-0.65***	-0.97***	-0.72***	-0.75***	-0.56***
	(0.14)	(0.28)	(0.15)	(0.17)	(0.10)	(0.10)	(0.10)	(0.12)	(0.06)
cons	-0.01	-0.01	0.00	0.00	0.00*	0.01**	0.01	0.01*	0.00
	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Country year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	1972	1972	1971	1971	1970.00	1968	1968	1796	1433

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

HHI is the Herfindahl index, CLI is the competition law index. Column h is the response of dependent variable at $t + h$.

and budget respectively. It seems that budget is associated with a smaller and temporary correlation while results with respect to the antitrust law remain similar to Figure 15. The results suggest that improvements in competition law are associated with larger and more persistent improvements in productivity growth, while increasing resources exhibits

Table 18: Growth (4)

Log of the TFP, from OLS estimation of revenue-based translog production function

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
HHI × CLI	0.60***	1.12***	0.87**	1.41***	1.32***	1.49***	1.20***	1.18***	0.83***
	(0.13)	(0.18)	(0.28)	(0.21)	(0.27)	(0.17)	(0.21)	(0.19)	(0.08)
CLI									
HHI	-0.27**	-0.44***	-0.44**	-0.75***	-0.76***	-0.91***	-0.81***	-0.80***	-0.67***
	(0.09)	(0.13)	(0.15)	(0.09)	(0.14)	(0.12)	(0.09)	(0.11)	(0.09)
cons	-0.01	-0.01	-0.00	0.00	0.00	0.01	0.01***	0.01**	0.02***
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
Country year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	2788	2785	2782	2774	2775	2773	2771	2524	2034

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

HHI is the Herfindahl index, CLI is the competition law index. Column h is the response of dependent variable at $t + h$.

Table 19: Growth (5)

Log of the TFP, OLS estimation of revenue-based translog production function with variable inputs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
HHI × CLI	0.27***	0.75***	0.38*	1.30***	1.30***	1.27***	0.99***	0.78***	0.85***
	(0.05)	(0.10)	(0.20)	(0.17)	(0.20)	(0.15)	(0.12)	(0.14)	(0.04)
CLI									
HHI	-0.20***	-0.40***	-0.15*	-0.66***	-0.66***	-0.65***	-0.53***	-0.39***	-0.58***
	(0.03)	(0.07)	(0.08)	(0.11)	(0.13)	(0.09)	(0.08)	(0.09)	(0.07)
cons	0.00	-0.01	-0.01	-0.01	-0.01	-0.01*	-0.01	-0.01	0.00
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)
Country year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	2786	2784	2784	2780	2779	2776	2776	2535	2048

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

HHI is the Herfindahl index, CLI is the competition law index. Column h is the response of dependent variable at $t + h$.

Table 20: Growth (6)

Log of the TFP, Wooldridge estimation of revenue-based translog production function with variable inputs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
HHI × CLI	0.33***	0.83***	0.39	1.30***	1.49***	1.57***	1.20***	1.30***	1.23***
	(0.04)	(0.15)	(0.36)	(0.24)	(0.23)	(0.23)	(0.26)	(0.29)	(0.31)
CLI									
HHI	-0.25***	-0.49***	-0.22	-0.74***	-0.83***	-0.82***	-0.67***	-0.69***	-0.75***
	(0.04)	(0.10)	(0.14)	(0.09)	(0.10)	(0.08)	(0.10)	(0.09)	(0.07)
cons	0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.00	-0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Country year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	2732	2730	2728	2728	2726	2725	2724	2483	2002

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

HHI is the Herfindahl index, CLI is the competition law index. Column h is the response of dependent variable at $t + h$.

a temporarily improvement. This result, however, requires further investigation.

Table 21: Growth (7)

Log of the TFP, Wooldridge estimation of revenue-based translog production function									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
HHI × CLI	0.93	1.23***	-0.16	0.87**	-0.17	0.54	1.29	1.35**	-0.02
	(0.56)	(0.33)	(0.22)	(0.37)	(0.21)	(0.62)	(0.77)	(0.48)	(0.31)
CLI									
HHI	-0.34	0.08	0.51	-0.56***	-0.26***	-0.37	-0.93*	-0.90	-0.20
	(0.32)	(0.28)	(0.31)	(0.13)	(0.07)	(0.23)	(0.46)	(0.61)	(0.28)
cons	-0.00	-0.03**	-0.01	0.01	0.03***	0.03*	0.04*	0.03	0.03
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.02)	(0.02)	(0.02)
Country year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	2399	2397	2392	2388	2382	2387	2383	2153	1732

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

HHI is the Herfindahl index, CLI is the competition law index. Column h is the response of dependent variable at $t + h$.

Table 22: Growth (8)

Log of the TFP, OLS estimation of value-added based Cobb-Douglas production function									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
HHI × CLI	0.24*	0.89***	0.71**	1.22***	1.25***	1.72***	1.82***	2.55***	1.17***
	(0.11)	(0.23)	(0.28)	(0.29)	(0.33)	(0.31)	(0.30)	(0.33)	(0.26)
CLI									
HHI	-0.04	-0.35**	-0.20	-0.51***	-0.57***	-0.97***	-1.03***	-1.46***	-0.74***
	(0.08)	(0.12)	(0.19)	(0.13)	(0.17)	(0.17)	(0.15)	(0.17)	(0.15)
cons	-0.00	-0.00	0.00	0.01	0.02	0.03**	0.03**	0.03**	0.04**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Country year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	2819	2817	2817	2812	2812	2809	2810	2569	2081

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

HHI is the Herfindahl index, CLI is the competition law index. Column h is the response of dependent variable at $t + h$.

Table 23: Growth (9)

Log of the TFP, Wooldridge estimation of value-added based Cobb-Douglas production function									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
HHI × CLI	0.24	0.85***	0.69***	0.96***	1.13***	1.63***	1.64***	2.46***	1.06***
	(0.30)	(0.24)	(0.16)	(0.21)	(0.28)	(0.27)	(0.34)	(0.37)	(0.16)
CLI									
hhi	-0.09	-0.47**	-0.40*	-0.46***	-0.62***	-1.05***	-1.08***	-1.63***	-0.83***
	(0.23)	(0.14)	(0.20)	(0.05)	(0.17)	(0.14)	(0.13)	(0.14)	(0.04)
cons	-0.00	0.01**	0.02*	0.01	0.02*	0.03***	0.04***	0.04***	0.04***
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Country year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	2769	2767	2766	2759	2758	2755	2754	2513	2028

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

HHI is the Herfindahl index, CLI is the competition law index. Column h is the response of dependent variable at $t + h$.

Table 24: Entry - Orbis

	(0)	(1)	(2)	(3)	(4)	(5)
CR × CLI	0.08***	0.06***	0.05***	0.06***	0.06***	0.0493***
	(0.01)	(0.0071)	(0.00)	(0.00)	(0.00)	(0.0066)
CLI						
Cr	-0.06***	-0.04***	-0.03***	-0.03***	-0.03***	-0.03***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
cons	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Country-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs	75464	75160	75132	75205	75267	75323

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
HHI is the Herfindahl index, CLI is the competition law index.
Column h is the response of dependent variable at $t + h$.

Table 25: Entry - Orbis

	(0)	(1)	(2)	(3)	(4)	(5)
HHI×CLI	0.07***	0.04***	0.03**	0.03**	0.02*	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
CLI						
HHI	-0.05***	-0.03***	-0.02**	-0.02**	-0.02**	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
cons	0.02***	0.02***	0.03***	0.03***	0.03***	0.03***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Country-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs	44207	44235	44233	44224	44183	44134

Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
HHI is the Herfindahl index, CLI is the competition law index.
Column h is the response of dependent variable at $t + h$.

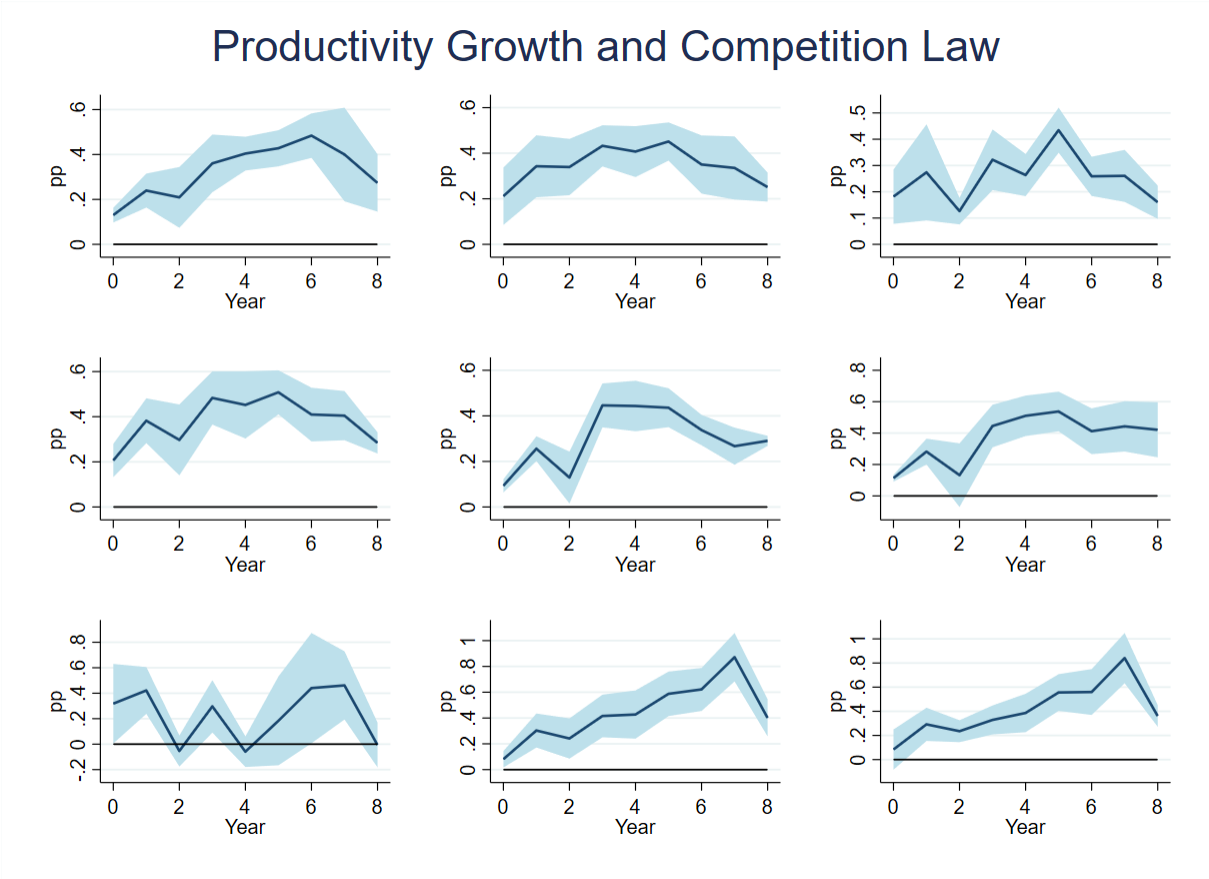


Figure 15: Competiton Law and Growth

Growth rates calculated for: (1) Logarithm of the total factor productivity, derived from OLS estimation of revenue-based Cobb-Douglas production function with intangibles (2) Logarithm of the total factor productivity, derived from OLS estimation of revenue-based Cobb-Douglas production function (3) Logarithm of the total factor productivity, derived from Wooldridge estimation of revenue-based Cobb-Douglas production function (4) Logarithm of the total factor productivity, derived from OLS estimation of revenue-based translog production function (5) Logarithm of the total factor productivity, derived from OLS estimation of revenue-based translog production function with variable inputs (6) Logarithm of the total factor productivity, derived from Wooldridge estimation of revenue-based translog production function with variable inputs (7) Logarithm of the total factor productivity, derived from Wooldridge estimation of revenue-based translog production function (8) Logarithm of the total factor productivity, derived from OLS estimation of value-added based Cobb-Douglas production function (9) Logarithm of the total factor productivity, derived from Wooldridge estimation of value-added based Cobb-Douglas production function. All estimations are at the sectoral level.
Shaded areas are 90% confidence intervals.

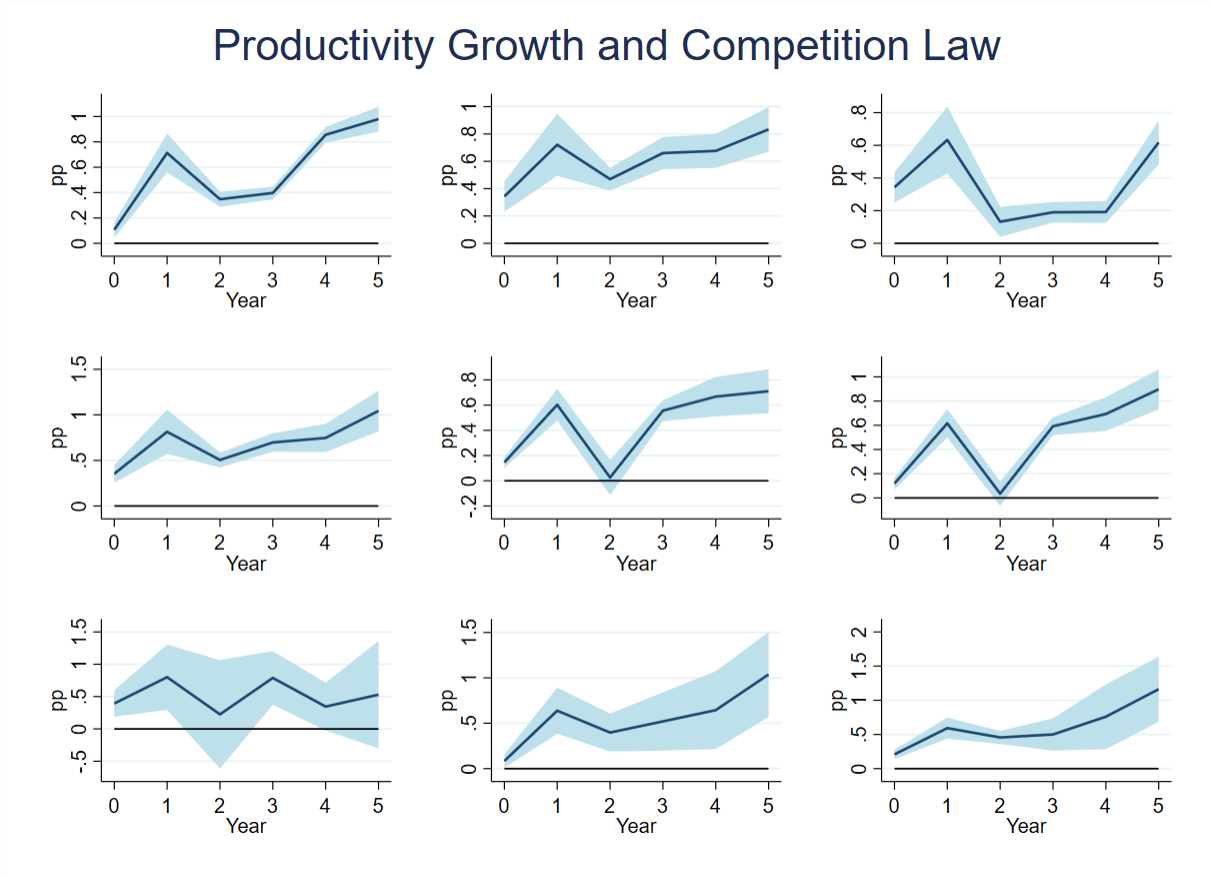


Figure 16: Competiton Law Index and Growth.

Growth rates calculated for: (1) Logarithm of the total factor productivity, derived from OLS estimation of revenue-based Cobb-Douglas production function with intangibles (2) Logarithm of the total factor productivity, derived from OLS estimation of revenue-based Cobb-Douglas production function (3) Logarithm of the total factor productivity, derived from Wooldridge estimation of revenue-based Cobb-Douglas production function (4) Logarithm of the total factor productivity, derived from OLS estimation of revenue-based translog production function (5) Logarithm of the total factor productivity, derived from OLS estimation of revenue-based translog production function with variable inputs (6) Logarithm of the total factor productivity, derived from Wooldridge estimation of revenue-based translog production function with variable inputs (7) Logarithm of the total factor productivity, derived from Wooldridge estimation of revenue-based translog production function (8) Logarithm of the total factor productivity, derived from OLS estimation of value-added based Cobb-Douglas production function (9) Logarithm of the total factor productivity, derived from Wooldridge estimation of value-added based Cobb-Douglas production function. All estimations are at the sectoral level.
Shaded areas are 90% confidence intervals.

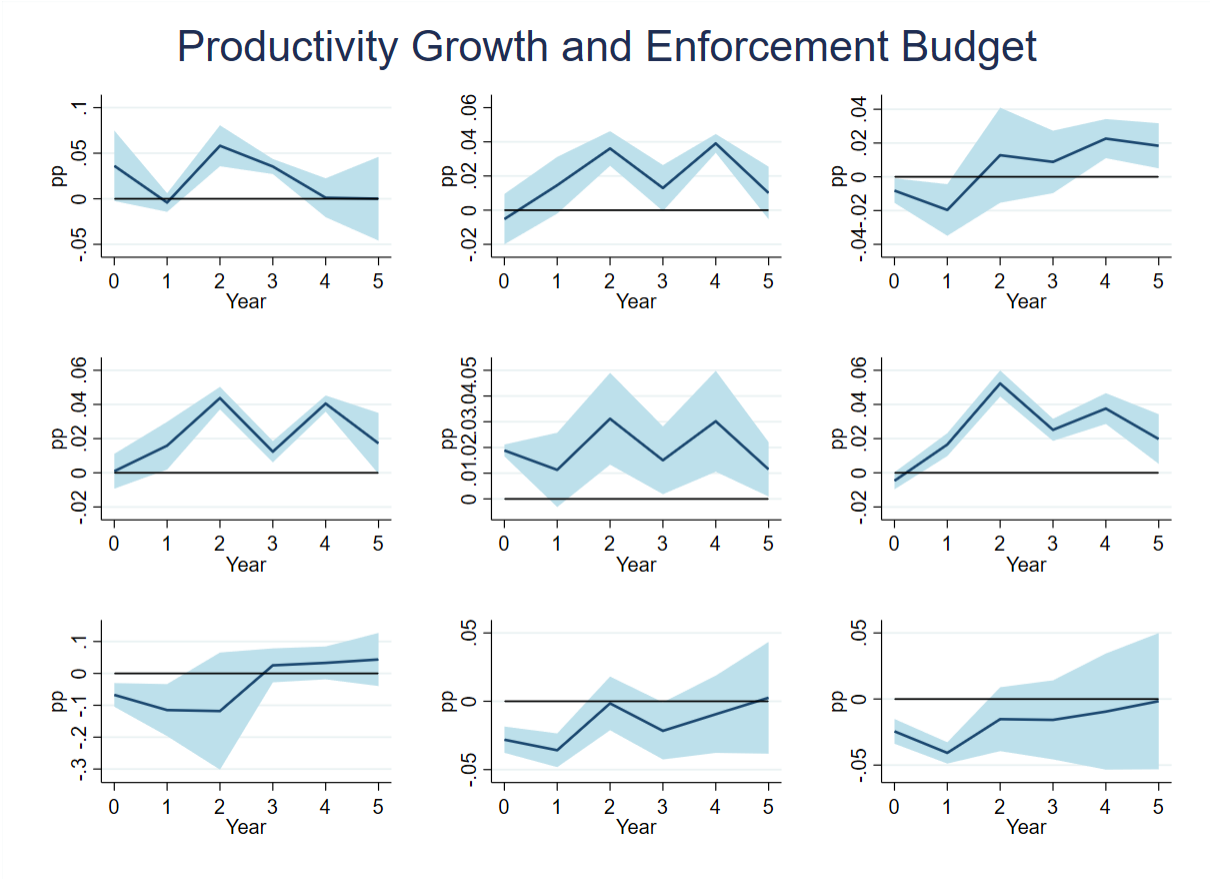


Figure 17: Enforcement Budget as a Share of GDP and Growth.

Growth rates calculated for: (1) Logarithm of the total factor productivity, derived from OLS estimation of revenue-based Cobb-Douglas production function with intangibles (2) Logarithm of the total factor productivity, derived from OLS estimation of revenue-based Cobb-Douglas production function (3) Logarithm of the total factor productivity, derived from Wooldridge estimation of revenue-based Cobb-Douglas production function (4) Logarithm of the total factor productivity, derived from OLS estimation of revenue-based translog production function (5) Logarithm of the total factor productivity, derived from OLS estimation of revenue-based translog production function with variable inputs (6) Logarithm of the total factor productivity, derived from Wooldridge estimation of revenue-based translog production function with variable inputs (7) Logarithm of the total factor productivity, derived from Wooldridge estimation of revenue-based translog production function (8) Logarithm of the total factor productivity, derived from OLS estimation of value-added based Cobb-Douglas production function (9) Logarithm of the total factor productivity, derived from Wooldridge estimation of value-added based Cobb-Douglas production function. All estimations are at the sectoral level.
Shaded areas are 90% confidence intervals.

Robustness Checks

In this section I provide a brief discussion on the robustness of the results, focusing on the measure of concentration from other sources, using profit margin as a measure of market power and the role of foreign competition

Concentration Measures from US Census Data- To measure concentration, I created the HHI from Compustat database. However, as Compustat only includes publicly traded companies, the literature has argued that it may have limitations in measuring the actual concentration value for a given industry (Ali et al., 2008). Instead, literature has suggested using concentration ratios produced from the US Census data. Census concentration ratios are available every 5 years for a subset of industries.[48] I use this measure to check the robustness of results shown in tables 26, 27 and 28. Results are qualitatively robust to using the measures provided by the Census, though the sample size drops to roughly 10% of the number of observations used in the previous subsection due to the limited availability of the Census data. More details are provided in the appendix.

Alternative Measures for Market Power- Besides the criticism to using HHI or concentration ratios from Compustat, the literature has questioned the suitability of these measures for antitrust purposes as they are industry-based and different from the definition of the relevant market used by antitrust authorities to assess anticompetitive practices (Affeldt et al., 2021). Since concentration ratios from the US Census data are based on the same industry definitions, similar concerns remain. In particular, for the purposes of antitrust, market definition often depends on the level of substitutability among products competing in a market which may not be well captured by the usual industry classifications (Berry et al., 2019). As the market definitions used by antitrust authorities (and the respective concentration measures) are not publicly available, I use profit ratio as a proxy for market power. While profit ratios do not directly measure the level of substitution between products, they potentially contain information about these values. In particular, if goods are highly substitutable, even with higher levels of concentration the profit ratio is expected to be relatively lower. Figures 18a, 18b and 18c report the results and discuss the measure in more details. It is worth noting that the sample size is roughly 15-20% smaller due to outliers on the measure of profits. Overall, results are qualitatively robust to using profit ratio as a measure of market power though slightly less significant.

[48] The relevant years for the analysis of this section are 2002, 2007, 2012 and 2017 which include data both on manufacturing and non-manufacturing industries. Earlier years only have information on the manufacturing sector.

Concentration Measure and Foreign Competition- Another possible concern is that despite increasing trends in domestic industry concentration, external competition from imports ensures that markets remain competitive. To make sure results are robust to inclusion of external competition I control for imports. First, in case of entry and innovation, I focus on the non-tradable sectors of the economy. For productivity growth, since the analysis is done only for the manufacturing sector, I take a different approach. NBER-CES Manufacturing Industry Database provides information on total industry sales for 6-digit NAICS sectors. I also get data on total imports of each sector from Schott (2008) and adjust the concentration measures by the import share.[49] I do the analysis using concentration measures from both the Compustat database and the Census data. Tables 26, 27 and 28 show the results using the concentration ratio of top 4 firms from the US Census data. Results look similar when using concentration ratios based on top 8, 20, and 50 firms. Census data is provided every 5 years and includes information on both manufacturing and non-manufacturing sectors. I use the concentration ratios provided for 4-digit NAICS industries to match the entry rates and productivity rates provided by BDS and BLS databases. For R&D expenditure share the analysis is done at firm level. I trim the data at 5% for outliers, but the results are robust to trimming at 1% as well. Column 2 of tables 26, 27 and 28 focuses on sectors with higher concentration levels (dropping the bottom 30% concentration ratios) such that the minimum level of CR4 is now 0.14 and the average value of CR4 increases from 0.27 to 0.35.

In the second robustness check I use an alternative measure to capture firms market power. This measure is based on firms' profits and is from Compustat database. The relevant variable is oiadp or operating income after depreciation as in Covarrubias et al. (2020). I create profit ratio by dividing this variable by firms' sale. To correct for outliers I drop all values of profit ratio that are above 1 or below -1. Next, I drop sectors in which less than 3 firms remain- this is to control for the sectors that had a high number of outliers or originally contained very few firms. I then find the median profit ratio for each sector at each year and drop the bottom/top 1%. I use that as the measure of market power. Results are similar when using a weighted average of profit ratio as well. For R&D expenditure ratio, since the analysis is done at the firm level, I drop values above 1 or below -1 and trim the data at 1%. Due to high number of outliers on oiadp variable, the sample size becomes 15-20% smaller compared to the main regressions of this paper. For the sector level regressions standard errors are clustered at sector and year level and for the firm level regression the clustering is at firm and year level.

In another robustness check, I investigate implications of external competition com-

[49] Data is available on Peter Schott's website.

Table 26: Growth Rate

Growth - Robustness Checks		
	(1)	(2)
L.CR4 × L.budget	11529.47*	11964.36***
	(4609.65)	(1531.32)
L.budget		
L.CR4	-0.14*	-0.16***
	(0.05)	(0.02)
cons	0.01**	0.02***
	(0.00)	(0.00)
Industry FE	Yes	Yes
Year FE	Yes	Yes
N	276	220

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Column (1) is on all values of concentration.

Column (2) on high concentration industries: trimming bottom 30%.

Concentration from Economic Census for NAICS-4 codes for 2002,2007,2012,2017.

Table 27: Entry Rate

Entry Rate - Robustness Checks		
	(1)	(2)
L.CR4 × L.budget	4542.93*	9046.85**
	(1768.60)	(1868.00)
L.CR4	-0.03	-0.08**
	(0.02)	(0.02)
L.budget		
cons	0.07***	0.07***
	(0.00)	(0.00)
Industry FE	Yes	Yes
Year FE	Yes	Yes
N	725	513

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Column (1) is on all values of concentration.

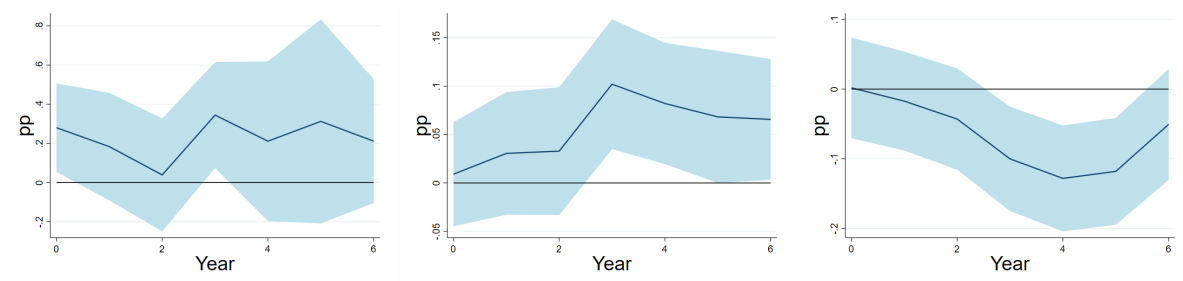
Column (2) on high concentration industries: trimming bottom 30%.

Concentration from Economic Census for NAICS-4 codes for 2002,2007,2012,2017.

Table 28: R&D Expenditure

R&D Expenditure - Robustness Checks		
	(1)	(2)
L.CR4 × L.budget	-7171.14**	-7488.46*
	(3402.44)	(4440.31)
L.budget		
L.CR4	0.08**	0.07
	(0.04)	(0.05)
cons	0.09***	0.10***
	(0.00)	(0.01)
Firm FE	Yes	Yes
Year FE	Yes	Yes
N	5950	4175

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Column (1) is on all values of concentration.
Column (2) on high concentration industries: trimming bottom 30%.
Concentration from Economic Census for NAICS-4 codes for 2002,2007,2012,2017.

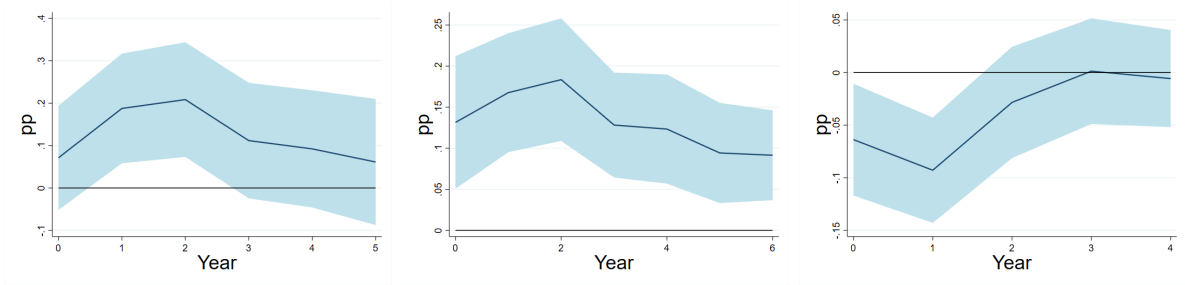


(a) Productivity Growth (b) Share of Entrants (c) R&D Expenditure

Figure 18: Dynamic responses - profit margin as the measure of market power
Shaded areas are 90% confidence intervals.

ing from imports. For entry and R&D since data is available for the entire economy, I restrict analysis to the non-tradable sector as this would eliminate the impact of foreign competition. As in Besley et al. (2020), tradable sectors that are excluded from the analysis are agriculture, mining and manufacturing. The outcome is presented in figure 19b and 19c. For productivity growth since the data is only available for the manufacturing sector which is highly exposed to imports competition, I adjust the measure of concentration as follows. NBER-CES provides data on manufacturing sector and in particular variable vship capturing total value of shipment, provides information on total sales of each industry at 6-digit level. I aggregate this variable to 4-digit industry level to match the measure of productivity. Further, I get the value for total imports from Schott (2008) between

1989-2011. I use gen_val_yr variable capturing total value of imports and aggregate it to 4-digit industry level. The correction term is defined by $\frac{totalshipment}{totalshipment + imports}$ similar to Covarrubias et al. (2020). The average value of import share in the manufacturing industry is 0.26 and the corrected value of concentration is 0.23(correction term × concentration). I do a similar analysis using the census data and results remain robust.



(a) Productivity Growth (b) Share of Entrants (c) R&D Expenditure

Figure 19: Dynamic responses - adjusted for foreign competition
Shaded areas are 90% confidence intervals.

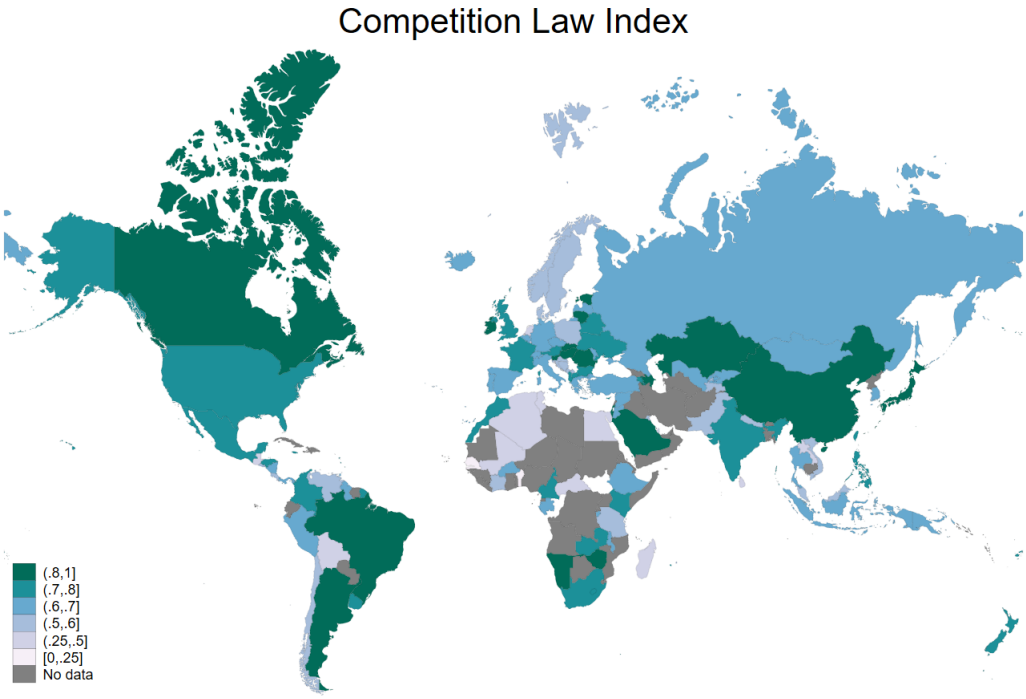


Figure 20: Competition Law Index for all countries in 2010

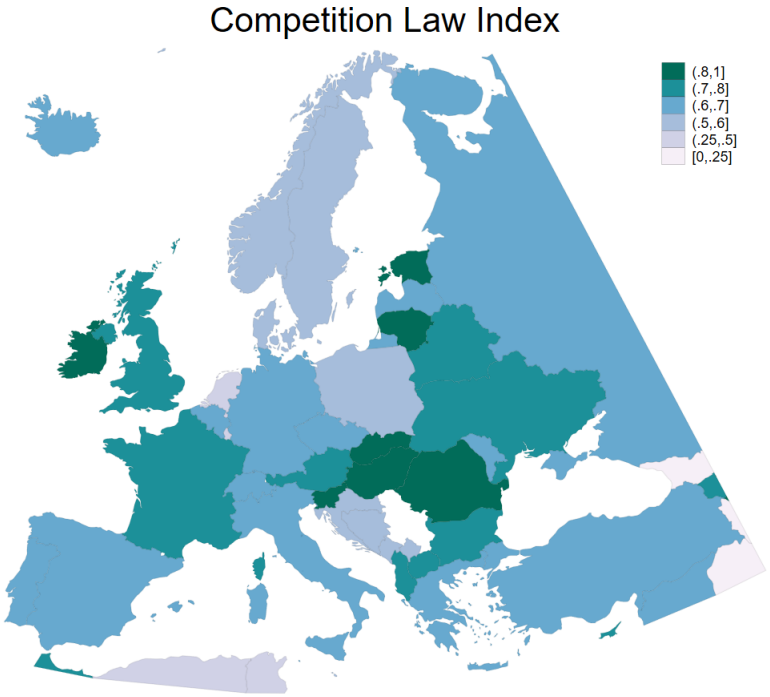


Figure 21: Competition Law Index for European countries in 2010

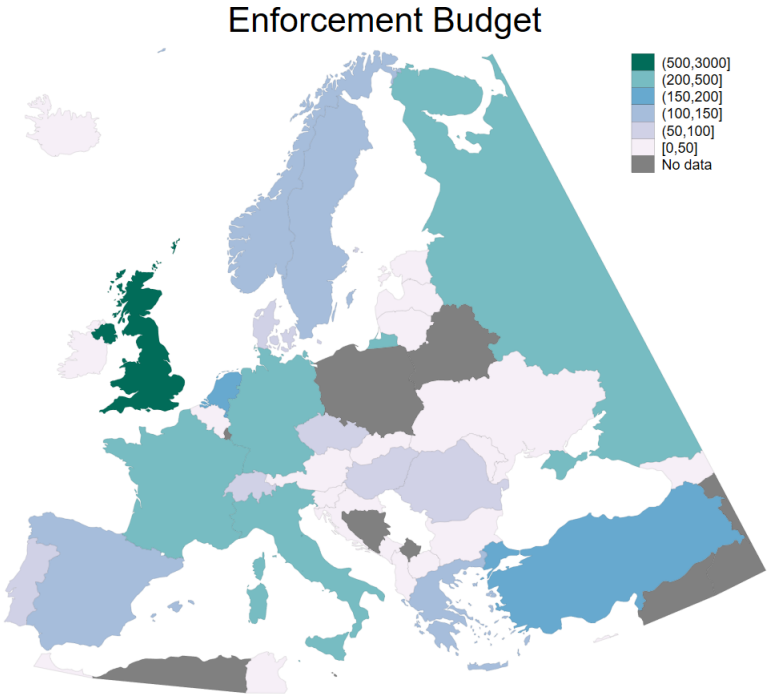


Figure 22: Enforcement Budget for European countries in 2010

Theoretical and Computational Appendix

Discussion on the equilibrium concept for deterrence strategies:

In this section I show that aggressive strategies in response to certain entry signals are Nash equilibrium which can be achieved under the game described in the model section. I also discuss that these strategies create higher values for the firm compared to the alternative of not acting aggressively.

As discussed in the previous section of the appendix, the model has multiple equilibria. I restrict the analysis to cases in which incumbents sacrifice a fraction fr of their profits to create deterrents. I will show this strategy by $D1$. The alternative strategy is when firms do not create deterrents and this strategy is denoted by $D0$.

This game has 2 pure Nash equilibria. First, take firm i and suppose $-i$ are playing $D0$. The definition of SPE implies that a strategy profile $s^* = (s_1^*, s_2^*, ...s_N^*)$ is a SPE for all i and all histories h

$$V(\phi_{ij}, \mu_j, \mu_{agg}|s^*, h) > V(\phi_{ij}, \mu_j', \mu_{agg}|s_i, s_{-i}^*, h) \quad \forall s_i$$

Therefore if $s_{-i}^* = D0$, then the best response of i is to play $D0$ as well. Deviating from it leads to a sacrifice of profits $fr\pi_i^*$ without any gain. Therefore playing $D0$ at every stage will be equilibrium. In fact this will be the minmax profile. The minmax is dependent on no single firm being able to unilaterally block the entry of firms. This assumption is checked in equilibrium.

The second equilibrium of the model is playing $D1$ in response to certain entry signals and $D0$ to others. Now let $s_{-i}^* = D1$. Then playing $D1$ delivers a higher payoff according to the incentive compatibility constraint (13):

$$\pi_{aggressive}(\phi_{ij}, \mu_j, \mu_{agg}) + \beta E[V(\phi_{ij}, \mu_j', \mu_{agg})] \geq \pi_{static}(\phi_{ij}, \mu_j, \mu_{agg}) + \beta E[V(\phi_{ij}, \mu_j", \mu_{agg})]$$

Deviating from $D1$ to $D0$ lowers the value of the firm and therefore is not a profitable deviation. Therefore $D1$ in response to certain entry signals is also Nash.

SPE can be written as:
- s_i^* plays $D1$ in response to entry signals $\phi^q \in \{\bar{\phi}_{ent}, \bar{\phi}_{ent,agr}\}$ and $D0$ in response to other signals as long as there been no deviations from this strategy in the past.
- s_i^* plays $D0$ otherwise.

Finally, denote v_i the minmax payoff of firm i. Folk theorem states that in any re-

peated game any vector of payoff with $u_i \geq v_i$ can be achieved as the average payoff of some SPE if the discount factor is sufficiently large. Since the payoff of playing $D1$ in response to entry signals specified above delivers a higher value than playing $D0$, this means these strategies can be sustained as an equilibrium of the model. Throughout the paper, the states describing the history of aggressive strategies have been dropped in the interest of space, and the analysis is done along the equilibrium path.

Describing the set of equilibria

The model presented in this paper has multiple equilibria with respect to deterrence strategies. In the above subsection I discussed the equilibrium that is the focus of this paper, and in this section I provide a description on the full set of equilibria.

First, define the firm incentive condition as:

$$V_i|_{D=1} > V_i|_{D=0}$$

To observe a firm behaving aggressively, the firm incentive condition must be satisfied, which states that the value of firm i under deterrence strategies $D = 1$ should be higher than otherwise ($D = 0$). Call ΔV_i the maximum amount firm i is willing to give up in an aggressive strategy to prevent entry. Then total amount of deterrent that the sector has the ability to create is:

$$\mathcal{K}_{tot,max} = \frac{1}{N}(\sum_{i=1}^{N} \Delta V_i^{\alpha_d})^{\frac{1}{\alpha_d}}$$

Recall from equation (15) that the amount of deterrent required to prevent entry is $\mathcal{K}_{tot}$. If

$$\mathcal{K}_{tot,max} > \mathcal{K}_{tot}$$

The model has multiple equilibria. Below I describe the set of equilibria in this model and later I will focus on only a subset of this set.

As discussed in the previous subsection, the minmax strategy is when no firm engages in deterrence activities, as long as no single firm alone has the ability to create sufficient amount of barriers to keep entrants out. Therefore, I will breakdown the description into two cases:

Case 1: No single firm alone has the ability and resources to create sufficient entry deter-

rence:

Formally, the above statement requires that $\zeta_{i,max} > 1$ for all i, where $\zeta_{i,max}$ can be solved for from:

$$\mathcal{K}_{tot} = \frac{1}{N}(\zeta_{i,max}\Delta V_i)$$

where $\mathcal{K}_{tot}$ is defined as (15) and can be found using backward induction as discussed in the model section of the paper.

Given $\zeta_{i,max} > 1$ for all i, the set of equilibria is any $\zeta = (\zeta_1, \zeta_2, ..., \zeta_N)$ such that $\zeta_i \leq 1$, $\forall i$ such that :

$$\mathcal{K}_{tot} = \frac{1}{N}(\sum_{i=1}^{N}(\zeta_i \Delta V_i)^{\alpha_d})^{\frac{1}{\alpha_d}}$$

Case 2: There is at least one firm that has the ability and resources to create sufficient entry deterrence all by itself. Formally, this requires $\zeta_{i,max} \leq 1$ for some i. The set of equilibria then will be $\zeta = (\zeta_1, \zeta_2, ..., \zeta_N)$ such that $\zeta_i = \zeta_{i,max}$ for the firm with $\zeta_{i,max} \leq 1$ and $\zeta_{-i} = 0$.

The full set of equilibria will be the combination of those described under case 1 and case 2. To avoid computational complications due to the multiplicity of equilibria in this paper I will only consider the equilibrium that are defined under case 1 and take the form described below.
Define a_i such that $\Delta V_i = a_i \pi$. Substitute for ΔV_i in the above equation to get:

$$\sum_{i=1}^{N} \zeta_i a_i \pi = \mathcal{K}_{tot}$$

Define o_i $\forall i$:

$$o_i = \begin{cases} fr_{gent}, & \text{if } \zeta_i a_i \geq fr_{gent} \\ 0, & \text{otherwise} \end{cases}$$

This paper focuses on equilibrium structures that have the above structure.

Discussion on mapping of different anticompetitive behaviour to the model set up

I will focus on aggressive (predatory) pricing and mergers and killer acquisitions.

1) Aggressive (predatory) pricing:

I show that there exists α_d such that aggressive pricing strategies can map into the framework presented in the theory section.
First knowing the signal for entry, the necessary sectoral price to deter entry can be calculated using the free entry condition of potential entrants. I will show this sectoral price by P_{pred}:

$$E[V_{ent}] > S$$

$$E[\pi_{ent}] + \beta E[_{ent}] > S$$

Where CV_{ent} shows the continuation value of entrant. I assume that potential entrants, knowing incumbents will price aggressively, give their best response to the aggressive sectoral price. For a given firm i predatory price $p_{ent,t,pred}$ is the best response of entrant to the aggressive sectoral price and is according to:

$$p_{ent} = \frac{\epsilon}{\epsilon - 1}$$

Which indicates that entrant would act as a price taker, knowing it cannot affect the sectoral price.
Now using the entry condition and making use of the pricing strategy:

$$p_{ent}q_{ent} - w(f + q_{ent}\lambda_{ent}) + \beta E[CV] = S$$

$$E[q_{ent}(p_{ent} - \lambda_{ent})] = S - \beta E[CV] + wf$$

Substituting the pricing strategy as above gives:

$$E[q_{ent}\frac{1}{\epsilon - 1}w\lambda_{ent}] = S - \beta E[CV] + wf$$

Where q_{ent} satisfies (4). Using this equation we have:

$$(\frac{p_{ent}}{P_{Pred}})^{-\epsilon}\frac{I_t}{N_t P_{Pred}}\frac{1}{\epsilon - 1}w\lambda_{ent} = S - \beta E[CV] + wf$$

Isolating P_{pred} on one side gives:

$$P_{pred}^{\epsilon-1} = \frac{N_t}{I_t}\frac{1}{w\lambda_{ent}}(\epsilon - 1)(\frac{\epsilon}{\epsilon - 1}w\lambda_{ent})^{\epsilon}(S - \beta E[CV] + wf)$$

This equation shows that when sunk costs and fixed costs of entry are high, less predatory behaviour is needed to keep potential entrants out. In other words, even higher sectoral prices can keep entrants out.
Knowing the predatory sectoral price, the next step is to pin down pricing strategy of

incumbent firms. Since in the focus of this paper is on equilibria that the aggressive strategy leads to giving up a fraction of profits, the incumbents strategy can be figured out by having:

$$p_{i,t}q_{i,t} - w(f + q_{i,t}\lambda_i) = (1 - fr_{pred})\pi_i*$$

Where $q_{i,t}$ satisfies (4) and π_i* is the profit relating to (9). fr_{pred} is the fraction of profits firms will sacrifice and needs to be solved. From equation above

$$q_{i,t}(p_{i,t} - w\lambda_i) = (1 - fr_{pred})\pi_i * +wf$$

Call $p_{i,t} - w\lambda_i = \mu_{pred,i,t}w\lambda_i$ where $\mu_{pred,t}$ is the markup and might be below one in cases of below marginal cost predatory pricing.

$$((1 + \mu_{pred,i,t})w\lambda_i)^{-\epsilon}P_{pred}^{\epsilon-1}\mu_{pred,i,t}w\lambda_i = \frac{N_t}{I_t}[(1 - fr_{pred})\pi_i * +wf]$$

$$(1 + \mu_{pred,i,t})^{-\epsilon}\mu_{pred,i,t} = \frac{N_t}{I_t}[(1 - fr_{pred})\pi_i * +wf]P_{pred}^{1-\epsilon}(w\lambda_i)^{\epsilon-1}$$

This relation holds for all incumbents and provides N equations. The unknown variables are $\mu_{pred,i,t}$ for all i (therefore N unknowns) and fr_{pred}. Therefore one extra equation is needed. This extra equation is the definition for aggregate sectoral price as (3). Together, these equations would allow to solve for all $\mu_{pred,i,t}$ and fr_{pred} at time t.
Now to see how the case of predatory pricing maps to the set up of this paper, find $\mathcal{K}_{tot}$ required to deter entry from the entry condition of firms.

$$EV_{ent} = S + \mathcal{K}_{tot}$$

Then using (16) and (15) $\mathcal{K}_i = fr_{pred}\pi*_i$ can be calculated. Using $\mathcal{K}_{tot}$ calculated above, there exists some α_d such that:

$$\mathcal{K}_{tot} = \frac{1}{N}(\sum_{1}^{N}(fr_{pred}\pi*_i)^{\alpha_d})^{\frac{1}{\alpha_d}}$$

Thus mapping aggressive pricing into the setup of this paper.

2) Mergers and killer acquisitions

The model with its current interpretation is not easily applicable to the case of mergers and acquisitions since in the model aggressive strategies affect some aggregate variable in the sector and mergers are directed at specific firms. Therefore, to do so, I suggest

an alternative way of interpreting variables. I show that acquisitions require a weaker condition compared to the aggressive strategy presented in the model section. Therefore, the aggressive strategies of incumbents can include mergers and killer acquisitions as these strategies require a higher sacrifice of profits.

To map the set up of the model to the case of mergers and acquisitions, I assume that firms previously denoted as potential entrants have entered however they are small such that $s_i \to 0$. I also assume there is uncertainty about their productivity but their expectation over their productivity is ϕ^q which previously was modelled as the signal for entry. To expand such that $s_i >> 0$ they have to pay a one-time expansion cost of S. At this stage they might get acquired by incumbents with a high market power. The participation constraint of the firms getting acquired implies:

$$EV - S \leq Val_{acq}$$

Where EV denotes the expected value of entrants after their expansion and Val_{acq} is the acquisition offer.

Comparing this with (18) it is clear that for acquisition to takes place $Val_{acq} = \mathcal{K}_{tot}$. However, previously $\mathcal{K}_{tot}$ was an aggregate object affecting the entire sector while now it is equal to the amount necessary to acquire a given firm. Recall that all entrants (or here all small firms) have the same signal. Therefore, the total amount necessary to acquire all small firms is equal to $MVal_{acq}$ or equally $M\mathcal{K}_{tot}$. I show that total amount of profit sacrifices under the main set up of the model is higher that $M\mathcal{K}_{tot}$, therefore, mergers and acquisitions are included under that setup.

Total amount required to acquire all firms:

$$Req = M\mathcal{K}_{tot} = \frac{M}{N}(\sum_{1}^{N}(fr\pi_i^*)^{\alpha_d})^{\frac{1}{\alpha_d}} \leq (\sum_{1}^{N}(fr\pi_i^*)^{\alpha_d})^{\frac{1}{\alpha_d}}$$

Where the inequality holds as long as $M \leq N$.

Total amount of profit sacrifices according to the model is:

$$Sacr = \sum_{1}^{N}(fr\pi_i^*)$$

To show that acquisitions are less costly it is necessary to show $Req \leq Sacr$.

Define $a_i = fr\pi_i^*$ and note that $a_i \geq 0$ for all i. We need to show

$$\sum_{1}^{N} a_i^{\alpha_d} \leq (\sum_{1}^{N} a_i)^{\alpha_d}$$

Let $\bar{a} = \sum_{1}^{N} a_i$. Assume at least one $a_i > 0$ then $\bar{a} > 0$. This is not a strong assumption as it is requiring at least one firm to be making profit sacrifices. This holds in the main set up if firms are to succeed in deterring entry.
$\forall i$ let $a_{rel,i} = \frac{a_i}{\bar{a}}$. Thus we have $0 \leq a_{rel,i} \leq 1$. So:

$$(a_{rel,i})^{\alpha_d} \leq a_{rel,i}$$

$$\sum_{1}^{N} (a_{rel,i})^{\alpha_d} \leq \sum_{1}^{N} a_{rel,i}$$

Also note that, $\sum_{1}^{N} a_{rel,i} = \sum_{1}^{N} \frac{a_i}{\bar{a}} = 1$.
Then:

$$\sum_{1}^{N} a_i^{\alpha_d} = \bar{a}^{\alpha_d} \sum_{1}^{N} a_{rel,i}^{\alpha_d} \leq \bar{a}^{\alpha_d} \sum_{1}^{N} a_{rel,i} = \bar{a}^{\alpha_d}$$

Using the definition of $\bar{a}$ we have:

$$\sum_{1}^{N} a_i^{\alpha_d} \leq (\sum_{1}^{N} a_i)^{\alpha_d}$$

Which is the required condition and holds as long as $\alpha_d > 1$.

While here it is possible to provide an interpretation of mergers and acquisitions and show that in general it is less costly than the alternatives, the analysis depend on the assumption that prior to getting acquired one firm was much smaller. This may not be the case in many sectors and therefore more costly strategies will be required. The model presented here is not able to directly analyse those cases. However we can think those cases are implicit in the model as the general set up required more costly action compared to the case analysed above.

Result: Aggressive strategies lower the entry. (depends on both change in cutoff and frequency of higher draws)

In the case without aggressive, free entry condition has:

$$EV_{ent}|_{\phi^q} \geq S$$

Where ϕ^q is the signal for productivity of potential entrants. As the value of the firm is increasing in productivity level, this implies existence of a cutoff for entry which I will denote by $\bar{\phi}_{ent}$.

Similarly, with aggressive pricing the entry condition can be written as:

$$EV_{ent}|_{\phi^q} \geq S + max_{\phi^q}\{\mathcal{K}_{tot}(\phi^q)\}$$

Call the cutoff associated with this constraint $\bar{\phi_{ent,agr}}$ and $\bar{\phi_{ent,agr}} > \bar{\phi_{ent}}$ as long as $\mathcal{K}_{tot} > 0$ for some signal.

The entry rate can be written as:

$$\int_0^1 \sum_{\phi^j \bar{\phi_{ent}}}^{\phi^{max}} Mh(\phi^j)dj = M(1 - H(\bar{\phi_{ent}})) \tag{1}$$

And for the aggressive case:

$$\int_0^1 \sum_{\phi^j \bar{\phi_{ent,agr}}}^{\phi^{max}} Mh(\phi^j)dj = M(1 - H(\bar{\phi}_{ent,agr})) \tag{2}$$

Where (1) > (2) as $H(\bar{\phi_{ent}}) < H(\bar{\phi_{ent,agr}})$. So the drop in rate depends on the change in cutoff due to aggressive strategies and the frequency by which these draws happen.

Result: Higher concentration (measured by fewer number of incumbents N) leads to more aggressive behaviour in a given sector.
Intuitively, a higher concentration which is associated with fewer incumbents, means sales share of incumbents will increase. This increase in market share, means that firms market power increases, leading to higher profits. Recall that firms have to sacrifice a fraction of their profits to create deterrents for new firms. Therefore the increase in profit of each firm translates to a higher level of deterrent give the competition law. Thus firms become more aggressive and $\mathcal{K}_{tot}$ increases allowing incumbents to deter entry even more.

However, it is possible that changes in number of firms, leads to heteregenous impact on incumbents such that sales share of some firms actually drops. Below I find the conditions under which sales share and therefore profits of incumbents increase and show that the incentive compatibility holds. First, I find the conditions under which fewer incumbents translate to higher sales share for incumbents. Then I show that profits of firms increase with higher s_i and finally I verify that incentive compatibility constraints hold.

Result: Sales share of a given firm i increases when the number of firms falls from K to

$K-1$ as long as[50]:

$$\hat{s}_{i,K} + \hat{s}_{i,K-1} < \frac{\epsilon}{\epsilon - 1}$$

Where $\hat{s}_i$ is sales share of firm i under monopolistic competition.

Proof:

The setup of this model does not admit an analytical solution. To be able to analyse changes in sales share of firms with number of incumbents in each sector, I use an approximation derived in Grassi (2017). Grassi (2017) approximates sales share of firms in an oligopolistic set up with sales share of firms under monopolistic competition $\hat{s}_i$. I will drop the firm subscript i from this point on. The subscript K shows the number of incumbents.

$$\begin{aligned} s_K - s_{K-1} &\approx \hat{s}_K - (1 - \frac{1}{\epsilon})\hat{s}_K^2 - \hat{s}_{K-1} + (1 - \frac{1}{\epsilon})\hat{s}_{K-1}^2 \\ &= \hat{s}_K - \hat{s}_{K-1} - (1 - \frac{1}{\epsilon})(\hat{s}_K^2 - \hat{s}_{K-1}^2) \\ &= (\hat{s}_K - \hat{s}_{K-1})\big(1 - (1 - \frac{1}{\epsilon})(\hat{s}_K + \hat{s}_{K-1})\big) \end{aligned}$$

I will consider 2 cases now: When the Kth firm has a higher productivity level compared to the average productivity level of firms in the market and second, when its productivity level was below the average.

First, consider the case with the Kth firm has a productivity level above the average. This means: $P_{K-1} > P_K$. Where P_K shows the aggregate price under monopolistic competition with K incumbents. Therefore, in the relation derived above:

$$\begin{aligned} (\hat{s}_K - \hat{s}_{K-1}) &= (\frac{\epsilon}{\epsilon - 1}\frac{\lambda_i}{P_K})^{1-\epsilon}\frac{1}{K} - (\frac{\epsilon}{\epsilon - 1}\frac{\lambda_i}{P_{K-1}})^{1-\epsilon}\frac{1}{K-1} \\ &= (\frac{\epsilon}{\epsilon - 1}\lambda_i)^{1-\epsilon}(\frac{P_K^{\epsilon-1}}{K} - \frac{P_{K-1}^{\epsilon-1}}{K-1}) < 0 \end{aligned}$$

For the second term we have:

$$\begin{aligned} &\big(1 - (1 - \frac{1}{\epsilon})(\hat{s}_K + \hat{s}_{K-1})\big) > 0 \\ &1 > \frac{\epsilon - 1}{\epsilon}(\hat{s}_K + \hat{s}_{K-1}) \\ &\frac{\epsilon}{\epsilon - 1} > (\hat{s}_K + \hat{s}_{K-1}) \end{aligned}$$

Therefore, given $(\hat{s}_K + \hat{s}_{K-1}) < \frac{\epsilon}{\epsilon-1}$[51], $s_K < s_{K-1}$ for all firms.

[50] This is a sufficient (but not necessary) condition

[51] This is not a strong requirement as under the monopolistic competition and for the approximation to remain valid $\hat{s} \to 0$

Now suppose moving from K to $K-1$, the Kth firm has a lower productivity level such that: $P_K > P_{K-1}$. Then:

$$\begin{aligned}(\hat{s}_K - \hat{s}_{K-1}) &= (\frac{\epsilon}{\epsilon-1}\frac{\lambda_i}{P_K})^{1-\epsilon}\frac{1}{K} - (\frac{\epsilon}{\epsilon-1}\frac{\lambda_i}{P_{K-1}})^{1-\epsilon}\frac{1}{K-1} \\ &= (\frac{\epsilon}{\epsilon-1}\lambda_i)^{1-\epsilon}(\frac{P_K^{\epsilon-1}}{K} - \frac{P_{K-1}^{\epsilon-1}}{K-1})\end{aligned}$$

Here, we cannot directly conclude that $\frac{P_K^{\epsilon-1}}{K} < \frac{P_{K-1}^{\epsilon-1}}{K-1}$. If this is the case, then we will have similar results to the case where $P_K < P_{K-1}$.
To show $\frac{P_K^{\epsilon-1}}{K} < \frac{P_{K-1}^{\epsilon-1}}{K-1}$, I use contradiction. Thus suppose $\frac{P_K^{\epsilon-1}}{K} > \frac{P_{K-1}^{\epsilon-1}}{K-1}$. Then:

$$\hat{s}_K - \hat{s}_{K-1} > 0$$

Also from before, as long as $(\hat{s}_K + \hat{s}_{K-1}) < \frac{\epsilon}{\epsilon-1}$ the second term is positive. These two facts combined give:

$$s_K - s_{K-1} > 0$$

This holds for all firms (as none of the derivations were dependent on the productivity of each individual firm). Therefore, sales share of all firms drop when there are $K-1$ firms in the market. Since $s_K \geq 0$ for all firms and $\sum_K s_i = 1$ we have arrived at a contradiction and it must be that $\frac{P_K^{\epsilon-1}}{K} < \frac{P_{K-1}^{\epsilon-1}}{K-1}$. Therefore:

$$s_K < s_{K-1}$$

Next step is to show that profits of incumbents is increasing in sales share. Denote profits of high concentration, $K-1$ number of firms with π' and profits of high number of firms, low concentration with π. The goal is to show that :

$$\Delta\pi = \pi' - \pi > 0$$

Then:

$$\begin{aligned}\pi_i{}' - \pi_i &= p_i{}'q_i{}' - w(f + q_i{}'\lambda_i) - [p_iq_i - w(f + q_i\lambda_i)] \\ &= q_i{}'\frac{1}{(\epsilon-1)(1-s')} - q_i\frac{1}{(\epsilon-1)(1-s)} \\ &= \frac{Iw\lambda_i}{\epsilon-1}[\frac{p_i{}'^{-\epsilon}P'^{\epsilon-1}}{(1-s')N'} - \frac{p_i{}^{-\epsilon}P^{\epsilon-1}}{(1-s)N}]\end{aligned}$$

To show profits increase, the term in brackets should be positive. Use the definition for

sales share to substitute in the above equation:

$$s_i = \frac{1}{N}(\frac{p_i}{P})^{1-\epsilon}$$

This gives:

$$\begin{aligned}
{\pi_i}' - \pi_i &== \frac{Iw\lambda_i}{\epsilon - 1}[\frac{s'}{(1-s')p_i{}'} - \frac{s}{(1-s)p_i}] \\
&= \frac{Iw\lambda_i}{\epsilon - 1}[\frac{s'}{(1-s')}\frac{(1-s')(\epsilon-1)}{(\epsilon(1-s')+s')\lambda_i} - \frac{s}{(1-s)p_i}\frac{(1-s)(\epsilon-1)}{(\epsilon(1-s)+s)\lambda_i}] \\
&= \frac{Iw\lambda_i}{\epsilon - 1}\frac{\epsilon-1}{w\lambda_i}[\frac{s'}{\epsilon(1-s')+s'} - \frac{s}{\epsilon(1-s)+s}] \\
&= I[\frac{s'}{\epsilon(1-s')+s'} - \frac{s}{\epsilon(1-s)+s}]
\end{aligned}$$

Which uses $p_i = \frac{\epsilon(1-s)+s}{(1-s)(\epsilon-1)}w\lambda_i$. I need to show that the term in brackets is positive. Note that the nominator $s' > s$ and the denominator $\epsilon(1-s') + s' < \epsilon(1-s) + s$. Therefore the term in brackets is positive and we have shown that

$${\pi_i}' - \pi_i > 0 \quad \forall i$$

Therefore profit of all incumbent firms increases. So,

$$N'^{\frac{-1}{\alpha_d}}(\sum_1^{N'}(fr{\pi_i}')^{\alpha_d})^{\frac{1}{\alpha_d}} \geq N^{\frac{-1}{\alpha_d}}(\sum_1^{N}(fr\pi_i)^{\alpha_d})^{\frac{1}{\alpha_d}}$$

Result 2: The change in sales share of a given firm i when the number of firms falls from K to $K-1$ is increasing in the productivity of the firm iff:

$$\frac{d(s_{i,K-1} - s_{i,K})}{d\phi_i} > 0 \quad \text{iff} \quad \hat{s}_{i,K} + \hat{s}_{i,K-1} < \frac{1}{2}\frac{\epsilon}{\epsilon - 1}$$

Where similar to before $\hat{s}_i$ is sales share of firm i under monopolistic competition.

Derivation:

Note $\frac{d(s_{i,K-1}-s_{i,K})}{d\phi_i} > 0$ is equivalent to showing $\frac{d(s_{i,K-1}-s_{i,K})}{d\lambda_i} < 0$. Using the approximation by Grassi (2018) and dropping the firm subscript i:

$$\frac{d(s_{K-1} - s_K)}{d\lambda} = \frac{d\hat{s}_{K-1}}{d\lambda} - \frac{d\hat{s}_K}{d\lambda} - 2(1 - \frac{1}{\epsilon})[\frac{d\hat{s}_{K-1}}{d\lambda}\hat{s}_{K-1} - \frac{d\hat{s}_K}{d\lambda}\hat{s}_K]$$

Where:

$$\frac{d\hat{s}_{K-1}}{d\lambda} - \frac{d\hat{s}_K}{d\lambda} = (\frac{\epsilon}{\epsilon-1})^{1-\epsilon}(1-\epsilon)\lambda^{-\epsilon}(\frac{P_{K-1}^{\epsilon-1}}{K-1} - \frac{P_K^{\epsilon-1}}{K})$$

and,

$$\frac{d\hat{s}_{K-1}}{d\lambda}\hat{s}_{K-1} - \frac{d\hat{s}_K}{d\lambda}\hat{s}_K =$$
$$(\frac{\epsilon}{\epsilon-1}\frac{\lambda}{P_{K-1}})^{1-\epsilon}\frac{1}{K-1}(\frac{\epsilon}{\epsilon-1})^{1-\epsilon}(1-\epsilon)\lambda^{-\epsilon}\frac{P_{K-1}^{\epsilon-1}}{K-1} - (\frac{\epsilon}{\epsilon-1}\frac{\lambda}{P_K})^{1-\epsilon}\frac{1}{K}(\frac{\epsilon}{\epsilon-1})^{1-\epsilon}(1-\epsilon)\lambda^{-\epsilon}\frac{P_K^{\epsilon-1}}{K} =$$
$$(\frac{\epsilon}{\epsilon-1}\lambda)^{1-\epsilon}(\frac{\epsilon}{\epsilon-1})^{1-\epsilon}(1-\epsilon)\lambda^{-\epsilon}(\frac{P_{K-1}^{2(\epsilon-1)}}{(K-1)^2} - \frac{P_K^{2(\epsilon-1)}}{K^2})$$

Combine the two:

$$\frac{d(s_{K-1}-s_K)}{d\lambda} = \frac{d\hat{s}_{K-1}}{d\lambda} - \frac{d\hat{s}_K}{d\lambda} - 2(1-\frac{1}{\epsilon})\big[\frac{d\hat{s}_{K-1}}{d\lambda}\hat{s}_{K-1} - \frac{d\hat{s}_K}{d\lambda}\hat{s}_K\big] =$$
$$(\frac{\epsilon}{\epsilon-1})^{1-\epsilon}(1-\epsilon)\lambda^{-\epsilon}(\frac{P_{K-1}^{\epsilon-1}}{K-1} - \frac{P_K^{\epsilon-1}}{K}) - 2(1-\frac{1}{\epsilon})(\frac{\epsilon}{\epsilon-1}\lambda)^{1-\epsilon}(\frac{\epsilon}{\epsilon-1})^{1-\epsilon}(1-\epsilon)\lambda^{-\epsilon}(\frac{P_{K-1}^{2(\epsilon-1)}}{(K-1)^2} - \frac{P_K^{2(\epsilon-1)}}{K^2}) =$$
$$(\frac{\epsilon}{\epsilon-1})^{1-\epsilon}(1-\epsilon)\lambda^{-\epsilon}(\frac{P_{K-1}^{\epsilon-1}}{K-1} - \frac{P_K^{\epsilon-1}}{K})\big[1 - 2(1-\frac{1}{\epsilon})(\frac{\epsilon}{\epsilon-1}\lambda)^{1-\epsilon}(\frac{P_{K-1}^{\epsilon-1}}{K-1} + \frac{P_K^{\epsilon-1}}{K})\big] =$$
$$(\frac{\epsilon}{\epsilon-1})^{1-\epsilon}(1-\epsilon)\lambda^{-\epsilon}(\frac{P_{K-1}^{\epsilon-1}}{K-1} - \frac{P_K^{\epsilon-1}}{K})\big[1 - 2(1-\frac{1}{\epsilon})(\hat{s}_{K-1} + \hat{s}_K)\big]$$

It was shown in the previous result that $\frac{P_{K-1}^{\epsilon-1}}{K-1} - \frac{P_K^{\epsilon-1}}{K} > 0$, and $1-\epsilon < 0$ for $\epsilon > 1$ therefore the expression is negative (decreasing in marginal cost) as long as:

$$1 - 2(1-\frac{1}{\epsilon})(\hat{s}_{K-1} + \hat{s}_K) > 0$$
$$\hat{s}_{K-1} + \hat{s}_K < \frac{1}{2}\frac{\epsilon}{\epsilon-1}$$

Investment Rule

Consider the value of firm with productivity i at sector j and entry signal ϕ^q. Then call the expected value of the firm conditional on the entry signal and successful innovation by CV_1. In the case that innovation is unsuccessful we call the continuation value CV_0. The problem of the firm can be written as:

$$V(\phi_i, \mu_j, \mu_{agg}) = (1 - fr \times D)\pi*(\phi_i, \mu_j, \mu_{agg}) - wb\frac{x^2}{2} + \beta max\{0, \begin{bmatrix}1-e^{-x} & e^{-x}\end{bmatrix} \times \begin{bmatrix}CV_1\\ CV_0\end{bmatrix}\}$$

If the final expression is equal to zero then $x = 0$, otherwise differentiate with respect to x:

$$\frac{\partial V}{\partial x} = -wbx + \beta e^{-x} CV_1 + \beta * (1 - e^{-x}) \frac{\partial CV_1}{\partial x} - \beta e^{-x} CV_0 + \beta \times e^{-x} \frac{\partial CV_0}{\partial x}$$

where:

$$\frac{\partial CV}{\partial x} = \beta * (1 - e^{-x_{cv}}) \frac{\partial V}{\partial x} = 0$$

Substituting this result in the First Order Condition gives:

$$-wbs + \beta e^{-x} CV_1 - \beta e^{-x} CV_0 = 0$$

Call $\Delta V = CV_1 - CV_0$,

$$\frac{\beta \Delta V}{wb} = xe^x$$

This gives the investment rule:

$$x = W\left(\frac{\beta \Delta V}{wb}\right)$$

Where $W(.)$ is the Lambert W function.

Computational Appendix

Here, I describe the numerical algorithm used to solve the model. I make an initial guess for N, M, the steady state sectoral distribution and wage. I discretise the (idiosyncratic) productivity state to K different values. I then solve for the Bellman equation described in the model section using value function iteration. At this stage, and given the distribution, the labour demand by firms can be calculated. Given the labour supply (normalised to 1) I solve for the wage and iterate until convergence. This gives the policy functions for the firm, including the deterring strategy and investment in innovation. These policy functions combined with the entry distribution can be used to write the transition matrix. I then find the steady state vector associated with the transition matrix. I endogenise N the number of firms such that the value of incumbent firms distributed at the steady state level (approximately) equals S the sunk cost of entry. The value will be approximate as N is an integer and therefore I choose the value such that increasing the number of incumbents to $N + 1$ drives the mean value below S. I endogenise M the number of entrants such that given signal ϕ^q, and the distribution of entrants $\mathcal{H}$ the free entry condition is satisfied. I iterate over these values until convergence (fixed point argument).

It should be noted as this is a dynamic oligopolistic competition, firms at every time period give the best response to their competitors strategies. This means when solving the value functions, the decision of firm cannot be considered in isolation from the other firms

in the same sector (the sectoral state). Therefore, at each stage, I solve the problem of N firms (K different types) together, and check that the incentive compatibility condition as in (13) and the ability condition (18) are consistent with decisions of firms.

Distribution of entrants and signals for entry is assumed to be a truncated Pareto distribution with probability density function:

$$\frac{G_e L^{G_e} \phi^{-G_e}}{1 - (\frac{L}{H})^{G_e}}$$

L denotes the lower bound and H is the upper bound. In the case of entrant's distribution these values are determined by the bounds of the productivity space. In the case of the signal for entry (determining the relative position of entrants with respect to incumbents) the lower bound is 1 ($= \gamma^0$) stating that entrants attach a positive probability in being able to copy the technology of the existing firms. The upper bound is chosen to be γ^3 meaning for the highest entry signal, entrants will attach a positive probability in being γ^3 times more productive than the current market leader. I estimate the model choosing H to be γ^2 and γ^4. Estimations for productivity growth, welfare and other targeted moments are robust, but the current choice provides a better fit for untargeted moments. Any value above γ^4 becomes computationally costly.

Finally, in the model, productivity growth is calculated as the weighted average of growth of incumbents through innovation, increase in productivity through entry of more productive firms, and increase in productivity through exit of less productive firms. The weights are determined by the share of each group in the sector.

Welfare

The figure below show the response of consumption in very long term in response to preventing all anticompetitive practices.

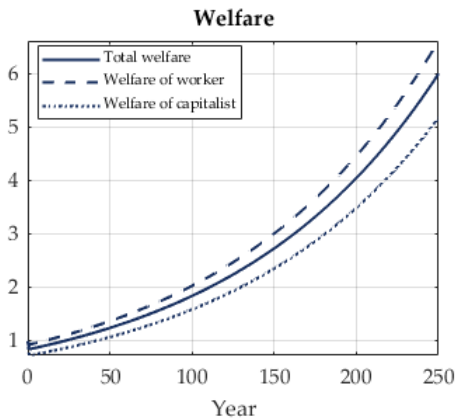


Figure 23: Welfare

This table decomposes welfare of capitalists into capital owners and profit owners. Panel A shows the strict case of antitrust policy while Panel B is the intermediate case.

Table 29: Breakdown of welfare of capitalists into capital owner and profit owner

	Welfare Present value of Consumption	Consumption (immediate)	Consumption (after 50 years)	Break even year
Panel A				
Capitalist	0.00	-0.27	0.07	41
Capital owner	0.28	-0.06	0.37	10
Profit owner	-0.57	-0.69	-0.54	149
Panel B				
Capitalist	-0.03	-0.20	0.02	46
Capital owner	0.12	-0.06	0.19	16
Profit owner	-0.35	-0.47	-0.31	127

This table provides a more conservative estimate of the impact of antitrust on inequality, by assuming those dependent on wage income are 14% of population in the US. This is an upper bound as presented in Lee (2019).

Table 30: The effect on antitrust law on inequality - a conservative estimate

	Baseline		strict
	$\psi_{cl} = 1$	$\psi_{cl} = 0.6$	$\psi_{cl} = 0$
consumption per worker	1	1.12	1.28
consumption per capitalist	4.57	4.41	4.57
P90 - P10 ratio	4.57	3.93	3.57