Competition, Profit Share and Concentration

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Concurrence, part des profits et concentration des entreprises

Résumé
Cet article étudie les effets distributionnels de la concurrence de type « winner-takes-most » (ou effet superstar), et son rôle dans les récentes tendances macroéconomiques des économies avancées. Nous documentons une corrélation positive entre les variations au niveau sectoriel des parts du travail et du capital dans la valeur ajoutée, et une corrélation positive entre les variations de la part des profits et la concentration sectorielle. Toutefois, en mobilisant des données sectorielles procurant des informations sur la distribution des marges au niveau des entreprises, nous trouvons une corrélation négative entre la concentration et de nombreux quantiles de cette distribution. Nous proposons un modèle d'équilibre général avec des entreprises hétérogènes selon lequel une augmentation de la concurrence, c'est-à-dire ici une augmentation de la sensibiliité des consommateurs aux prix relatifs des différentes variétés d'un même bien, et donc une diminution du taux de marque des entreprises, conduit à une augmentation de la concentration sectorielle, une diminution des parts des profits au niveau des entreprises mais une augmentation des parts des profits au niveau sectoriel. Nous étudions l'effet d'un changement d'environnement compétitif sur le sentier de croissance équilibré (SCE). Contrairement aux modèles à entreprise représentative, la concurrence réduit la probabilité de succès à l'entée et donc la diversité des produits. Si les consommateurs valorisent cette dernière, nous montrons que la croissance, le taux d'intérêt naturel et le bien-être décroissent avec le niveau de concurrence.

Competition, Profit Share and Concentration

Abstract
This paper investigates the distributional impact of 'winner-takes-most' competition and its role in shaping recent macroeconomic trends in advanced economies. We document a positive correlation between variations in industry labor and capital shares, and a positive correlation between variations in industry profit shares and industry concentration levels. However using micro-based industry data on firm-level profit margins, we find a negative correlation between industry concentration and a wide range of moments from the distribution of profit shares. We propose a dynamic general equilibrium model with heterogeneous firms, in which an increase in competition, whereby consumers become more price-sensitive and firm markups decrease, leads to a rise in concentration, a decrease in *firm-level* profit shares but an increase in *industry-level* profit shares. We study the effect of a change in the competitive environment on the Balanced Growth Path (BGP). In contrast with representative firm models, competition reduces the probability of successful entry and product diversity. If consumers value product diversity, we show that output growth, the natural interest rate, and welfare decrease with competition.

1 Introduction

The forces of globalization and new technologies have changed the nature of competition (Van Reenen, 2018) and while the effects of competition on innovation and growth (Aghion et al., 2005) or on the sharing of the economic surplus among producers and consumers have been widely studied, more recent work has begun to examine the impact of a rise in competition on the distribution of value-added among workers, capital owners, and firm owners.

A large body of work has documented a decline in the aggregate labor share of GDP in many advanced economies since the beginning of the 1990s (Elsby et al., 2013; Karabarbounis and Neiman, 2014; Piketty and Zucman, 2014; Dao et al., 2017). In the USA, Autor et al. (2020) show that larger firms have lower labor shares and that the fall in industry-level labor shares is mainly attributable to a reallocation of market shares from high-labor-share firms to low-labor-share firms, while the labor share for the *average* firm has in fact been on the rise. Lashkari et al. (2019) find similar evidence for France. These authors also document a positive correlation between decreases in the labor share and the rise in concentration and a negative correlation between firm size and labor share. Specifically, Bessen (2017) documents a rise in concentration in the US since 1980, and Autor et al. (2020) suggest that 'winner-takes-most' competition drives these changes. Traditional aggregate neoclassical analysis of the distribution of aggregate income cannot account for these patterns because in this framework, labor share variations occur within industry-level representative firms.

In this paper, we explore the claim that labor shares have decreased and profit shares have increased in advanced economies. We find substantial heterogeneity across industries and countries, and we document important evidence of a positive correlation between variations in concentration and *industry-level* profits but a negative correlation between variations in concentration and *firm-level* profits, using micro-based industry-level data for the largest countries of the Eurozone.

To rationalize these facts, we extend the framework in Autor et al. (2020) and build a tractable dynamic general equilibrium model which features firm heterogeneity and endogeneous entry *à-la* Melitz (2003), and a cross-sectional positive correlation between firm size and profit share. We perform a simple calibration exercise and study the response of the model in moving from a low to a high competition environment. We show that an increase in product market competition decreases *firm-level* profit shares, which contributes negatively to the aggregate profit share (*within-firm* effect), and increases concentration, which, together with the fact that larger firms have higher profit shares, contributes positively to the aggregate profit share (*reallocation* effect). We show that when market shares are distributed according to a Pareto law, the *reallocation* effect is stronger than the *within-firm* effect. Moreover, our model predicts that a rise in competition decreases business dynamism and aggregate output growth in the long run.

In our model, an increase in competition is captured by a increase of the elasticity of substitution across goods, which leads to a decrease in firm level markups. This type of competition is in fact an increase in "market toughness" from the point of view of firms, meaning that consumers react more

strongly to variations in prices, and should not be confused with a decrease in barriers to entry or stronger antitrust laws as in Gutiérrez and Philippon (2018). An increase in market toughness could stem from technology if marketing and now internet platforms made price comparison easier for consumers, from globalization, if international competition reduced firm level markups, or, keeping with our model, from preferences if varieties are simply now more substitutable to the consumer than before.

Prior works by Barkai (2020) and Karabarbounis and Neiman (2018) have emphasised that the fall in labor shares has not been accompanied by a rise in the productive capital share of GDP, but by a rise in the 'factorless' share of income, therefore casting further doubt on the contribution of the automation of tasks performed by workers (Acemoglu et al., 2016), or of substitution away from labor following a fall in the price of capital (Karabarbounis and Neiman, 2014; Piketty and Zucman, 2014). In particular, for substitution to explain a fall in the labor share of income, the aggregate elasticity of substitution has to be above 1, an assumption that is not in line with the bulk of the empirical literature (Lawrence, 2015; Oberfield and Raval, 2014). Another strand in the literature has focused on the role of firm-level markups in advanced economies to explain that the rise in the profit share of aggregate income, and find that there has been a significant reallocation of market share from low to high markup firms, together with a fattening of the upper tail, and that the aggregate profit share increased, both in the US and in advanced economies. (De Loecker et al., 2020; De Loecker and Eeckout, 2018). The role of competition behind these evolutions has however seldom been studied, with the exception of Berkowitz et al. (2017), who use firm-level data from China to show that product-market deregulation can explain the majority of the decline in labor shares through a decline in political pressure to protect employment in state-owned enterprises. There is controversy over the degree to which the fall in the labor share is attributable to measurement issues, for instance the treatment of non salaried workers (Elsby et al., 2013), and housing capital (Rognlie, 2015) or intangible capital (Elsby et al., 2013; Rognlie, 2015; Koh et al., 2015).

The macroeconomic consequences of firm heterogeneity have been the focus of much recent work in the trade and business cycle literature. For instance, because of firm productivity heterogeneity, exposure to trade has important implications on the extensive as well as the intensive margin of exports, leading to important reallocation towards more productive firms and efficiency gains (Melitz, 2003; Eaton et al., 2011). Gabaix (2011) shows that idiosyncratic firm-level shocks explain an important part of aggregate variations of output growth. Importantly, Luttmer and Luttmer (2007) shows that random growth of firms, selection and imitation by entrants with entry and innovation frictions lead to fat-tailed distribution of firm market shares, and that about half of output growth can be attributed to selection. Moreover, the possible negative impact of competition has been documented by among others Aghion et al. (2005); Goettler and Gordon (2014), who both document a inverted U relationship between competition and innovation, and show in different settings that this relationship can be rationalized by the fact that competition discourages laggard firms from innovating. We add to these contribution by showing that despite the increase in

aggregate profits, competition reduces the probability of successful entry and product diversity. If consumers value product diversity, we show that output growth, the natural interest rate, and welfare decrease with competition.

In this paper, we do not take a stance on the underlying forces behind an broad increase in product market competition. For instance, on the demand side, price comparison websites can increase consumer willingness to substitute for slightly different but cheaper options. Conversely, on the supply side product standardization can increase the comparability of similar goods. We will use the terms 'competition' and 'market toughness' interchangeably throughout this paper.

The remainder of this paper is organized as follows: Section 2 presents our methodology for computing aggregate profit shares and key empirical facts about the distribution of income, Section 3 presents our key empirical facts about the relationship between profits and concentration. Section 4.1 discusses the main elements of our theory, and Section 4.2 presents the calibration results, then Section 5 concludes.

2   Facts

2.1   Measuring the Profit Share

In this section, we describe our methodology to compute the aggregate shares of income accruing to labor, capital and finally to firm owners, and we document a positive correlation between the labor and the capital share at the country and industry level, suggesting that a large part of the variation in factor shares are attributable to shifts in the total cost share, and therefore to shifts in the aggregate profit share. Profit shares have been increasing dramatically in the US from 1990 to 2015 across a wide selection of sectors. In France, the profit share is humped-shaped with a maximum around the year 2000, and industry level profit share variation are not homogeneous.

By definition, at the country level, total nominal value added or income PY equals the sum of payments to labor WL, payments to capital $R^K K$ and economic profits V earned by firm owners selling the output of the firm at a price that exceeds the average cost of production.

$$R = WL + R^K K + V. \tag{1}$$

Dividing both sides by R to express each component as a share of income, we obtain the profit share of income V/R as the residual of Equation (1).

First, to measure total payments to labor we need to go beyond the accounting definition of compensation of employees which does not encompass all payments to labor, for instance when accounting profits are used as compensation for the work of self-employed or sole proprietors. We follow Jäger (2017) and make the assumption that the imputed hour wage of non-employees is the observed average hourly wage of employees of the same industry i. Letting W_i^{emp} be the hourly wage in industry i, L_i^{emp} hours worked by employees, and L_i^{nonemp} hours worked by non-employees, we can express total payments to labor WL at the country level as:

$$WL = \sum_i W_i^{emp} \left(L_i^{emp} + L_i^{nonemp} \right). \tag{2}$$

Second, to measure total payments to capital requires measuring the returns to productive capital R^K. Jäger (2017) assumes that there is no economic profit at the industry level and uses that assumption to back out R^K from Equation (1). Because our goal is precisely to measure the profit share, we follow Hall and Jorgenson (1967) and Barkai (2020) and make the following assumptions:

Assumption 1. *Households are indifferent between owning productive capital and government bonds.*

Assumption 2. *Firms are indifferent between renting from households and owning their productive capital stock.*

Let there be J different asset types of productive capital. Assumption 1 implies that if government

bonds yield a nominal rate R^n, type j asset whose current investment price is P^j and depreciates is δ^j has a nominal return R^j to households of:

$$R^j = P^j \left[R^n + \delta^j - E[\Pi^j] \right], \tag{3}$$

where $E[\Pi^j]$ is the expected inflation of P^j, which reflects either the resale value of capital at the end of the next period, or the opportunity gain of investing now instead of during the next period.[1] This assumption in particular implies that investing in productive capital is not riskier than investing in government bonds. Assumption 2 implies that this return applies also to capital owned by firms. We observe K_i^j the total capital stock of type j used in production in industry i, therefore total payments to capital at the country level are:

$$R^K K = \sum_i R_i^K K_i = \sum_i \sum_j R^j K_i^j, \tag{4}$$

where we define K_i (and K) as the chained volume index of the aggregate capital stocks across all types of asset (and industries). The EU KLEMS database (Jäger, 2017) provides aggregate data from National Accounts on value added at factor costs, investment, investment price, and capital stock for 10 types of capital, including intangible capital, as well as wages, employment and hours worked for employed and non-employed workers, at for 27 industries covering the whole economy of 20 countries of the European Union and the United States (USA), with varying historical depth.[2]

Figure 1 displays compensation of employees and total labor payments including compensation of self-employed workers as a share of value added in France, Germany, the United Kingdom (UK) and the USA, from 1987 to 2015, for the market economy.[3] The decline of the labor share observed in the USA starting in 2000, is not a shared feature of those four countries. In France, compensation of employees as a share of value added actually is broadly stable, and the decrease of the labor share from 1985 to 2000 is mainly driven by the decrease in the share of payments to non salaried workers, which given our assumption about the wages of non salaried workers, reflects a structural shift toward salaried employment; in 2015 payments to labor in the market economy as a share of value added had almost recovered their mid-80s level, with the 2009 recession appearing to have no discernible impact on this trend. In the UK, despite strong fluctuations in 1990's, overall payments to both employees and total labor appear stable over the period but for a decline in 2014 and 2015. In Germany[4] the pattern resembles what occurred in the USA, with a decline in the labor share beginning around the first half of the 1990's and a leveling since the great recession.

Figure 4 displays the capital share for those same four countries, at the market economy level, using

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[1]The proof of this equation will be straightforward in Section 4.2.

[2]Data availability is summed up in Appendix C.

[3]We restrict our analysis to industries outside the public sector where the National Accounts make stringent assumptions about the capital share in order to measure the non-market value-added, namely that capital payments are equal the cost of depreciation, which correspond to $R = 0$ and $E[\Pi^j] = 0$ in Equation 3.

[4]Pre-1991 data for Germany back-casted based on West Germany aggregate data.

a five year moving average for the investment price per type of capital as a proxy for $E[\Pi^j]$[5], and long-term or short-term bond rates from the OECD as a proxy for R^n. Long-term interest rates refer to government bonds maturing in ten years. Short-term interest rates are based on three-month money market rates. Both rates are implied by the prices at which the government bonds are traded on financial markets, not the interest rates at which the loans were issued, in order to reflect current information available and the effective opportunity cost of capital for investors. Both definitions yield similar result and as a convention we will use long term rates in the remainder of the paper. Aggregate productive capital data starts in 1995 in Germany and 1997 in the UK. Contrary to labor shares, capital shares have been decreasing in all four economies. In all countries they amount to around 15% of value-added in 2015. In Germany, the capital share fell from 25% to 30% in 1996, in the UK from 20% in 1998, and in the USA it fell from 25% to 30% in 1985 to almost 10% in 2005 before recovering around the 2008 recession. In France, the capital share increased from 19% in the mid-80s to 22% in 1990, and then decreased to 15% in 2015, with a hump around 2010.

These results are consistent with existing evidence from other research. Autor et al. (2020) document falls in labor shares in the US and advanced economies, and their measures for the USA, at the aggregate and detailed per broad industries are very close to the patterns described here. However, our measure of the labor share in France shows a rise at the end of the time period that is not apparent in Autor et al. (2020). We attribute this difference to the fact they use employee compensation as a measure for payments to labor, while we also include imputed payments to self employed workers. Cette et al. (2019) show that this correction is especially important in the context of France. Barkai (2020) shows that for the US, the aggregate capital share fell from close to 30% in 1985 to around 15% in 2014, and that the profit share rose from 2% to 15% in the same period. Although their is a difference in the level of the profit share, which we attribute to the fact that Barkai (2020) computes the after tax profit share, the trends are very similar. De Loecker and Eeckout (2018) computes aggregate markups from micro data on publicly traded firms in many countries and find substantial increases everywhere. De Loecker et al. (2020) also shows an increase of aggregate markups using more exhaustive data for the USA. This evidence is consistent with an increase in aggregate profit shares. Finally, Gutiérrez and Philippon (2018) measure the profit share as gross operating surplus over value added or output, a different measure than in this paper, where we distinguish between capital and profit. First, consistently with our analysis of the labor share, they find a slight increase in the profit plus capital share in Europe, although not as big as in the USA. In our paper, the European modest rise in aggregate profit shares is in fact more driven by the fall in capital shares than by the fall in labor shares.

We further explore the contributions to these variations in capital shares. A popular explanation of the fall in labor shares is that capital and labor are substitutes and that a fall in the price of capital is accompanied by a rise in the capital stock which more than offsets the fall in price, such that the total capital shares increases. Given that we find that capital shares are broadly falling, our

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[5]$E_t[\Pi^j] = \frac{1}{5} \sum_{\tau=t-2}^{t+2} \Pi_\tau^j$

analysis provides some insight about where this substitution may be failing. Rewriting Equation (4) in share of nominal value added PY, we obtain an expression for the capital share:

$$\frac{R^K K}{PY} = \sum_i \sum_j \frac{P^j K_i^j}{PY} \left[R^n - E[\Pi] + \delta^j - (E[\Pi^j] - E[\Pi]) \right]$$

$$= \left(\underbrace{R^n - E[\Pi]}_{\text{Real Interest Rate}} + \sum_j \underbrace{\frac{K^j}{K}}_{\text{Composition}} \underbrace{\frac{P^j}{P^K} \left[\delta^j - E[\Pi^j - \Pi)] \right]}_{\text{Net Replacement Cost}} \right) \underbrace{\frac{K}{Y}}_{\text{Intensity}} \underbrace{\frac{P^K}{P}}_{\text{Relative Price}}, \quad (5)$$

where $K^j = \sum_i K_i^j$ is aggregate stock of type j capital across all industries, P^K and K are the chained price and volume indexes and of aggregate investment and capital across all types of capital and all industries, and Π is value-added price inflation. We do an "accounting" decomposition of aggregate variations in the capital share into five components:

1. Real interest rate : a decrease in the real interest rate reduces the opportunity cost of investing into productive capital, and therefore reduces the required return for all types of capital.

2. Composition : Because of higher depreciation or lower resale price inflation, some asset types are more user-costly than others. When the composition of the aggregate capital stock shifts towards those asset types, the aggregate rate of return mechanically increases.

3. Net Replacement Cost : holding the composition of the capital stock constant, when one or several type of capital are expected to lose value at a faster rate, investors ask for a higher rate of return.

4. Relative Price : the nominal rate of return is the product of the real rate of return and the price of investment. All other things equal, when the price of investment is lower, the nominal rate is lower.

5. Intensity : holding the nominal rate constant, a lower stock of capital relative to value added reduces the capital share.

Figure 5 reports the contributions of each component to the capital share (computed with long term interest rate) for France, Germany, the UK and the USA.[6] In all countries, the real interest rate and the relative investment price both contributed, in accounting terms, to the fall in the

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[6] Let $X_t = f \left[(Z_t^c)_{c \in C = [1;5]} \right]$ be the capital share at time t as a function of each component Z^c in Equation (5). The contribution ΔZ_x^c of component Z^c to the variation $\Delta X = X_1 - X_0$ between periods 0 and 1 is given by:

$$\Delta Z_x^c = f \left[Z_1^c, \left(Z_0^{c'} \right)_{c' \in C \setminus \{c\}} \right] - f \left[Z_0^c, \left(Z_0^{c'} \right)_{c' \in C \setminus \{c\}} \right].$$

The sum of contributions does not therefore perfectly equal the aggregate variation.

capital share. With the exception of the UK, the composition of the capital stock contributed to a rise, indicating that the composition of productive capital shifted towards assets that depreciate more quickly or lose value more quickly, and for which investor ask for a higher rate. On the other hand, this composition effect is mostly offset by the fact that those types of capital became less and less costly to replace. Finally, in the US and the UK, capital intensity increased steadily, while it decreased then increased in France, and remained broadly stable in Germany, which does not suggest that substitution towards capital played a substantial role in the fall in the labor share.

We now provide evidence that these declining trends in capital share evolution were not offset by similar increasing trends in labor shares, suggesting significant evolution in profit share over the period, and that that capital and labor shares tend to move together at the industry level in most advanced economies. Figures 6 and 7 show the correlations between four year variations in smoothed labor shares and smoothed capital shares for a wider sample of countries of the European Union plus the USA, for 30 industries of the market economy. The grey line draws the frontier at which the profit share is stable, we report below each scatter plot the results of separate regressions of capital share variations on labor share variations for each period. First, except in the run-up to and after the great recession, most countries and industries have experienced increases in profit share. Second, in the last 25 years, the correlation between variations in factor shares is never significantly negative. At the country level, the correlation is positive and significant at least at the 10% level half of the time (1992-1996, 2000-2004 and 2004-2008), and non significant the remaining half. At the industry level, labor and capital shares variations were uncorrelated only in the aftermath of the great recession.

Because variations in factor shares tend to be correlated, these variations are reflected in variations of the profit share. Figures 8 and 9 show the evolution of the smoothed profit share of income resulting from the capital and labor shares previously calculated, in France and in the US for a selection of broad industries and for the whole market economy, either as a share of value added or output. Profit shares have been increasing in most US industries, and therefore in the entire market economy, while in France patterns differ across industries and the evolution of the aggregate profit share is hump-shaped. Therefore, we find no evidence in favor of the explanation of the decline in labor shares as a result of substitution towards capital.

To what are these profit share patterns attributable to? Our profit measure captures all that is not included in measured payments to labor or capital. For instance non produced assets such as land and natural resources are not included in the measure of productive capital. Profits here are the sum of *Ricardian rents*, i.e., the returns to fixed, firm-specific, inimitable factors that distinguish firms from one another, and to assets whose quantity is constant and cannot be accumulated.

Capital may also be a riskier asset than government bonds, contrary to assumption 1, and the profit share patterns we observe may then include risk premium variations. However, as the next section will show, most of our results related to profit shares variations remain (with an opposite sign) when we relate them to labor shares, which suggest that most of the patterns we aim to explain

here are driven by true cost variations rather than risk premium variations. Profits fluctuate with many factors related to the competitive environment, such as competition, product differentiation, market size, returns to scale or monopolistic power, and we will now focus on these determinants.

3 Industry Concentration and Profit Shares

In this section, we study further the link between profit share variations and the competitive environment, and show that variations in industry-level concentration are positively (resp. negatively) correlated with variations in industry level profit shares (resp. factor shares), but are negatively correlated with variations in firm-level profit shares, which suggests that some strong reallocation forces are at play: if firms which gain market shares both are larger and have higher profit shares, then we will both observe a rise of concentration and an increase in the aggregate profit share, holding firm level profit constant. In fact, we document evidence that in European countries, increases in concentration were accompanied by decreases in firm level profit profits.

The CompNet (Competitive Research Network) database provides micro-based data on the distribution of firm market shares and profit shares at the two-digit NACE level for 14 European countries (di Mauro and Lopez-Garcia, 2015).[7] While the CompNet database does not provide the micro data on which it is based, it provides information on selected percentiles (p1, p5, p10, p25, p50, p75, p90, p95 and p99), as well as weighted and unweighted means from 2000 to 2012 for most industries and countries.

We begin our analysis by investigating how variations in industry-level factor shares, as computed in the previous section, are correlated with variations in industry-level concentration. For an industry k in country c at time t, we apply regressions of the form:

$$Concentration_{kct} = \alpha Share_{kct} + FE_{kc} + FE_t + \epsilon_{kct}, \tag{6}$$

where $Concentration_{kct}$ denotes a measure of industry level concentration, $Share_{kct}$ denotes labor, capital, or profit shares, FE_{kc} stands for a flexible set of industry-country fixed effects, and FE_t denotes year fixed-effects.

Table 1 reports the coefficient α for separate regressions corresponding to the specification in equation 6, where concentration is either the share of total industry turnover of the largest 1% or 5% of firms, or the logarithm of the ratio of the 99th or 95th percentile of market share to the median market share, and where factor and profit shares are in ratio of industry value added or industry output. Industry-level labor share variations are negatively correlated with industry-level variations in concentration : an increase of the aggregate labor share of value added (resp. of output) of 1 percentage point is associated with a decrease of the market share of the largest 1% of firms of around 0.05% (resp. 0.08%), a decrease of market share of the largest 5% of firms of around

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[7]For more detail on ComptNet data coverage, see Appendix C.

0.11% (resp. 0.23%). The ratios of the 99th and 95th percentile to the median market share also decrease. The correlation between capital shares and concentration is less strong, but overall, the correlation between industry level profit share variations and variations in concentration is strongly positive : an increase of the aggregate profit share of 1 percentage point is associated with an increase in concentration of around 3% to 12%.

We now ask whether this pattern is still true at the firm level. The CompNet database provides information on the distribution of firm-level profit shares, computed as one minus the ratio of costs to firm turnover, with two alternative measures for total costs, one that only includes labor and intermediary inputs, and one that includes also a proxy similar to ours for capital costs, but at the level of the firm. For an industry k in country c at time t, we apply regressions of the form:

$$Concentration_{kct} = \alpha FirmShareIndex_{kct} + FE_{kc} + FE_t + \epsilon_{kct}, \qquad (7)$$

where $Concentration_{kct}$ denotes a measure of industry level concentration, $FirmShareIndex_{kct}$ denotes an element of the distribution of firm-level profit shares, FE_{kc} stands for a flexible set if industry-country fixed effects, and FE_t denotes year fixed-effects.

Table 2 reports the coefficient α for separate regressions corresponding to the specification in equation 7, where concentration is measured as in table 1, and firm-level profits shares of value added are proxied by the unweighted mean profit share, the median, the 95th percentile or the 99th percentile of the distribution of profit shares. Table 2 shows a mostly negative relationship between shifts of the distribution of the profit share and industry level concentration. The only exception is for the 99th percentile of the distribution, where increases in concentration are associated with increases of the top 1% profit shares.

A possible interpretation of the fact that higher concentration is associated with higher industry level profit share but with lower firm-level profit share (with the exception of firms in the top 1% of profit shares) is that the profit share decreased over the period at the firm level but this decrease was more than offset by the effects of a reallocation of market shares towards firms with higher profit shares, which increases the profit share at the industry level, and with higher market shares, which increases concentration. We now explore the possible drivers of the positive correlation between aggregate profit shares and concentration, between a reallocation of market shares towards larger firms, or an increase in top profit shares. Because the CompNet data does not provide information on the joint distribution of profit shares and size, an exact decomposition is not possible, but we can asses how quantitatively important each driver is. For an industry k in country c at time t, we apply regressions of the form:

$$ProfitShare_{kct} = \alpha TopProfitShare_{kct} + \beta TopMarketShare_{kct} + FE_{kc} + FE_t + \epsilon_{kct}, \qquad (8)$$

where $ProfitShare_{kct}$ denotes the aggregate profit share, $TopProfitShare_{kct}$ denotes the top per-

centile of profit shares, and $TopMarketShare_{kct}$ denotes the share of larger firm in total industry sales. Tables 3 and 4 show that the correlation with the share of larger firms is two orders of magnitude higher that the correlation with top profit shares, which suggests that reallocation toward larger firms is a more important driver of the rise in aggregate profit shares. In the next section, we will characterize conditions on the heterogeneity of firms for which a variation in competition explains these two facts.

4 Theory

In this section, we provide a theory that rationalizes the empirical facts that we uncovered in the previous section. The core of the model is a simple industry equilibrium with heterogeneous firms and monopolistic competition *à-la* Melitz (2003) where the underlying distribution of firm productivities determines the extent to which increasing industry competition, captured by the industry level unique demand elasticity, leads to an increase or a decrease in aggregate profit shares: when productivity is Pareto-distributed, the aggregate profit share increases with competition. We discuss in Section 4.1 the intuition behind our result in partial equilibrium, and then in Section 4.2 we construct a general equilibrium model with a capital good sector and balanced growth that matches the empirical facts uncovered in the previous section in order to examine the long run macroeconomic implications of increasing competition.

4.1 Partial Equilibrium

In this section, we describe the economic environment of the final good industry, and show that the three stylized facts from the previous section can be replicated with a simple model of industry imperfect competition. This partial equilibrium reproduces all the facts regardless of general equilibrium forces.

Economic Environment

Consider an industry with a continuum of goods indexed by i. We assume that consumers choose their bundle $\{q_i\}_{i \in I}$ to maximize instantaneous utility Q according to the following CES aggregator:

$$Q \equiv \left(M^{\frac{\nu-1}{\rho}} \int_{i \in I} q_i^{\frac{\rho-1}{\rho}} di \right)^{\frac{\rho}{\rho-1}}, \tag{9}$$

where M is the mass of available goods and is equal to the measure of the set I, the parameter $\nu \in [0; 1]$ captures the extent to which consumer value increased diversity as in Felbermayr et al. (2011),[8] and the elasticity of substitution ρ verifies the restriction $\rho > 1$. Given prices $\{p_i\}_{i \in I}$, total consumer expenditure R in the industry is:

$$R \equiv \int_{i \in I} r_i di, \tag{10}$$

where $r_i = p_i q_i$ is expenditure in good i. This program yields optimal expenditure decisions for

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[8]Consider the symmetric case where all firms produce q units of each good. Then $Q = M^{1+\frac{\nu}{\rho-1}} q$. If $\nu = 0$, then consumer utility is the same whether she consumes M different goods in quantity Q/M or $2M$ different goods in quantities $Q/2M$, therefore good diversity has no increasing impact on consumer utility. If $\nu = 1$, the production function takes the conventional Dixit-Stiglitz form. The ratio $\frac{\nu}{\rho-1}$ can also be interpreted as the degree of aggregate economies of scale in the economy.

individual good i pinned down by the share ψ_i of each good in total expenditure :

$$\psi_i \equiv \frac{r_i}{R} = \frac{1}{M}\left(\frac{p_i}{\tilde{p}}\right)^{1-\rho}, \tag{11}$$

where $\tilde{p}$ is a measure of the average price, which we define as:

$$\tilde{p} \equiv \left(\frac{1}{M}\int_{i\in I}p_i^{1-\rho}di\right)^{\frac{1}{1-\rho}} \equiv M^{\frac{\nu}{\rho-1}}P, \tag{12}$$

where P is the CES price index of the bundle P that verifies $R = PQ$.

Firm's problem

There is continuum of firms in the industry, each choosing to produce a different good i. Firm i has technology such that the cost of producing quantity q_i is the sum of a fixed cost f and a variable cost $\frac{\mathscr{C}(q_i,\mathbb{W})}{z_i}$. The variable cost function $\mathscr{C}$ is common to all firms belonging in the same industry and depends on production and the vector $\mathbb{W}$ of production factors rental costs, that is the wage and the cost of capital. We assume that the variable cost function exhibits constant returns to scale such that the marginal cost of a given firm is does not vary with its output q_i.[9] Firms differ by their productivity level z_i.

As in Equation (1), each firm has profit v_i defined as the revenue from production q_i sold at price p_i minus the cost:

$$v_i \equiv r_i - f - \frac{\mathscr{C}(q_i,\mathbb{W})}{z_i} = p_iq_i - f - \frac{cq_i}{z_i}. \tag{13}$$

Firms are in monopolistic competition and therefore choose their price and production in order to maximize their profit, under the constraint given by Equation (11). Given that the demand elasticity is the same for all firms the profit maximization program of all firms results in the same pricing rule, where the price is fixed at a markup over marginal cost:

$$p_i(z_i) = \frac{\rho}{\rho-1}\frac{c}{z_i}. \tag{14}$$

Industry equilibrium

An industry-equilibrium will be characterized by a mass M of firms (and hence M different goods) and an endogenous distribution $h(z)$ of productivity levels. We assimilate each firm to its productivity level, and assuming moments of order $\rho-1$ of the ex-post productivity distribution $h(.)$ exist, we can rewrite Equations (11), (12), and (13) in terms of the productivity distribution, and com-

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[9]See Appendix D

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bine with Equation (14). The average price, and the revenue and profit of firm with productivity z become:

$$\tilde{p} = \left(\int_0^\infty p(z)^{1-\rho} h(z) dz \right)^{\frac{1}{1-\rho}} = c \frac{\rho}{\rho - 1} \tilde{z}^{-1}, \tag{15}$$

$$r(z) = \psi(z) R = \frac{R}{M} \left(\frac{z}{\tilde{z}} \right)^{\rho-1}, \tag{16}$$

$$v(z) = \frac{r(z)}{\rho} - f = \frac{R}{M\rho} \left(\frac{z}{\tilde{z}} \right)^{\rho-1} - f, \tag{17}$$

where $\tilde{z}$ is a measure of industry average productivity:

$$\tilde{z} \equiv \left(\int_0^\infty z^{\rho-1} h(z) dz \right)^{\frac{1}{\rho-1}}. \tag{18}$$

First, Equations (16) and (17) show that firms with higher productivity enjoy higher revenue, market share and profit relative to firms with lower productivity. Second, they show that because of fixed costs of production, there exists a positive productivity cutoff level z^* below which profits are always strictly negative. The cut-off level is endogenously determined at the industry level and is the same for all firms.

Profits of a firm at the cutoff level $v(z^*)$ are equal to zero, a condition from which we derive firm revenue at the cut-off: $r(z^*) = \rho f$. From Equation (16), we have that the ratio of any two firms' revenue is a function of the ratio of their productivities, therefore:

$$\frac{r(z)}{r(z^*)} = \left(\frac{z}{z^*} \right)^{\rho-1}. \tag{19}$$

We have therefore two simpler expressions for firm-level revenue and profits:

$$r(z) = \rho f \left(\frac{z}{z^*} \right)^{\rho-1}, \tag{20}$$

$$v(z) = f \left[\left(\frac{z}{z^*} \right)^{\rho-1} - 1 \right], \tag{21}$$

which we can integrate to obtain average revenue $\tilde{r}$ and average profit $\tilde{v}$:

$$\tilde{r} = \frac{R}{M} = \int_0^\infty r(z) h(z) dz = \rho f \left(\frac{\tilde{z}}{z^*} \right)^{\rho-1}, \tag{22}$$

$$\tilde{v} = \frac{V}{M} = \int_0^\infty v(z) h(z) dz = f \left[\left(\frac{\tilde{z}}{z^*} \right)^{\rho-1} - 1 \right] = \frac{\tilde{r}}{\rho} - f. \tag{23}$$

Next, we assume that there is a large and unbounded pool of prospective entrants into the industry. To enter, firms must make an unobserved initial irreversible investment f_e, then draw a productivity

level z from known distribution $g(z)$ with support $[0; +\infty]$, and decide whether to produce or to exit the industry without producing. Firms that draw a productivity level below z^* exit and never produce. Conditional on successful entry, the resulting productivity distribution $h(z)$ is therefore :

$$h(z) = \begin{cases} \frac{g(z)}{1-G(z^*)} & \text{if } z \geq z^*, \\ 0 & \text{if } z < z^*. \end{cases} \tag{24}$$

This defines the average productivity level as a function of the cutoff productivity level :

$$\tilde{z}(z^*) = \left(\frac{1}{1-G(z^*)} \int_{z^*}^{\infty} z^{\rho-1} g(z) dz \right)^{\frac{1}{\rho-1}}, \tag{25}$$

and from there all other average quantities (profit, revenue and price).[10] The net value of attempting entry is equal to the probability of successful entry $1 - G(z^*)$ multiplied by the expected profit conditional on successful entry, minus the cost of entry. We assume that free entry implies that the net value of attempting entry is zero, therefore we obtain a condition linking average profits and the cutoff productivity level:

$$(1 - G(z^*))\tilde{v} = f_e, \tag{26}$$

where f_e can also be thought of as a barrier to entry. To sum up, the industry partial equilibrium is entirely characterized by three variables: average productivity level $\tilde{z}$ among producing firms, threshold productivity level z^*, average profit level $\tilde{v}$; and by the following three equations: the definition of average productivity, the zero-cutoff-profit condition stating that the marginal firm entering earns zero profit, and the zero-expected-profit condition stating that firms will attempt to enter until expected profits from production cover the fixed cost of entry.

$$\tilde{z}(z^*) = \left[\int_{z^*}^{\infty} z^{\rho-1} \frac{g(z)}{1-G(z^*)} dz \right]^{\frac{1}{\rho-1}} \tag{Avg Prod}$$

$$\tilde{v} = f \left[\left(\frac{\tilde{z}(z^*)}{z^*} \right)^{\rho-1} - 1 \right] \tag{ZCP}$$

$$\tilde{v} = \frac{f_e}{1-G(z^*)} \tag{ZEP}$$

The solution to this equilibrium is not straightforward. However, the right-hand-side of Equation (ZEP) is an increasing function of z^*, the right hand side of Equation (ZCP) is a monotonically decreasing function of z^* for several common families of distribution: lognormal, exponential, gamma, Weibull and truncations of normal, logistic, extreme value and Laplace.[11] Figure 12 draws

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[10]Note that at this point, we are considering a partial equilibrium, therefore total expenditure R, the mass of firms M, and the utility Q are not pinned down.

[11]In fact, it is decreasing for all distributions verifying that $zg(z)/(1-G(z))$ is increasing, see Melitz (2003).

the case of a Lognormal productivity distribution. In the case of a Pareto distribution Equation (ZCP) becomes constant and the system can be solved in closed form.

Effects of Increased Competition

In this section, we are interested in rationalizing the stylized facts uncovered in Sections 2 and 3. To this end, we take a direct look at what determines concentration, firm-level profit shares and industry-level profit share. Studying the effects of an increase in competition through a variation of the elasticity of substitution is a modelling choice that is not innocuous. Autor et al. (2020) study the implications of an increase of the elasticity of substitution in a static model. This type of competition is in fact an increase in "market toughness" from the point of view of firms, meaning that consumers react more strongly to variations in prices, and should not be confused with a decrease in barriers to entry or stronger antitrust laws as in Gutiérrez and Philippon (2018). This increase in market toughness could stem from technology if marketing and now internet platforms made price comparison easier for consumers, from globalization, if international competition reduced firm level markups, or, keeping with our model, from preferences if varieties are simply now more substitutable to the consumer than before.

We find that an increase in competition will increase concentration and decrease firm-level profit shares. The effect on the aggregate profit share is ambiguous: while the profit share of the typical firm decreases, the fact that more productive and therefore larger firms have higher profit shares means that the reallocation of market shares towards those firms has a positive effect on the aggregate profit share. We find that if the underlying productivity distribution is Pareto, the reallocation effect is stronger than the within firm effect.

From the equilibrium, we have firm revenues and profits and compute any index of concentration, as well as firm-level and industry-level average profit shares. In particular, firm-level profit share is given by :

$$\frac{v(z)}{r(z)} = \frac{1}{\rho}\left[1 - \left(\frac{z^*}{z}\right)^{\rho-1}\right],\tag{27}$$

and given z^*, the profit share of firms grows with z and converges to $\frac{1}{\rho}$. We simulate the equilibrium from six different productivity distributions : Pareto, Uniform, Lognormal, Exponential, Gamma and Weibull.

Figure 13 shows the effect of an increase in competition corresponding to a decrease of the industry markup $\mu = \frac{1}{\rho-1}$ from $\mu_1 = 33\%$ to $\mu_1 = 25\%$ on the profit share of firms along percentiles of the productivity distribution. The y-axis is in percentages compared to before shock profit share. First, the least productive active firm has zero profit after the shock while it had positive profit before the shock, showing that the cutoff level increased: competition makes entry harder. Second, competition decreases firm-level profit shares across the entire distribution, but the decrease is smaller for

larger firms. Regardless of the distribution and moving along the productivity distribution towards the most productive firms, effect of a rise in competition on firm-level profit share converges to the a level of around $-20\% \approx \frac{\rho_1}{\rho_2} - 1 = \frac{\mu_1^{-1}+1}{\mu_2^{-1}+1} - 1$, equal to the decrease in the firm-level markup.

Figures 14 and 15 display the relationship between concentration at the industry equilibrium and the level of competition, proxied by the industry markup. In Figure 14, concentration is proxied by the share of industry revenue of the 1% and 5% largest firms, while in Figure 15 it is proxied by the logarithm of ratio of the 99th and 95th percentiles to the median revenue, as in the CompNet dataset we use in Section 3. In all cases, concentrations monotonically increases with the level of competition, that is, when the markup decreases.

Finally, Figure 16 report the relationship between the average industry profit share at the industry equilibrium and the level of competition. In the Pareto case only, average profit share increases with competition, indicating that in that case only is the positive reallocation effect stronger than the within firm negative effect.

To sum up, the positive correlation between concentration and aggregate profit shares, the negative correlation between concentration and firm-level profit shares, and the fact that this negative correlation is stronger for less productive than for more productive firms, which are our facts documented in Sections 2 and 3, are replicated by our theory as responses to an increase in competition, as long as there is a strong heterogeneity between firms, in particular if the distribution of firms productivity follows a Pareto distribution, as opposed to the other distributions studied here that do not exhibit large tails.

The next section shows that in the Pareto case, the partial equilibrium conclusions regarding concentration, and aggregate and firm level profit shares are not affected when we take into account general equilibrium effects. However, but those are important to understand the effects that increased competition has on the determination of the mass of firms, aggregate output and revenue. We study the dynamic implications of increased competition by constructing a general equilibrium model of a monopolistically competitive industry, where firms productivities are distributed according to a Pareto law.

4.2 General Equilibrium

In order to study the macroeconomic implications of increased competition on firm entry and growth, we move to a dynamic model in which at each period new goods are endogenously introduced by firms while existing varieties exit at a constant rate. The representative household smooths consumption through capital accumulation. We assume that upon entry, the productivity at which each good is produced is drawn from a Pareto distribution and that all varieties are renewed each period. We assume a unitary long-run elasticity of substitution between capital and labor and compute the Balanced Growth Path (BGP) of the resulting economy. We show that the macroeconomic effects of increased competition are a reduction of the labor share, of the growth

rate and the level of the real interest rate.

Households

Households maximize intertemporal utility subject to financial wealth and capital accumulation. There are $L_t = L_0 e^{nt}$ households who each inelastically provide one unit of labor in exchange for the nominal wage w_t. Households consumes C_t at price P_t and invest I_t at price P_t^K. The nominal rate on assets is r_t, each unit of capital has return r_t^K. The capital stock K_t depreciates with rate δ and total household financial assets are in zero net supply $A_t = 0$. Finally, households also collect the flow of profit V_t from firms. The representative household's program is:

$$\max_{(c_t),(i_t),(a_t),(k_t)} U_T = L_T \int_T^\infty e^{-(\beta-n)t} \frac{c_t^{1-\theta} - 1}{1-\theta} dt,$$

$$s.t \begin{cases} \dot{a}_t + P_t c_t + P_t^K i_t = (r_t - n)a_t + w_t + r_t^K k_t + v_t, \\ \dot{k}_t + (\delta + n)k_t = i_t, \end{cases} \tag{28}$$

where lower case variables are per capita. As is standard in the neoclassical growth literature, per capita consumption growth is proportional to the real interest rate minus the discount rate, and inversely proportional to risk aversion θ; and at equilibrium the nominal return of capital must be equal to the user-cost of capital where $\pi_t^K = \dot{P}_t^K/P_t^K$ is investment price inflation and $\pi_t = \dot{P}_t/P_t$ is consumption price inflation:

$$\frac{\dot{c}_t}{c_t} = \frac{1}{\theta}(r_t - \pi_t - \beta), \tag{29}$$

$$r_t^K = P_t^K(r_t + \delta - \pi_t^K). \tag{30}$$

Final good sector

Final goods are produced by firms that differ only in their productivity level. The core economic environment is the the one described in Section 4.1. We add the following elements to the economic environment : labor and capital as production factors, determination of the equilibrium mass of firms.

All firms in the final good sector have the same production function, except for random productivity variable z. We assume that capital and labor elasticity of substitution is unitary in the long-run so that the production function is Cobb-Douglas, and that each factor are perfectly mobile across firms : $q(z, k, l) = z.k^\alpha l^{1-\alpha}$. First firms choose their capital/labor ratio by equalizing the marginal rate of transformation to the relative cost of labor with respect to capital, common to all firms.

$$\frac{k_t(z)}{l_t(z)} = \frac{\alpha}{1-\alpha}\frac{w_t}{r_t^K}. \tag{31}$$

Defining $mc_t(w_t, r_t^K)$ as the cost of the capital-labor bundle for a given wage and user cost of capital:

$$mc_t = \left(\frac{r_t^K}{\alpha}\right)^\alpha \left(\frac{w_t}{1-\alpha}\right)^{1-\alpha}. \tag{32}$$

We posit that firms also face fixed costs fmc_t, such that total cost are $C_t(z) = mc_t\left(\frac{q_t(z)}{z} + f\right)$. As in Section 4.1, the pricing rule of the firm is $p_t(z) = \frac{\rho}{\rho-1}\frac{mc_t}{z}$. We have that aggregate output, aggregate revenue and aggregate value are:

$$Q_t = \left(M_t^{\frac{\nu-1}{\rho}} \int_0^\infty q_t^{\frac{\rho-1}{\rho}} h_t(z)dz\right)^{\frac{\rho}{\rho-1}} = M_t^{1+\frac{\nu}{\rho-1}}\tilde{q}_t, \tag{33}$$

$$R_t = P_t Q_t = M_t \tilde{r}_t, \tag{34}$$

$$V_t = M_t \tilde{v}_t. \tag{35}$$

Firms make an unobserved initial investment $mc_t f_e$ measured in units of the capital-labor bundle. They then draw their productivity level from a Pareto distribution with scale z_t^0 and shape $k > \rho-1$, where we assume that the scale parameter grows at rate g. We assume that firms that are hit by a bad shocks exit and lose their initial investment $mc_t f_e$. The ex ante productivity density function is then:

$$g_t(z) = \begin{cases} k(z_t^0)^k z^{-k-1} & z \geq z_t^0, \\ 0 & z < z_t^0. \end{cases}$$

Upon entry with a low productivity draw, a firm may decide to immediately exit and not take part in production. Otherwise, she produces for one period, earning profit $v_t(z)$. The ex post productivity density function is also Pareto,[12] with scale z^*:

$$h_t(z) = \begin{cases} k(z_t^*)^k z^{-k-1} & z \geq z_t^*, \\ 0 & z < z_t^*. \end{cases}$$

As in Section 4.1, average productivity is thus proportional to the cut-off quality level, and average price and revenue are given by:

$$\tilde{z}_t = \left(\frac{k}{k-(\rho-1)}\right)^{\frac{1}{\rho-1}} z_t^*, \tag{36}$$

$$\tilde{p}_t = \frac{\rho}{\rho-1}\frac{mc_t}{\tilde{z}_t}, \tag{37}$$

$$\tilde{r}_t = \rho(\tilde{v}_t + mc_t f), \tag{38}$$

$$\tilde{r}_t = \tilde{p}_t \tilde{q}_t, \tag{39}$$

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[12] A truncated Pareto distribution remains a Pareto distribution.

The average profit becomes:

$$\tilde{v}_t = \frac{\tilde{r}_t}{\rho} - mc_t f = \left(\frac{\tilde{z}_t}{z_t^*}\right)^{\rho-1} \frac{r_t(z_t^*)}{\rho} - mc_t f = mc_t f \left(\frac{\rho-1}{k-(\rho-1)}\right). \tag{40}$$

The free entry condition implies that expected profits $\tilde{v}_t(1 - G_t(z_t^*))$ are equal to the investment cost $mc_t f_e$ required for entry. Moreover, the mass of firms at equilibrium equals the mass of firms attempting entry M_t^e multiplied by the probability of successful entry:

$$\tilde{v}_t = mc_t f_e \left(\frac{z_t^*}{z_t^0}\right)^k, \tag{41}$$

$$M_t = \left(\frac{z_t^0}{z_t^*}\right)^k M_t^e. \tag{42}$$

Investment Good Sector and Equilibrium

We assume that the investment good sector is in perfect competition. The representative firm in that sector transforms one unit of final good into z_t^K units of investment goods, with productivity z_t^K growing at rate g^K. Equality of the marginal product to the marginal costs yields the price of the investment good:

$$P_t^K = \frac{P_t}{z_t^K}. \tag{43}$$

Because all firms have the same production function and choose the same capital-labor ratio k/l defined in Equation (31), one can define the capital-labor bundle supplied by households to final good firms:

$$(k/l)_t^\alpha L_t = (K_t/L_t)^\alpha L_t = K_t^\alpha L_t^{1-\alpha}.$$

The aggregate capital-labor bundle is used for production in the final good sector, and is sunk by prospective entrants. We can therefore write the equilibrium condition on the capital-labor bundle market as the sum for all firms of firm-level usage of the bundle, which equal to total firm-level cost (*ie.* revenue minus profit) divided the bundle marginal cost, plus the sum for all prospective entrants of the sunk cost:

$$K_t^\alpha L_t^{1-\alpha} = \underbrace{\int_0^\infty \left[mc_t^{-1}(r_t - v_t)\right] M_t h_t(z)dz}_{\text{Intermediary Good Sector}} + \underbrace{f_e M_t^e}_{\text{Entrants}}$$

$$\Rightarrow mc_t K_t^\alpha L_t^{1-\alpha} = R_t - V_t + mc_t f^e M_t^e. \tag{44}$$

Equilibrium on the final good market closes the model:

$$Q_t = L_t c_t + \frac{I_t}{z_t^K}. \tag{45}$$

Comparative Statics

Along the unique BGP driven by three exogenous sources of growth in the model: quality and productivity growth g and g^K, and demographic growth n,[13] the mass of available goods grows at rate:

$$g_M = \left[1 - \alpha\left(1 + \frac{\nu}{\rho - 1}\right)\right]^{-1} [\alpha(g + g^K) + (1 - \alpha)n]. \tag{46}$$

The average firm's productivity grows at rate g, as does the quantity it produces. Aggregate output and consumption grow at rate:

$$g_Q = \left(1 + \frac{\nu}{\rho - 1}\right) g_M + g, \tag{47}$$

Productivity growth in the investment good or intermediary good sectors increases the available quantity of capital goods, and population growth increases the available quantity of labor. Both tend to increase the growth rate of the economy size, as production factors become more abundant. An important parameter governing the dynamics of the model is the economies of scale parameter $\nu/(\rho - 1)$. Because a rise in ρ tends to decrease entry and diversity, this will decrease the growth of final good output directly, but it also has a negative effect on g_M via the investment channel: because aggregate output growth decreases, aggregate investment good growth also decreases, which decreases the growth of the available quantity of capital goods to the intermediary good sector. This effect can not be too big or there is no non-degenerate balance growth path. The parameter restriction is:

$$\nu < \frac{1 - \alpha}{\alpha}(\rho - 1).$$

Finally the steady-state real interest rates is:

$$r = \theta(g_Q - n) + \beta. \tag{48}$$

As long as ν is even slightly positive, g_M, g_Q and r are decreasing with ρ[14]. Moreover, from Equations (34), (35), (38) and (40), we can compute the aggregate profit share :

$$\text{Profit} = \frac{V}{R} = \frac{1}{k}\left(1 - \frac{1}{\rho}\right) = \frac{1}{k(1 + \mu)}, \tag{49}$$

where $\mu = \frac{1}{\rho - 1}$ is the markup common to all intermediary firms. In the case of a Pareto productivity distribution, the aggregate profit share can be computed in closed form and is decreasing with the markup. Turning to concentration, we obtain from Equations (11), (14), (36), and (37) that a firm

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[13]see Appendix D for a derivation of the BGP and the steady-state.

[14]The usual neoclassical result with Hicks-neutral productivity is obtained when there is perfect substitution $\rho \to +\infty$, and one good only $g^K = 0$. This yields long-term output growth: $g_Q = \frac{g}{1 - \alpha} + n$.

market share at time t, Ψ_t, follows a Pareto distribution with shape $k/(\rho-1)$ and scale ψ_t^*, with the cumulative density function F_t given by:

$$F_t(\psi) = \mathbf{P}\left(\Psi_t \leq \psi\right) = \mathbf{P}\left(Z_t \leq (M_t\psi)^{\frac{1}{\rho-1}}\tilde{z}_t\right)$$

$$= 1 - \left(\frac{(M_t\psi)^{\frac{1}{\rho-1}}\tilde{z}_t}{z_t^*}\right)^{-k}$$

$$= 1 - \left(\frac{M_t k}{k-(\rho-1)}\psi\right)^{-\frac{k}{\rho-1}}$$

$$= 1 - \left(\frac{\psi}{\psi_t^*}\right)^{-\frac{k}{\rho-1}},$$

where ψ_t^* is the market share of the cut-off firm. The tail index of the distribution of market shares decreases with the level of competition, which means that concentration increases with competition. For instance, keeping the same definitions as in Sections 3 and 4.1, the ratio of the $1-p$-th percentile of market share to the median market share is given by:

$$\text{Top}_{p\%}/\text{Median} = (2p)^{1-\frac{\rho-1}{k}}, \tag{50}$$

while the share of total revenues in firms with market share above the $1-p$-th percentile is given by:

$$\text{Top}_{p\%} = \int_{F_t^{-1}(1-p)}^{\infty} \psi M_t dF_t(\psi) = M_t\psi_t^* \frac{p^{1-\frac{\rho-1}{k}}}{1-\frac{\rho-1}{k}} = p^{1-\frac{\rho-1}{k}}. \tag{51}$$

The right-hand side of Equation (50) increases with ρ when $p < 1/2$ and the right hand side of Equation (51) increases with ρ. This means that when competition increases, the upper half of the distribution of firm market shares gain market shares relative to the bottom half and the market share taken up by larger firms increases.

To sum up, our model predicts that an increase in market toughness will:

1. Decrease firm-level profit shares;

2. Increase concentration;

3. Increase the aggregate profit share;

4. Decrease output growth;

5. Decrease the real interest rate.

We now look at the effect that a decrease in ρ has on aggregate welfare. The main channels through which it affects welfare are the price level and output growth. The price level depends on

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the mass of firms and on firms individual prices, while output growth depends on the growth of the mass of firms. Additionally, how households value future output growth against current output will also depend on the intertemporal substitution elasticity: the higher θ is, the more households value an increase in future output against a decrease in current output. We compare the effect of changes in competition for three different calibrations of our model. From Equation (28), we can compute the representative household welfare assuming that the economy will stay on a BGP, and compare different BGPs when competition ρ varies. Table 5 shows the baseline calibration of model parameters. We use average population and output growth, capital relative price deflation, the capital and profit shares of value added, the ratio of investment to capital, and the real interest rate from KLEMS and OECD for the weigthed average aggregate market economy of France and Germany after 2000 and before 2007. We calibrate the Pareto-tail index for the distribution of market shares using the Compnet data on top market share quantiles in France and calculate the tail index of the market share distribution $\frac{k}{\rho-1}$ using the ratio of the top 1% over the top 5%. We calibrate the intertemporal substitution elasticity and fixed cost of production to 1, and the probability of successful entry to 0.7. This allows us to back out depreciation δ, automation α, the underlying total factor productivity growth in the intermediate good sector g, the discount rate β, the fixed cost of entry f_e, the tail index for the productivity distribution k, and the initial level of competition ρ.

We simulate a change in competition (ie a decrease or increase in ρ) around the calibrated value, leaving all other parameters unchanged. Results are displayed in Figures 17, 18 and 19, for three different values of the returns to product diversity ν, which is the key parameter. Regardless of its value, the probability of successful entry and diversity decreases when competition increases, while concentration and profit shares increase.

When there are no economies of scale, an increase in competition has no effect on output growth and the real interest rate; but more competition increases consumption per capita, increases welfare through a parallel increase in per capita consumption along the BGP. Here, because the slope of output is unchanged by competition, welfare always increases with competition regardless of the intertemporal elasticity θ.

However, with economies of scale, output growth is decreasing in competition: both the mass of firms and mass of firms growth decline with competition and because the number of intermediate firms has a positive effect on productivity of the final good sector, output growth is lower. Welfare becomes decreasing in competition when competition is low. The same pattern is observed for different intertemporal elasticities θ.

An increase in competition leads to increases in aggregate profit shares and concentration through a reallocation of market shares towards more productive firms. Entry becomes harder and the mass of firms decreases. If households value diversity, or alternatively, if there are economies of scale in the aggregation of the final goods, then an increase in competition can lead to decreased output growth and interest rates, with possible negative effects on welfare.

5 Conclusion

In this paper, we presented a novel mechanism through which an increase in market toughness explains, within each industry, both a positive correlation between concentration and profit shares, and a negative correlation between concentration and moments of the firm-level distribution of profit shares. The main channel is that while an increase in competition decreases firm-level profit shares, it shifts market shares towards more productive firms, who tend to be both larger and with higher profit shares, and decreases business dynamism, proxied by the rate of successful entry of firms. Moreover, we provided a simple theoretical dynamic general equilibrium model of industry growth to study the aggregate implications of positive returns to diversity when competition increases. In particular, we showed that the decrease in business dynamism results in a decrease in output growth, real interest rates and welfare.

It is important to note that an increase in market toughness, by increasing concentration, can have an additional effect if the top firms that benefit from the 'winner-takes-most' dynamics also exhibit increasing anti-competitive behavior. This is not the focus of this paper, a choice that is motivated by the fact documented in Section 2 that variations in aggregate profit shares are not strongly positively correlated with variations the top profit shares, but this channel may have an importance in certain industries and for welfare purposes. Further research should focus on the role of oligopolistic competition and a departure from the iso-elastic demand framework to better study the welfare implications of an increase in market toughness.

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A   Tables

Table 1: Correlation between Industry Concentration and Factor Shares

	Top 1% Share		Top 5% Share		Top 1% / Median		Top 5% / Median	
Labor Share								
Labor Share of Value Added	-0.0469		-0.1127		-1.0189		-0.5402	
	(0.0131)		(0.0210)		(0.1879)		(0.1329)	
Labor Share of Output		-0.0759		-0.2337		-1.8679		-0.8739
		(0.0284)		(0.0454)		(0.4065)		(0.2874)
Observations	1,499	1,499	1,499	1,499	1,498	1,498	1,499	1,499
R2	0.9512	0.9510	0.9009	0.9007	0.9216	0.9212	0.9081	0.9076
Capital Share								
Capital Share of Value Added	-0.0430		0.0057		0.3200		-0.4991	
	(0.0193)		(0.0311)		(0.2778)		(0.1950)	
Capital Share of Output		-0.0173		0.0893		1.9691		-0.4757
		(0.0485)		(0.0781)		(0.6955)		(0.4907)
Observations	1,499	1,499	1,499	1,499	1,498	1,498	1,499	1,499
R2	0.9510	0.9508	0.8988	0.8989	0.9200	0.9204	0.9075	0.9071
Profit Share								
Profit Share of Value Added	0.0336		0.0552		0.4365		0.3881	
	(0.0093)		(0.0150)		(0.1340)		(0.0941)	
Profit Share of Output		0.0496		0.1228		0.7198		0.6286
		(0.0221)		(0.0355)		(0.3182)		(0.2238)
Observations	1,499	1,499	1,499	1,499	1,498	1,498	1,499	1,499
R2	0.9512	0.9510	0.8998	0.8997	0.9206	0.9202	0.9082	0.9075

Note: This table reports the results of within industry-country correlations between concentration on the left-hand-side and industry level labor, capital, and profit shares of industry value-added or output on the right-hand-side. Top x% Share is the turnover market share of the x% largest firms, top x% /Median is the logarithm of the ratio of the 100-x quantile of market share to the median market share. Data source for factor shares is KLEMS, data source for concentration indexes is CompNet. Each observation is one of the 27 KLEMS level industry for 14 European Countries covered in CompNet in a given year (see Appendix C for data coverage). Concentration indexes are computed at the 2-digit level and averaged into the 34 industries, weighing by industry value added. A flexible set of industry-country and year fixed effects are included.

Table 2: Correlation between Industry Concentration and Firm-Level Profit Shares

	Top 1% Share		Top 5% Share		Top 1% / Median		Top 5% / Median	
Unweighted Mean Profit Share								
Profit Share (excl. capital cost)	0.0452		-0.0089		-0.0692		-0.1556	
	(0.0084)		(0.0109)		(0.0878)		(0.0650)	
Profit Share (incl. capital cost)		-0.0212		-0.0422		-0.4646		-0.1287
		(0.0077)		(0.0099)		(0.0797)		(0.0590)
Observations	8,079	8,118	8,079	8,118	8,079	8,118	8,079	8,118
R2	0.9518	0.9516	0.9354	0.9354	0.9575	0.9575	0.9412	0.9413
Median Profit Share								
Profit Share (excl. capital cost)	-0.1982		-0.4152		-3.3889		-1.1425	
	(0.0179)		(0.0227)		(0.1834)		(0.1384)	
Profit Share (incl. capital cost)		-0.2162		-0.4431		-3.7483		-1.5990
		(0.0211)		(0.0259)		(0.2144)		(0.1623)
Observations	8,079	6,086	8,079	6,086	8,079	6,086	8,079	6,086
R2	0.9524	0.9565	0.9382	0.9460	0.9594	0.9636	0.9417	0.9468
Top 5% Profit Share								
Profit Share (excl. capital cost)	-0.0371		-0.0116		-0.4773		-0.0652	
	(0.0087)		(0.0112)		(0.0902)		(0.0668)	
Profit Share (incl. capital cost)		-0.0380		-0.0134		-0.4599		-0.0911
		(0.0097)		(0.0122)		(0.1006)		(0.0749)
Observations	8,118	6,086	8,118	6,086	8,118	6,086	8,118	6,086
R2	0.9517	0.9558	0.9353	0.9431	0.9574	0.9617	0.9412	0.9459
Top 1% Profit Share								
Profit Share (excl. capital cost)	-0.0074		0.0499		0.1181		0.1136	
	(0.0059)		(0.0075)		(0.0613)		(0.0453)	
Profit Share (incl. capital cost)		-0.0216		0.0336		-0.0703		0.0923
		(0.0068)		(0.0084)		(0.0701)		(0.0520)
Observations	8,118	6,086	8,118	6,086	8,118	6,086	8,118	6,086
R2	0.9516	0.9557	0.9356	0.9433	0.9573	0.9615	0.9413	0.9459

Note: This table reports the results of within industry-country correlations between concentration on the left-hand-side and measures of firm-level profit share, including or excluding a proxy for capital costs, on the right-hand-side. Top x% Share is the turnover market share of the x% largest firms, top x% /Median is the logarithm of ratio of the 100-x quantile of market share to the median market share. Data source is Compnet, each observation is a 2-digit sector for 14 European Country covered in CompNet in a given year (see Appendix C for data coverage). A flexible set of industry-country and year fixed effects are included.

Table 3: Aggregate Profit Shares Decomposition at the Top

	Aggregate Profit Share		
Top 1%			
Top Share of Sales	0.2856		0.2814
	(0.0802)		(0.0801)
Top Percentile Profit Share		-0.0019	-0.0019
		(0.0008)	(0.0008)
Observations	1,499	1,499	1,499
R2	0.8791	0.8785	0.8796
Top 5%			
Top Share of Sales	0.1891		0.1671
	(0.0490)		(0.0498)
Top Percentile Profit Share		-0.0283	-0.0224
		(0.0094)	(0.0095)
Observations	1,499	1,499	1,499
R2	0.8793	0.8788	0.8798

Note: This table reports the results of correlations between industry level profit shares of value-added on the left-hand-side and the top share of sales and/or the top percentile of the distribution of firm profit shares (excluding a proxy for capital costs) on the right-hand-side. Data source is Compnet, each observation is a 2-digit sector for 14 European Country covered in CompNet in a given year (see Appendix C for data coverage). A flexible set of industry-country and year fixed effects are included.

Table 4: Aggregate Profit Shares Decomposition at the Top

	Aggregate Profit Share		
Top 1%			
Top Share of Sales	0.2856		0.2963
	(0.0802)		(0.0801)
Top Percentile Profit Share		-0.0061	-0.0065
		(0.0021)	(0.0021)
Observations	1,499	1,499	1,499
R2	0.8791	0.8787	0.8799
Top 5%			
Top Share of Sales	0.1891		0.1801
	(0.0490)		(0.0497)
Top Percentile Profit Share		-0.0192	-0.0124
		(0.0112)	(0.0113)
Observations	1,499	1,499	1,499
R2	0.8793	0.8782	0.8794

Note: This table reports the results of correlations between industry level profit shares of industry on the left-hand-side and the top share of sales and/or the top percentile of the distribution of firm profit shares (including a proxy for capital costs) on the right-hand-side. Data source is Compnet, each observation is a 2-digit sector for 14 European Country covered in CompNet in a given year (see Appendix C for data coverage). A flexible set of industry-country and year fixed effects are included.

Table 5: Calibration

Parameter		Value	Source
Observed			
Population growth	n	1.9%	KLEMS
Output growth	g_Q	3.0%	KLEMS
Capital relative price deflation	g^K	1.0%	KLEMS
Profit share	V/R	5.0%	KLEMS, OECD
Capital share	$\alpha(1 - V/R)$	20.0%	KLEMS, OECD
Investment ratio	I/K	12.0%	KLEMS
Real interest rate	r	3.0%	KLEMS, OECD
Market Share Pareto-tail index	$\frac{k}{\rho - 1}$	1.3	Compnet
Probability of entry	$(z^*)^{-k}$	0.7	OECD
Calibrated			
Intertemporal substitution elasticity	θ	1.0	Assumption
Fixed cost of production	f	1.0	Assumption
Inferred			
Depreciation rate	δ	9.0%	
Automation	α	21.1%	
Intermediary good sector productivity growth	g	0.2%	
Discount rate	β	2.2%	
Substitution Elasticity	ρ	15.4	
Productivity Pareto-tail index	k	18.7	
Fixed cost of entry	f_e	2.3	

Note: Sources are the value added weighted average of France's and Germany's market economy from 2000 to 2007. Inferred parameters are solved simultaneously using the steady-state equations in appendix D.

B Figures

Figure 1: Labor Shares

Figure 2: Smoothed Labor Shares, US
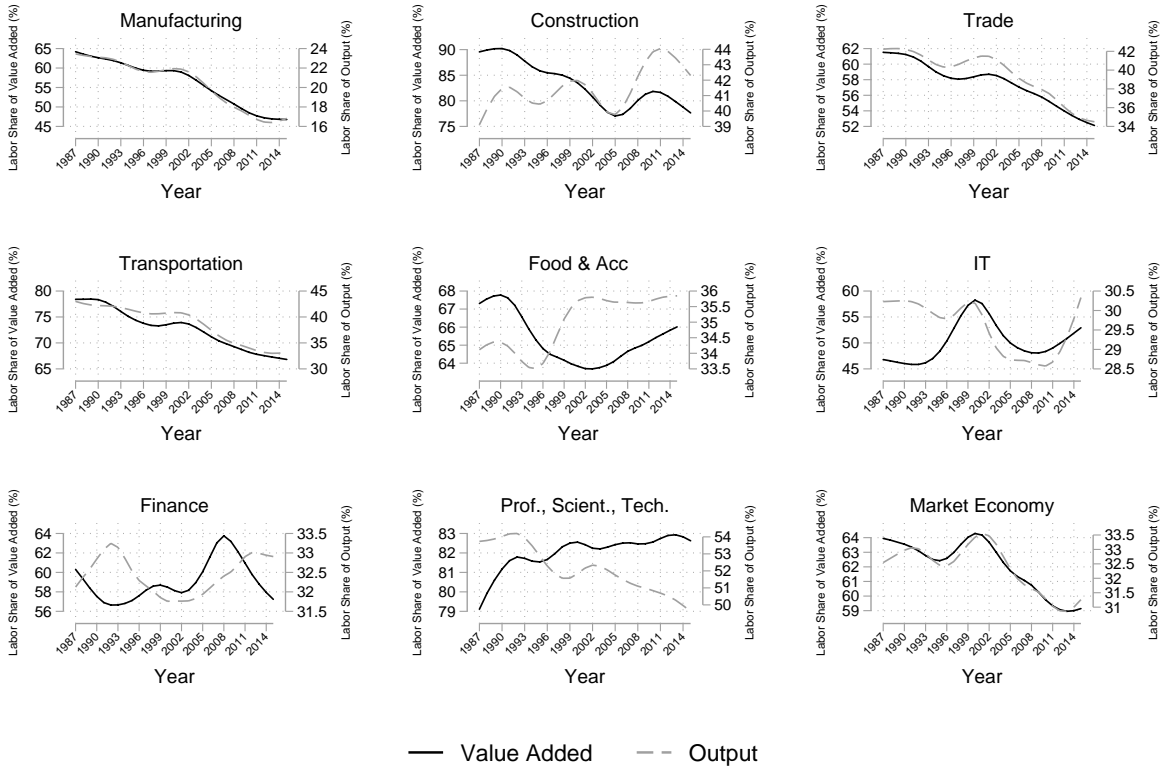
Note: This figure plots variations in smoothed labor shares for broad industries and the market economy in the US. Smoothed labor shares are calculated using a trend-cycle decomposition from an HP filter with smoothing parameter 6.25, as in Ravn and Uhlig (2002). Data source is KLEMS.

Figure 3: Smoothed Labor Shares, France

Figure 4: Capital Share

France — Share of Value Added (%) — Year

USA — Share of Value Added (%) — Year

Germany — Share of Value Added (%) — Year

UK — Share of Value Added (%) — Year

——— Long Term Rate   – – – Short Term Rate
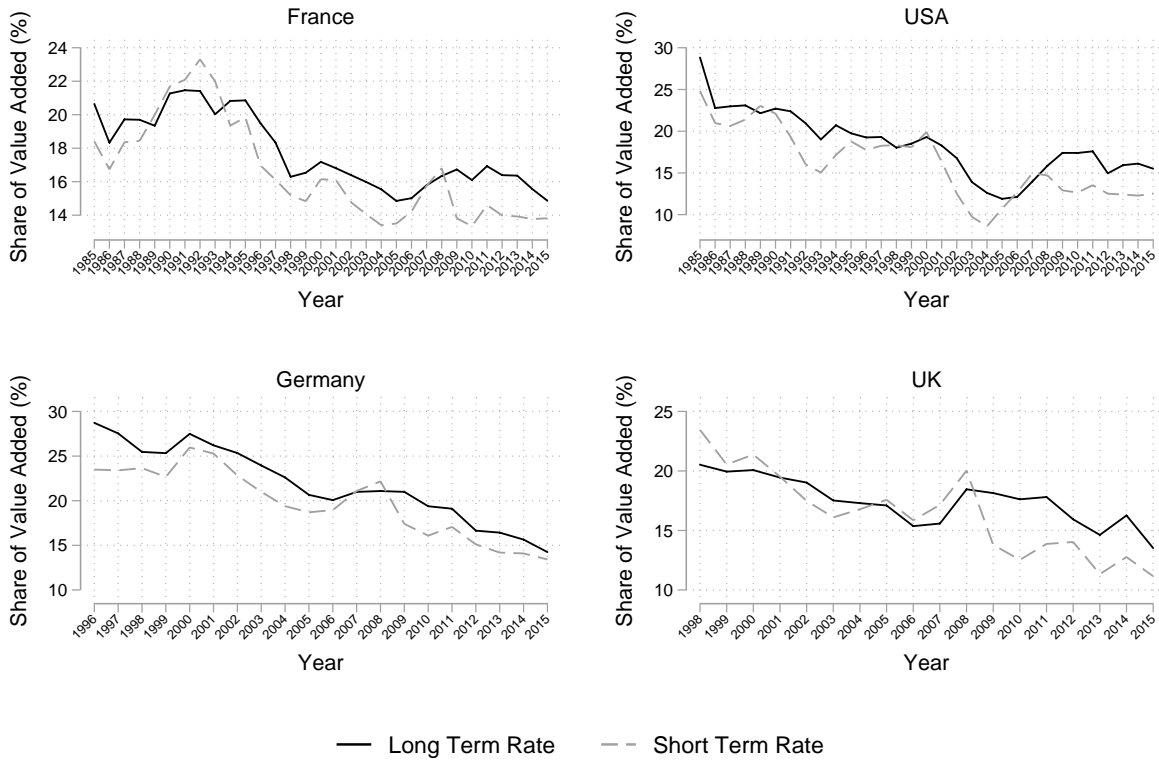
Note: This figure reports payments to capital as a share of value added in the market economy for France, Germany, the UK and the US. Long term and short term rates are used to compute the returns to capital. Data sources are KLEMS and OECD.

Figure 5: Contributions to Capital Share
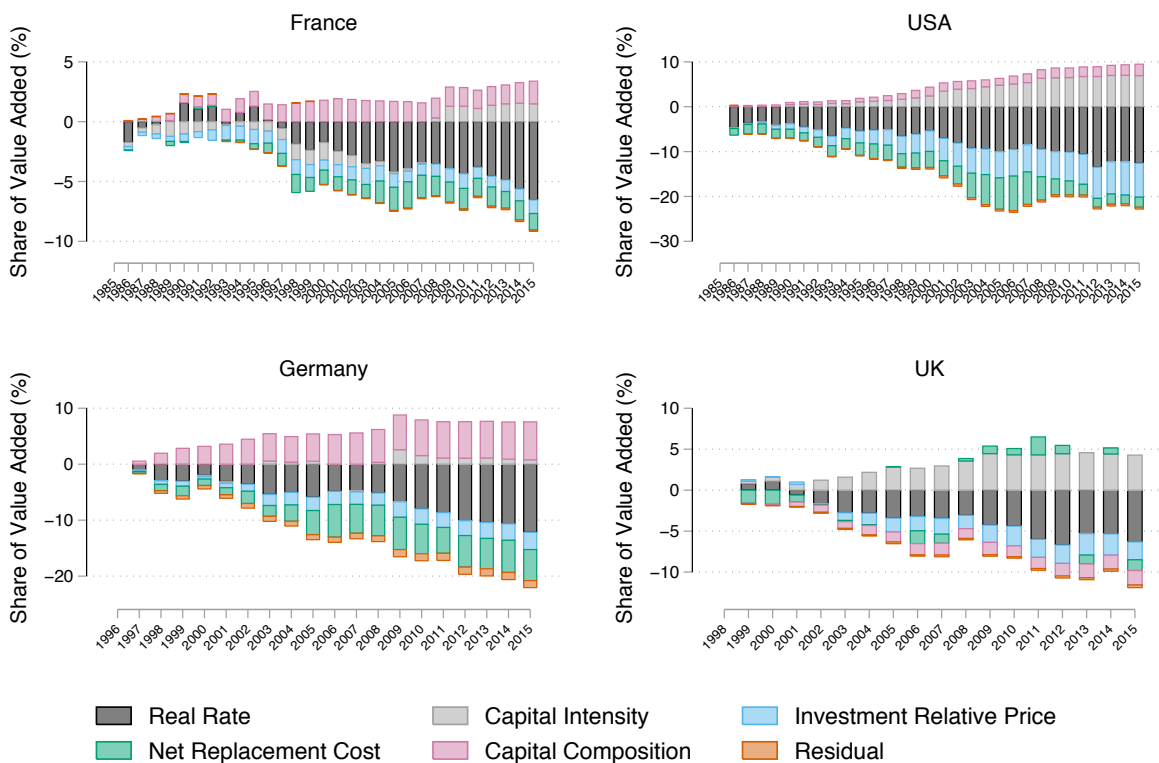
Note: This figure reports the decomposition from equation 5 of the capital share in the market economy for France, Germany, the UK and the US. Data sources are KLEMS and OECD.

Figure 6: Country Level Correlations between Factor Shares Variations
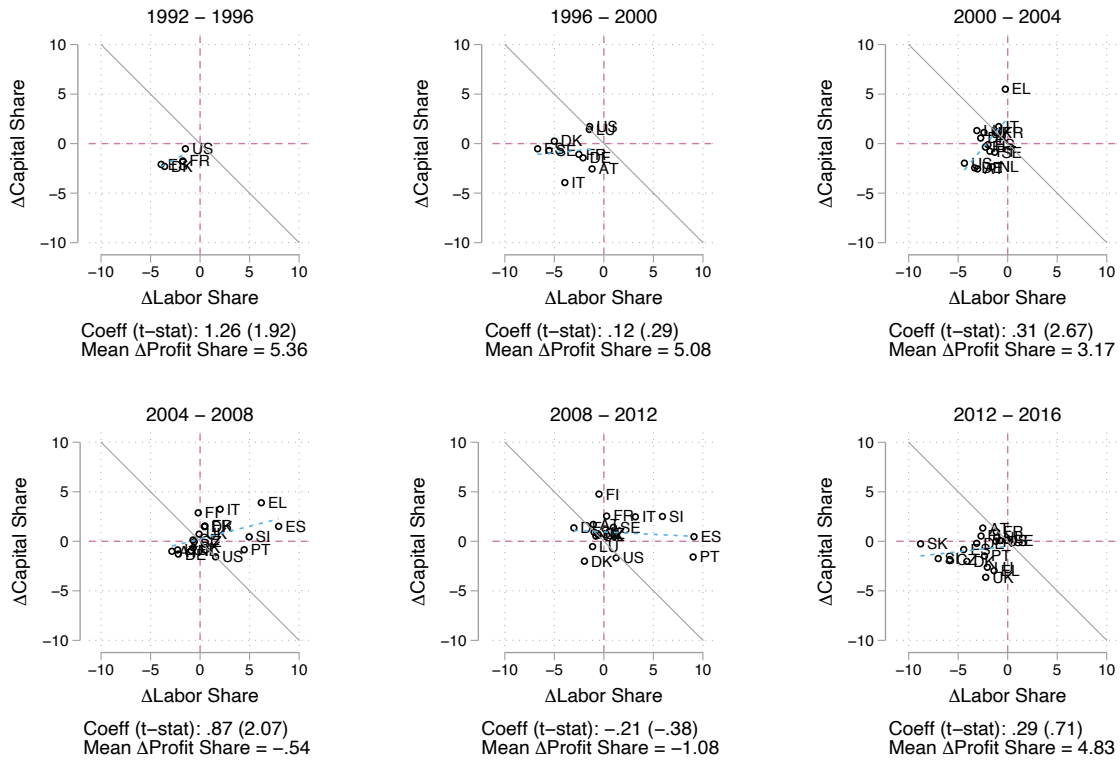
Note: This figure plots four year variations in smoothed capital and labor shares for the market economy in 28 European Union countries and the US. Smoothed labor and capital shares are calculated using a trend-cycle decomposition from an HP filter with smoothing parameter 6.25, as in Ravn and Uhlig (2002). Data sources are KLEMS and OECD.

Figure 7: Industry Level Correlations between Factor Shares Variations

Figure 8: Smoothed Profit Shares, US
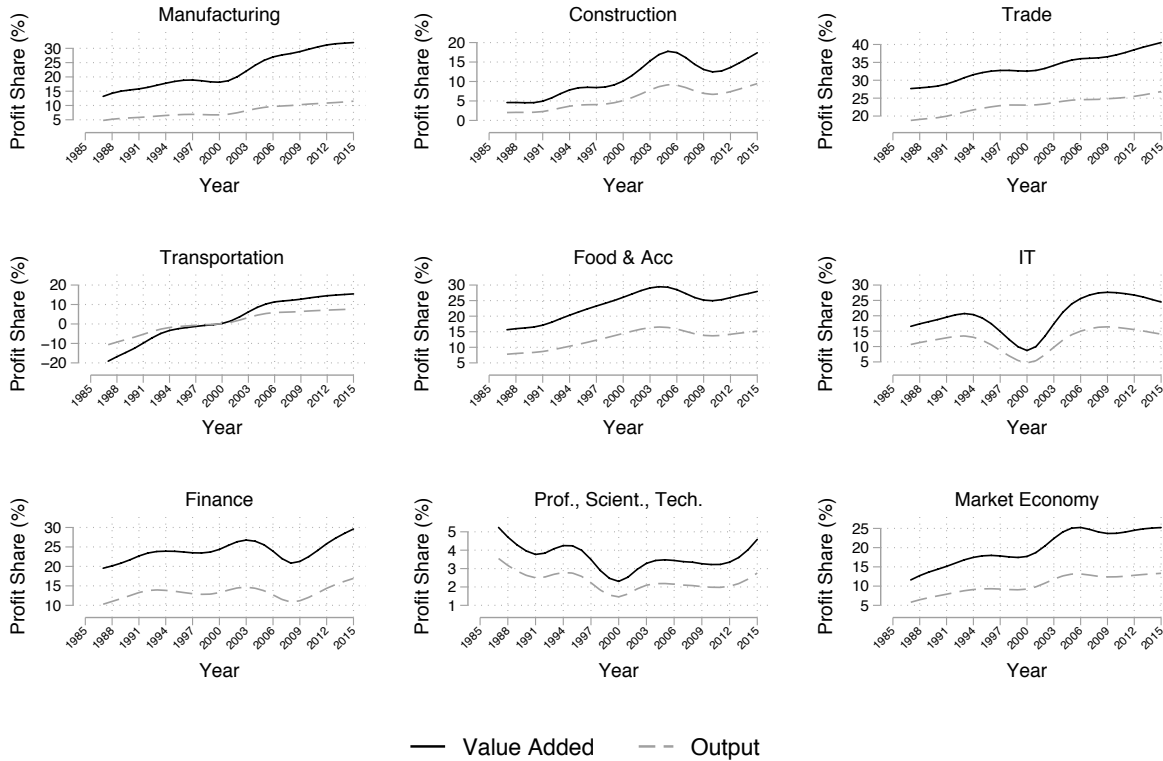
Note: This figure plots variations in smoothed profit shares for broad industries and the market economy in the US. Smoothed profit share is calculated as the residual in equation 1 where smoothed labor and capital shares are calculated using a trend-cycle decomposition from an HP filter with smoothing parameter 6.25, as in Ravn and Uhlig (2002). Data sources are KLEMS and OECD.

Figure 9: Smoothed Profit Shares, France
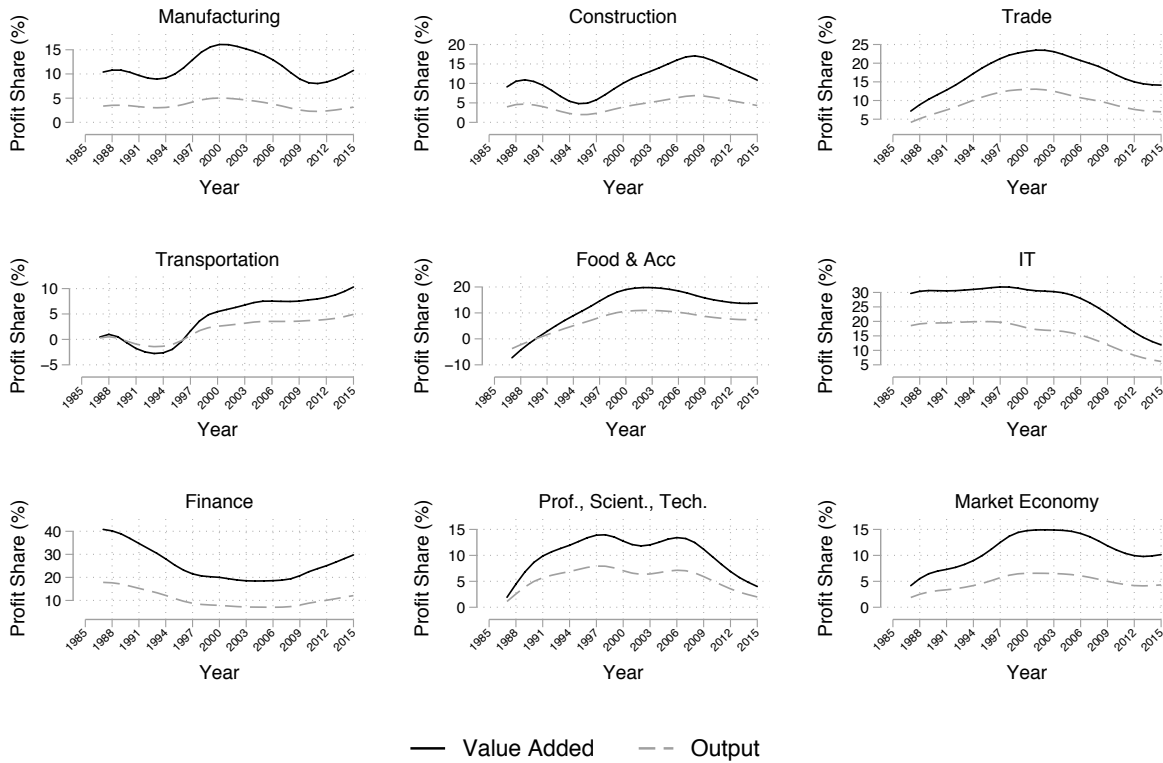
Note: This figure plots variations in smoothed profit shares for broad industries and the market economy in France. Smoothed profit share is calculated as the residual in equation 1 where smoothed labor and capital shares are calculated using a trend-cycle decomposition from an HP filter with smoothing parameter 6.25, as in Ravn and Uhlig (2002). Data sources are KLEMS and OECD.

Figure 10: Concentration and Firm-Level Profit Share, France
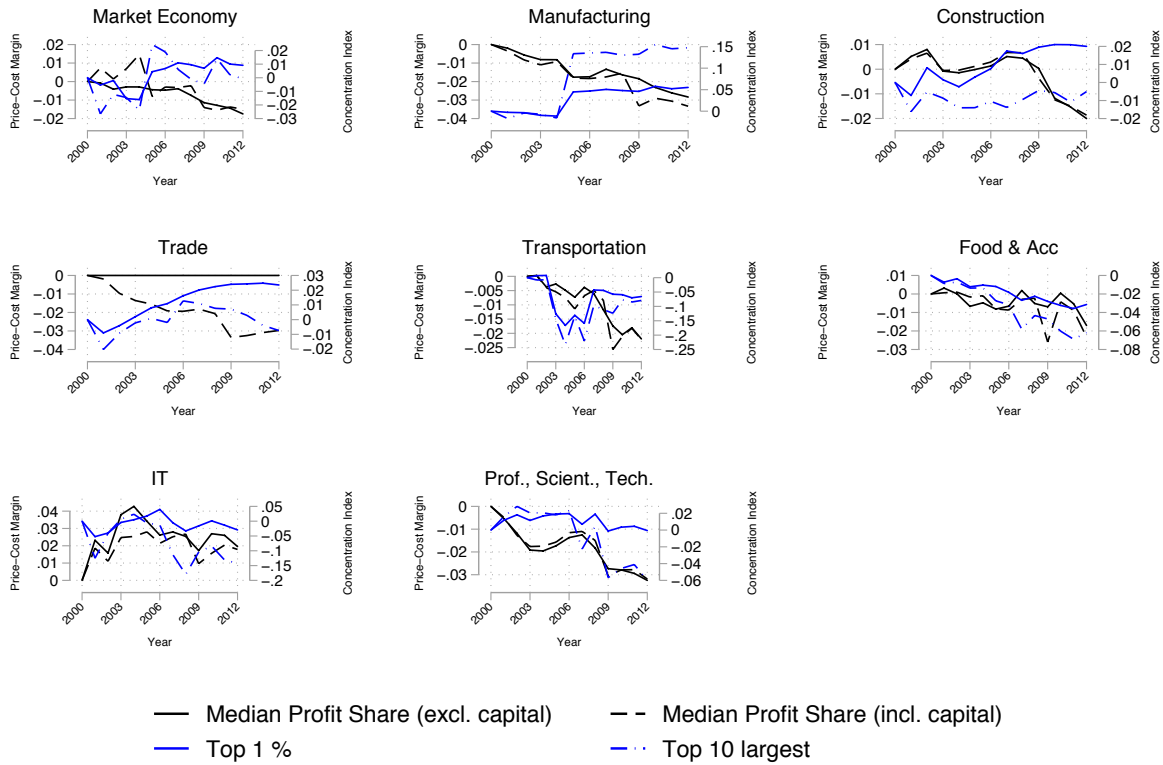
Note: This figure plots variations in industry level concentration and median firm-level profit share, for broad industries and the market economy in France. Data source is CompNet, concentration index and median profit shares are computed are the 2-digit industry level and averaged across industries weighted by their share in aggregate value added.

Figure 11: Concentration and Firm-Level Profit Share, Germany
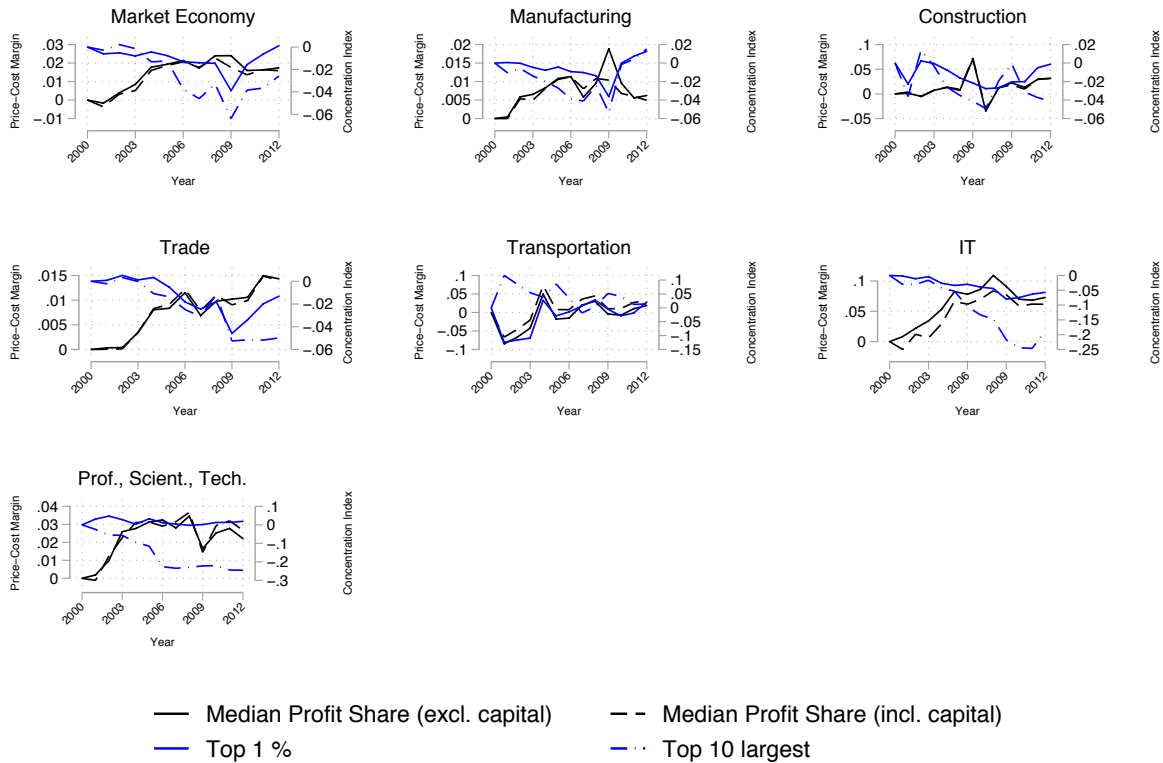
- Median Profit Share (excl. capital)
- - - Median Profit Share (incl. capital)
- Top 1 %
- - ·· Top 10 largest

Note: This figure plots variations in industry level concentration and median firm-level profit share, for broad industries and the market economy in Germany. Data source is CompNet, concentration index and median profit shares are computed are the 2-digit industry level and averaged across industries weighted by their share in aggregate value added.

Figure 12: Partial Equilibrium
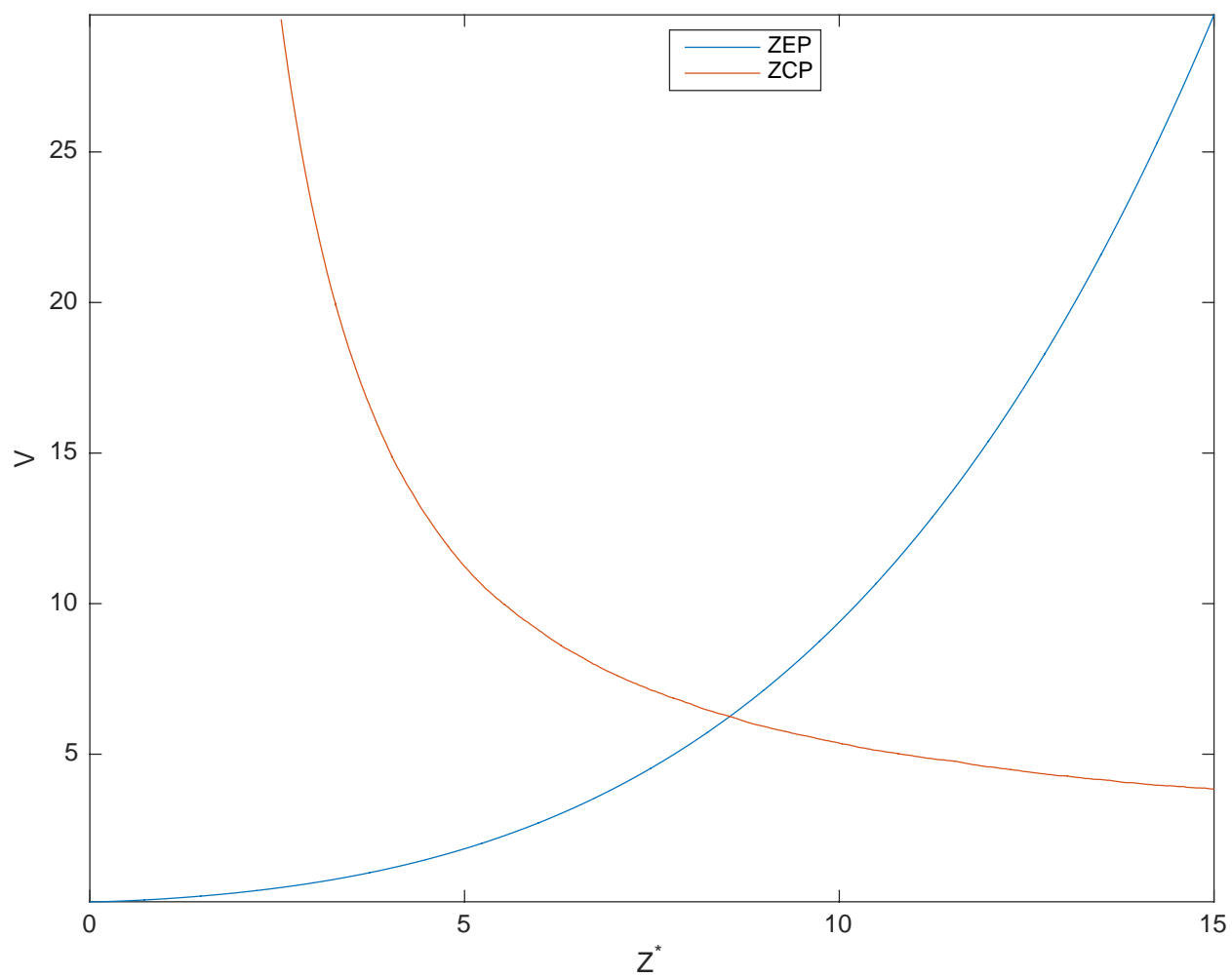
Note: This figures displays the determination of the industry level equilibrium from equations Avg Prod, ZCP and ZEP. Distribution of productivity is log-normal, and industry-level calibrated parameters are in table 5.

Figure 13: Effect of Increase in Competition on Firm-Level Profit Share
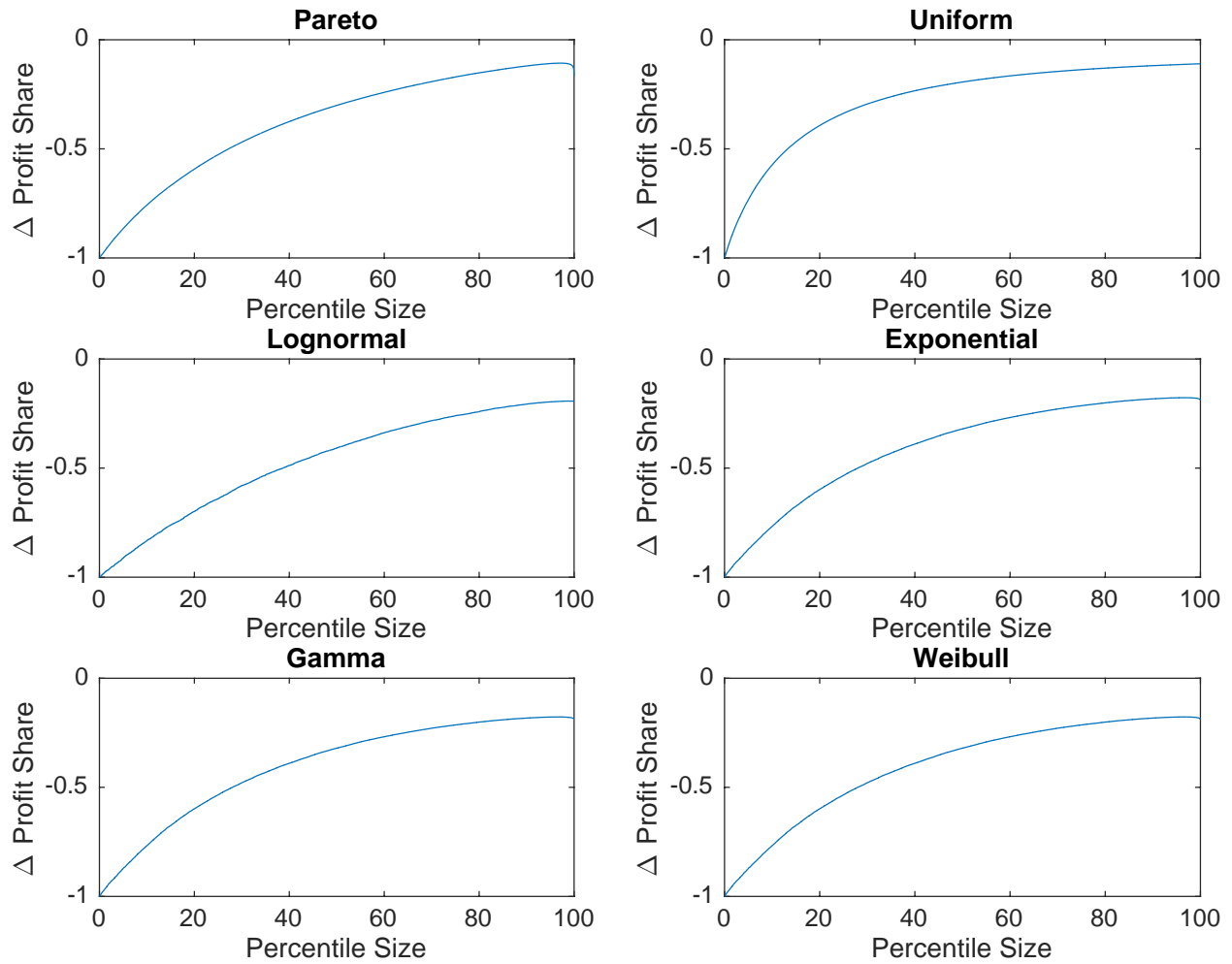
Note: This figures displays the reduction of profit shares of firms of different sizes following an increase in competition resulting in a decrease in markups from 33% to 25% on the industry level equilibrium from equations Avg Prod, ZCP and ZEP, for different distributions of productivities. Industry-level calibrated parameters are in table 5.

Figure 14: Relationship between Competition and Industry Concentration
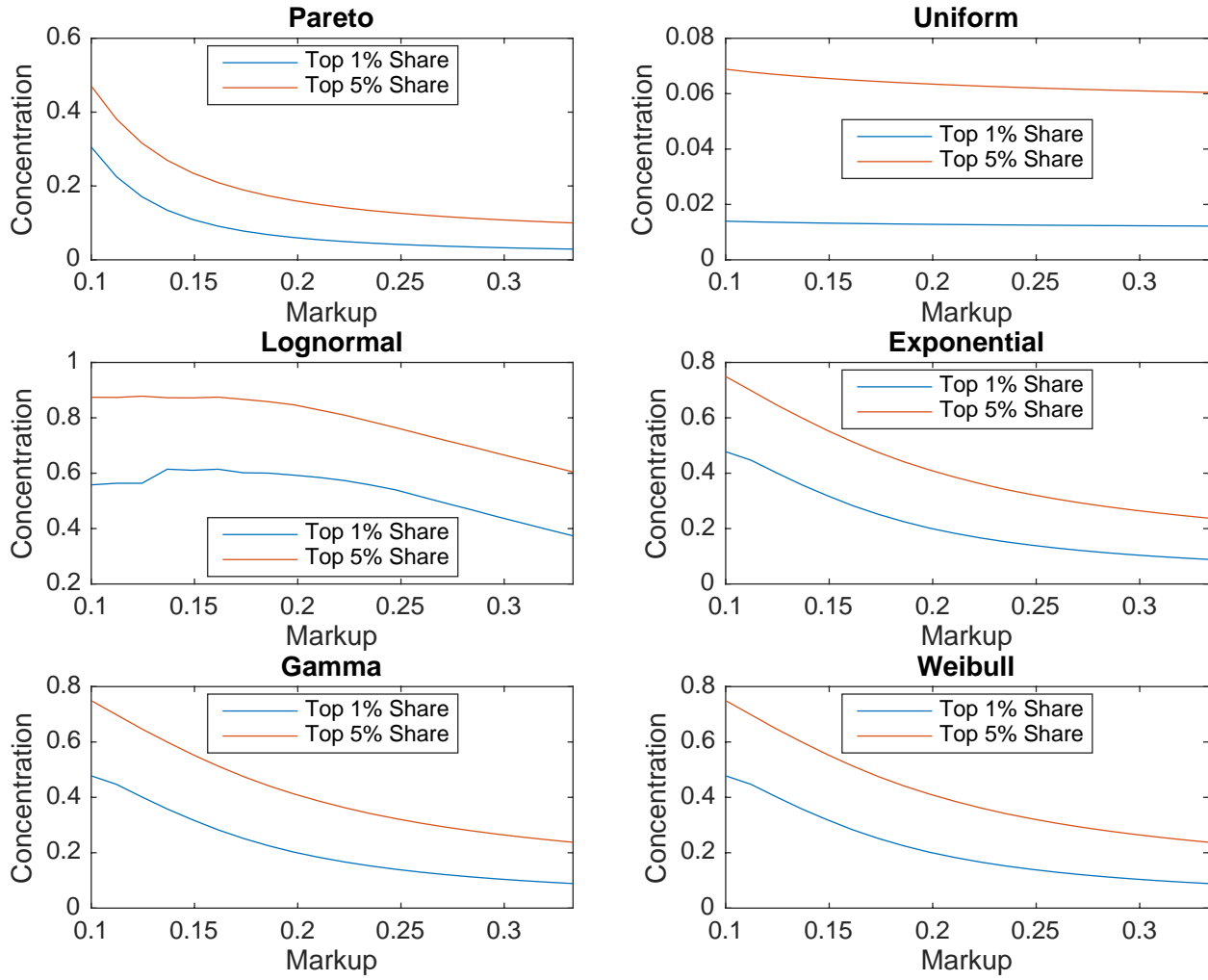
Note: This figures displays relationship between the firm-level markup and industry concentration at the industry equilibrium from equations Avg Prod, ZCP and ZEP, for different distributions of productivities. Concentration is defined as the share of revenues accruing to the largest 1% or 5% of firms. Industry-level calibrated parameters are in table 5.

Figure 15: Relationship between Competition and Industry Concentration
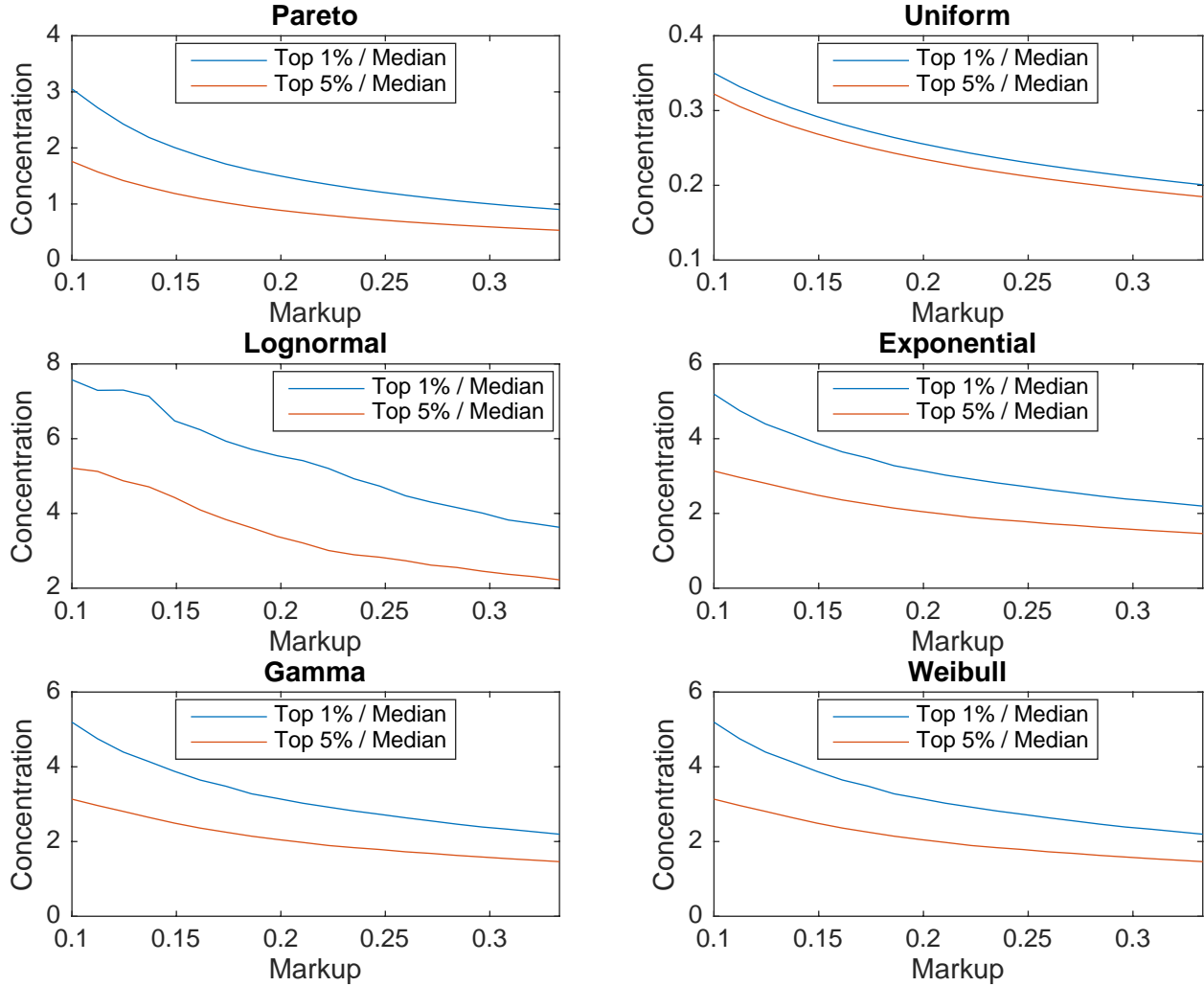
Note: This figures displays relationship between the firm-level markup and industry concentration at the industry equilibrium from equations Avg Prod, ZCP and ZEP, for different distributions of productivities. Concentration is defined as the log ratio of the 99th or 95th percentile of market share over the median market share. Industry-level calibrated parameters are in table 5.

Figure 16: Relationship between Competition and Industry-Level Profit Share
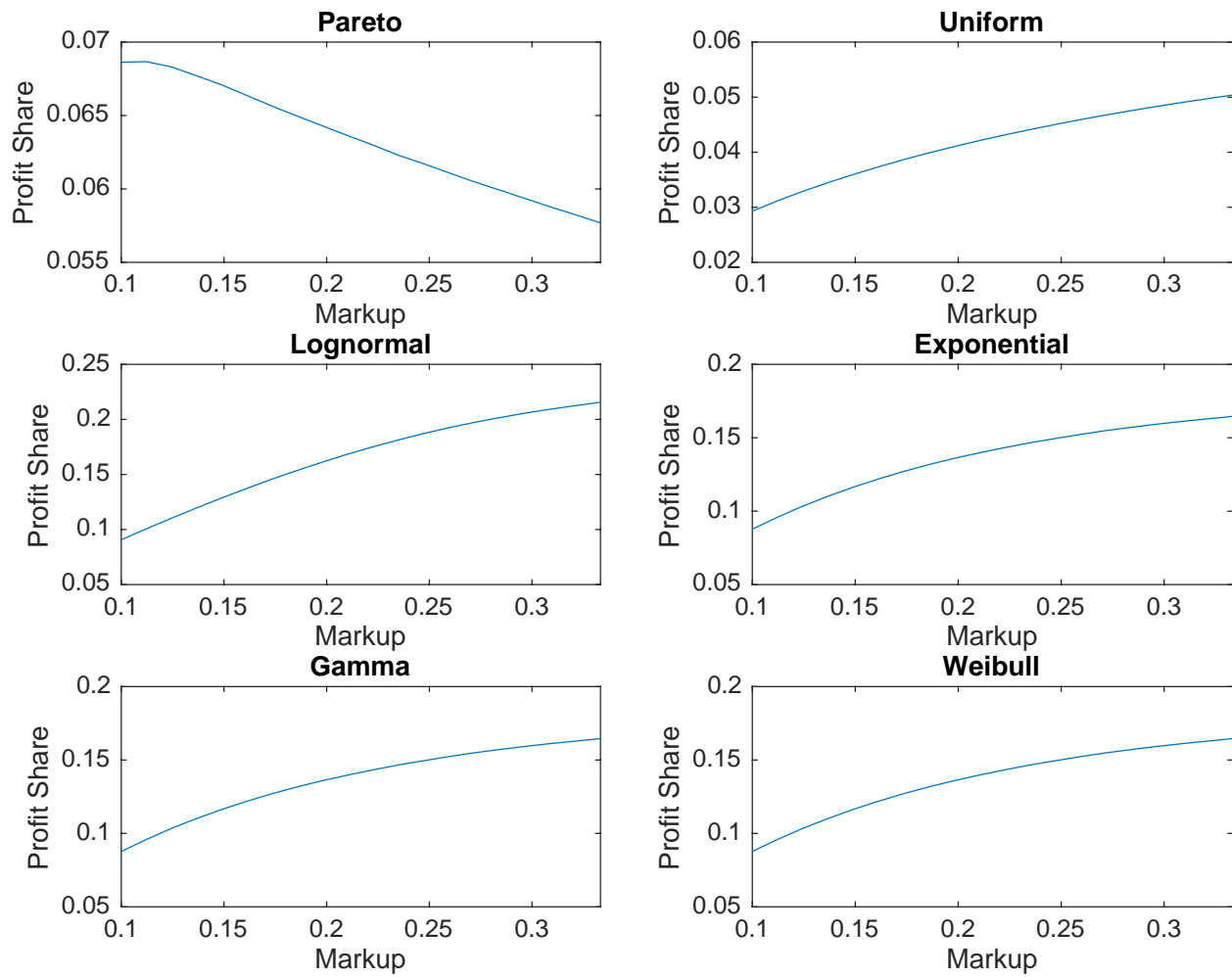
Note: This figures displays relationship between the firm-level markup and industry average profit share at the industry equilibrium from equations Avg Prod, ZCP and ZEP, for different distributions of productivities. Industry-level calibrated parameters are in table 5.

Figure 17: Effect of change in competition, $\nu = 0$

Figure 18: Effect of change in competition, $\nu = 0.5$

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C Data

C.1 KLEMS Database

The 2017 release of the KLEMS database is based on National Accounts (ESA 2010) for all 28 member states of the European Union and the United States up to 2015. Data on labor compensation, hours, capital stock, investment price and depreciation rates is available for up to 42 NACE 2 industry levels. Table 6 displays the number of industries and years at the country level for which we were able to construct the profit share with the procedure described in Section 2.1, with the addition of long term government bond 10-year rates taken from OECD.

Table 6: KLEMS 2017 data on labor compensation, hours and capital services

Countries	Indutries	Year min	Year max	Obs
Austria	27	1997	2014	486
Czech Rep.	27	2001	2014	378
Germany	24	1997	2014	432
Denmark	27	1989	2014	702
Greece	27	1998	2014	459
Spain	24	1980	2014	840
Finland	27	1989	2014	702
France	24	1980	2014	840
Hungary	11	2010	2014	55
Ireland	11	1998	2013	176
Italy	24	1997	2013	408
Lithuania	11	2001	2013	143
Luxemburg	18	1997	2014	324
Netherlands	24	2000	2014	360
Poland	11	2003	2013	121
Portugal	27	2000	2013	378
Sweden	25	1995	2013	475
Slovenia	12	2004	2014	132
Slovakia	27	2004	2014	297
UK	27	1999	2014	432
USA	25	1987	2014	700
TOTAL				8840

Figure 19: Effect of change in competition, $\nu = 1$
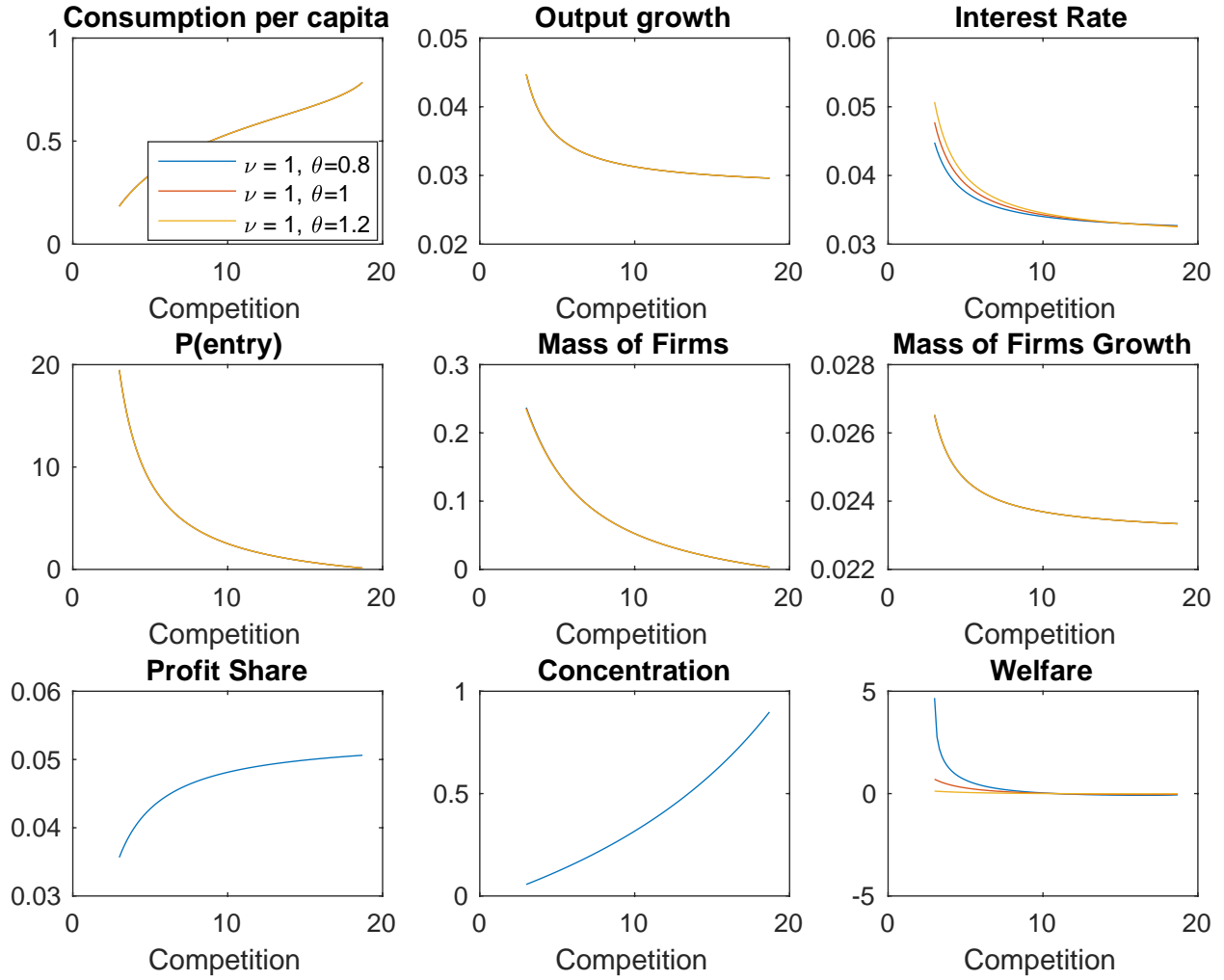
Note: This figures displays relationship between competition (ie ρ) and selected variables at the general equilibrium. Calibrated parameters are in table 5, when the value of increased diversity is equal to 0.

C.2 CompNet

The CompNet firm-level balance sheet database comprises 17 Countries and 56 industries within the manufacturing and service sectors over the period 1995-2012. The concentration and markup module of the database starts in 2000 for 15 countries, and is based on the full sample of firms available within each country. Comparisons between countries may be biased because of specific methodologies and samples but within country estimates should be consistent. [15]

Table 7: CompNet 4th round data on industry concentration

Countries	Indutries	Year min	Year max	Obs
Italy	53	2001	2012	636
Estonia	53	2000	2012	689
Portugal	53	2006	2012	371
Slovenia	53	2000	2012	689
Slovakia	53	2001	2011	583
Finland	53	2000	2012	689
Belgium	53	2001	2011	583
Germany	45	2000	2012	585
Poland	53	2005	2012	424
France	53	2000	2012	689
Latvia	53	2006	2012	371
Romania	53	2003	2012	530
Austria	50	2000	2012	650
Lithuania	53	2001	2011	583
TOTAL				8072

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[15]The reader must be aware that data collection rules and procedures across countries are different, and out of CompNet's control. Hence, despite all efforts made to improve sample comparability across countries (including the use of population weights), some country samples might still suffer from biases.

D   Proofs

Constant Returns to Scale

We show that a if variable costs exhibit constant returns to scale, the marginal cost of the firm is constant.

Proof. Let $\mathscr{C}(q, \mathbb{W})$ be the variable cost function, not specific to firm i. Let ϵ be the elasticity of variable cost with respect to production q, the assumption of constant returns to scale is that variable costs increase by 1% for each increase in production of 1%, for all levels of production q:

$$\epsilon(q) \equiv \frac{\partial \mathscr{C}}{\partial q}(q, \mathbb{W}) \frac{q}{\mathscr{C}(q, \mathbb{W})} = 1,$$

which implies that total variable cost is the product of marginal cost and production :

$$\mathscr{C}(q, \mathbb{W}) = q \frac{\partial \mathscr{C}}{\partial q}(q, \mathbb{W}).$$

Taking the derivative with respect to q shows that the marginal cost does not depend on q and is equal to $c(\mathbb{W})$, and that total variable cost is a linear function of production:

$$\mathscr{C}(q, \mathbb{W}) = c(\mathbb{W})q.$$

$\square$

Equilibrium and Steady State

Equilibrium is characterized by the determination of the path of the 19 following endogenous variables K_t, I_t, c_t, P_t^K, r_t, r_t^K, w_t, P_t, Q_t, R_t, V_t, $\tilde{p}_t$, $\tilde{q}_t$, $\tilde{r}_t$, $\tilde{v}_t$, M_t, M_t^e, $\tilde{z}_t$, z_t^*, from Equations (9) to (45). This is done by first expressing all variables in ratio over factor cost mc_t, effectively using the capital-labor bundle as the numeraire. One can solve for average profit $\tilde{v}_t$ using the zero cutoff profit condition in Equation (40).

Using the free entry condition (41), Equation (36), and the pricing rule (37) one obtains the cut-off productivity level z_t^*, the average quality level $\tilde{z}_t$, and the average price level $\tilde{p}_t$. From Equations (38) and (39) one also obtains average revenue $\tilde{r}_t$ and production $\tilde{q}_t$. Aggregates P_t, Q_t, R_t, V_t, defined in Equations (12) and (33) to (35) can all be expressed as functions of M_t and average variables that have all already been solved, as can the mass of prospective entrants in Equation (42). Equation (44) links M_t to aggregate capital K_t and equilibrium on the final good market (45), together with capital accumulation (28), gives a relationship between K_t and c_t, so all aggregate variables, including P_t and K_t are now defined as functions of c_t.

From there, we obtain a first relationship between c_t and r_t^K using the factor cost frontier in Equation (31) and the cost of the capital-labor bundle in Equation (32). Finally, the Euler equation (29), and investment (43) and user-cost of capital (30), together with consumption price P_t expressed as a function of c_t yield a second relationship between c_t and r_t^K.

To prove the existence of the steady-state one first needs to find a balanced growth path (BGP) on which all 19 variables must grow at constant rates in the long-run. The three exogenous sources of growth in the model are the two sectoral quality and productivity growth g and g^K, and demographic growth n. Writing g_x the constant long-run growth rate of variable x, the 19 Equations (28) to (45) (Equation (34) includes in fact two equations) imply that:

$$
\begin{cases}
g_I = g_K \\
g_c = \theta^{-1}(r - \pi - \beta) \\
g_{r-\pi} = 0 \\
g_{r^K} = g_{P^K} = \pi^K \\
\pi = g_{\tilde{p}} - \frac{\nu}{\rho-1}g_M \\
g_w = g_K - n + \pi^K \\
g_{mc} = \alpha\pi^K + (1-\alpha)g_w \\
g_Q = \left(1 + \frac{\nu}{\rho-1}\right)g_M + g_{\tilde{q}} \\
g_R = \pi + g_Q = g_M + g_{\tilde{r}} \\
g_V = g_M + g_{\tilde{v}}
\end{cases}
\quad /* \quad
\begin{cases}
g_{\tilde{z}} = g_{z^*} \\
g_{\tilde{p}} = g_{mc} - g_{\tilde{z}} \\
g_{\tilde{r}} = g_{\tilde{v}} = g_{mc} \\
g_{\tilde{r}} = g_{\tilde{p}} + g_{\tilde{q}} \\
g_{\tilde{v}} = g_{mc} \\
g_{z^*} = g \\
g_M = g_{M^e} \\
g_{P^K} = \pi - g^K \\
g_{mc} + \alpha g_K + (1-\alpha)n = g_R = g_V = g_{mc} + g_{M^e} \\
g_Q = n + g_c = g_I - g^K
\end{cases}
$$

It is straightforward to verify that this system has a unique solution with zero price inflation $\pi = 0$, which we describe below. Replacing variables in Equations (28) to (45) with their stationary counterparts $x_t \leftarrow x_t \exp(-g_x t)$ and assuming the economy is on the BGP, one can solve for the steady-state:

$$
\begin{cases}
P^K = 1 \\
r = \theta(g_Q - n) + \beta \\
r^K = r + \delta + g^K \\
z^* = \left(\frac{f}{f_e} \frac{\rho-1}{k-(\rho-1)}\right)^{\frac{1}{k}} \\
\tilde{z} = \left(\frac{k}{k-(\rho-1)}\right)^{\frac{1}{\rho-1}} z^* \\
\tilde{q} = \tilde{z} f(\rho-1)\left(\frac{\tilde{z}}{z^*}\right)^{\rho-1} \\
M = \left[\tilde{z}^{\frac{\rho-1}{\rho}} \tilde{q}^{\alpha-1}\left(\frac{r^K}{\alpha}\right)^{-\alpha}\right]^{\frac{1}{1-\alpha\left(1+\frac{\nu}{\rho-1}\right)}} \\
mc = \tilde{z}^{\frac{\rho-1}{\rho}} M^{\frac{\nu}{\rho-1}} \\
\tilde{p} = M^{\frac{\nu}{\rho-1}} \\
\tilde{r} = \tilde{q}\tilde{p}
\end{cases}
\qquad
\begin{cases}
\tilde{v} = \frac{\tilde{r}}{\rho} - mcf \\
Q = M^{1+\frac{\nu}{\rho-1}}\tilde{q} \\
R = M\tilde{r} \\
V = M\tilde{v} \\
K = \left(\frac{Q}{mc}\right)^{\frac{1}{\alpha}} \\
I = (g_Q + g^K + \delta)K \\
C = Q - I \\
w = (1-\alpha)mcK^\alpha \\
M^e = (z^*)^k M
\end{cases}
$$

Finally, along the BGP, the distribution of de-trended productivity is also stationary, Pareto with scale z^* and shape k. Its cumulative density function is:

$$
H(z) = \mathbf{P}\left(\frac{Z}{z_t^0} \leq z\right) = 1 - \left(\frac{z^*}{z}\right)^k
$$

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