

w o r k i n g  
p a p e r

20 35

**Macroeconomic Changes with Declining  
Trend Inflation: Complementarity  
with the Superstar Firm Hypothesis**

Takushi Kurozumi and Willem Van Zandweghe



FEDERAL RESERVE BANK OF CLEVELAND

ISSN: 2573-7953

**Working papers** of the Federal Reserve Bank of Cleveland are preliminary materials circulated to stimulate discussion and critical comment on research in progress. They may not have been subject to the formal editorial review accorded official Federal Reserve Bank of Cleveland publications. The views stated herein are those of the authors and not necessarily those of the Bank of Japan, the Federal Reserve Bank of Cleveland, or the Board of Governors of the Federal Reserve System.

Working papers are available on the Cleveland Fed's website at:

**[www.clevelandfed.org/research](http://www.clevelandfed.org/research)**.

**Macroeconomic Changes with Declining Trend Inflation:  
Complementarity with the Superstar Firm Hypothesis**

Takushi Kurozumi and Willem Van Zandweghe

Recent studies indicate that, since 1980, the average markup and the profit share of income have increased, while the labor share and the investment share of spending have decreased. We examine the role of monetary policy in these changes as inflation has concurrently trended down. In a simple staggered price model with a non-CES aggregator of differentiated goods, a decline in trend inflation as measured since 1980 can account for a substantial portion of the changes. Moreover, introducing a rise in the productivity of “superstar firms” in the model can better explain not only the macroeconomic changes but also the micro evidence on the distribution of firms’ markups, including the flat median markup.

Keywords: average markup, profit share, labor share, trend inflation, Non-CES aggregator, superstar firm hypothesis.

JEL Classification: E52, L16.

Suggested citation: Kurozumi, Takushi, and Willem Van Zandweghe. 2020. “Macroeconomic Changes with Declining Trend Inflation: Complementarity with the Superstar Firm Hypothesis.” Federal Reserve Bank of Cleveland, Working Paper No. 20-35. <https://doi.org/10.26509/frbc-wp-202035>.

---

Takushi Kurozumi is at the Bank of Japan ([takushi.kurozumi@boj.or.jp](mailto:takushi.kurozumi@boj.or.jp)). Willem Van Zandweghe is at the Federal Reserve Bank of Cleveland ([willem.vanzandweghe@clev.frb.org](mailto:willem.vanzandweghe@clev.frb.org)). The authors are grateful to David Berger, Vincenzo Quadrini, Richard Rogerson, Nao Sudo, and seminar participants at the Federal Reserve Bank of Cleveland for comments and discussions. Kristen Tauber provided excellent research assistance.

# 1 Introduction

Recent studies have documented profound changes to the US economy since 1980. The average price–cost markup has increased, as illustrated by the solid (blue) line in panel (a) of Figure 1.<sup>1</sup> Concurrently, the profit share of income has increased, while the labor share of income and the investment share of spending have decreased, as displayed in panels (b), (c), and (d) of the figure, respectively.<sup>2</sup>

A growing literature has studied possible linkages between the US macroeconomic changes. [Barkai \(2020\)](#) analyzes the link between the increase in the average markup and the decrease in the labor share using aggregate data, and shows that the decrease has been more than offset by a rise in pure profits, thus suggesting that the decreasing labor share is due to a decline in competition.<sup>3</sup> [Autor et al. \(2020\)](#) utilize micro panel data to address the link, and find evidence consistent with a rise since the early 1980s of highly productive “superstar firms,” which have increased concentration and markups and reduced the labor share in their industries.<sup>4</sup> In this context, [De Loecker et al. \(2020\)](#) investigate firm-level data and indicate that the increase in the average markup is driven mainly by the upper tail of the distribution of firms’ markups. The link between higher markups and the lower investment share is investigated by [Gutiérrez and Philippon \(2017a\)](#), who document a decrease in business investment during the last two decades and attribute it to a rise in concentration and a decline in competition.<sup>5</sup> As for the forces driving some of the US macroeconomic changes, the literature has pointed to globalization and technological changes ([Autor et al. \(2020\)](#)), weakened antitrust enforcement ([Gutiérrez and Philippon \(2017b\)](#)), and patent concentration ([Akcigit](#)

---

<sup>1</sup>The average markup is a cost-weighted counterpart of the sales-weighted average markup of [De Loecker et al. \(2020\)](#). As displayed in their Figure I, the sales-weighted average markup exhibits a larger increase, to 1.6 in 2016, because firms with higher markups tend to have higher sales weights relative to their cost weights. [Edmond et al. \(2019\)](#) thus indicate that the cost-weighted average markup is the relevant statistic that summarizes the distortions to employment and investment decisions, and they show a time series of the average markup similar to ours.

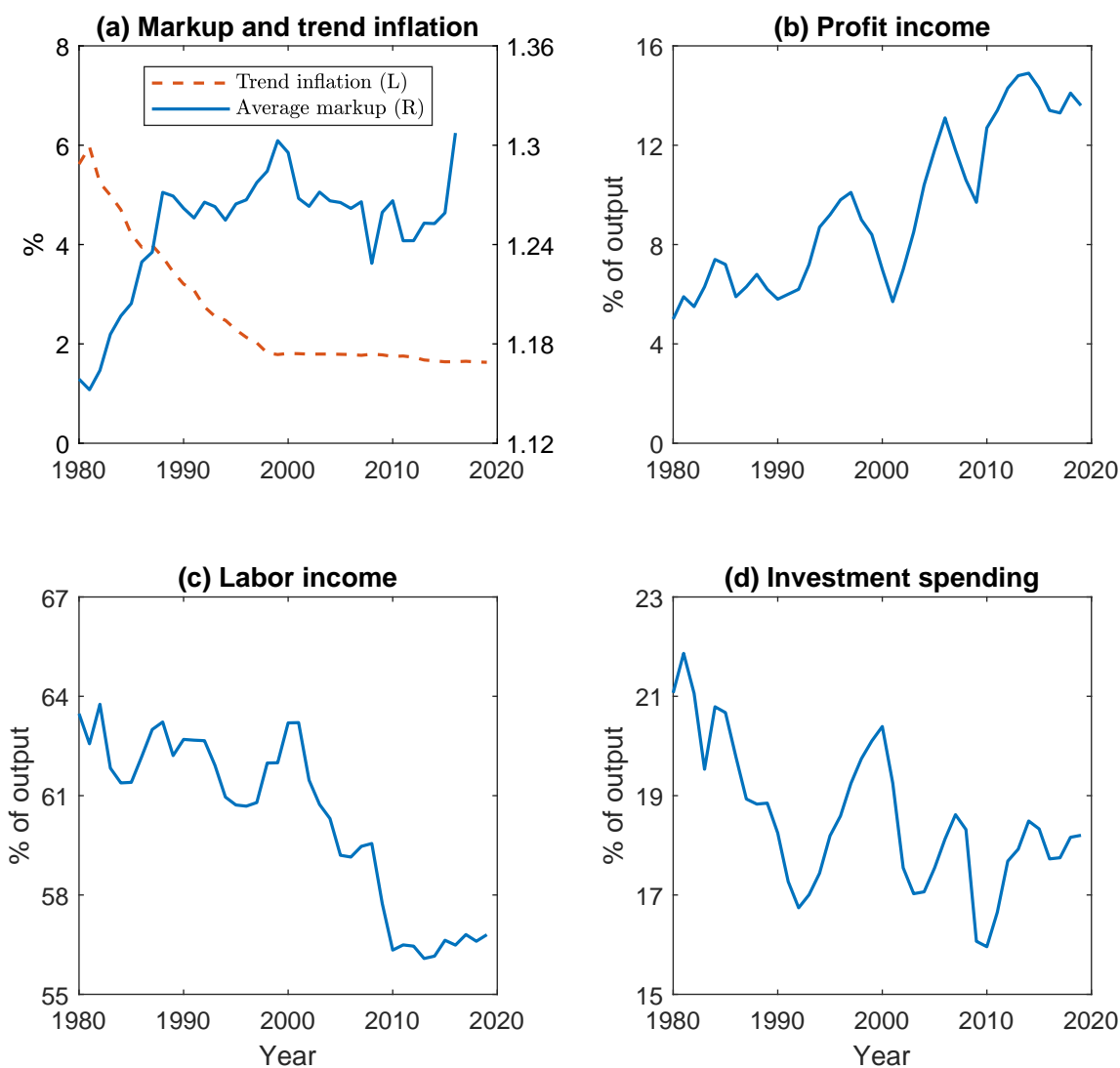
<sup>2</sup>[Akcigit and Ates \(forthcoming\)](#) highlight 10 facts on declining business dynamism in the US since 1980, including the increases in the average markup and the profit share and the decrease in the labor share.

<sup>3</sup>[Barkai \(2020\)](#) calculates that the profit share rose by 13.5 percentage points during the period 1984–2014, a larger rise than that seen in panel (b) of Figure 1 (i.e., 7.5 percentage points during the same period). [Karabarbounis and Neiman \(2019\)](#) cast doubt on the rising profit share.

<sup>4</sup>See also [Elsby et al. \(2013\)](#), [Karabarbounis and Neiman \(2014\)](#), and [Kehrig and Vincent \(forthcoming\)](#) for analyses of the decreasing labor share.

<sup>5</sup>[Basu \(2019\)](#) and [Syverson \(2019\)](#) provide excellent reviews of related studies.

Figure 1: Evolution of key US macroeconomic variables.



*Notes:* The figure displays key US macroeconomic time series from 1980 to 2019 or for available years. In panel (a), the solid (blue) line illustrates the average price–cost markup, which is a cost-weighted counterpart of the sales-weighted average markup of [De Loecker et al. \(2020\)](#), while the dashed (red) line displays the trend inflation rate of the personal consumption expenditures (PCE) price index estimated by [Chan et al. \(2018\)](#). Panel (b) shows corporate profits adjusted for inventory valuation and capital consumption as a share of value added of the nonfinancial corporate sector. Panel (c) plots the labor share in the nonfarm business sector. Panel (d) presents the share of business fixed investment in spending, where spending is measured as the sum of business fixed investment, PCE for nondurable goods, and PCE for services.

*Sources:* [Chan et al. \(2018\)](#), [De Loecker et al. \(2020\)](#), US Bureau of Labor Statistics, US Bureau of Economic Analysis, Haver Analytics.

and Ates (forthcoming)).

This paper examines the role of monetary policy as a driving factor behind the increases in the average markup and the profit share and the decreases in the labor share and the investment share. In tandem with these macroeconomic changes, the dashed (red) line in panel (a) of Figure 1 shows that the trend inflation rate, which is estimated by Chan et al. (2018), has declined steadily since the Volcker disinflation in the early 1980s, a trend that is well-known but has hitherto not been linked to the other macroeconomic changes illustrated in the figure.<sup>6</sup> The average markup and the trend inflation rate in the figure have a strong negative correlation of  $-0.84$ .<sup>7</sup> A negative correlation of this sort is also apparent across countries. Figure 2 plots the average markup of 37 countries and regions in 2016, obtained from Table 1 of De Loecker and Eeckhout (2020), against the average annual inflation rate over the period 2012–2015 that proxies for trend inflation. The negative slope of the regression line in the figure is statistically different from zero at the 5 percent significance level. The strong negative correlation between the average markup and trend inflation evident in US time series and cross-country data is suggestive of a structural relationship between the two macroeconomic variables.

The paper investigates the implications of the declining trend inflation for the increasing average markup and the other three macroeconomic changes, using a simple staggered price model.<sup>8</sup> A key feature of the model is that, each period, a fraction of individual goods' prices remains unchanged in line with micro evidence, while the other prices are set given demand curves arising from a not-necessarily-CES aggregator of individual differentiated goods of the sort proposed by Kimball (1995) and developed by Dotsey and King (2005) and Levin et al. (2008), which includes the CES aggregator as a special case. The non-CES aggregator provides a parsimonious way of introducing variable (price) elasticity of demand,

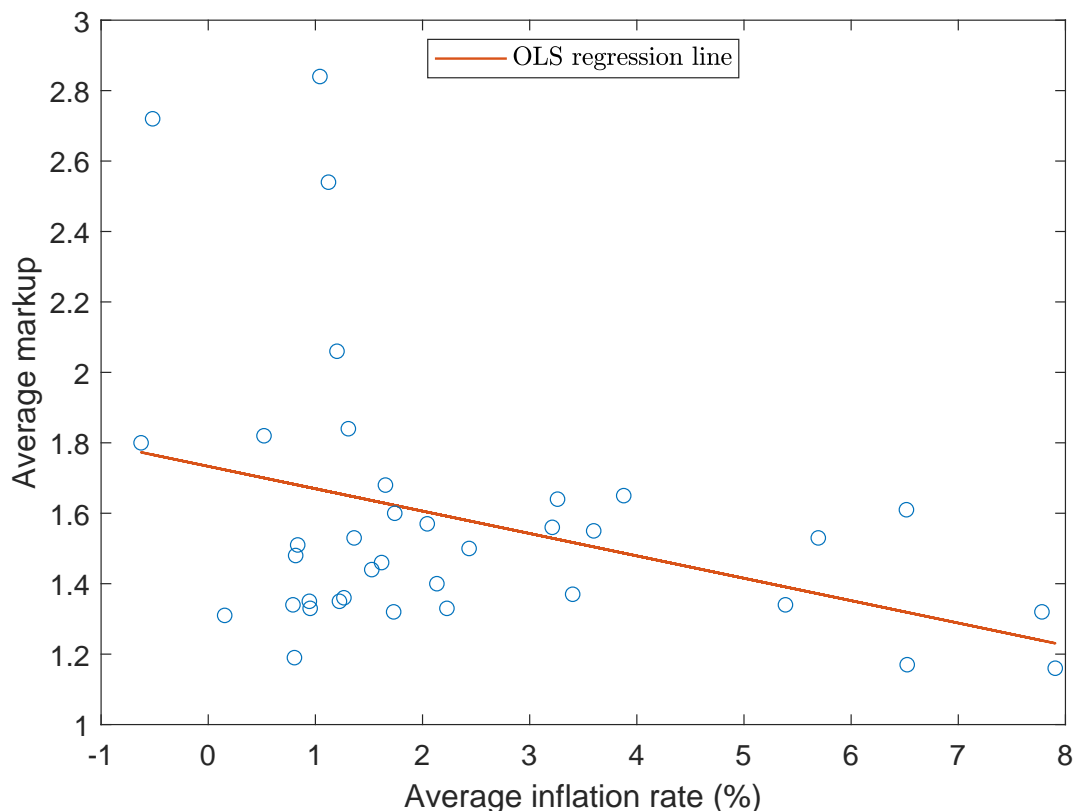
---

<sup>6</sup>We thank Todd Clark for sharing the updated series of the trend inflation rate. See, e.g., Ireland (2007), Cogley and Sbordone (2008), and Ascari and Sbordone (2014) for alternative estimates of trend inflation. The estimated series of Chan et al. (2018) exhibits a decline similar to those of the previous studies.

<sup>7</sup>The strong negative correlation between the average markup and the trend inflation rate survives for the longer period from 1961, where the correlation is  $-0.83$ .

<sup>8</sup>One may wonder how our paper treats the natural rate hypothesis. Despite the widely held view going back to Friedman (1968), the empirical evidence on whether monetary policy has long-run real effects is not as clear-cut. Various recent empirical research has supported the notion that monetary policy can have long-lasting real effects. For example, Moran and Queralto (2018) demonstrate increases in R&D and medium-run TFP following an expansionary monetary policy shock. Jordà et al. (2020) show that the effect of monetary policy on TFP, capital accumulation, and the production capacity of the economy is long lived.

Figure 2: Cross-country relation between average markup and average inflation.



*Notes:* The horizontal axis represents the average annual inflation rate of the consumer price index over the period 2012–2015, while the vertical axis shows the average markup in 2016. The three dots indicating the top three average markups are Denmark, Switzerland, and Italy. The two dots indicating the top two average inflation rates are India and Turkey. The remaining 32 countries and regions are Australia, Austria, Belgium, Brazil, Canada, Chile, China, Colombia, Finland, France, Germany, Greece, Hong Kong, Indonesia, Ireland, Japan, Malaysia, Mexico, Netherlands, Norway, Pakistan, Peru, Philippines, Portugal, Spain, Sweden, South Africa, South Korea, Thailand, United Kingdom, United States, and New Zealand.

*Sources:* [De Loecker and Eeckhout \(2020\)](#), IMF International Financial Statistics, Haver Analytics.

and has been widely used as a source of strategic complementarity in firms' price-setting in the macroeconomic literature.<sup>9</sup>

The calibrated model shows that a decline in trend inflation as measured since 1980 can account for a substantial portion of the macroeconomic changes in the presence of the non-CES aggregator. The model attributes around 30 percent of the increases in the average markup and the profit share and the decrease in the labor share and about 20 percent of the decrease in the investment share to the decline in trend inflation. The economic intuition behind this result is as follows. While the CES aggregator leads price-adjusting firms to choose a smaller price increase for the declining trend inflation, the non-CES aggregator induces strategic complementarity in firms' price-setting and thereby makes price-adjusting firms' behavior less responsive to trend inflation. The effects of trend inflation on the relative prices of non-adjusting firms' products—their relative prices are less severely eroded by the decline in trend inflation—are similar between the cases of the CES and non-CES aggregators. Consequently, the average markup increases in the presence of the non-CES aggregator. The increase of the average markup in turn raises the profit share and reduces the labor share and the investment share in the model, and it contrasts with the case of the CES aggregator in which the average markup is almost flat and thus keeps the other macroeconomic variables almost unchanged.

To reconcile our analysis with the existing literature that has advocated the superstar firm hypothesis as a leading explanation of the increasing average markup, the model is extended by introducing such firms, which are distinguished from ordinary firms by their higher productivity. The non-CES aggregator plays a dual role in the extended model. One role is serving as a source of strategic complementarity in firms' price-setting as in the baseline model. The other is serving as a source of markup heterogeneity between firms with different productivity levels, since the aggregator implies that more productive, larger firms face less elastic demand and therefore choose higher markups when they can adjust their prices.<sup>10</sup> In the calibrated model, adding a rise of superstar firms increases the average markup further, by raising the upper tail of the distribution of firms' markups in line with

---

<sup>9</sup>See, e.g., [Eichenbaum and Fisher \(2007\)](#), [Smets and Wouters \(2007\)](#), and [Kurozumi and Van Zandweghe \(2016\)](#).

<sup>10</sup>See, e.g., [Edmond et al. \(2019\)](#) and [Autor et al. \(2020\)](#) for the use of non-CES aggregators as a source of markup heterogeneity between firms.



the micro evidence, and therefore it can better explain the macroeconomic changes: more than half of the increases in the average markup and the profit share and the decrease in the labor share, and more than one third of the decrease in the investment share. Moreover, the rise of superstar firms and the decline in trend inflation have offsetting effects on the median markup, thus keeping it almost unchanged. The flat median markup is consistent with the micro evidence reported by [Autor et al. \(2020\)](#) and [De Loecker et al. \(2020\)](#) for the period since the early 1980s. In this way, the decline in trend inflation complements the rise of superstar firms in accounting for the empirical changes in the distribution of firms' markups and the macroeconomic variables.

The remainder of the paper proceeds as follows. Section 2 presents a simple staggered price model with trend inflation and a Kimball-type aggregator. Section 3 investigates the implications of declining trend inflation for the average markup, the profit and labor shares of income, and the investment share of spending in the model. Section 4 extends the analysis by introducing the rise of superstar firms in the model. Section 5 concludes.

## 2 Model

This section presents a staggered price model with trend inflation and a Kimball-type aggregator of individual differentiated goods. The model consists of households, composite-good producers, firms, and a monetary authority. A key feature of the model is that, each period, a fraction of individual goods' prices remains unchanged, while the other prices are set given demand curves arising from the aggregator. The non-CES aggregator generates variable (price) elasticity of demand.<sup>11</sup> In what follows, each economic agent's behavior is described in turn.

---

<sup>11</sup>For a micro-foundation of the variable elasticity of demand, see [Benabou \(1988\)](#), [Heidhues and Koszegi \(2008\)](#), and [Gourio and Rudanko \(2014\)](#), among others. [Benabou \(1988\)](#) develops a model of customer search, where a search cost gives rise to a reservation price above which a customer continues to search for a seller. [Heidhues and Koszegi \(2008\)](#) consider customers' loss aversion, which increases the price responsiveness of demand at higher relative to lower market prices. [Gourio and Rudanko \(2014\)](#) construct a model of customer capital, where firms have a long-term relationship with customers whose demand is unresponsive to a low price.

## 2.1 Households

There is a representative household that consumes a composite good  $C_t$ , makes a capital investment  $I_t$ , and supplies labor  $l_t$  so as to maximize the utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t \left( \log(C_t) - \frac{l_t^{1+\chi}}{1+\chi} \right)$$

subject to the budget constraint

$$P_t C_t + P_t I_t = P_t W_t l_t + P_t r_{k,t} K_{t-1} + P_t J_t$$

and the capital accumulation equation

$$K_t = (1 - \delta) K_{t-1} + I_t, \tag{1}$$

where  $E_t$  denotes the expectation operator conditional on information available in period  $t$ ,  $\beta \in (0, 1)$  is the subjective discount factor,  $\chi > 0$  is the inverse of the elasticity of labor supply,  $\delta \in (0, 1)$  is the depreciation rate of capital,  $P_t$  is the price of the composite good,  $W_t$  is the real wage rate,  $r_{k,t}$  is the real rental rate of capital  $K_{t-1}$ , and  $J_t$  is the real value of firm profits received.

Combining the first-order conditions for utility maximization with respect to consumption, labor supply, and capital investment yields

$$W_t = l_t^\chi C_t, \tag{2}$$

$$1 = E_t \left[ \frac{\beta C_t}{C_{t+1}} (r_{k,t+1} + 1 - \delta) \right]. \tag{3}$$

## 2.2 Composite-good producers

There are a representative composite-good producer and a continuum of firms  $f \in [0, 1]$ , each of which produces an individual differentiated good  $Y_t(f)$  and is subject to staggered price-setting that is detailed in the next subsection. As in [Kimball \(1995\)](#), the composite good  $Y_t$  is produced by aggregating individual differentiated goods  $\{Y_t(f)\}$  with

$$\int_0^1 F \left( \frac{Y_t(f)}{Y_t} \right) df = 1. \tag{4}$$

Following [Dotsey and King \(2005\)](#) and [Levin et al. \(2008\)](#), the function  $F(\cdot)$  is assumed to be of the form

$$F\left(\frac{Y_t(f)}{Y_t}\right) = \frac{\gamma}{(1+\epsilon)(\gamma-1)} \left( (1+\epsilon) \frac{Y_t(f)}{Y_t} - \epsilon \right)^{\frac{\gamma-1}{\gamma}} + 1 - \frac{\gamma}{(1+\epsilon)(\gamma-1)},$$

where  $\gamma \equiv \theta(1+\epsilon)$  is a composite parameter. The parameter  $\epsilon$  governs the curvature ( $-\epsilon\theta$ ) of the demand curve for each individual good. In the special case of  $\epsilon = 0$ , the aggregator (4) is reduced to the CES one  $Y_t = [\int_0^1 (Y_t(f))^{\theta-1} df]^{\theta/(\theta-1)}$ , where  $\theta > 1$  represents the elasticity of substitution between individual differentiated goods. The case of  $\epsilon < 0$  is of particular interest in this paper because it gives rise to strategic complementarity in firms' price-setting as explained later.

The composite-good producer maximizes profit  $P_t Y_t - \int_0^1 P_t(f) Y_t(f) df$  subject to the aggregator (4), given individual goods' prices  $\{P_t(f)\}$ . Combining the first-order conditions for profit maximization and the aggregator (4) leads to

$$\frac{Y_t(f)}{Y_t} = \frac{1}{1+\epsilon} \left[ \left( \frac{P_t(f)}{P_t} \right)^{-\gamma} + \epsilon \right], \quad (5)$$

$$d_t = \left[ \int_0^1 \left( \frac{P_t(f)}{P_t} \right)^{1-\gamma} df \right]^{\frac{1}{1-\gamma}}, \quad (6)$$

$$1 = \frac{1}{1+\epsilon} d_t + \frac{\epsilon}{1+\epsilon} e_t, \quad (7)$$

where  $d_t$  is the Lagrange multiplier on the aggregator (4) and

$$e_t \equiv \int_0^1 \frac{P_t(f)}{P_t} df \quad (8)$$

is the average relative price. The Lagrange multiplier  $d_t$  represents the real marginal cost of producing the composite good (or aggregating individual differentiated goods), and consists of the aggregate of the relative prices of individual goods that corresponds to the aggregator (4), as shown in (6). In the special case of  $\epsilon = 0$ , where the aggregator (4) becomes the CES one as noted above, eqs. (5)–(7) can be reduced to  $Y_t(f)/Y_t = (P_t(f)/P_t)^{-\theta}$ ,  $P_t = \left[ \int_0^1 (P_t(f))^{1-\theta} df \right]^{1/(1-\theta)}$ , and  $d_t = 1$ , respectively. The last equation shows that the real marginal cost is constant in the case of the CES aggregator.<sup>12</sup>

---

<sup>12</sup>Moreover, if all firms share the same production technology (as assumed later) and all individual goods' prices are flexible, the prices are all identical and thus eqs. (6) and (7) imply that  $d_t = 1$  even in the case of

Eq. (5) is the demand curve for each individual good  $Y_t(f)$  and features a variable (price) elasticity of demand for the good given by  $\eta_t(f) = \theta [1 + \epsilon - \epsilon (Y_t(f)/Y_t)^{-1}]$ . When  $\epsilon < 0$ , the elasticity  $\eta_t(f)$  varies inversely with relative demand  $Y_t(f)/Y_t$ . That is, relative demand for each individual good becomes more price-elastic for an increase in the relative price of the good, whereas relative demand becomes less price-elastic for a decrease in the relative price. This feature induces strategic complementarity in firms' price-setting, because firms that face the increasing elasticity keep their goods' relative prices near those of other firms (when they can adjust prices). In the special case of  $\epsilon = 0$ , the demand curve is reduced to  $Y_t(f)/Y_t = (P_t(f)/P_t)^{-\theta}$  and the elasticity of demand becomes constant:  $\eta_t(f) = \theta$ .

The output of the composite good is equal to the household's consumption and investment:

$$Y_t = C_t + I_t. \quad (9)$$

## 2.3 Firms

Each firm  $f$  produces one kind of differentiated good  $Y_t(f)$  using the Cobb-Douglas production function

$$Y_t(f) = A_t (K_t(f))^\alpha (l_t(f))^{1-\alpha}, \quad (10)$$

where  $\alpha \in (0, 1)$  is the capital elasticity of output,  $A_t$  represents the level of technology and is assumed to be identical to all firms and grow at a constant rate  $A_t/A_{t-1} = g^{1-\alpha}$ , and  $K_t(f)$  and  $l_t(f)$  are firm  $f$ 's inputs of capital and labor.

Firm  $f$  minimizes cost  $TC_t(f) = P_t W_t l_t(f) + P_t r_{k,t} K_t(f)$  subject to the production technology (10), given the wage rate and the capital rental rate. In the presence of economy-wide, perfectly competitive factor markets, combining the first-order conditions for cost minimization shows that all firms choose an identical capital-labor ratio<sup>13</sup>

$$\frac{K_t(f)}{l_t(f)} = \frac{\alpha}{1 - \alpha} \frac{W_t}{r_{k,t}} = \frac{K_{t-1}}{l_t} \quad (11)$$

---

the non-CES aggregator.

<sup>13</sup>The last equality in (11) can be obtained by using the capital and labor market clearing conditions  $K_{t-1} = \int_0^1 K_t(f) df$  and  $l_t = \int_0^1 l_t(f) df$ .

and face the same real marginal cost of producing their individual goods

$$mc_t(f) = \frac{1}{A_t} \left( \frac{W_t}{1 - \alpha} \right)^{1-\alpha} \left( \frac{r_{k,t}}{\alpha} \right)^\alpha = mc_t. \quad (12)$$

In the face of the demand curve (5) and the marginal cost (12), firms set their products' prices on a staggered basis as in Calvo (1983). In each period, a fraction  $\xi \in (0, 1)$  of firms keeps prices unchanged, while the remaining fraction  $1 - \xi$  sets the price  $P_t(f)$  so as to maximize relevant profit

$$E_t \sum_{j=0}^{\infty} \xi^j Q_{t,t+j} (P_t(f) - P_{t+j} mc_{t+j}) \frac{Y_{t+j}}{1 + \epsilon} \left[ \left( \frac{P_t(f)}{P_{t+j} d_{t+j}} \right)^{-\gamma} + \epsilon \right],$$

where  $Q_{t,t+j}$  is the (nominal) stochastic discount factor between period  $t$  and period  $t + j$ . Using the equilibrium condition  $Q_{t,t+j} = \beta^j (C_t/C_{t+j}) / (P_t/P_{t+j})$ , the first-order condition for profit maximization can be written as

$$E_t \sum_{j=0}^{\infty} (\beta \xi)^j \frac{Y_{t+j}}{C_{t+j}} \left[ \left( \frac{p_t^*}{d_{t+j}} \right)^{-\gamma} \prod_{k=1}^j \pi_{t+k}^\gamma \left( p_t^* \prod_{k=1}^j \pi_{t+k}^{-1} - \frac{\gamma}{\gamma - 1} mc_{t+j} \right) - \frac{\epsilon}{\gamma - 1} p_t^* \prod_{k=1}^j \pi_{t+k}^{-1} \right] = 0, \quad (13)$$

where  $p_t^* \equiv P_t^*/P_t$ ,  $P_t^*$  is the price set by firms that can change prices in period  $t$ , and  $\pi_t \equiv P_t/P_{t-1}$  is the gross inflation rate of the composite good's price. Moreover, under staggered price-setting, eqs. (6) and (8) can be reduced to, respectively,

$$d_t^{1-\gamma} = \xi \pi_t^{\gamma-1} d_{t-1}^{1-\gamma} + (1 - \xi) (p_t^*)^{1-\gamma}, \quad (14)$$

$$e_t = \xi \pi_t^{-1} e_{t-1} + (1 - \xi) p_t^*. \quad (15)$$

## 2.4 Monetary authority and equilibrium conditions

The monetary authority is assumed to choose the trend inflation rate  $\pi$ , which represents its inflation target in the model. The trend inflation rate influences real outcomes in steady state through its effects on two distortions in the model: the average markup and the relative price distortion. We discuss each of the distortions in turn.

The relative price distortion is obtained by combining the demand curve (5), the production function (10), and the capital and labor market clearing conditions  $K_{t-1} = \int_0^1 K_t(f) df$

and  $l_t = \int_0^1 l_t(f)df$ , which leads to the following aggregate production function:

$$Y_t \Delta_t = A_t K_{t-1}^\alpha l_t^{1-\alpha}. \quad (16)$$

Here

$$\Delta_t \equiv \frac{s_t + \epsilon}{1 + \epsilon} \quad (17)$$

represents the relative price distortion, and

$$s_t \equiv \int_0^1 \left( \frac{P_t(f)}{P_t d_t} \right)^{-\gamma} df, \quad (18)$$

which can be reduced, under staggered price-setting, to

$$d_t^{-\gamma} s_t = \xi \pi_t^\gamma d_{t-1}^{-\gamma} s_{t-1} + (1 - \xi)(p_t^*)^{-\gamma}. \quad (19)$$

The relative price distortion  $\Delta_t$  measures the inefficiency of aggregate production under staggered price-setting and coincides with the demand dispersion

$$\Delta_t = \int_0^1 \frac{Y_t(f)}{Y_t} df,$$

which can be obtained by combining eqs. (5), (17), and (18). If all prices are flexible, then all firms charge the same price because they share the same production function (10), and thus eqs. (17) and (18) demonstrate no relative price distortion, i.e.,  $\Delta_t = s_t = 1$ , and the aggregate production equation (16) implies no inefficiency in producing aggregate output using aggregate capital and labor. On the other hand, staggered price-setting increases demand dispersion, that is, the relative price distortion, and thus raises the inefficiency of aggregate production, and this is exacerbated by higher trend inflation.

The paper follows [Edmond et al. \(2019\)](#) to consider the cost-weighted average price-cost markup

$$\mu_t = \int_0^1 \frac{Y_t(f)}{Y_t \Delta_t} \frac{P_t(f)}{P_t m c_t} df = \frac{1}{m c_t \Delta_t}, \quad (20)$$

where each firm's cost weight is given by

$$\frac{TC_t(f)}{\int_0^1 TC_t(f) df} = \frac{P_t m c_t Y_t(f)}{\int_0^1 P_t m c_t Y_t(f) df} = \frac{Y_t(f)}{Y_t \Delta_t}.$$

Therefore, the average markup coincides with the reciprocal of the real marginal cost of

producing differentiated goods  $mc_t$  and the relative price distortion  $\Delta_t$ . If all prices are flexible then firms can attain their desired markup  $\theta/(\theta - 1)$ . With staggered price-setting, however, firms choose a price that meets the profit-maximizing condition (13) if they can adjust their prices. Thus, a firm's markup varies depending on how long its price has remained unchanged, and higher trend inflation exacerbates the erosion of firms' relative prices and hence their markups in between price changes.

The equilibrium conditions of the model consist of (1)–(3), (7), (9), (11)–(17), and (19). These conditions are rewritten in terms of detrended variables:  $y_t \equiv Y_t/\Upsilon_t$ ,  $c_t \equiv C_t/\Upsilon_t$ ,  $i_t \equiv I_t/\Upsilon_t$ ,  $k_t \equiv K_t/\Upsilon_t$ ,  $w_t \equiv W_t/\Upsilon_t$ , and  $j_t \equiv J_t/\Upsilon_t$ , where  $\Upsilon_t = A_t^{1/(1-\alpha)}$ . This implies that the growth rate of  $\Upsilon_t$  (i.e.,  $\Upsilon_t/\Upsilon_{t-1} = g$ ) represents the rate of balanced growth.

## 2.5 Steady state

For the steady state to be well defined, the following condition is assumed to be satisfied:

$$\xi \max(\pi^\gamma, \pi^{\gamma-1}, \pi^{-1}) < 1. \quad (21)$$

This condition is rewritten as  $\xi \max(\pi^\theta, \pi^{\theta-1}) < 1$  in the special case of the CES aggregator, i.e.,  $\epsilon = 0$ .<sup>14</sup>

Using the equilibrium conditions, we can obtain the following equations for the real marginal cost of producing differentiated goods and the relative price distortion in the steady state with trend inflation  $\pi$ :

$$mc = \frac{\gamma - 1 - \epsilon_2}{\gamma} \frac{1 - \beta\xi\pi^\gamma}{1 - \beta\xi\pi^{\gamma-1}} \left[ \frac{1}{1 + \epsilon} \left( \frac{1 - \xi}{1 - \xi\pi^{\gamma-1}} \right)^{\frac{1}{1-\gamma}} + \frac{\epsilon}{1 + \epsilon} \frac{1 - \xi}{1 - \xi\pi^{-1}} \right]^{-1}, \quad (22)$$

$$\Delta = \frac{1}{1 + \epsilon} \frac{1 - \xi}{1 - \xi\pi^\gamma} \left( \frac{1 - \xi}{1 - \xi\pi^{\gamma-1}} \right)^{\frac{\gamma}{1-\gamma}} + \frac{\epsilon}{1 + \epsilon}, \quad (23)$$

where  $\epsilon_2 \equiv \epsilon_1(1 - \beta\xi\pi^{\gamma-1})/(1 - \beta\xi\pi^{-1})$  and  $\epsilon_1 \equiv \epsilon[(1 - \xi)/(1 - \xi\pi^{\gamma-1})]^{\gamma/(\gamma-1)}$ . The average markup equation (20) gives its steady-state value

$$\mu = \frac{1}{mc \Delta}. \quad (24)$$

---

<sup>14</sup>The condition is always met in the special case of zero trend inflation, i.e.,  $\pi = 1$ .

The profit and labor shares of income are given by

$$\frac{j}{y} = 1 - \frac{1}{\mu}, \quad (25)$$

$$\frac{wl}{y} = (1 - \alpha) \frac{1}{\mu}, \quad (26)$$

and the investment share of spending  $i/y$  is the product of the investment-capital ratio  $i/k = 1 - (1 - \delta)/g$  and the capital-output ratio  $k/y = \alpha g / (r_k \mu)$ , where  $r_k = g/\beta - (1 - \delta)$ , so that

$$\frac{i}{y} = \alpha \beta \left( \frac{g - (1 - \delta)}{g - \beta(1 - \delta)} \right) \frac{1}{\mu}. \quad (27)$$

Note that the cost-weighted average markup is the only and the common driver of the profit share (25), the labor share (26), and the investment share (27).<sup>15</sup> That is, trend inflation  $\pi$  influences the three shares through its effect on the steady-state average markup  $\mu$ .

### 3 Effects of declining trend inflation

Using the steady-state equations (22)–(27), this section evaluates the quantitative effects of a decline in trend inflation as measured since 1980 on the steady-state values of the average markup, the labor and profit shares of income, and the investment share of spending.

#### 3.1 Calibration of model parameters

As seen in the preceding section, the steady-state equations (22)–(27) are highly nonlinear functions of trend inflation  $\pi$  and thus a calibration of model parameters is used to illustrate how the steady-state values vary with  $\pi$ . Table 1 summarizes the calibration of parameters in the quarterly model.<sup>16</sup> We set the subjective discount factor at  $\beta = 0.99$ , the depreciation rate of capital at  $\delta = 0.025$ , and the capital elasticity of output at  $\alpha = 0.3$ , which all are common values in the macroeconomic literature. The rate of balanced growth is chosen at  $g = 1.005$  (i.e., 2 percent annually). The probability of no price change is set at  $\xi = 0.75$ , which

---

<sup>15</sup>As pointed out by Basu (2019) and Syverson (2019), the average markup can be written as  $\mu = [1/(1 - j/y)](ac/mc)$ , where the term in brackets involves the profit share of income and the term  $ac/mc$  is the inverse of the elasticity of costs with respect to quantity, with  $ac$  denoting the average cost. Comparing this equation with eq. (25) shows that the cost elasticity is equal to one in the model.

<sup>16</sup>The value for the inverse of the elasticity of labor supply  $\chi$  has no effect on the steady-state values of the macroeconomic variables.



implies that prices change every four quarters on average in line with the micro evidence on the frequency of price changes (Klenow and Malin (2010)). The parameter governing the elasticity of substitution between individual differentiated goods is chosen at  $\theta = 4.1$  to target an average markup of 1.31 at the annualized trend inflation rate of 1.6 percent, their values for 2016 displayed in panel (a) of Figure 1. Nakamura and Steinsson (2010) observe that such a value of  $\theta$  matches estimates from the literature on industrial organization and international trade. As for the parameter governing the curvature of demand curves, we select a value of  $\epsilon = -8$ , which implies, given our calibration of  $\theta$ , a curvature of  $-\epsilon\theta = 32.8$ .<sup>17</sup> This degree of curvature is near the high value of 33 considered by Eichenbaum and Fisher (2007) and is intermediate between those implied by the two estimates of Guerrieri et al. (2010).<sup>18</sup> To meet the assumption (21) under the model parameter values presented above, the trend inflation rate needs to be greater than  $-3.9$  percent annually.

Table 1: Calibration of parameters in the quarterly model.

Parameter	Description	Value
$\beta$	Subjective discount factor	0.99
$\delta$	Depreciation rate of capital	0.025
$\alpha$	Capital elasticity of output	0.3
$g$	Rate of balanced growth	1.005
$\xi$	Probability of no price change	0.75
$\theta$	Parameter governing the elasticity of substitution between goods	4.1
$\epsilon$	Parameter governing the curvature of demand curves	-8

## 3.2 Quantitative effects

Trend inflation in the US economy has declined steadily after the Volcker disinflation in the early 1980s, as displayed in Figure 1. Figure 3 illustrates the steady-state effects of lower

<sup>17</sup>We also considered selecting values of  $\theta$  and  $\epsilon$  by minimizing the distance between the empirical cost-weighted average markup and its model counterpart. Let  $X_t$  and  $Z_t$  denote the time series of the trend inflation rate and the cost-weighted average markup, respectively. Then, the values of  $\theta$  and  $\epsilon$  that minimize the distance  $d(\mu(X_t), Z_t)$ , where  $\mu(X_t)$  is a vector of steady-state values of the average markup at  $X_t$ , are  $\theta = 4.6$  and  $\epsilon = -25.6$ . Because these values imply a high curvature of  $-\theta\epsilon = 116$ , this paper adopts the more conservative values presented in Table 1.

<sup>18</sup>Guerrieri et al. (2010) use international trade data and the New Keynesian Phillips curve of an open-economy model to estimate the degree of curvature and obtain two estimates based on two distinct assumptions for the static markup implied by  $\theta$ . Their baseline and alternative estimates assume  $\theta = 6$  and  $\theta = 11$  and imply a curvature of 16.7 and 65.9, respectively.

trend inflation in the model with the non-CES aggregator. As shown by the solid (blue) lines, the aggregator leads lower trend inflation to increase the average markup (panel a) and the profit share (panel b) and to decrease the labor share (panel c) and the investment share (panel d). The increasing average markup is consistent with the evidence of [De Loecker et al. \(2020\)](#), [Edmond et al. \(2019\)](#), and [Hall \(2018\)](#) that the average markup has risen since the early 1980s. The increasing profit share is in line with the rise of this share observed since 1980 as presented in panel (b) of Figure 1 and the evidence of [Barkai \(2020\)](#), who documents a rise in the profit share from 1984. Likewise, the decreasing labor share and the decreasing investment share of spending in the model are consistent with the declines of these shares observed since 1980 as plotted, respectively, in panels (c) and (d) of Figure 1. In contrast, the dashed (red) lines represent the case of the CES aggregator in which lower trend inflation has minor effects on all the macroeconomic variables.

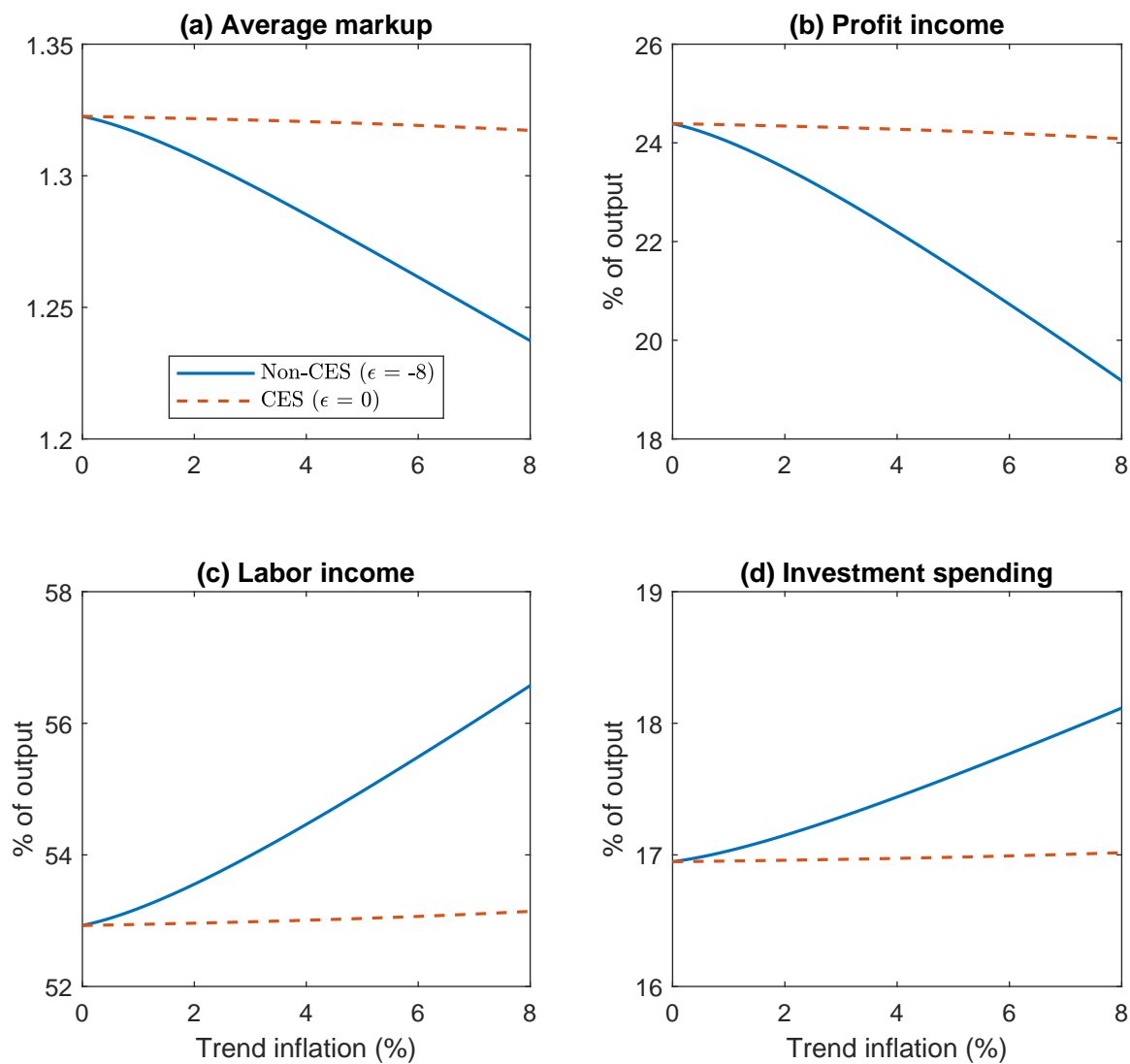
To understand why the non-CES aggregator leads lower trend inflation to raise the average markup, we can look at how the aggregator affects the distribution of markups across firms. In steady state, the average markup consists of the markups of  $1 - \xi$  firms that set their prices in the current period, those of  $(1 - \xi)\xi$  firms that set their prices in the previous period, and so forth. The age of a firm's price also determines its cost weight, as can be seen from each individual good's demand curve (5). Thus, the distribution of markups is represented as

$$\mu = \sum_{j=0}^{\infty} \left\{ (1 - \xi)\xi^j \frac{1}{\Delta} \left[ \frac{1}{1 + \epsilon} \left( \frac{1 - \xi}{1 - \xi\pi^{\gamma-1}} \right)^{\frac{\gamma}{1-\gamma}} \pi^{\gamma j} + \frac{\epsilon}{1 + \epsilon} \right] \right\} \left( \frac{p^* \pi^{-j}}{mc} \right),$$

where  $p^*/mc = [\gamma/(\gamma - 1 - \epsilon_2)][(1 - \beta\xi\pi^{\gamma-1})/(1 - \beta\xi\pi^\gamma)]$ .

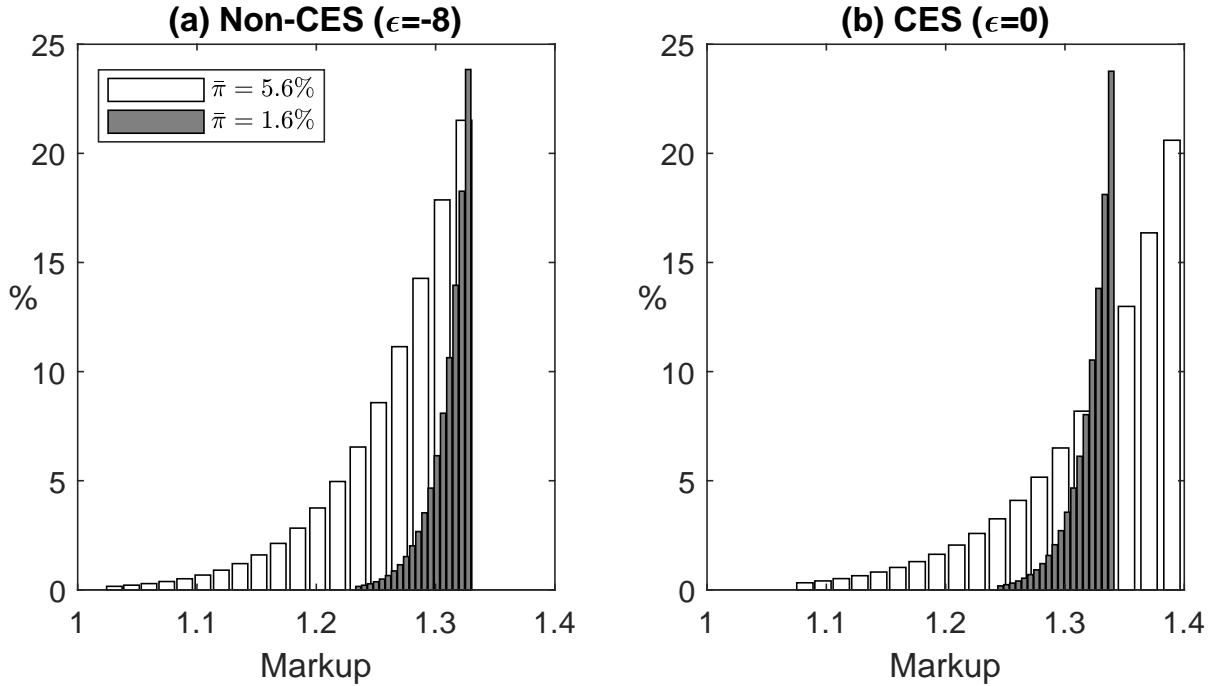
Figure 4 displays the steady-state markup distribution obtained with the non-CES aggregator (panel a) and with the CES aggregator (panel b) for two values of annualized trend inflation, 5.6 percent (white bars) and 1.6 percent (gray bars), using the values of other model parameters presented in Table 1. The annualized trend inflation rates are those in 1980 and 2019 as plotted in panel (a) of Figure 1. The lower trend inflation reduces the lower tail of the markup distribution, regardless of the CES or non-CES aggregator, because firms that keep their nominal prices unchanged experience a less severe erosion of their relative prices and hence their markups. Then, with the CES aggregator, the lower trend inflation also induces

Figure 3: Steady-state values of the macroeconomic variables as functions of trend inflation.



*Notes:* This figure illustrates the effects of trend inflation  $\bar{\pi}$  ( $\equiv 400 \log \pi$ ) on the average markup, the profit and labor shares, and the investment share in the steady states of the models with the non-CES aggregator (solid blue lines) and with the CES aggregator (dashed red lines). The values of model parameters used here are reported in Table 1.

Figure 4: Steady-state distribution of firms' markups with cost weights.



*Notes:* This figure illustrates the effects of trend inflation  $\bar{\pi}$  ( $\equiv 400 \log \pi$ ) on the distribution of firms' markups with cost weights in the steady states of the models with the non-CES aggregator (left panel) and with the CES aggregator (right panel). The values of model parameters used here are reported in Table 1.

price-adjusting firms to choose a smaller price increase as firms are forward-looking. The resulting lower markups of price-adjusting firms offset most of the contribution of the less severely eroding markups of non-adjusting firms, and as a consequence, the average markup is almost flat for the lower trend inflation, as shown by the dashed (red) line in panel (a) of Figure 3. In contrast, the non-CES aggregator induces strategic complementarity in firms' price-setting through the variable (price) elasticity of demand as noted above, and thus it makes price-adjusting firms' behavior less responsive to the lower trend inflation. Consequently, the lower trend inflation raises the average markup through the thinner lower tail of non-adjusting firms' markups.<sup>19</sup> This implies that the non-CES aggregator leads the lower trend inflation to reduce the skewness to the left of the steady-state markup distribution, thereby increasing the average markup.

To quantify how much of the macroeconomic changes can be attributed to the decline in

<sup>19</sup>In the customer search model of Benabou (1988), lower inflation likewise erodes firms' relative prices less severely and increases their monopoly power.

Table 2: Macroeconomic changes from 1980 to 2019.

	Trend Inflation (% pa)	Average markup	Profit share (%)	Labor share (%)	Investment share (%)
<i>US economy</i>					
1980	5.6	1.16	5.00	63.48	21.07
2019	1.6	1.31 <sup>a</sup>	13.60	56.80	18.20
Change (percentage points)	-4.0	14.86	8.60	-6.68	-2.87
<i>Model</i>					
Steady-state value	5.6	1.27	21.03	55.28	17.70
Steady-state value	1.6	1.31	23.72	53.40	17.10
Change (percentage points)	-4.0	4.46	2.69	-1.88	-0.60
<i>Extended model</i>					
Steady-state value with $z = 1.0$	5.6	1.27	21.03	55.28	17.70
Steady-state value with $z = 1.6$	1.6	1.35	25.82	51.92	16.63
Change (percentage points)	-4.0	8.18	4.79	-3.36	-1.07

*Notes:* The data for the US economy shown in the top part of this table are described in the notes to Figure 1. The value marked by ‘a’ pertains to 2016, the most recent available observation. The values of model parameters used for the middle part of the table are reported in Table 1. They are also used for the bottom part of the table, along with the values of ordinary firms’ share of  $n = 0.86$  and superstar firms’ relative productivity  $z$  presented here.

trend inflation measured since 1980, the top part of Table 2 presents the percentage point changes in the annualized trend inflation rate, the average markup, the profit share, the labor share, and the investment share from 1980 to 2019 or the most recent year as displayed in Figure 1, while the middle part of the table reports the model-predicted changes in the steady-state values of the macroeconomic variables induced by a decline in trend inflation of equal size. The annualized trend inflation rate declined by 4 percentage points from 5.6 percent in 1980 to 1.6 percent in 2019. The average markup increased by 14.9 percentage points, whereas the model predicts that the decline in trend inflation increases the average markup by 4.5 percentage points. The profit share for the US economy rose by 8.6 percentage points, while the model predicts a rise of 2.7 percentage points. The labor share and the investment share decreased by 6.7 percentage points and 2.9 percentage points from 1980 to 2019, respectively, and their counterparts in the model prediction are decreases of 1.9 percentage points and 0.6 percentage points, respectively. In sum, the model attributes around 30 percent of the increases in the average markup and the profit share and the decrease in the labor share and about 20 percent of the decrease in the investment share to

the decline in trend inflation.<sup>20</sup>

## 4 Complementarity with superstar firm hypothesis

The analysis in the preceding section indicates that the decline in trend inflation as measured since 1980 may have contributed substantially to the concurrent rise in the average markup but is not the only driving factor. In the existing literature, the superstar firm hypothesis first proposed by [Autor et al. \(2020\)](#)—that the rising average markup stems from the increased importance of highly productive superstar firms with large markups—is a leading explanation for the rise in the average markup.<sup>21</sup> This section thus examines the joint effect of the decline in trend inflation and the rise of superstar firms on the average markup and the other macroeconomic variables. To this end, our model is extended by introducing highly productive superstar firms. Specifically, the extended model assumes that a fraction  $1 - n$  of firms (i.e., superstar firms) is more productive than the other  $n$  firms (i.e., ordinary firms).<sup>22</sup> The production function (10) is then replaced with

$$Y_t(f) = z(f)A_t (K_t(f))^\alpha (l_t(f))^{1-\alpha}, \quad (28)$$

where  $z(f) = 1$  if  $f \in [0, n]$  and  $z(f) = z$  otherwise. Aggregating the production function (28) for ordinary firms  $f \in [0, n]$  and for superstar firms  $f \in (n, 1]$  leads to, respectively,

$$Y_t \Delta_{1,t} = A_t l_{1,t}^{1-\alpha} K_{1,t}^\alpha, \quad (29)$$

$$Y_t \Delta_{z,t} = A_t l_{z,t}^{1-\alpha} K_{z,t}^\alpha, \quad (30)$$

---

<sup>20</sup>The corresponding numbers under the alternative calibration of  $\theta = 4.6$  and  $\epsilon = -25.6$  presented in footnote 17 are slightly larger: 33 percent, 37 percent, 34 percent, and 25 percent for the increases in the average markup and the profit share and the decreases in the labor share and the investment share, respectively. The results are thus robust for a wide range of values for the curvature of the demand curves for individual differentiated goods.

<sup>21</sup>[Autor et al. \(2020\)](#) raise the hypothesis to explain the rising average markup and the declining labor share. Meanwhile, [Kehrig and Vincent \(forthcoming\)](#) present evidence that supports a demand-driven explanation of the declining labor share.

<sup>22</sup>The appendix presents the details of the extended model and proves the proposition that, for the two types of firms with product prices of the same age, a superstar firm has a higher markup in steady state than an ordinary firm if and only if the aggregator is the non-CES one, i.e.,  $\epsilon < 0$ .

where  $l_{1,t} \equiv \int_0^n l_t(f) df$ ,  $K_{1,t} \equiv \int_0^n K_t(f) df$ ,  $l_{z,t} \equiv \int_n^1 l_t(f) df$ ,  $K_{z,t} \equiv \int_n^1 K_t(f) df$ , and

$$\Delta_{1,t} \equiv \frac{1}{1+\epsilon} \int_0^n \left( \frac{P_t(f)}{P_t d_t} \right)^{-\gamma} df + \frac{n\epsilon}{1+\epsilon} = \frac{s_{1,t} + n\epsilon}{1+\epsilon}, \quad (31)$$

$$\Delta_{z,t} \equiv \frac{1}{1+\epsilon} \int_n^1 \left( \frac{P_t(f)}{P_t d_t} \right)^{-\gamma} df + \frac{(1-n)\epsilon}{1+\epsilon} = \frac{s_{z,t} + (1-n)\epsilon}{1+\epsilon} \quad (32)$$

denote the relative price distortions that affect the production of ordinary and superstar firms, respectively. Moreover, the real marginal costs of these firms are given by

$$mc_{1,t} = \frac{1}{A_t} \left( \frac{W_t}{1-\alpha} \right)^{1-\alpha} \left( \frac{r_{k,t}}{\alpha} \right)^\alpha, \quad (33)$$

$$mc_{z,t} = \frac{1}{A_t z} \left( \frac{W_t}{1-\alpha} \right)^{1-\alpha} \left( \frac{r_{k,t}}{\alpha} \right)^\alpha, \quad (34)$$

so that they are proportional, i.e.,  $mc_{1,t} = z mc_{z,t}$ . Then, the cost-weighted average markup is calculated as

$$\mu_t = \int_0^1 \frac{TC_t(f)}{\int_0^1 TC_t(f) df} \frac{P_t(f)}{P_t mc_t(f)} df = \frac{1}{mc_{1,t} \Delta_{1,t} + mc_{z,t} \Delta_{z,t}},$$

so that its steady-state value is given by

$$\mu = \frac{1}{mc_1 \Delta_1 + mc_z \Delta_z}. \quad (35)$$

Note that, given a value of the steady-state average markup  $\mu$ , the steady-state values of the profit share, the labor share, and the investment share are still determined by eqs. (25)–(27), respectively.

Facing the different real marginal costs, ordinary and superstar firms that can adjust their products' prices in period  $t$  set different prices  $P_{1,t}^*$  and  $P_{z,t}^*$ , respectively. Then, the steady-state distribution of firms' markups is represented as

$$\begin{aligned} \mu = & \sum_{j=0}^{\infty} \left\{ (1-\xi) \xi^j \frac{mc_1 n}{mc_1 \Delta_1 + mc_z \Delta_z} \left[ \frac{1}{1+\epsilon} \left( \frac{d}{p_1^*} \right)^\gamma \pi^{\gamma j} + \frac{\epsilon}{1+\epsilon} \right] \right\} \left( \frac{p_1^* \pi^{-j}}{mc_1} \right) \\ & + \sum_{j=0}^{\infty} \left\{ (1-\xi) \xi^j \frac{mc_z (1-n)}{mc_1 \Delta_1 + mc_z \Delta_z} \left[ \frac{1}{1+\epsilon} \left( \frac{d}{p_z^*} \right)^\gamma \pi^{\gamma j} + \frac{\epsilon}{1+\epsilon} \right] \right\} \left( \frac{p_z^* \pi^{-j}}{mc_z} \right), \quad (36) \end{aligned}$$

where  $p_1^*$  and  $p_z^*$  are respectively the steady-state relative prices of ordinary and superstar firms that can change their prices. The distribution shows that there are two markups

associated with each price vintage,  $\{p_1^* \pi^{-j}/mc_1, p_z^* \pi^{-j}/mc_z\}_{j=0}^{\infty}$ .

To examine the joint effect of the decline in trend inflation and the rise of superstar firms, the calibration presented in Table 1 is supplemented with values for the two new parameters,  $n$  and  $z$ . The value of superstar firms' relative productivity  $z$  is set to target the empirical ratio of the 90th percentile to the median markup. Edmond et al. (2019) (their Table 3) report that the former exceeded the latter by 50 percent in 2012, and thus we choose  $z = 1.6$  to target a ratio of the 90th percentile to the median markup of 1.5 at the trend inflation rate of 1.6 percent annually. The share of ordinary firms  $n$  is then set at its largest possible value that enables the ratio of the 90th percentile to the median markup, which is  $n = 0.86$ . That is, a larger value of  $n$  would generate a smaller ratio, while a smaller value of  $n$  would turn even firms with markups below the 90th percentile into superstar firms.

The bottom part of Table 2 reports the joint effect of the decline in trend inflation and the rise of superstar firms on the average markup, the profit share, the labor share, and the investment share. The extended model predicts that the two factors increase the average markup by 8.2 percentage points and the profit share by 4.8 percentage points, while they decrease the labor share by 3.4 percentage points and the investment share by 1.1 percentage points. In sum, the extended model attributes more than half of the increases in the average markup and the profit share and the decrease in the labor share, and more than one third of the decrease in the investment share to the decline in trend inflation and the rise of superstar firms. Therefore, these two factors together can account for the macroeconomic changes better than only the decline in trend inflation does.

To understand the joint effect of the two factors in more detail, Table 3 shows to what extent each of them affects the average, the median, and the 90th percentile markups. The decline in trend inflation (going from the second to the third row of the table) increases all three markups, whereas the rise of superstar firms (going from the third to the fourth row) raises the average and the 90th percentile markups while reducing the median markup. Therefore, adding the rise of superstar firms increases the average markup further, by raising the 90th percentile; that is, the upper tail of the markup distribution increases in line with the micro evidence provided by, for example, De Loecker et al. (2020) (their Figure III).

Moreover, the decline in trend inflation and the rise of superstar firms have offsetting effects on the median markup, thus keeping it roughly unchanged. The flat median markup



Table 3: Effects of a decline in trend inflation and a rise of superstar firms.

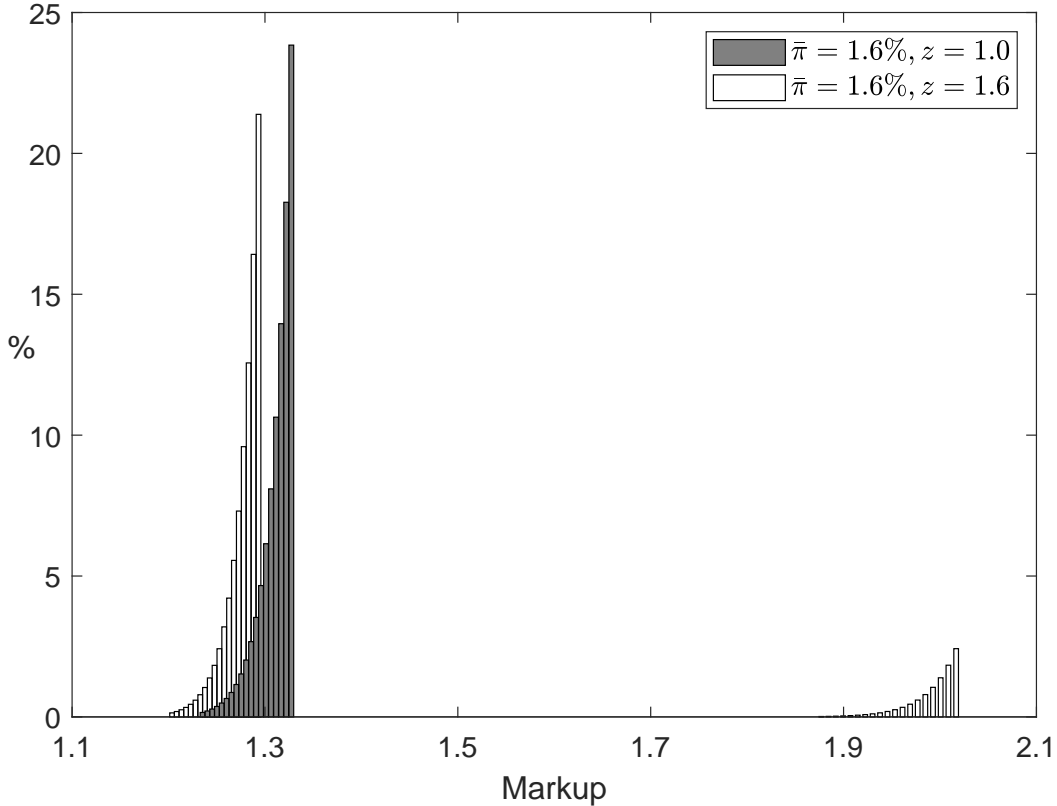
Parameter values	Average	Median	p90
$\bar{\pi} = 5.6\%$ and $z = 1.0$	1.27	1.27	1.31
$\bar{\pi} = 1.6\%$ and $z = 1.0$	1.31	1.31	1.32
$\bar{\pi} = 1.6\%$ and $z = 1.6$	1.35	1.28	1.92

*Notes:* This table reports the effects of a decline in trend inflation and a rise of superstar firms on the average, the median, and the 90th percentile markups. The share of ordinary firms is set at  $n = 0.86$ ,  $\bar{\pi}$  ( $\equiv 400 \log \pi$ ) and  $z$  denote the annualized trend inflation rate and superstar firms' relative productivity, and the values of other model parameters used here are reported in Table 1.

is consistent with the micro evidence reported by Autor et al. (2020) (their Figure 10), who show that the median markup in manufacturing has been essentially flat, rising or falling slightly depending on the estimation method, and De Loecker et al. (2020) (their Figure III), who indicate that the median markup among publicly traded firms is likewise invariant over time. Therefore, the two factors together can explain the empirical observation of the rising average markup and the flat median markup better than either does in isolation. In this way, the decline in trend inflation complements the rise of superstar firms in accounting for the empirical changes in the distribution of firms' markups (and the other macroeconomic variables).

Before proceeding to the concluding section, we investigate why the rise in superstar firms' relative productivity  $z$  reduces the median markup. Figure 5 plots the steady-state distribution of firms' markups at the trend inflation rate of 1.6 percent annually for the cases of  $z = 1$  (gray bars) and  $z = 1.6$  (white bars). Comparing the two cases shows that the rise of superstar firms (i.e.,  $z = 1.6$ ) leads the markup distribution to become more diffuse, by not only giving the distribution an upper tail but also increasing the frequency of firms with low markups. On balance these two effects then lead to a lower median markup. Under the calibration presented in Table 1, it can be verified that the presence of superstar firms raises ordinary firms' steady-state marginal cost, that is,  $mc_1 > mc$ . Because the equation for  $mc_t$  (12) and that for  $mc_{1,t}$  (33) are identical, and because the steady-state capital rental rate  $r_k$  is the same for any value of  $z$ , it follows that the larger value of  $z = 1.6$  induces a larger steady-state real wage rate  $w$ . Therefore, the rise of superstar firms drives up the marginal cost, thereby lowering ordinary firms' markups and hence the median markup.

Figure 5: Steady-state distribution of markups across two types of firms.



*Note:* The share of ordinary firms is set at  $n = 0.86$ ,  $\bar{\pi} (\equiv 400 \log \pi)$  and  $z$  denote the annualized trend inflation rate and superstar firms' relative productivity, and the values of other model parameters used here are reported in Table 1.

## 5 Concluding remarks

Since 1980, the US economy has undergone increases in the average markup and the profit share of income and decreases in the labor share and the investment share of spending. In tandem with these macroeconomic changes, inflation has trended down steadily. Thus, this paper has examined the role of monetary policy in the macroeconomic changes using a simple staggered price model with trend inflation. The calibrated model has shown that a decline in trend inflation as measured since 1980 can account for a substantial portion of the changes in the presence of a non-CES aggregator of individual differentiated goods, which induces strategic complementarity in firms' price-setting.<sup>23</sup> Moreover, an extension of the

---

<sup>23</sup>This result implies that zero trend inflation—which the previous literature reviewed by, for example, [Schmitt-Grohé and Uribe \(2010\)](#) considers to be the optimal inflation rate when price rigidity is the main

model that introduces highly productive superstar firms has demonstrated that adding a rise of superstar firms can better account for not only the macroeconomic changes but also the micro evidence on the distribution of firms' markups.

Macroeconomic changes in recent years may also have influenced inflation dynamics. As [Yellen \(2017\)](#) points out, the US economy overall has become more concentrated and thus some firms' price-setting power tends to rise, whereas the growing importance of online shopping, by increasing the competitiveness of the US retail sector, has reduced price margins and restrained the ability of firms to raise prices in response to increasing demand.<sup>24</sup> In this way, a rise of superstar firms may lead to not only an increase in the average markup but also weak inflation developments in the US. Against this backdrop, further research could investigate a potential negative feedback loop between a decline in trend inflation and an increase in the average markup in our model. Such research could provide additional background for the recent changes in the Fed's monetary policy strategy that aim to keep long-run inflation expectations anchored in the face of the effective lower bound on nominal interest rates.<sup>25</sup>

Finally, in the model, the presence of the non-CES aggregator enriches the analysis through the more realistic market microstructure (relative to the case of the CES aggregator) it induces. Instead of the aggregator, incorporating firm dynamics in the model along the lines of [Bilbiie et al. \(2008\)](#) and [Bilbiie et al. \(2012\)](#) might be a more direct way of analyzing the changes in the average markup, the profit and labor shares, and the investment share. This approach might be a fruitful agenda for future research.

---

source of monetary non-neutrality—leads to a high average markup, that is, a large distortion in the model. In this context, [Kurozumi and Van Zandweghe \(2020\)](#) propose strategic complementarity in firms' price-setting as a new rationale for the positive inflation targets of central banks.

<sup>24</sup>See, e.g., [Cavallo \(2018\)](#) for the impact of online retailers on inflation.

<sup>25</sup>The Fed adopted these changes in its revised Statement on Longer-Run Goals and Monetary Policy Strategy, which is available on the Federal Reserve Board's website at [https://www.federalreserve.gov/monetarypolicy/files/FOMC\\_LongerRunGoals.pdf](https://www.federalreserve.gov/monetarypolicy/files/FOMC_LongerRunGoals.pdf).

## Appendix: Extended model with superstar firms

This appendix describes the extended model, which generalizes the model presented in Section 2 by considering two types of firms: ordinary firms  $f \in [0, n]$ , whose type is indexed by subscript  $i = 1$ , and highly productive superstar firms  $f \in (n, 1]$ , whose type is indexed by subscript  $i = z$ . In this model the decision problems of the representative household and the representative composite-good producer remain unchanged. For firms, the production function is generalized as the form (28), which leads to the two firm-types' real marginal costs (33) and (34). All firms continue to choose an identical capital-labor ratio, so that

$$\frac{\alpha}{1 - \alpha} \frac{W_t}{r_{k,t}} = \frac{K_{1,t}}{l_{1,t}} = \frac{K_{z,t}}{l_{z,t}}.$$

The aggregate production function (16) is then replaced with ordinary and superstar firms' aggregate production functions (29) and (30), where the respective relative price distortions are given by (31) and (32), which replace the relative price distortion (17). The laws of motion for  $s_{1,t}$  and  $s_{z,t}$  are given by

$$\begin{aligned} d_t^{-\gamma} s_{1,t} &= \xi \pi_t^\gamma d_{t-1}^{-\gamma} s_{1,t-1} + (1 - \xi) n (p_{1,t}^*)^{-\gamma}, \\ d_t^{-\gamma} s_{z,t} &= \xi \pi_t^\gamma d_{t-1}^{-\gamma} s_{z,t-1} + (1 - \xi) (1 - n) (p_{z,t}^*)^{-\gamma}, \end{aligned}$$

which replace the law of motion (19) for  $s_t$ . The law of motion (14) for  $d_t$  is extended to

$$\begin{aligned} d_t^{1-\gamma} &= d_{1,t}^{1-\gamma} + d_{z,t}^{1-\gamma}, \\ d_{1,t}^{1-\gamma} &= \xi \pi_t^{\gamma-1} d_{1,t-1}^{1-\gamma} + (1 - \xi) n (p_{1,t}^*)^{1-\gamma}, \\ d_{z,t}^{1-\gamma} &= \xi \pi_t^{\gamma-1} d_{z,t-1}^{1-\gamma} + (1 - \xi) (1 - n) (p_{z,t}^*)^{1-\gamma}. \end{aligned}$$

Similarly, the law of motion (15) for  $e_t$  is extended to

$$\begin{aligned} e_t &= e_{1,t} + e_{z,t}, \\ e_{1,t} &= \xi \pi_t^{-1} e_{1,t-1} + (1 - \xi) n p_{1,t}^*, \\ e_{z,t} &= \xi \pi_t^{-1} e_{z,t-1} + (1 - \xi) (1 - n) p_{z,t}^*. \end{aligned}$$

The first-order condition of the price-setting problem for each firm type  $i \in \{1, z\}$  can be

written as

$$E_t \sum_{j=0}^{\infty} (\beta\xi)^j \frac{Y_{t+j}}{C_{t+j}} \left[ \left( \frac{p_{i,t}^*}{d_{t+j}} \right)^{-\gamma} \prod_{k=1}^j \pi_{t+k}^{\gamma} \left( p_{i,t}^* \prod_{k=1}^j \pi_{t+k}^{-1} - \frac{\gamma}{\gamma-1} mc_{i,t+j} \right) - \frac{\epsilon}{\gamma-1} p_{i,t}^* \prod_{k=1}^j \pi_{t+k}^{-1} \right] = 0,$$

where  $p_{i,t}^* \equiv P_{i,t}^*/P_t$  and  $P_{i,t}^*$  is the price set by firms that can change prices in period  $t$ . Note that the model described here coincides with that presented in Section 2 if  $z = 1$ .

The equilibrium conditions lead to the relevant steady-state conditions

$$\begin{aligned} mc_i &= \frac{\gamma-1}{\gamma} \frac{1-\beta\xi\pi^\gamma}{1-\beta\xi\pi^{\gamma-1}} \left[ 1 - \frac{\epsilon}{\gamma-1} \left( \frac{p_i^*}{d} \right)^\gamma \frac{1-\beta\xi\pi^{\gamma-1}}{1-\beta\xi\pi^{-1}} \right] p_i^*, \quad i \in \{1, z\}; \\ \Delta_1 &= \frac{1}{1+\epsilon} \frac{(1-\xi)n}{1-\xi\pi^\gamma} \left( \frac{d}{p_1^*} \right)^\gamma + \frac{n\epsilon}{1+\epsilon}; \quad \Delta_z = \frac{1}{1+\epsilon} \frac{(1-\xi)(1-n)}{1-\xi\pi^\gamma} \left( \frac{d}{p_z^*} \right)^\gamma + \frac{(1-n)\epsilon}{1+\epsilon}; \\ d^{1-\gamma} &= d_1^{1-\gamma} + d_z^{1-\gamma}; \quad d_1 = \left( \frac{(1-\xi)n}{1-\xi\pi^{\gamma-1}} \right)^{\frac{1}{1-\gamma}} p_1^*; \quad d_z = \left( \frac{(1-\xi)(1-n)}{1-\xi\pi^{\gamma-1}} \right)^{\frac{1}{1-\gamma}} p_z^*; \\ e &= e_1 + e_z; \quad e_1 = \frac{(1-\xi)n}{1-\xi\pi^{-1}} p_1^*; \quad e_z = \frac{(1-\xi)(1-n)}{1-\xi\pi^{-1}} p_z^*; \quad 1 = \frac{1}{1+\epsilon} d + \frac{\epsilon}{1+\epsilon} e. \end{aligned}$$

Combining the steady-state conditions yields the following three nonlinear equations for the three steady-state variables  $\{d, p_1^*, p_z^*\}$ :

$$\begin{aligned} 1 &= \frac{1}{1+\epsilon} d + \frac{\epsilon}{1+\epsilon} \frac{1-\xi}{1-\xi\pi^{-1}} [np_1^* + (1-n)p_z^*], \\ d^{1-\gamma} &= \frac{(1-\xi)n}{1-\xi\pi^{\gamma-1}} (p_1^*)^{1-\gamma} + \frac{(1-\xi)(1-n)}{1-\xi\pi^{\gamma-1}} (p_z^*)^{1-\gamma}, \\ \left[ \gamma-1 - \epsilon \frac{1-\beta\xi\pi^{\gamma-1}}{1-\beta\xi\pi^{-1}} \left( \frac{p_1^*}{d} \right)^\gamma \right] p_1^* &= \left[ \gamma-1 - \epsilon \frac{1-\beta\xi\pi^{\gamma-1}}{1-\beta\xi\pi^{-1}} \left( \frac{p_z^*}{d} \right)^\gamma \right] (z p_z^*), \end{aligned} \quad (37)$$

which can be solved numerically using the values of model parameters presented in Table 1,  $z = 1.6$ , and  $n = 0.86$ . The solution allows us to calculate the steady-state real marginal costs  $mc_1, mc_z$ ; the steady-state relative price distortions  $\Delta_1, \Delta_z$ ; the steady-state average markup (35); the steady-state profit share (25); the steady-state labor share (26); the steady-state investment share (27); and the steady-state markup distribution (36).

The following proposition shows that, for the two types of firms with product prices of the same age, a superstar firm has a higher markup in steady state than an ordinary firm if and only if the aggregator is the non-CES one, i.e.,  $\epsilon < 0$ .

**Proposition 1** *Assume that Assumption (21) holds and that  $z > 1$ . Consider ordinary firms and superstar firms whose product prices have remained unchanged for  $j$  periods. Then, the steady-state markup of the superstar firms exceeds that of the ordinary firms if and only if*

$\epsilon < 0$ .

*Proof.* Let the steady-state markup of a firm of type  $i \in \{1, z\}$  with a price of age  $j$  be denoted by  $\mu_{i,j} = p_i^* \pi^{-j} / mc_i$ . The proposition then claims that  $\mu_{1,j} < \mu_{z,j}$  iff  $\epsilon < 0$ .

First, assume  $\epsilon < 0$  and suppose the contrary  $\mu_{1,j} \geq \mu_{z,j}$ . Then,  $mc_1 = z mc_z$  implies that  $p_1^* \geq z p_z^* > p_z^*$ . Without loss of generality, we have  $\gamma - 1 - \epsilon \frac{1 - \beta \xi \pi^{\gamma-1}}{1 - \beta \xi \pi^{-1}} \left( \frac{p_1^*}{d} \right)^\gamma = \gamma \frac{1 - \beta \xi \pi^{\gamma-1}}{1 - \beta \xi \pi^\gamma} \frac{mc_1}{p_1^*} \neq 0$  under Assumption (21). Then, from eq. (37), it follows that

$$\frac{\gamma - 1 - \epsilon \frac{1 - \beta \xi \pi^{\gamma-1}}{1 - \beta \xi \pi^{-1}} \left( \frac{p_z^*}{d} \right)^\gamma}{\gamma - 1 - \epsilon \frac{1 - \beta \xi \pi^{\gamma-1}}{1 - \beta \xi \pi^{-1}} \left( \frac{p_1^*}{d} \right)^\gamma} (z p_z^*) = p_1^* \geq z p_z^* \quad \Leftrightarrow \quad \frac{\gamma - 1 - \epsilon \frac{1 - \beta \xi \pi^{\gamma-1}}{1 - \beta \xi \pi^{-1}} \left( \frac{p_z^*}{d} \right)^\gamma}{\gamma - 1 - \epsilon \frac{1 - \beta \xi \pi^{\gamma-1}}{1 - \beta \xi \pi^{-1}} \left( \frac{p_1^*}{d} \right)^\gamma} \geq 1.$$

If  $\gamma - 1 - \epsilon \frac{1 - \beta \xi \pi^{\gamma-1}}{1 - \beta \xi \pi^{-1}} \left( \frac{p_1^*}{d} \right)^\gamma = \gamma \frac{1 - \beta \xi \pi^{\gamma-1}}{1 - \beta \xi \pi^\gamma} \frac{mc_1}{p_1^*} > 0$ , we have that  $\gamma > 0$  and  $(p_z^*)^\gamma \geq (p_1^*)^\gamma$  under Assumption (21). Then, it follows that  $(p_z^*)^\gamma \geq (p_1^*)^\gamma > (p_z^*)^\gamma$ , which is a contradiction. If  $\gamma - 1 - \epsilon \frac{1 - \beta \xi \pi^{\gamma-1}}{1 - \beta \xi \pi^{-1}} \left( \frac{p_1^*}{d} \right)^\gamma = \gamma \frac{1 - \beta \xi \pi^{\gamma-1}}{1 - \beta \xi \pi^\gamma} \frac{mc_1}{p_1^*} < 0$ , we have that  $\gamma < 0$  and  $(p_z^*)^\gamma \leq (p_1^*)^\gamma$  under Assumption (21). Then, it follows that  $(p_z^*)^{-\gamma} \geq (p_1^*)^{-\gamma} > (p_z^*)^{-\gamma}$ , which is a contradiction.

Next, assume that  $\mu_{1,j} < \mu_{z,j}$  and suppose the contrary  $\epsilon = 0$ . Then, eq. (37) can be reduced, without loss of generality, to  $p_1^* = z p_z^*$ . From  $mc_1 = z mc_z$ , it follows that  $\mu_{1,j} = \mu_{z,j} > \mu_{1,j}$ , which is a contradiction. ■

## References

- Akcigit, Ufuk and Sina T. Ates (forthcoming). “Ten facts on declining business dynamism and lessons from endogenous growth theory.” *American Economic Journal: Macroeconomics*.
- Ascari, Guido and Argia M. Sbordone (2014). “The macroeconomics of trend inflation.” *Journal of Economic Literature*, 52(3), pp. 679–739. doi:[10.1257/jel.52.3.679](https://doi.org/10.1257/jel.52.3.679).
- Autor, David, David Dorn, Lawrence F. Katz, Christina Patterson, and John Van Reenen (2020). “The fall of the labor share and the rise of superstar firms.” *Quarterly Journal of Economics*, 135(2), pp. 645–709. doi:[10.1093/qje/qjaa004](https://doi.org/10.1093/qje/qjaa004).
- Barkai, Simcha (2020). “Declining labor and capital shares.” *Journal of Finance*, 75(5), pp. 2421–2463. doi:[10.1111/jof.12909](https://doi.org/10.1111/jof.12909).
- Basu, Susanto (2019). “Are price-cost markups rising in the United States? A discussion of the evidence.” *Journal of Economic Perspectives*, 33(3), pp. 3–22. doi:[10.1257/jep.33.3.3](https://doi.org/10.1257/jep.33.3.3).
- Benabou, Roland (1988). “Search, price setting and inflation.” *Review of Economic Studies*, 55(3), pp. 353–376. doi:[10.2307/2297389](https://doi.org/10.2307/2297389).
- Bilbiie, Florin O., Fabio Ghironi, and Marc J. Melitz (2008). “Monetary policy and business cycles with endogenous entry and product variety.” In Daron Acemoglu, Kenneth Rogoff, and Michael Woodford, editors, *NBER Macroeconomics Annual 2007*, volume 22, chapter 5, pp. 299–353. University of Chicago Press. doi:[10.1086/ma.22.25554968](https://doi.org/10.1086/ma.22.25554968).
- Bilbiie, Florin O., Fabio Ghironi, and Marc J. Melitz (2012). “Endogenous entry, product variety, and business cycles.” *Journal of Political Economy*, 120(2), pp. 304–345. doi:[10.1086/665825](https://doi.org/10.1086/665825).
- Calvo, Guillermo A. (1983). “Staggered prices in a utility-maximizing framework.” *Journal of Monetary Economics*, 12(3), pp. 383–398. doi:[10.1016/0304-3932\(83\)90060-0](https://doi.org/10.1016/0304-3932(83)90060-0).
- Cavallo, Alberto F. (2018). “More Amazon effects: Online competition and pricing behaviors.” In *Changing Market Structures and Implications for Monetary Policy : Economic Policy Symposium, Jackson Hole, Wyoming, August 23-25, 2018*, pp. 291–329. Federal Reserve Bank of Kansas City.
- Chan, Joshua C.C., Todd E. Clark, and Gary Koop (2018). “A new model of inflation, trend inflation, and long-run inflation expectations.” *Journal of Money, Credit and Banking*, 50(1), pp. 5–53. doi:[10.1111/jmcb.12452](https://doi.org/10.1111/jmcb.12452).
- Cogley, Timothy and Argia M. Sbordone (2008). “Trend inflation, indexation, and inflation

- persistence in the New Keynesian Phillips curve.” *American Economic Review*, 98(5), pp. 2101–2126. doi:[10.1257/aer.98.5.2101](https://doi.org/10.1257/aer.98.5.2101).
- De Loecker, Jan and Jan Eeckhout (2020). “Global market power.” *Mimeo*.
- De Loecker, Jan, Jan Eeckhout, and Gabriel Unger (2020). “The rise of market power and the macroeconomic implications.” *Quarterly Journal of Economics*, 135(2), pp. 561–644. doi:[10.1093/qje/qjz041](https://doi.org/10.1093/qje/qjz041).
- Dotsey, Michael and Robert G. King (2005). “Implications of state-dependent pricing for dynamic macroeconomic models.” *Journal of Monetary Economics*, 52(1), pp. 213–242. doi:[10.1016/j.jmoneco.2004.10.004](https://doi.org/10.1016/j.jmoneco.2004.10.004).
- Edmond, Chris, Virgiliu Midrigan, and Daniel Yi Xu (2019). “How costly are markups?” *Mimeo*. URL <http://www.chrisedmond.net/Edmond%20Midrigan%20Xu%202019%20How%20Costly%20Are%20Markups.pdf>.
- Eichenbaum, Martin and Jonas D. M. Fisher (2007). “Estimating the frequency of price re-optimization in Calvo-style models.” *Journal of Monetary Economics*, 54(7), pp. 2032–2047. doi:[10.1016/j.jmoneco.2006.07.004](https://doi.org/10.1016/j.jmoneco.2006.07.004).
- Elsby, Michael W. L., Bart Hobijn, and Aysegul Sahin (2013). “The decline of the U.S. labor share.” *Brookings Papers on Economic Activity*, (Fall), pp. 1–52. doi:[10.1353/eca.2013.0016](https://doi.org/10.1353/eca.2013.0016).
- Friedman, Milton (1968). “The role of monetary policy.” *American Economic Review*, 58(1), pp. 1–17. URL <https://www.jstor.org/stable/1831652>.
- Gourio, Francois and Leena Rudanko (2014). “Customer capital.” *Review of Economic Studies*, 81(3), pp. 1102–1136. doi:[10.1093/restud/rdu007](https://doi.org/10.1093/restud/rdu007).
- Guerrieri, Luca, Christopher Gust, and J. David López-Salido (2010). “International competition and inflation: A New Keynesian perspective.” *American Economic Journal: Macroeconomics*, 2(4), pp. 247–280. doi:[10.1257/mac.2.4.247](https://doi.org/10.1257/mac.2.4.247).
- Gutiérrez, Germán and Thomas Philippon (2017a). “Declining competition and investment in the U.S.” Working Paper 23583, National Bureau of Economic Research. doi:[10.3386/w23583](https://doi.org/10.3386/w23583).
- Gutiérrez, Germán and Thomas Philippon (2017b). “Investment-less growth: An empirical investigation.” *Brookings Papers on Economic Activity*, (Fall), pp. 89–169. doi:[10.1353/eca.2017.0013](https://doi.org/10.1353/eca.2017.0013).
- Hall, Robert E. (2018). “Using empirical marginal cost to measure market power in



- the US economy.” Working Paper 25251, National Bureau of Economic Research. doi:[10.3386/w25251](https://doi.org/10.3386/w25251).
- Heidhues, Paul and Botond Koszegi (2008). “Competition and price variation when consumers are loss averse.” *American Economic Review*, 98(4), pp. 1245–1268. doi:[10.1257/aer.98.4.1245](https://doi.org/10.1257/aer.98.4.1245).
- Ireland, Peter N. (2007). “Changes in the Federal Reserve’s inflation target: Causes and consequences.” *Journal of Money, Credit and Banking*, 39(8), pp. 1851–1882. doi:[10.1111/j.1538-4616.2007.00091.x](https://doi.org/10.1111/j.1538-4616.2007.00091.x).
- Jordà, Òscar, Sanjay R. Singh, and Alan M. Taylor (2020). “The long-run effects of monetary policy.” Working Paper 26666, National Bureau of Economic Research. doi:[10.3386/w26666](https://doi.org/10.3386/w26666).
- Karabarbounis, Loukas and Brent Neiman (2014). “The global decline of the labor share.” *Quarterly Journal of Economics*, 129(1), pp. 61–103. doi:[10.1093/qje/qjt032](https://doi.org/10.1093/qje/qjt032).
- Karabarbounis, Loukas and Brent Neiman (2019). “Accounting for factorless income.” In Martin Eichenbaum and Jonathan A. Parker, editors, *NBER Macroeconomics Annual 2018*, volume 33, chapter 3, pp. 167–228. University of Chicago Press. doi:[10.1086/700894](https://doi.org/10.1086/700894).
- Kehrig, Matthias and Nicolas Vincent (forthcoming). “The micro-level anatomy of the labor share decline.” *Quarterly Journal of Economics*.
- Kimball, Miles S. (1995). “The quantitative analytics of the basic neomonetarist model.” *Journal of Money, Credit and Banking*, 27(4), pp. 1241–1277. doi:[10.2307/2078048](https://doi.org/10.2307/2078048).
- Klenow, Peter J. and Benjamin A. Malin (2010). “Microeconomic evidence on price-setting.” In Benjamin M. Friedman and Michael Woodford, editors, *Handbook of Monetary Economics*, volume 3A, chapter 6, pp. 231–284. Elsevier. doi:[10.1016/b978-0-444-53238-1.00006-5](https://doi.org/10.1016/b978-0-444-53238-1.00006-5).
- Kurozumi, Takushi and Willem Van Zandweghe (2016). “Kinked demand curves, the natural rate hypothesis, and macroeconomic stability.” *Review of Economic Dynamics*, 20, pp. 240–257. doi:[10.1016/j.red.2015.02.003](https://doi.org/10.1016/j.red.2015.02.003).
- Kurozumi, Takushi and Willem Van Zandweghe (2020). “Output-inflation trade-offs and the optimal inflation rate.” Working Paper 20-20, Federal Reserve Bank of Cleveland. doi:[10.26509/frbc-wp-202020](https://doi.org/10.26509/frbc-wp-202020).
- Levin, Andrew T., J. David López-Salido, Edward Nelson, and Tack Yun (2008). “Macroeconomic equivalence, microeconomic dissonance, and the design of mon-

- etary policy.” *Journal of Monetary Economics*, 55(Supplement), pp. S48–S62. doi:[10.1016/j.jmoneco.2008.07.013](https://doi.org/10.1016/j.jmoneco.2008.07.013).
- Moran, Patrick and Albert Queralto (2018). “Innovation, productivity, and monetary policy.” *Journal of Monetary Economics*, 93, pp. 24–41. doi:[10.1016/j.jmoneco.2017.10.006](https://doi.org/10.1016/j.jmoneco.2017.10.006).
- Nakamura, Emi and Jón Steinsson (2010). “Monetary non-neutrality in a multisector menu cost model.” *Quarterly Journal of Economics*, 125(3), pp. 961–1013. doi:[10.1162/qjec.2010.125.3.961](https://doi.org/10.1162/qjec.2010.125.3.961).
- Schmitt-Grohé, Stephanie and Martín Uribe (2010). “The optimal rate of inflation.” In Benjamin M. Friedman and Michael Woodford, editors, *Handbook of Monetary Economics*, volume 3B, chapter 13, pp. 653–722. Elsevier. doi:[10.1016/B978-0-444-53454-5.00001-3](https://doi.org/10.1016/B978-0-444-53454-5.00001-3).
- Smets, Frank and Rafael Wouters (2007). “Shocks and frictions in US business cycles: A Bayesian DSGE approach.” *American Economic Review*, 97(3), pp. 586–606. doi:[10.1257/aer.97.3.586](https://doi.org/10.1257/aer.97.3.586).
- Syverson, Chad (2019). “Macroeconomics and market power: context, implications, and open questions.” *Journal of Economic Perspectives*, 33(3), pp. 23–43. doi:[10.1257/jep.33.3.23](https://doi.org/10.1257/jep.33.3.23).
- Yellen, Janet L. (2017). “Inflation, uncertainty, and monetary policy.” Speech at the “Prospects for Growth: Reassessing the Fundamentals” 59th Annual Meeting of the National Association for Business Economics, Cleveland, Ohio, September 26.