# The Return on Capital in Disaggregated Economies: Theory and Measurement*

Andrea Chiavari† Julia Faltermeier‡ Sampreet Singh Goraya§

We develop a dynamic general equilibrium model of disaggregated economies with heterogeneous firms and flexible demand and production functions. The model delivers a non-parametric, closed-form decomposition of the aggregate return on capital into the risk-free rate, and firm-level profits, capital gains, risk premia, and capital wedges. Using U.S. data, we show that once profits are accounted for, the true return on capital has fallen from 9% to 6% since 1982, though it remains above the risk-free rate. Capital wedges–driven by reallocation toward new high-wedge cohorts–are the key obstacle, and removing them would raise aggregate productivity by 2–13%.

**Keywords:** Return on capital, risk-free rate, risk premia, misallocation, profits.

**JEL Codes:** D24, D25, E22, E23, E43, G12, G31

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†University of Oxford. Email: andrea.chiavari@economics.ox.ac.uk.

‡International Monetary Fund. Email: jfaltermeier@imf.org.

§Stockholm School of Economics. Email: Sampreet.Goraya@hhs.se.

# 1 Introduction

It is well established that the return on risk-free assets in the U.S. has experienced a secular decline since the 1980s, suggesting low returns on savings. However, the return on capital has remained stable over the same period. The divergence between these two returns challenges the standard Neoclassical growth model, which predicts investors should be indifferent across investment opportunities, and has profound aggregate implications.

One interpretation of the secular decline in the risk-free rate is that it signals economic stagnation (Summers, 2014). However, persistently high return on capital challenges this interpretation (Gomme et al., 2015) and forces central banks to choose which rate should guide their policy actions (Reis, 2022). Moreover, persistently high returns on capital, combined with low economic growth, may lead to a growing share of national income accruing to capital owners, potentially fueling wealth inequality (Piketty, 2014).

The existing literature highlights several complementary explanations for the divergence between the return on capital and risk-free assets. Eggertsson et al. (2021) emphasize the rise in profits, while Caballero et al. (2017) focus on risk premia. Considering both channels, Farhi and Gourio (2018) find evidence for the importance of each. More recently, Reis (2022) highlights the role of capital frictions. Although all these mechanisms lead to a gap between measured capital returns and the risk-free rate, they have different policy implications: some call for intervention, while others do not. As a result, normative conclusion depends critically on correctly identifying the dominant channel in the data. Yet, no existing study analyzes all these mechanisms jointly, potentially distorting conclusions about their relative importance.

The objective of this paper is to fill this gap. We develop a dynamic general equilibrium theory of the aggregate return on capital in disaggregated economies, allowing for general consumer preferences over goods and flexible producer characteristics, including arbitrary production technologies, markups, risk premia, and capital frictions. In practice, as in Hsieh and Klenow (2009) and Baqaee and Farhi (2020), static firms demand inputs and set prices, generating markups showing up as a distortion to the marginal revenue product of variable inputs, while risk premia and capital wedges act as shifters affecting the capital-to-variable input ratio. Crucially, these wedges enter the ratio in an isomorphic manner, leading to a non-identification problem.

In contrast to standard approaches in the literature allowing for either risk premia or capital wedges to restore identification, we extend the model by introducing households that lend capital intertemporally to firms in the presence of aggregate risk.[1] This provides an extra pricing condition–a generalized Capital Asset Pricing Model (CAPM)–in which excess returns on capital depend not only on risk premia, but also on markups and capital wedges. By considering the joint behavior of firms and households, we obtain an additional equilibrium condition that restores exact identification and allows us to separate risk premia from capital wedges.

This model yields a new, non-parametric closed-form decomposition of changes in the measured aggregate return on capital—defined as the return on non-variable inputs—into four components: markups, capital gains, risk premia, and capital wedges. Thus, this decomposition allows us to characterize the aggregate implications of micro-level changes in these different objects. A key distinction is made between the measured and the true return on capital, which coincide only in the absence of profits (Caselli and Feyrer, 2007).

We demonstrate the empirical relevance and broad applicability of our framework by applying it to conventional firm-level data. Our analysis draws on Compustat data, which offers several advantages: it covers the largest firms, accounting for the majority of aggregate capital (Crouzet and Mehrotra, 2020), and spans a wide range of sectors. The dataset also provides detailed information on sales, costs, and capital. We find that Compustat closely mirrors the aggregate return on capital reported in the national accounts, making it a suitable laboratory for studying its dynamics.

The model yields a three-stage identification procedure of markups, risk premia, and capital wedges. First, markups are recovered from the static first-order condition of the variable input, following De Loecker and Warzynski (2012), with the production function identified under imperfect competition without price data as in Ackerberg and De Loecker (2024). Second, risk premia are estimated based on the augmented CAPM derived from the household consumption–saving decision using empirical factors from Hou et al. (2015). Finally, capital wedges are inferred from the capital first-order condition as a residual.

To strengthen the credibility of our measures, we apply the methodology of Bils et al. (2021) to assess how much of the measured capital wedges can be attributed to measurement error, finding that it accounts for 26% on average. We also provide cross-sectional evidence that the estimated capital wedges are associated with standard proxies for investment and capital market frictions, such as liquidity and text-based measures of financial constraints

[1]We do so by adopting the modern finance view that asset prices move not only with expected cash flows but also with discount rates (Campbell and Shiller, 1988).

as in Hoberg and Maksimovic (2015), proxies of investment frictions such as Tobin's Q, and intensity of intangible investments. Taken together, these patterns support the interpretation of wedges as genuine frictions rather than measurement error.

We also subject our measures of markups, risk premia, and capital wedges to a range of robustness checks, including alternative production function estimators, different markup measures, and alternative factor models to estimate the CAPM. The results remain largely unchanged across these specifications. With this validation in place, we now turn to the main empirical findings of the paper:

**Fact 1:** *Of the divergence between the measured return on capital and the risk-free rate, 20% is due to the profit wedge, while 80% is due to the missing decline in the true return on capital.*

**Fact 2:** *Unlike previous findings, the divergence between the true return on capital and the risk-free rate has been driven mainly by a rising capital wedge, while the risk premium has remained relatively stable.*

**Fact 3:** *Changes in sectoral composition played no role in the rise of capital wedges.*

**Fact 4:** *The increase in capital wedges is driven by the reallocation of capital toward newer cohorts with higher capital wedges.*

These four facts offer a novel perspective on the divergence between the return on capital and the risk-free rate. A significant portion of this gap is driven by rising profit wedges, which have been misattributed to the return on capital. This is consistent with a broader upward trend in markups as reviewed by Syverson (2024). Once profits and measurement error are properly accounted for, we find that, since 1982, the true return on capital has declined from roughly 9% to 6%. Despite this decline, the estimated return on capital remains above both the average growth rate of GDP per capita and the risk-free rate. This confirms the observation by Piketty (2014) that capital returns have exceeded economic growth—and, at least in theory, wage growth—and reinforces the concern raised by Reis (2022) regarding the dilemma faced by central banks in choosing whether to anchor policy rates to the risk-free rate or to the return on capital.

Our analysis finds that the main factor preventing convergence between the true return on capital and the risk-free rate is the rise in capital wedges, not risk premia which appear stable over the sample period.[2] This conclusion follows from our empirical methodology, which estimates risk premia in the presence of both markups and capital wedges–unlike prior works attributing excess returns to either risk or wedges only. The rise in capital wedges reflects within-sector changes in cohort composition rather than a shift in the sectoral structure of the U.S. economy. In particular, we find that the rise in capital wedges stems from the reallocation of capital toward higher-wedge cohorts.

Finally, by introducing additional structure on consumer demand and producer technology, we examine the aggregate implications of capital wedges. We find that they generate excess dispersion in the cost of capital across firms, thereby reducing allocative efficiency. Counterfactual experiments suggest that removing these wedges could yield aggregate productivity gains ranging from 2% to 13%.

Despite their generality, our results have limitations. First, the framework abstracts from producers' entry and exit dynamics and international factors related to trade in goods and capital, which may also influence the aggregate return on capital. Second, we model markups, risk premia, and capital frictions as exogenous wedges. The advantage is that we characterize the response of the equilibrium to a change in the wedges without committing to any particular theory of wedge determination. The downside is that this makes it hard to perform counterfactuals when wedges are endogenous. However, in these cases, our results are still relevant as part of a larger analysis that accounts for the endogenous response of wedges.

**Related literature.** This paper relates to several strands of literature. First, we contribute to the misallocation literature by developing a novel, closed-form disaggregated dynamic general equilibrium model that explicitly links markups, risk premia, and capital wedges to the aggregate return on capital. The seminal work of Hsieh and Klenow (2009) used standard data to quantify the aggregate productivity impact of firm-level frictions captured by wedges. Baqaee and Farhi (2020) generalize their approach to economies with arbitrary input-output linkages and flexible production and demand systems. David and Venkateswaran (2019) separate capital frictions from markups, Bils et al. (2021) focus on measurement error, while Faria-e Castro et al. (2025) show how to use credit registry microdata to unpack capital frictions into

[2]This finding of stable risk-premia is in line with standard proxies for risk and estimates from the empirical asset pricing literature reviewed in Section 4.3.3.

different financial components.[3] Our contribution is to integrate the household's dynamic consumption-saving decision into this framework, allowing for a modern asset pricing perspective that separates capital wedges from risk premia. In this respect, we are close to David et al. (2022), who develop a firm-level parametric model of risk premia and adjustment costs. In contrast, our approach is non-parametric, accommodates markups and broad capital frictions beyond adjustment costs, and can be implemented directly on standard data.

Second, our paper is related on the extensive literature on CAPM, dating back to Sharpe (1964), Treynor (1962), Lintner (1965a,b), and Mossin (1966). Our framework generalizes the standard CAPM by incorporating markups and capital wedges into firm-level returns on capital, thereby relating our results to the literature on markups and equity returns, for example Corhay et al. (2020), Cho et al. (2023), and Greenwald et al. (2025). We show that insights from modern asset pricing are a key addition to standard firm-level production frameworks to perform a comprehensive firm-level anatomy of the aggregate return on capital.

Third, we contribute to the literature on the divergence between the return on capital and the risk-free rate by presenting a model that provides a closed-form decomposition of the joint role of the main firm-level explanations. In contrast, most existing studies focus on one factor at a time, with their conclusions being limited by the ability of aggregate data to distinguish between them. For example, Eggertsson et al. (2021) emphasize rising profits; Caballero et al. (2017) and Marx et al. (2021) focus on risk premia; and Reis (2022) highlights capital frictions. Closest to our approach is Farhi and Gourio (2018), who first stressed the importance of jointly analyzing multiple factors, but exclude capital wedges and conclude that risk premia are the dominant force. Our findings challenge this view by identifying capital wedges—not risk premia—as the key driver. This result stems from our firm-level measurement strategy, which isolates risk premia from confounding effects such as markups and capital wedges.

Finally, by showing that the central role of capital frictions is largely driven by the reallocation of capital toward high-wedge cohorts, we contribute to the growth literature that emphasizes the importance of ex-ante firm heterogeneity (Sterk et al., 2021; Moreira, 2016; Sedláček and Sterk, 2017) and cohort effects (Bowen III et al., 2023; Ma et al., 2024).

**Outline.** Section 2 reviews the facts on the divergence between the return on capital and

[3] Recently, production-function-free methodologies have been developed to measure misallocation by using (quasi-)experimental variation to estimate marginal products directly (e.g., Carrillo et al., 2023; Hughes and Majerovitz, 2023). However, such variation is rare, which means these approaches are difficult to implement with standard data sources and are typically limited to specialized settings where experimental variation is available.

the risk-free rate. Section 3 introduces our framework. Section 4 describes the data and the measurement. Section 5 presents the main results, and Section 6 discusses macro implications. Section 7 concludes.

## 2 Return on Capital and Risk-Free Rate Divergence

This section reviews the basic facts about the evolution of the return on capital and the risk-free rate since the 1980s, the period most often studied in the literature (e.g., Farhi and Gourio, 2018). While the risk-free rate is typically observed directly in the data, the return on capital is a model-implied concept, which we discuss in detail below.

We measure the aggregate return on capital in line with established literature. As noted by Caselli and Feyrer (2007), under the standard assumptions of constant returns to scale and perfect competition, the aggregate net output can be expressed as follows:

$$Y_t - \delta K_t = (R - \delta_t)\, K_t + W_t L_t, \tag{1}$$

where $Y_t$ represents the value added, $\delta_t$ is the depreciation rate, $K_t$ is the total capital, $R_t$ is the rental price of capital, and $W_t L_t$ is the total labor bill. Equation (1) indicates that net output, $Y_t - \delta_t K_t$, is allocated either to payments to labor services, $W_t L_t$, or capital services, $(R_t - \delta_t)\, K_t$. Hence, while $W_t$ denotes the return on labor, $\mathcal{R}_t := R_t - \delta_t$ represents the return on capital, which can be measured as follows:[4]

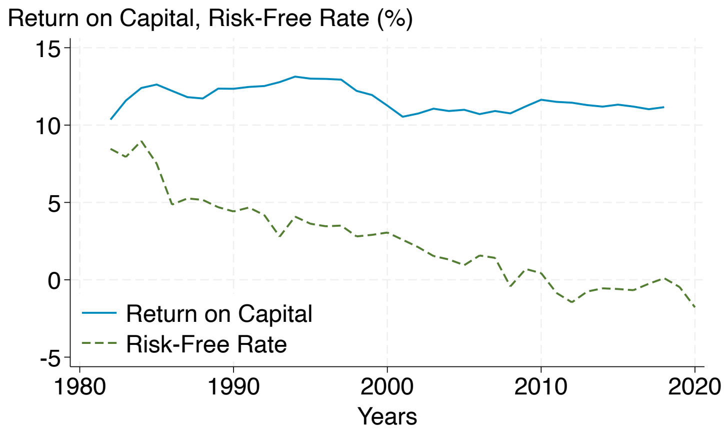
$$\mathcal{R}_t = \frac{Y_t - \delta_t K_t - W_t L_t}{K_t}. \tag{2}$$

Note that, since investors should be indifferent between investing one unit of output in capital or an investment yielding a risk-free return $r_t$, we would expect $\mathcal{R}_t$ to equal $r_t$. Figure 1 illustrates the evolution of the return on capital and the risk-free rate. The return on capital is calculated using equation (2) with data from the BEA, while the risk-free rate is represented by the real market yield on U.S. Treasury securities with a 10-year constant maturity. Additional details on these calculations are provided in Appendix A.

Since the 1980s, the risk-free rate has steadily declined, falling from just below 10 percent

[4]More generally, this methodology for calculating the aggregate return on capital can be applied in the presence of any general set of variable inputs, using the formula $\mathcal{R}_t = (GO_t - \delta_t K_t - X_t)/K_t$, where $GO_t$ is gross output and $X_t$ denotes total nominal variable input costs, including labor and all types of intermediate inputs.

**Figure 1: Evolution of Return on Capital and Risk-Free Rate**




Note. Figure 1 shows the evolution of the return on capital and of the risk-free rate, measured in percent, since 1982. The return on capital is measured using equation (2) with NIPA data. The risk-free rate is the market yield on U.S. Treasury securities with a 10-year constant maturity net of expected inflation from Michigan.

to near 0 percent. In contrast, the return on capital has remained relatively stable, consistently hovering just above 10 percent. This divergence, following decades of convergence between the two rates (see Appendix A for the historical evolution of these measures), has puzzled researchers and spurred various potential explanations, including markups, risk premia, and capital frictions.

Appendix A demonstrates that alternative measures of the risk-free rate, as outlined in Rachel and Summers (2019), including the real Aaa corporate bond yield, the real Baa corporate bond yield, and the real S&P 500 earnings yield, exhibit a similar downward trend. Further, Appendix A shows that alternative measures of the return on capital based on Gomme et al. (2011) yield similar patterns, with no evidence of a decline over time. They report measures based solely on the business sector, excluding the impact of housing, which produces results closely aligned with ours which are going to be based on Compustat. Additionally, they present measures both with and without capital gains and before and after taxes, demonstrating that neither adjustment accounts for the missing decline in the return on capital.

# 3 Model

This section introduces a disaggregated dynamic general equilibrium framework in the presence of heterogeneous markups, risk premia, and capital frictions. It provides a closed-form decomposition of the aggregate return on capital and characterizes how shocks to firm-level risk premia, markups, and capital frictions affect it.

## 3.1 Household Side

Time is discrete and indexed by $t$. The economy is populated by a representative household that makes consumption-saving decisions. The representative maximizes the expected utility,

$$\max_{C_t, B_{t+1}, \{q_{it}, k_{it+1}\}_{\forall i}} E_0 \sum_{t=0}^{\infty} \beta^t U(C_t; Z_t); \tag{3}$$

subject to the following constraints:

$$C_t + B_{t+1} \leq \sum_{i \in \mathcal{I}} \left( R_{it} P_t^k k_{it} - P_{t+1}^k x_{it} \right) + W_t L_t + (1 + r_t) B_t + \Pi_t, \tag{4}$$

$$x_{it} = k_{it+1} - (1 - \delta_{it}) k_{it}, \tag{5}$$

$$C_t = \mathcal{D}(\{q_{it}\}); \tag{6}$$

where $\beta$ is the discount factor; $U(\cdot)$ represents the utility derived from aggregate consumption $C_t$; $Z_t$ denotes a discount factor shock that have been proven important to rationalize asset prices fluctuations since at least Campbell and Shiller (1988); $B_t$ represents the risk-free bond with the associated risk-free rate $r_t$; $R_t$ indicates the return from investing $x_{it}$ units of capital in firm $i$, with $\mathcal{I}$ being the set of active firms; $P_t^k$ is the relative price of capital $k_{it}$ and capital depreciation rate is $\delta_{it}$; $W_t$ is the aggregate price of the primary factor $L_t$, supplied inelastically by the household; $\Pi_t$ denotes aggregate profits; and finally, $\mathcal{D}(\cdot)$ aggregates the demand across firm-specific goods $q_{it}$.

Our specification allows for arbitrary functional forms of the demand aggregator, and the only assumptions needed are that the individual demand curves are downward-sloping in prices. An implicit assumption in equation (4)—dating back at least to Mossin (1966) and standard in neoclassical models—is that the return on household savings equals the return on firms' investments. Moreover, since we consider a closed economy, equation (4) naturally embeds the assumption that households own all firms and receive their profits. However, this ownership structure can be generalized to a more realistic equity market, which would require introducing additional asset pricing equations and that will yield a well-defined notion of firm-level equity premia. Although such an extension is feasible in our framework, we abstract from it for simplicity, as firm-level equity premia would not affect the results presented below on the return on capital and would introduce unnecessary complexity.

The household problem yields two familiar Euler equations, given by:

$$1 = \mathbb{E}_{t-1}\left[M_t(1+r_t)\right], \tag{7}$$

$$1 = \mathbb{E}_{t-1}\left[M_t\left(R_t + (1-\delta_{it})\frac{P^k_{t+1}}{P^k_t}\right)\right]; \tag{8}$$

where $M_t := \beta U_c(C_{t+1}; Z_{t+1})/U_c(C_t; Z_t)$ is the stochastic discount factor. With straightforward algebra, we can derive the following capital supply equation:

$$R_{it} = r_t + \delta_{it} - (1-\delta_{it})\left(\frac{P^k_{t+1}}{P^k_t} - 1\right) + \left(\frac{\mathbb{C}_{t-1}\left[M_t, R_{it}\right]}{\mathbb{V}_{t-1}\left[M_t\right]}\right)\left(-\frac{\mathbb{V}_{t-1}\left[M_t\right]}{\mathbb{E}_{t-1}\left[M_t\right]}\right) + \varepsilon_{it}, \tag{9}$$

where $\varepsilon_{it} \sim iid(0, \sigma^2_\varepsilon)$ denotes an expectational error.

Equation (9) represents an asset pricing relationship indicating that a household investing in firm $i$ requires a return equal to the standard sum of the risk-free rate and depreciation, $r_t + \delta_{it}$, plus three additional terms: (i) a capital gain term, $-(1-\delta_t)\left(\frac{P^k_{t+1}}{P^k_t} - 1\right)$; (ii) a risk premium, $\left(\frac{\mathbb{C}_{t-1}[M_t, R_{it}]}{\mathbb{V}_{t-1}[M_t]}\right)\left(-\frac{\mathbb{V}_{t-1}[M_t]}{\mathbb{E}_{t-1}[M_t]}\right)$; and (iii) the expectational error, $\varepsilon_{it}$.

## 3.2 The Firm Problem

Firms are static, indexed by $i \in \mathcal{I}$, and produce using the following production function:

$$q_{it} = q(z_{it}, \ell_{it}, k_{it}), \tag{10}$$

where $q_{it}$ denotes the output quantity, $z_{it}$ represents Hicks-neutral productivity, $\ell_{it}$ is the variable input, and $k_{it}$ is the capital input. We define the output elasticities of the variable input as $\mathcal{E}_\ell$ and the output elasticities of the capital input as $\mathcal{E}_k$.

Firms borrow capital from the representative household, paying a rental rate $R_{it}$. Additionally, we account for the possibility of capital-specific frictions, which we represent in reduced form as a wedge $\tau_{it}$. Appendix B.1 provides various alternative microfoundations for this term, explicitly relating it to either adjustment costs or financial frictions. Finally, firms face an overhead cost $f_{it}$ to operate their production technology. Thus, the objective function associated with the firm's cost minimization problem is:

$$\mathcal{L}(\ell_{it}, k_{it}, \xi_{it}) = W_t \ell_{it} + (R_{it} + \tau_{it}) P_t^k k_{it} + f_{it} - \xi_{it} \left( q(\cdot) - q_{it} \right), \tag{11}$$

where $\xi$ is the Lagrange multiplier, $q(\cdot)$ represents the production technology as specified in equation (10), and $q_{it}$ is a scalar.

We assume that firms take variable and capital input prices as given and that firms set the output price according to $p_{it} = \mu_{it}\xi_{it}$, where $\mu_{it}$ is the price-cost markup and $\xi_{it}$ is the marginal cost of production. This is consistent with the general demand structures as specified in the household problem in Section 3.1. Thus, the first-order conditions of the firm side are given by the following two equations:

$$\mu_{it} = \mathcal{E}_\ell \frac{p_{it} q_{it}}{W_t \ell_{it}} := \frac{MRPL_{it}}{W_t}, \tag{12}$$

$$(R_{it} + \tau_{it})\mu_{it} = \mathcal{E}_k \frac{p_{it} q_{it}}{P_t^k k_{it}} := \frac{MRPK_{it}}{P_t^k}. \tag{13}$$

Equation (12) determines the markup as the ratio of the revenue-based marginal product of labor ($MRPL_{it}$) to the aggregate price of the primary factor. Importantly, this equation defines the markup in terms of observables, similar to Hall (1988) and De Loecker and Warzynski (2012). Equation (13) illustrates that the ratio of the revenue-based marginal product of capital ($MRPK_{it}$) to the price of capital is equal to the firm-specific markup multiplied by the sum of a firm-specific return and capital wedge. Essentially, equation (13) generalizes Hsieh and Klenow (2009), nesting their specification as a special case when markups and returns are common across firms.

## 3.3 General Equilibrium

For every period $t \in [0, \infty)$, given the exogenous primary factor supply $L_t$, discount factor shock $Z_t$, capital input prices $P_t^k$, Hicks-neutral productivity $z_{it}$, markups $\mu_{it}$, frictions $\tau_{it}$, expectational errors $\varepsilon_{it}$, fixed costs $f_{it}$, and depreciation rate $\delta_{it}$, a general equilibrium is defined as a set of output prices $p_{it}$, primary factor input prices $W_t$, quantities $q_{it}$, variable input choices $\ell_{it}$, capital input choices $k_{it}$, investment decisions $x_{it}$, and final consumption $C_t$, satisfying the following conditions: each firm minimizes its costs and set prices to charge the relevant markup on its marginal cost; the household chooses consumption and savings to maximize utility subject to a budget constraint; and markets for all goods and factors clear.

## 3.4 Equilibrium in the Market for Capital and Identification

### 3.4.1 Equilibrium in the Market for Capital

In this section, we study the equilibrium in the market for capital described by equations (9) and (13) and we show that this can be summarized by a generalized capital asset pricing model (CAPM).

**Proposition 1 (Generalized CAPM)** *The capital market equilibrium can be summarized by the following generalized CAPM:*

$$\frac{MRPK_{it}}{P_t^k} = r_t + \delta_{it} - \boldsymbol{\varrho}_{it} + \boldsymbol{\mu}_{it} + \boldsymbol{\tau}_{it} + \boldsymbol{\zeta}_{it}, \quad \forall i \in \mathcal{I}; \tag{14}$$

*where* $\boldsymbol{\varrho}_{it} := (1-\delta_{it})\left(\frac{P_{t+1}^k}{P_t^k} - 1\right)$ *denotes the capital gains;* $\boldsymbol{\mu}_{it} := \left(1 - \frac{1}{\mu_{it}}\right) MRPK_{it}$ *is a markup wedge;* $\boldsymbol{\tau}_{it} := \tau_{it} + \varepsilon_{it}$ *is an augmented capital wedge; and* $\boldsymbol{\zeta}_{it} := \boldsymbol{\beta}_{it}\boldsymbol{\lambda}_t$ *represents the risk premium, with* $\boldsymbol{\beta}_{it} := \frac{\mathbb{C}_{t-1}\left[M_t, \mu_{it}^{-1}\frac{MRPK_{it}}{P_t^k}\right]}{\mathbb{V}_{t-1}[M_t]}$ *denoting the firm's riskiness and* $\boldsymbol{\lambda}_t := \left(-\frac{\mathbb{V}_{t-1}[M_t]}{\mathbb{E}_{t-1}[M_t]}\right)$ *denoting the aggregate price of risk.*

**Proof.** See Appendix B.2.1. ■

Equation (14) expresses the risk premium as the product of two components: the exposure of the return to movements in the stochastic discount factor—i.e., the firm's riskiness—summarized by $\boldsymbol{\beta}_{it}$, and the aggregate price of risk, summarized by $\boldsymbol{\lambda}_t$. Thus, it extends the standard capital asset pricing model by showing how capital gains, markups, capital wedges, and risk premia jointly raise the revenue-based marginal product of capital above the risk-free rate and depreciation.[5] This motivates the following corollary of Proposition 1, which relates to the identification of the model.

**Corollary 1 (Identification)** *Proposition 1 implies that the standard identification strategy for*

[5]Note that the (augmented) capital wedge $\boldsymbol{\tau}_{it}$ here combines the original capital wedge $\tau_{it}$ and the expectational error $\varepsilon_{it}$. We group these without loss of generality, as both terms capture residual variation in the revenue-based marginal revenue product of capital without conveying additional separate information. Thus, from now on, we use the terms capital wedge and augmented capital wedge interchangeably.

*capital wedges $\boldsymbol{\tau}_{it}$ and risk premia $\boldsymbol{\zeta}_{it}$ does not hold in our framework. Specifically,*

$$\boldsymbol{\tau}_{it} \neq \frac{MRPK_{it}}{P_t^k} - r_t - \delta_{it}, \quad \textit{and} \quad \boldsymbol{\zeta}_{it} \neq \frac{MRPK_{it}}{P_t^k} - r_t - \delta_{it}. \tag{15}$$

**Proof.** Omitted. ■

Corollary 1 shows that in our model–where capital gains, markups, risk premia, and capital wedges jointly determine outcomes–the standard approach of identifying risk premia or capital wedges in isolation from the revenue-based marginal product of capital in excess of the risk-free rate and depreciation rate fails. This result highlights the importance of considering these factors jointly, as analyzing them separately would misattribute the variation arising from omitted factors to only those explicitly included. Next, we develop a model-consistent identification strategy that simultaneously accounts for all these components.

### 3.4.2 Model-Driven Identification

Here, we demonstrate how to utilize the model's structure, combined with insights from the misallocation and empirical asset pricing literature, to develop an identification strategy for capital gains, markups, risk premia, and capital wedges. We defer the details of the empirical implementation to Section 4.

We start by noting that risk-free rates $r_t$, depreciation rates $\delta_{it}$, and capital gains $\boldsymbol{\varrho}_{it}$ are measurable using standard data sources. Moreover, markups $\mu_{it}$ and consequently markup wedges $\boldsymbol{\mu}_{it}$ can, in principle, be computed using equation (12).[6] Thus, we are left with two objects still to be measured: the risk premia $\boldsymbol{\zeta}_{it}$ and the capital wedges $\boldsymbol{\tau}_{it}$.

To measure risk premia, we rely on equation (14) from Proposition 1 and employ a standard approach widely used in the empirical asset pricing literature, which dates back at least to Fama and MacBeth (1973). In practice, given a state-of-the-art measure of the stochastic discount factor $M_t$—discussed in detail in the empirical implementation in Section 4.3.3—equation (14) can be estimated using a two-stage procedure.

The first step involves estimating $\boldsymbol{\beta}_{it}$, which captures a firm's exposure to movements in the stochastic discount factor. This exposure is defined as the covariance between $\mu_{it}^{-1}\frac{MRPK_{it}}{P_t^k}$ and $M_t$ divided by the variance of $M_t$, it can be estimated using a simple firm-specific OLS

[6] This computation requires estimating the output elasticity of inputs, a point we revisit in Section 4.3.1 when describing the empirical implementation of our approach.

regression of the form:

$$\mu_{it}^{-1}\frac{MRPK_{it}}{P_t^k} = \alpha_{i\tau} + \boldsymbol{\beta}_{i\tau}M_t + \varepsilon_{it}, \tag{16}$$

which is usually implemented using backward-looking rolling windows of $N_\tau$ years–i.e., for each year $\tau$, data from the period $t \in [\tau - N_\tau, \tau]$ are used.

In the second stage, given the time-varying firm-level estimate $\boldsymbol{\beta}_{it}$, we estimate the aggregate price of risk $\boldsymbol{\lambda}_t$ using equation (14). In practice, this involves estimating the following cross-sectional regression for each year:

$$\frac{MRPK_{it}}{P_t^k} = r_t + \delta_{it} - \boldsymbol{\varrho}_{it} + \boldsymbol{\mu}_{it} + \boldsymbol{\beta}_{it}\boldsymbol{\lambda}_t + \boldsymbol{\tau}_{it}, \tag{17}$$

where $\boldsymbol{\tau}_{it}$ is naturally treated as a residual, since by definition it captures variation in revenue-based marginal returns on capital that is unrelated to all other variables. Regression (17) again highlights the importance of jointly including and properly controlling for all competing explanations in the estimation of the risk premium. Finally, the time-varying firm-level risk premium is measured as $\boldsymbol{\zeta}_{it} = \boldsymbol{\beta}_{it}\boldsymbol{\lambda}_t$.

Finally, we recover the capital wedge following the approach used in the misallocation literature—treating it as the residual of equation (17) after jointly accounting for all other factors affecting the revenue-based marginal product of capital. Next, we present the micro-to-macro link that highlights how these firm-level objects can be used to analyze the dynamics of the aggregate return on capital.

## 3.5 Micro-to-Macro Link

In this section, we demonstrate how the divergence of the return on capital, $\mathcal{R}_t$, from the risk-free rate, $r_t$, can be explained by (i) firm-level capital gains, (ii) firm-level risk premia, (iii) firm-level capital wedges, and (iv) firm-level profit wedges. Building on the commonly used definition of the return on capital in the literature, as presented in Section 2—which states that the return on capital is effectively the net return from non–labor payments–we define the firm-level return on capital in the same way as:

$$\mathcal{R}_{it} := \frac{p_{it}q_{it} - f_{it} - \delta_{it}P_t^k k_{it} - W_t\ell_{it}}{P_t^k k_{it}}. \tag{18}$$

The above definition represents the measured firm-level return on capital, following the same approach used to compute capital return in the aggregate data. Now we present its link with the true return on capital and profits.

**Proposition 2 (Firm-Level Return on Capital and Profits)** *The measured firm-level return on capital, $\mathcal{R}_{it}$, can be decomposed into the sum of the true return on capital, $R^k_{it}$, and the profit wedge, $\pi_{it}$:*

$$\mathcal{R}_{it} = R^k_{it} + \boldsymbol{\pi}_{it}. \tag{19}$$

*The true return on capital is defined as*

$$R^k_{it} := \mu^{-1}_{it} \frac{MRPK_{it}}{P^k_{it}} - \delta_{it} = r_t - \boldsymbol{\varrho}_{it} + \boldsymbol{\zeta}_{it} + \boldsymbol{\tau}_{it}. \tag{20}$$

*The profit wedge is given by*

$$\boldsymbol{\pi}_{it} := \left(1 - \frac{\mathcal{E}_k + \mathcal{E}_\ell}{\mu_{it}}\right) \frac{p_{it} q_{it}}{P^k_t k_{it}} - \frac{f_{it}}{P^k_t k_{it}}, \tag{21}$$

*which represents the return per unit of capital from markups, net of the portion attributed to fixed costs.*

**Proof.** See Appendix B.2.2. ■

The fact that the measured return on capital equals the true one plus a profit wedge stems from the fact that the standard measurement assumes zero profits. Therefore, our methodology enables the distinction between movements in the true return on capital and movements in the return to firm ownership, as captured by the profit wedge.

To link these firm-level objects to the aggregate divergence of interest, we start with the definition of the measured aggregate capital return $\mathcal{R}_t$ presented in Section 2, which can be expressed as:

$$\mathcal{R}_t = \frac{Q_t - \delta_t K_t - W_t L_t}{K_t}, \tag{22}$$

$$= \sum_{i \in \mathcal{I}} \omega_{it} \left( \frac{p_{it} q_{it} - f_{it} - \delta_{it} P^k_t k_{it} - W_t \ell_{it}}{P^k_t k_{it}} \right) \tag{23}$$

$$= \sum_{i \in \mathcal{I}} \omega_{it} \mathcal{R}_{it}; \tag{24}$$

where $K_t \equiv \sum_{i \in \mathcal{I}} P_t^k k_{it}$ is the aggregate capital, $Q_t - W_t L_t \equiv \sum_i (p_{it} q_{it} - f_{it} - W_t \ell_{it})$ is the total GDP net of the aggregate wage bill, $\delta_t K_t = \delta_{it} P_t^k k_{it}$ is the total aggregate depreciation, and $\omega_{it} = \left(P_t^k k_{it}\right)/K_t$ is the firm-level capital share. Equations (22)-(24) demonstrate that the measured aggregate return on capital can be precisely represented as the capital-weighted average of the measured firm-level returns on capital. This observation enables us to introduce the central theorem of the paper, linking firm-level unobservable factors to the aggregate return on capital.

**Theorem 1 (Decomposition of the Aggregate Return on Capital I)** *The difference between the return on capital and the risk-free rate is given by:*

$$\mathcal{R}_t - r_t = \sum_{i \in \mathcal{I}} \omega_{it} \left(R_{it}^k - r_t\right) + \sum_{i \in \mathcal{I}} \omega_{it} \boldsymbol{\pi}_{it}, \tag{25}$$

$$= - \sum_{i \in \mathcal{I}} \omega_{it} \boldsymbol{\varrho}_{it} + \sum_{i \in \mathcal{I}} \omega_{it} \boldsymbol{\zeta}_{it} + \sum_{i \in \mathcal{I}} \omega_{it} \boldsymbol{\tau}_{it} + \sum_{i \in \mathcal{I}} \omega_{it} \boldsymbol{\pi}_{it}. \tag{26}$$

**Proof.** See Appendix B.2.3. ■

Equation (25) demonstrates that the divergence between the measured return on capital, $\mathcal{R}_t$, and the risk-free rate, $r_t$, can be decomposed into two main components: the divergence between the capital-weighted average of the firm-level wedge between the true returns on capital, $R_{it}^k$, and the risk-free rate, $r_t$, as well as the capital-weighted average profit wedge.

Furthermore, equation (26) breaks down the divergence between $R_t^k$ and $r_t$ into three aggregate components, each representing a capital-weighted average of the corresponding firm-level factors. Capital gains capture changes in the compensation required by investors as capital prices vary over time. Risk premia reflect a reduced willingness of investors to supply capital to firms, which leads firms to operate with less capital, resulting in higher returns on capital. Finally, capital-specific wedges show up as deadweight losses that affect the revenue-based marginal product of capital.

Shifting to profit-related explanations, markups and fixed costs, as defined by the profit wedge in equation (21), influence the measured divergence between the aggregate return on capital and the risk-free rate. This occurs because they represent deviations from the perfect competition assumption, which standard measurements in the literature rely on, as explained in Section 2. When this assumption does not hold, the rise in returns to firm ownership is incorrectly attributed to capital ownership. Therefore, while an increase in markups, by boosting profits, can contribute to the widening gap between $\mathcal{R}_t$ and $r_t$, a rise in fixed costs would have the opposite effect, as it implies a reduction in profits.

Theorem 1 can be equivalently expressed in terms of cumulative changes, which leads to the following corollary.

**Corollary 2 (Decomposition of the Aggregate Return on Capital II)** *The decomposition presented in Theorem 1 can be equivalently expressed in terms of cumulative changes as follows:*

$$\Delta_t(\mathcal{R}_t - r_t) = \Delta_t(R_t^k - r_t) + \Delta_t \boldsymbol{\pi}_t \tag{27}$$

$$= -\Delta_t \boldsymbol{\varrho}_t + \Delta_t \boldsymbol{\zeta}_t + \Delta_t \boldsymbol{\tau}_t + \Delta_t \boldsymbol{\pi}_t, \tag{28}$$

*where $\Delta_t x_t := x_t - x_{t_0}$, with $t_0$ denoting the base year for the cumulative difference, and $R_t^k = \sum_i \omega_{it} R_{it}^k$, $\boldsymbol{\varrho}_t := \sum_i \omega_{it} \boldsymbol{\varrho}_{it}$, $\boldsymbol{\zeta}_t := \sum_i \omega_{it} \boldsymbol{\zeta}_{it}$, $\boldsymbol{\tau}_t := \sum_i \omega_{it} \boldsymbol{\tau}_{it}$, and $\boldsymbol{\pi}_t := \sum_i \omega_{it} \boldsymbol{\pi}_{it}$.*

**Proof.** Omitted. ■

Corollary 2 shows that the cumulative divergence between the measured aggregate return on capital and the risk-free rate can be exactly decomposed into the cumulative differences of each component from Theorem 1. In particular, equation (27) highlights that this divergence can be expressed as the sum of the cumulative difference between the true return on capital and the risk-free rate, and the cumulative change in the profit wedge. Moreover, equation (28) further decomposes the divergence into the cumulative changes in capital gains, risk premia, the capital wedge, and the profit wedge. Hence, identifying cumulative differences in the data is as informative as identifying levels—a point that will prove useful in the empirical application.

# 4 Data, Variable Definitions, and Measurement

This section presents the data sources used for the empirical analysis, defines each empirical variable, and describes the measurement of the fundamental objects underlying our theory.

## 4.1 Data Sources

**Firm-level data.** The primary data source is Compustat, a firm-level database that provides balance sheet information for all U.S. publicly traded firms covering the entire period of interest. The key advantage of using Compustat is its comprehensive coverage of the relevant time frame and a wide range of sectors. While publicly traded firms represent only a small fraction of the total number of firms, they are often among the largest in the economy, accounting for approximately 30% of U.S. employment Davis et al. (2006). More relevant to our focus on capital, the particularly right-skewed distribution of capital across firms makes these large firms highly informative for understanding aggregate capital, as noted by Crouzet and Mehrotra (2020). According to our calculations, they represent approximately 60 percent of total non-residential capital.

**Aggregate risk factors data.** We obtain data on aggregate risk factors from various sources. For the standard CAPM, the five-factors data from Hou et al. (2015) can be accessed at http://global-q.org/factors.html. Additionally, the five-factors, three-factors, and one-factor data from Fama and French (2023) are available on Kenneth French's website at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/. Finally, when using the consumption CAPM, we employ a single-factor model that incorporates the consumption growth rate from the NIPA tables.

## 4.2 Definition and Construction of Variables

In this section, we provide a brief overview of how we define and compute the main variables of interest used in the empirical analysis. See Appendix C.1 for further details on the cleaning process and for summary statistics of our main variables.

### 4.2.1 Construction of Variables

**Capital Stock and Depreciation.** We compute the total capital stock of a firm as a sum of tangible capital and intangible capital following Peters and Taylor (2017). The tangible capital is constructed using the perpetual inventory method:

$$k_{it}^{T} = (1 - 0.07)k_{it-1}^{T} + x_{it}^{T}, \tag{29}$$

where $x_{it}^T - 0.07k_{it-1}^T \equiv \texttt{ppent}_{it} - \texttt{ppent}_{it-1}$, and values are deflated. The initial capital stock is set as $k_{i0}^T = \texttt{ppegt}_{it}$. We measure intangible capital stock as the sum of three components, following best practices in corporate finance (Peters and Taylor, 2017; Ewens et al., 2024). The first component, knowledge capital, is capitalized R&D, defined as:

$$k_{it}^{KNWL} = (1 - \delta_{s(i)}^{KNWL})k_{it-1}^{KNWL} + \texttt{xrd}_{it}, \tag{30}$$

where sector-level depreciation rates, $\delta_{s(i)}^{KNWL}$, are from Ewens et al. (2024), and $k_{i0}^{KNWL} = 0$.[7] The second component, organizational capital, is constructed by capitalizing a portion of selling, general, and administrative expenses as follows:

$$k_{it}^{ORG} = (1 - 0.20)k_{it-1}^{ORG} + \gamma_{s(i)}\texttt{xsga}_{it}, \tag{31}$$

where $\gamma_{s(i)}^{ORG}$ is from Ewens et al. (2024), and $k_{i0}^{ORG} = 0$. The third component, balance sheet intangible capital net of goodwill, is defined as: $k_{it}^{BS} = \texttt{intano}_{it}$.[8] Total intangible capital is calculated as: $k_{it}^I = k_{it}^{KNWL} + k_{it}^{ORG} + k_{it}^{BS}$, and values are deflated. Thus, the firm-level total capital stock and depreciation rate are defined as follows:

$$k_{it} = k_{it}^I + k_{it}^T, \quad \text{and} \quad \delta_{it} = \frac{k_{it}^T}{k_{it}}\delta^T + \frac{k_{it}^I}{k_{it}}\delta^I. \tag{32}$$

**Output, and variable and fixed costs.** The Compustat data include detailed firm-level financial statements, such as sales, input expenditures, capital stock, and industry classifications. We use sales, $\texttt{sale}_{it}$, to measure firm output, cost of goods sold, $\texttt{cogs}_{it}$, to capture variable input, and the non-capital fraction of selling, general, and administrative expenses, $(1 - \gamma_{s(i)}^{ORG})\texttt{xsga}_{it}$, to measure fixed costs. We deflate all variables to obtain their real values.

**Relative prices.** We measure the relative price of tangible capital, $P_t^T$, as the ratio of the tangible capital investment deflator to the GDP deflator, and the relative price of intangible capital, $P_t^I$, as the ratio of the intangible capital deflator to the GDP deflator. The final capital

[7] We provide results with a different measure of initial capital stock as the ratio of the initial investment and the depreciation rate.

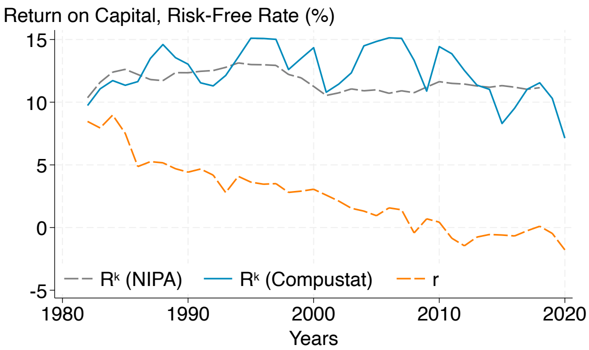
[8] This component is crucial to include, as it typically accounts for most software on the balance sheet, which is the fastest-growing segment of aggregate intangible capital according to BEA data. For a detailed discussion on software accounting standards, see Chiavari and Goraya (2025) and Aum and Shin (2024).

relative price is defined as follows:

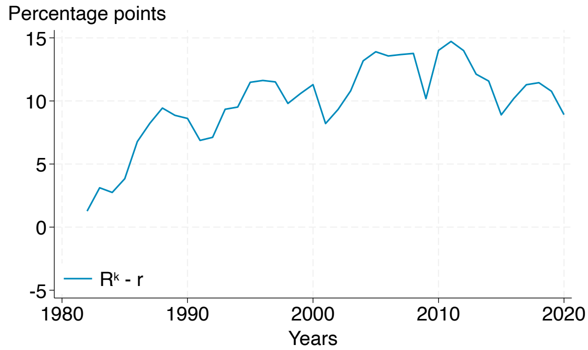
$$P_t^k = \left( |\mathcal{I}_t|^{-1} \sum_{i \in \mathcal{I}_t} \frac{k_{it}^T}{k_{it}} \right) P_t^T + \left( |\mathcal{I}_t|^{-1} \sum_{i \in \mathcal{I}_t} \frac{k_{it}^I}{k_{it}} \right) P_t^I. \tag{33}$$

**Firm-level and aggregate return on capital.** We calculate the firm-level return on capital, $\mathcal{R}_{it}$, using equation (18). To assess how closely the aggregate return on capital from Compustat aligns with national accounts, we aggregate the firm-level returns, weighting them by total capital: $\mathcal{R}_t = \sum_i \omega_{it} \mathcal{R}_{it}$, in accordance with equation (24).

**Figure 2: Comparison Between National Accounts and Compustat**




**(a) Return on Capital and Risk-Free Rate**




**(b) Return on Capital and Risk-Free Rate Gap**

Note. Figure 2a illustrates the evolution of the aggregate return on capital from national accounts and the risk-free rate, as previously presented in Figure 1, alongside the aggregate return on capital from Compustat. Figure 2b highlights the aggregate divergence between the return on capital from Compustat and the risk-free rate.

Figure 2a displays the evolution of the return on capital from national accounts (NIPA) and firm-level data (Compustat), showing a strong correlation between the two. This is unsurprising, given the well-established fact that capital distribution is heavily skewed toward larger firms, which are disproportionately represented in aggregate movements. This confirms that Compustat is a reliable dataset for studying the divergence of the return on capital from the risk-free rate. Figure 2b quantifies this divergence, which grew from nearly zero in 1982 to almost 10 percentage points by 2019. Next, we measure the firm-level components that form equation (26).

## 4.3 Firm-Level Measurements

### 4.3.1 Production Function Elasticities, Markups, and the Profit Wedge

This section outlines our baseline production function and markup measurement, describes the main findings, and presents a series of additional exercises we conduct to evaluate their robustness. We retain a general specification for firm-level demand, but restrict the production technology to a Cobb-Douglas form with time-varying, sector-specific coefficients, as described below.

**Production function and markup measurement.** The two most prominent approaches in the literature for estimating firm-level production functions are the cost share approach and the control function approach. Although the former requires a measure of the user cost of capital–which depends on unobservable risk premia and capital frictions—the latter does not.[9] For this reason, we adopt the control function approach.

A key challenge in implementing this approach with Compustat data is the absence of separate information on output prices and quantities. While this limitation is common across many datasets, it forces researchers to use revenue—rather than physical output quantities—on the right-hand side of production function estimations, as recently emphasized by Bond et al. (2021). Although our model is sufficiently general to accommodate flexible demand and production function assumptions, this empirical constraint necessitates the imposition of additional identifying restrictions.

To address this challenge, we follow Ackerberg and De Loecker (2024), who provide a recent framework for estimating production functions under imperfect competition (i.e., variable markups) and in settings where only revenue data are available. Consistent with their approach, we assume a sector-specific, time-varying Cobb-Douglas production function at the 2-digit NAICS level. On the demand side, we consider three market structures: the Homogeneous Goods Quantity-Setting Model, the Logit Nash-Bertrand Model, and the Nested Logit Nash-Bertrand Model. These assumptions allow us to use the revenues of competing firms within an industry as a sufficient statistic to control for demand variation—and thus for variable markups—effectively restoring the scalar unobservability condition required for first-stage estimation. In addition, this approach introduces demand-side variation similar to

[9] The literature often sidesteps this challenge by either assuming away risk premia and frictions or calibrating them. This is not feasible in our setting, as these are precisely the objects required to be estimated as inputs of our theory.

that of an oligopoly instrument, helping to overcome the non-identification issues associated with gross-output production functions, as highlighted by Gandhi et al. (2020).

We embed this first-stage approach in a system GMM estimation framework, using moment conditions from Blundell and Bond (1998), which accommodate firm-level fixed effects in productivity. Although our empirical strategy is exact under the assumed demand structures, there is no guarantee that these assumptions fully reflect the true nature of competition in the data. However, because our main exercise of interest is to identify cumulative changes relative to a baseline year, as stated by Corollary 2, we emphasize that accurately capturing trends in output elasticities and markups is more important than identifying levels. In richer settings where price data are observed, De Ridder et al. (2024) show that using revenue instead of output quantity data affects the levels of estimated elasticities but still captures trends well–which is our primary concern.

Finally, with time-varying sector-level estimates of production function elasticities in hand, we construct markups following De Loecker and Warzynski (2012), which coincides with equation (12). This approach recovers firm-level markups as the product of the elasticity with respect to the variable input and the ratio of revenues to variable input expenditures.

**Baseline estimates.** Appendix C.2 presents the evolution of the estimated elasticities of the production function and markups. In line with De Loecker et al. (2020) and Chiavari and Goraya (2025), we observe a steady increase in the elasticity of capital over time, accompanied by a modest decline in the elasticities of variable costs and a slight increase in returns to scale. Additionally, we find a steady increase in average markups, which aligns with the extensive literature documenting this development, as reviewed recently by Syverson (2024).

**Robustness exercises.** We demonstrate in Appendix C.2 that our estimates of the elasticities of the production function and markups are robust across a variety of different methodologies.

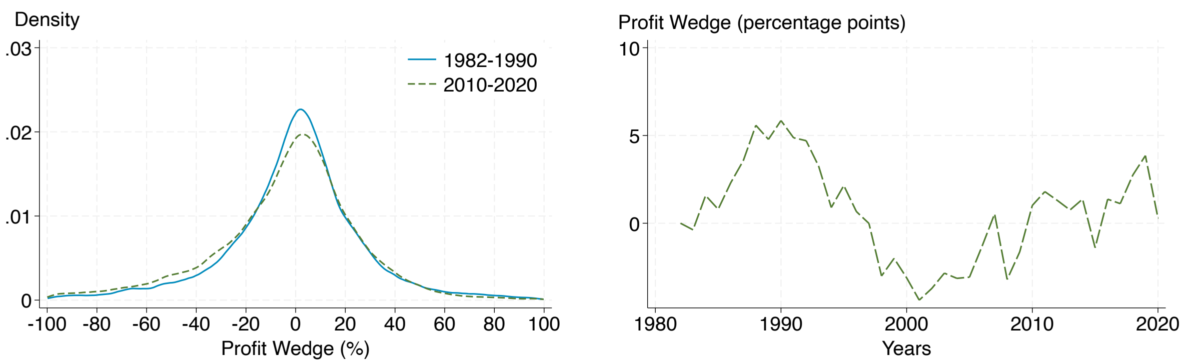
First, we sidestep the first stage of the production function estimation by collapsing it to a standard system GMM estimator in the spirit of Blundell and Bond (1998). Alternatively, we retain the original first-stage procedure and instead modify the second stage by applying a set of moment conditions, following the approach of Ackerberg et al. (2015). As a further robustness check, we employ the method developed by Collard-Wexler and De Loecker (2021), which accounts for classical measurement error in capital stock. Across these approaches, we find that the estimated output elasticities and markups exhibit trends consistent with those obtained from our baseline method.

Additionally, we consider an alternative markup measure to that proposed by De Loecker and Warzynski (2012). Specifically, we adopt the accounting profit approach from Baqaee and Farhi (2020), calculating markups as the ratio of sales to total costs, including both variable and fixed overhead costs. This alternative yields markup estimates broadly in line with those derived from our baseline method.

**Profit wedges.** Having measured the production function elasticities and markups, we are now ready to present our measure of firm-level profit wedges, as defined in equation (21).

Figure 3a presents the distribution across two different periods and Figure 3b its capital-weighted evolution over time. Overall, we find that profit wedges are dispersed and have been rising since the early 2000s. This trend may differ from the profit rate measured by De Loecker et al. (2020). Appendix C.3 demonstrates that the discrepancy between our profit wedge and the profit rate in De Loecker et al. (2020) arises from the distinct theoretical concepts they capture, rather than any data-related issue.

**Figure 3: Profit Wedge Distribution and Evolution**




**(a) Profit Wedge Distribution** **(b) Profit Wedge Evolution**

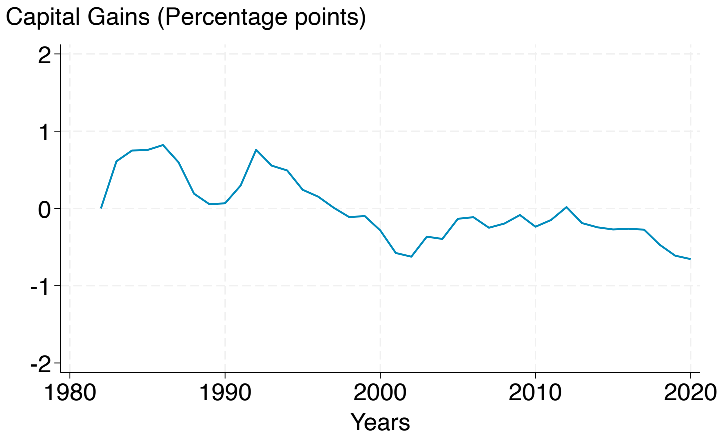
Note. Figure 3a displays the distribution of firm-level profit wedges for the periods 1982-1990 and 2010-2020. Figure 3b illustrates the evolution of the cumulative change in the capital weighted average of the profit wedges.

### 4.3.2 Capital Gains

Here, we present the evolution of capital gains, measured according to the definition provided in Proposition 1. Figure 4 illustrates this evolution.

Overall, Figure 4 shows that capital gains have declined by approximately 0.5 percentage points since the 1980s. Figure C.7 in the Appendix C.4 demonstrates that the capital gains

**Figure 4: Evolution of Capital Gains**




Note. Figure 4 shows the evolution of capital gains from 1982 to 2020, expressed as deviations from the initial years and measured according to the definition provided in Proposition 1.

evolution presented in this section is robust when computed using the relative price of investment goods (PIRIC) from FRED, as well as the capital gains estimates from Gomme et al. (2011).

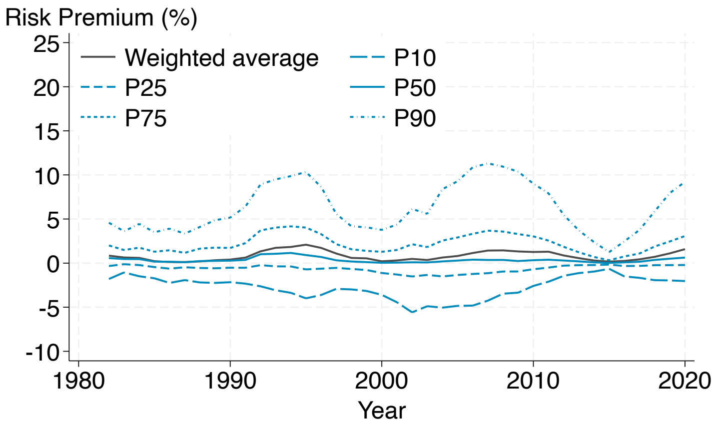
### 4.3.3 Risk Premium

Risk premia are estimated following the methodology outlined in Section 3.4.2. We implement this two-stage procedure by approximating the stochastic discount factor, $M_t$, using the five-factor model from Hou et al. (2015), which has been shown to track cross-sectional firm-level variation well and was recently applied in a similar context by David et al. (2022). These factors include (i) the market return, (ii) the return on a portfolio that is long in small firms and short in large firms, (iii) the return on a portfolio that is long in low-investment firms and short in high-investment firms, (iv) the return on a portfolio that is long in high-profitability (return on equity) firms and short in low-profitability firms, and (v) the return on a portfolio that is long in firms with high expected 1-year-ahead investment-to-assets changes and short in firms with low ones. Finally, the time-varying firm-level risk premium is measured as a 3-year moving average of $\boldsymbol{\zeta}_{it} = \boldsymbol{\beta}_{it}\boldsymbol{\lambda}_t$.

Figure 5 illustrates the evolution of estimated firm-level risk premia.[10] It highlights the 10th, 25th, 50th, 75th, and 90th percentiles, along with the capital-weighted average, which serves as the input for equation (26). We find that most firms exhibit modest risk premia of

[10]Given our longer-term focus, we apply a 5-year moving average to firm-level risk premia to smooth out excess volatility.

**Figure 5: Evolution of the Risk Premium Distribution**




Note. Figure 5 shows the evolution of various moments in the distribution of firm-level risk premia from 1982 to 2020, specifically reporting the 10th, 25th, 50th, 75th, and 90th percentiles, as well as the capital-weighted average.

approximately 2% on average, while the overall distribution is right-skewed, with a long right tail of firms facing substantially higher risk premia. Moreover, while the distribution of risk premia fluctuates significantly over time—widening notably during recessions—its average has remained remarkably stable over the past four decades.

Appendix C.5 validates our firm-level estimates of risk premia. Specifically, we show that firms with higher risk premia tend to exhibit higher returns on equity, lower levels of capital stock, and a lower capital-to-variable-costs ratio, as expected. Moreover, consistent with the findings of David et al. (2022), we observe that sectors with more dispersed risk premia also display greater dispersion in revenue-based marginal products of capital and revenue total factor productivity.

Moreover, in Appendix C.5, we demonstrate that alternative factor models commonly used in the literature, such as the Fama and French (2023) 5-factor, 3-factor, and 1-factor models, as well as the consumption CAPM, produce a quantitatively similar evolution of the average capital-weighted risk premium over time when compared to the Hou et al. (2015) model. With these validations in place, we proceed to discuss how these estimates align with the existing evidence on risk premia in the literature.

**Relation with existing evidence.** Our estimated risk premium is consistent with a broad body of evidence and the asset pricing literature. Common risk indicators, such as the VIX Index, the SKEW Index, the spread between the Fed Funds Rate and the Three-Month Treasury Bill Rate used in Drechsler et al. (2018), the spread between risky and safe assets in Jordà et al. (2019), the Excess Bond Premium from Gilchrist and Zakrajšek (2012), the Economic Policy Uncertainty Index by Baker et al. (2016), Robert Shiller's CAPE Ratio, the Chicago Fed's NFCI risk subindex, the financial uncertainty index of Jurado et al. (2015), the risk appetite index of Bauer et al. (2023), the risk aversion index of Bekaert et al. (2022), and the variance risk premium from Bekaert and Hoerova (2014), show no upward trend over time.

Moreover, several papers in asset pricing have estimated the risk premium over time.[11] Campbell and Thompson (2008), Lettau et al. (2008), Avdis and Wachter (2017) find no rise in the risk premium since the early 1980s, being either constant or declining. Jagannathan et al. (2001) using a Gordon-like stock valuation model finds similar results. Martin (2017) reports a risk premium that has been constant since the mid-1990s. Similarly, Gagliardini et al. (2016), using a time-varying cross-sectional risk premium estimator, finds a stable risk premium over time. Gormsen and Huber (2023) estimate a constant perceived risk premium since the early 2000s, and Duarte and Rosa (2015), in their review of the asset pricing literature, show that risk premium estimates are generally either constant or at times declining.

An exception in the literature is Farhi and Gourio (2018), who argue that while the risk premium remained stable during the 1980s and 1990s, it began rising in the 2000s, particularly around the Great Recession. Although this is broadly consistent with the sharp increase we capture during the Great Recession, the fact that our estimates show a subsequent reversal and no sustained long-run trend underscores the importance of controlling for factors beyond risk premia—such as capital wedges and markups—that may drive the divergence between the return on capital and the risk-free rate and act as confounding forces in this relationship.

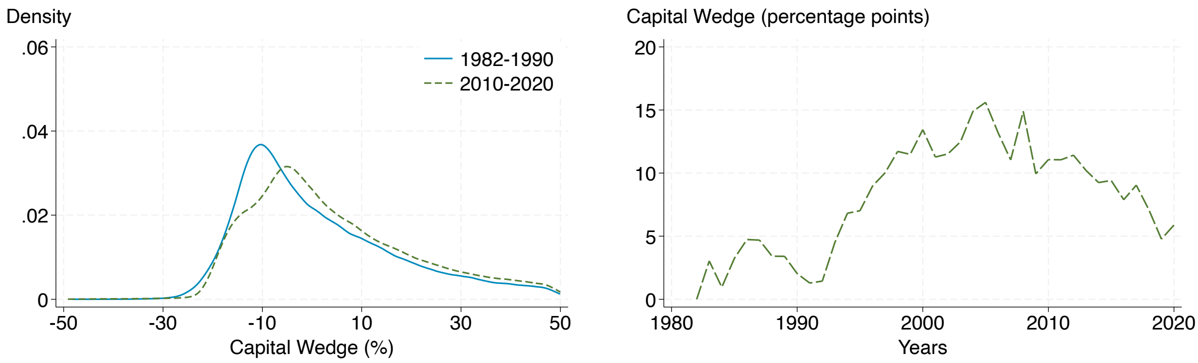
#### 4.3.4 Capital Wedges

Using our firm-level measures of markups, capital gains, and risk premia, we compute capital wedges $\tau_{it}$ as residuals according to equation (17). Figure 6a summarizes the distribution of capital wedges across different periods, while Figure 6b illustrates the evolution of the aggregate capital wedge over time, measured as the capital-weighted average of firm-level wedges. Several observations stand out: first, there is substantial dispersion in the capital wedge, ranging from −30 percent to +50 percent; second, this dispersion has modestly increased over time; and third, the aggregate capital wedge has risen, reaching a level approximately 5 percentage

[11] Most of the existing asset pricing literature has concentrated on the equity risk premium. However, an important contribution by David et al. (2022) demonstrates that equity risk premia and capital risk premia are closely related and proportional, meaning that movements in one directly inform the other.

points higher in 2020 compared to the 1980s.

**Figure 6: Capital Wedge Distribution and Evolution**




**(a) Capital Wedge Distribution** **(b) Capital Wedge Evolution**

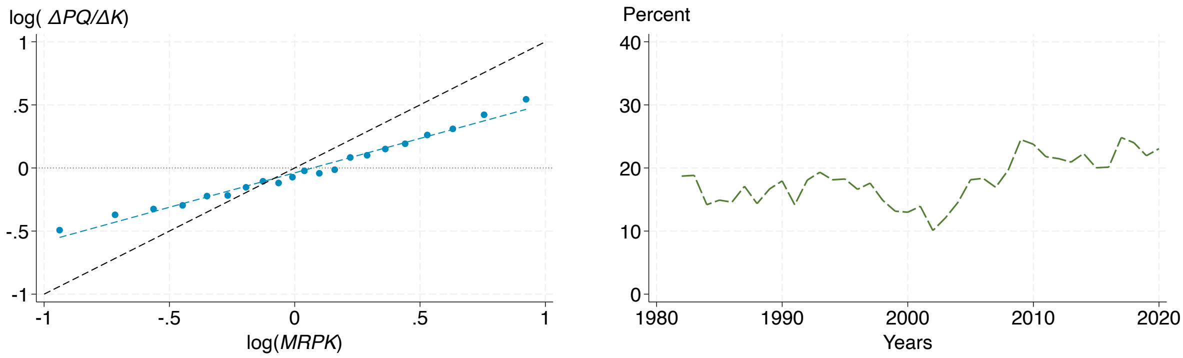
Note. Figures 6a display the distribution of firm-level $\tau_{it}$ for the periods 1982-1990 and 2010-2020. Figure 6b illustrates the evolution of the cumulative change in the weighted average of the capita-specific wedge.

Since the wedge may reflect either frictions or measurement errors, we next examine the role of the latter in explaining the rise of the capital wedge over time. We then adjust for the estimated measurement error and interpret the remaining component as reflecting frictions, which we validate using standard proxies commonly employed in the empirical literature.

**Capital wedge mismeasurement.** We begin by assessing the potential extent of measurement error in our estimates of capital wedges using a simple approach proposed by Bai et al. (2024). This method leverages the definition of the revenue-based marginal product of capital as the change in output relative to the change in capital input, i.e., $MRPK \approx \Delta pq/\Delta k$. This differencing not only provides a complementary measure of the revenue-based marginal product but also helps to eliminate persistent measurement error, as suggested by Bai et al. (2024). Comparing our baseline measure with this alternative offers a straightforward diagnostic of the possible presence of measurement error in each component. Specifically, in the absence of measurement error, the two measures should be perfectly correlated. In contrast, if the original variation arises entirely from measurement error, the two measures should be uncorrelated.

Figure 7a displays the correlation between our baseline measure and the alternative measure constructed using first differences. Overall, we find that the two measures are highly correlated, indicating that measurement error accounts only for a portion of the observed variation in $\tau_{it}$. Specifically, the alternative measure explains approximately 60% of the variation

**Figure 7: Measurement Error in Revenue-Based Marginal Product of Both Capital**




**(a) Alternative Measures of MRPK** **(b) Evolution of Mismeasurement**

Note. Figure 7a illustrates the relationship between our baseline measure of observed revenue-based marginal product and the measure constructed using the first differences of sales over capital. Both variables are deviations from sector time averages. The blue dots represent the relationship between $\log(MRPK)$ and $\log(\Delta PQ/\Delta K)$. The dotted line indicates the best-fit line. Figure 7b presents the evolution of measurement error in the capital wedge, measured as the variance of $\log \beta_\kappa$ to the variance of $\log MRPK$ as in Bils et al. (2021).

in $\log MRPK$, suggesting that our baseline measure largely reflects underlying economic factors, although it still contains a non-trivial degree of measurement error.

To quantify and isolate this measurement error, we adopt the approach of the seminal work of Bils et al. (2021), as implemented in David and Venkateswaran (2019) and Bai et al. (2024). This method allows us to estimate the extent of additive measurement error by estimating the following regression:

$$\Delta \log p_{it} q_{it} = \alpha_\kappa + \beta_\kappa \log \Delta k_{it} + \varepsilon_{it}, \tag{34}$$

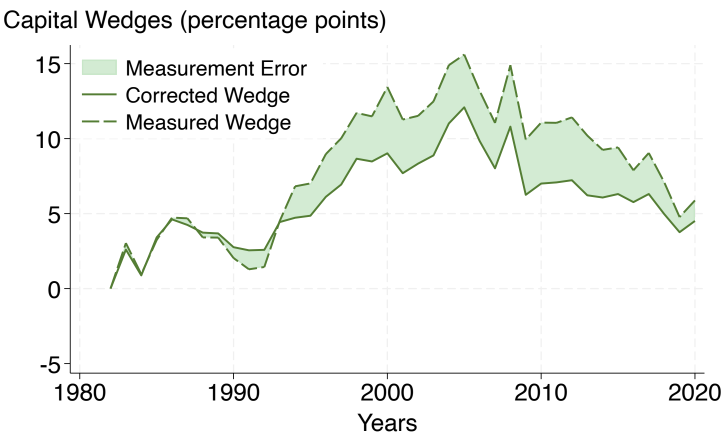
Here, $\Delta \log pq$ and $\Delta \log k$ represent the log changes in sales and capital, respectively, and $\kappa$ denotes the decile of $MRPK$. The key parameter of interest is the coefficient $\beta_k$. Intuitively, if the observed deviations in $MRPK$ are primarily driven by additive measurement error, then firms with high observed $MRPK$ should exhibit a lower elasticity of sales with respect to capital. Bils et al. (2021) show that, under certain assumptions, this coefficient identifies the exact extent of additive measurement error, allowing for the construction of a corrected measure:

$$\log \widehat{MRPK} = \log MRPK + \log \beta_\kappa. \tag{35}$$

Hence, the ratio of the variance of $\log \beta_x$ to the variance of $\log MRPK$ provides an estimate of the extent of measurement error in capital-specific wedges. Figure 7b presents our results. Several key observations emerge. First, capital wedges exhibit substantial measurement error, up to 20%. Second, measurement error has slightly increased, particularly toward the end of the sample period. This finding is consistent with the results of Bils et al. (2021), who show, using data from the U.S. Annual Survey of Manufacturers in the Longitudinal Research Database, that measurement error in revenue-based total factor productivity has increased over time.

Finally, using these measurement error estimates, we construct an adjusted wedge, $\tau_{it}^{\text{adj}}$, purged of measurement error. Figure 8 shows its capital-weighted evolution alongside that of the original wedge, $\tau_{it}$. We find that measurement error contributed to the rise in capital wedges, but not enough to account for the overall increase. The adjusted wedge still rose by approximately 5 percentage points over the past four decades, indicating that the underlying trend remains substantial even after accounting for mismeasurement.

**Figure 8: Role of Frictions and Measurement Error**




Note. Figure 7a presents the evolution of the capital wedge over time. The shaded area is the proportion of the measurement error. The $\tau$ as the dotted line and $\tau^{\text{adj}}$ as the solid line.

**Relationship between capital wedge and frictions.** Here, we present suggestive evidence that the adjusted capital wedge, $\tau_{it}^{\text{adj}}$, captures frictions such as financial frictions and adjustment costs. To do so, we collect several proxies of firm-level frictions commonly used in the literature.

These include liquidity, measured as the ratio of cash and short-term investments to total assets; leverage, defined as total debt divided by total assets; and the financial constraint indices of Hoberg and Maksimovic (2015), updated through recent years by Linn and Weagley (2024), which capture debt- and equity-based financial constraints.[12] We also include the

[12]The debt-based index identifies firms likely to delay investment due to liquidity issues, while the equity-based

average Tobin's Q, defined as the ratio of market value to total capital, as a proxy for investment frictions. Finally, we consider the investment rate in intangible capital, motivated by recent literature showing that intangible investment is highly frictional due to both higher adjustment costs (Peters and Taylor, 2017; Belo et al., 2022; Chiavari and Goraya, 2025) and the lower collateralizability of intangible assets (Caggese and Pérez-Orive, 2022; Falato et al., 2022). We estimate the following regression model,

$$\boldsymbol{\tau}_{it}^{\text{adj}} = \beta \Upsilon_{it} + \gamma_i + \gamma_t + \varepsilon_{it}, \tag{36}$$

where $\boldsymbol{\tau}_{it}^{\text{adj}}$ denotes the measurement-error-adjusted capital wedge, and $\Upsilon_{it}$ represents the vector of observable firm-level proxies for financial and investment frictions described above.

**Table 1: Relationship Between Capital Wedge and Frictions**

| *Dependent Variable* | $\boldsymbol{\tau}_{it}^{\text{adj}}$ (1) | $\boldsymbol{\tau}_{it}^{\text{adj}}$ (2) |
|---|---|---|
| *Financial and investment constraints proxies* | | |
| Leverage | 0.000 | 0.000 |
| | (0.000) | (0.000) |
| Liquidity | 0.016 | -0.055*** |
| | (0.023) | (0.012) |
| Average Tobin's Q | 0.001** | 0.006*** |
| | (0.001) | (0.002) |
| *Text-based proxies by Hoberg and Maksimovic (2015)* | | |
| Debt-based Constraints | 0.017*** | 0.017*** |
| | (0.004) | (0.003) |
| Equity-based Constraints | -0.023*** | -0.018*** |
| | (0.005) | (0.003) |
| *Intangibles* | | |
| Intangible Investment Rate | 0.131*** | 0.041*** |
| | (0.024) | (0.015) |
| *Fixed Effects* | | |
| Firm | ✓ | ✓ |
| Year | ✓ | ✓ |
| Observations | 124,608 | 105,524 |

Note. This table reports regression coefficients with $\boldsymbol{\tau}_{it}^{\text{adj}}$ as the dependent variable and proxies for frictions as independent variables. The regressions include firm and year fixed effects. Column 1 uses all observations, while Column 2 restricts the sample to firms older than three years. Standard errors, clustered at the firm level, are reported in parentheses. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.

The results, reported in Table 1, indicate that the adjusted capital wedge is correlated with most of the proxies included in the regression above. In particular, it is positively associated

index captures firms at risk of delaying investment for liquidity reasons and firms planning to issue equity.

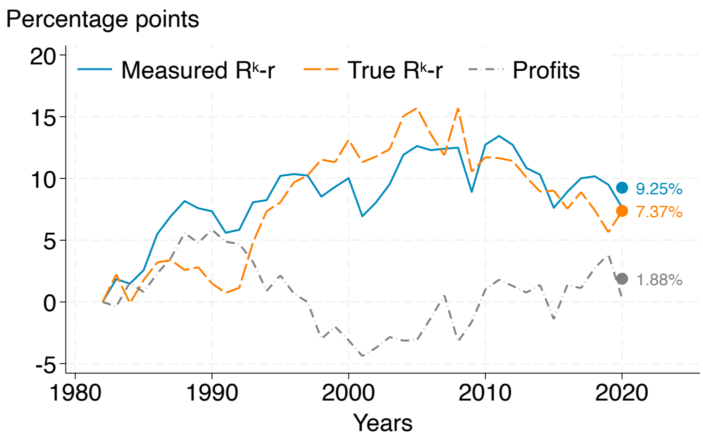
with average Tobin's Q, debt-based measures of financial constraints, and the investment rate in intangible capital. It is negatively associated with liquidity levels, although this relationship holds only for older firms. Conversely, the adjusted capital wedge is negatively correlated with the equity-based constraint proxy. One interpretation of these findings is that firms with higher capital wedges are more likely to face barriers to debt financing, while their access to equity markets appears relatively less constrained. Overall, our regression results suggest that adjusted capital wedges likely reflect underlying frictions related to capital.

# 5 The Micro-Anatomy of the Divergence

This section presents the main empirical findings of the paper, shedding light on the primary drivers of the divergence between the measured aggregate return on capital and the risk-free rate.

## 5.1 The Macroeconomic Drivers

**Figure 9: The Role of Profits and True Return on Capital**




Note. Figure 9 presents the decomposition based on equation (27) for the period 1982 to 2020. It illustrates the evolution of the gap between the return on capital and the risk-free rate (solid blue line), alongside the contributions of the profit wedge (dash-dotted grey line) and the true return on capital (long-dashed orange line). The dots highlight the average between 2015-2020 for every variable.

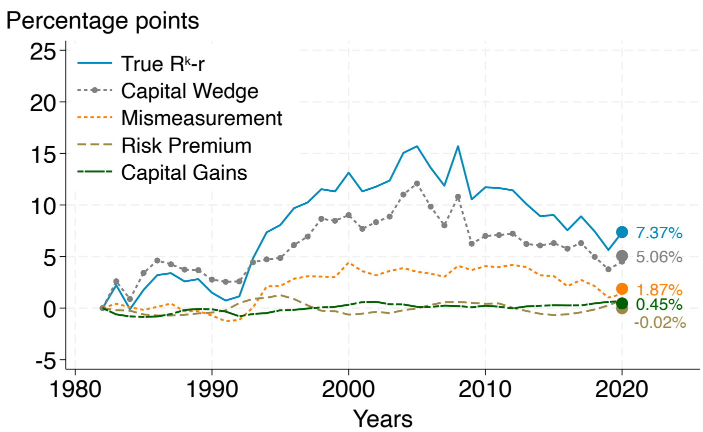
After measuring all the necessary firm-level objects required by our theory, we start by using equation (27) to isolate the contribution of the profit wedge from the underlying dynamics of the true return on capital. Figure 9 illustrates the evolution of these components and establishes our first main finding.

**Fact 1:** *Of the divergence between the measured return on capital and the risk-free rate, 20% is due to the profit wedge, while 80% is due to the missing decline in the true return on capital.*

Figure 9 shows that the gap between the measured return on capital and the risk-free rate has widened over time, averaging 9.25 percentage points between 2015 and 2020. It also depicts the counterfactual evolution of this gap under scenarios where only the profit wedge or only the true return on capital changes over time. If the profit wedge was the sole driver, the gap would have increased by about 1.88 percentage points, accounting for 20% of the divergence. In contrast, if only the true return on capital was responsible, the gap would have reached 7.37 percentage points, or 80%.

Thus, if the profit wedge was properly accounted for, the gap between the measured return on capital and the risk-free rate would have widened less over time. The finding that the rise in the profit wedge plays an important role aligns with the large literature documenting increased market power, as reviewed by Syverson (2024). Appendix C.3 shows that decomposing the profit wedge into markups and fixed costs reveals that both factors contributed roughly equally to the widening gap between the return on capital and the risk-free rate.

**Figure 10: The Drivers of The True Return on Capital and Risk-Free Rate Divergence**




Note. Figure 10 presents the decomposition based on equation (28) for the period 1982 to 2020. It illustrates the evolution of the gap between the true return on capital and the risk-free rate (solid blue line), alongside the contributions of the capital wedge (dotted grey line with circles), mismeasurment (dotted orange line), risk premium (dashed brown line), and capital gains (dash-dotted green line). The dots highlight the average between 2015-2020 for every variable.

Next, we investigate why the true return on capital has diverged from the risk-free rate. Using the decomposition in equation (28), we assess which of the potential drivers—capital gains, risk premia, missmeasurement, or the capital wedge—best accounts for this divergence.

Figure 10 presents the results of this decomposition and establishes our second main finding.

**Fact 2:** *Unlike previous findings, the divergence between the true return on capital and the risk-free rate has been driven mainly by a rising capital wedge, while the risk premium has remained relatively stable.*

Figure 10 shows that the capital wedge has been the main contributor to the divergence between the true return on capital and the risk-free rate, accounting for 5.06 percentage points—nearly 70% of the total divergence. The remaining gap is explained by mismeasurement, which increased by 1.87 percentage points. By contrast, the contributions of capital gains and the risk premium are minimal, at 0.45 and −0.02 percentage points, respectively. Appendix D.1 demonstrates that the results in Figure 10 are robust to using alternative production functions, markup measures, and risk premium estimates, as discussed in Sections 4.3.1 and 4.3.3.

## 5.2 Unpacking the Capital Wedge

Here, we examine the roles of sectors, cohorts, and individual firms in driving the rise in the capital wedge.

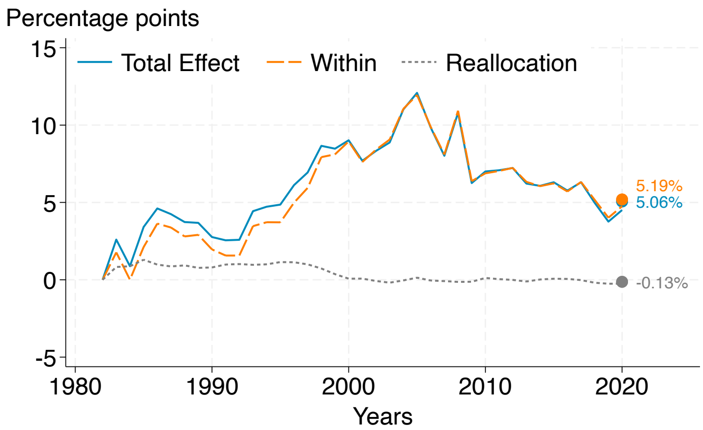
### 5.2.1 The Role of Sectors

This section examines the role of sectors—and their changing importance in the aggregate economy over time—in driving the rise in the capital wedge. To this end, we implement the following sectoral decomposition:

$$\Delta \boldsymbol{\tau}_t^{\text{adj}} = \underbrace{\sum_s \omega_{st-1} \Delta \boldsymbol{\tau}_{st}^{\text{adj}}}_{\Delta\text{within}} + \underbrace{\underbrace{\sum_s \Delta\omega_{st} \boldsymbol{\tau}_{st-1}^{\text{adj}}}_{\Delta\text{between}} + \underbrace{\sum_s \Delta\omega_{st} \Delta\tau_{st}^{\text{adj}}}_{\Delta\text{cross term}}}_{\Delta\text{reallocation}}, \tag{37}$$

where $\boldsymbol{\tau}_{st}^{\text{adj}} := \frac{\sum_{i \in \mathcal{I}^s} \omega_{it} \boldsymbol{\tau}_{it}^{\text{adj}}}{\sum_{i \in \mathcal{I}^s} \omega_{it}}$, $\omega_{st} := \sum_{i \in \mathcal{I}^s} \omega_{it}$, and $s$ represents a 2-digit NAICS sector. Although the main text focuses specifically on capital wedges, as they are the primary driver of the divergence, Appendix D.2 provides a similar analysis for the other components outlined in equation (28).

**Figure 11: Sectoral Decomposition of the Return on Capital and Risk-Free Rate Gap**




Note. Figure 11 illustrates the results of the sectoral decomposition in equation (37) for the period from 1982 to 2020. The solid blue line represents the evolution of the capital wedge, while the long dashed orange line depicts the evolution of the $\Delta$within component. The short dashed grey line shows the evolution of the $\Delta$reallocation component. The dots highlight the average between 2015-2020 for every variable.

Figure 11 presents the results of the sectoral decomposition in equation (37) for the period 1982–2020 and establishes our third main finding.

**Fact 3:** *Changes in sectoral composition played no role in the rise of capital wedges.*

We find that $\Delta$within accounts for the entire divergence between the return on capital and the risk-free rate, while $\Delta$reallocation makes no substantial contribution to this divergence. This remains true even when decomposing $\Delta$reallocation into $\Delta$between and $\Delta$cross-term components, both of which remain very small throughout the analysis period. Overall, these findings suggest that the root causes of the rise in the capital wedge are not driven by changes in the sectoral composition of the U.S. economy and must be sought elsewhere—a point to which we turn in the next section.

### 5.2.2 The Role of Cohorts

Here, we explore instead the role of cohorts in explaining the rise in the capital wedge. To this end, we implement the following cohort-level decomposition:

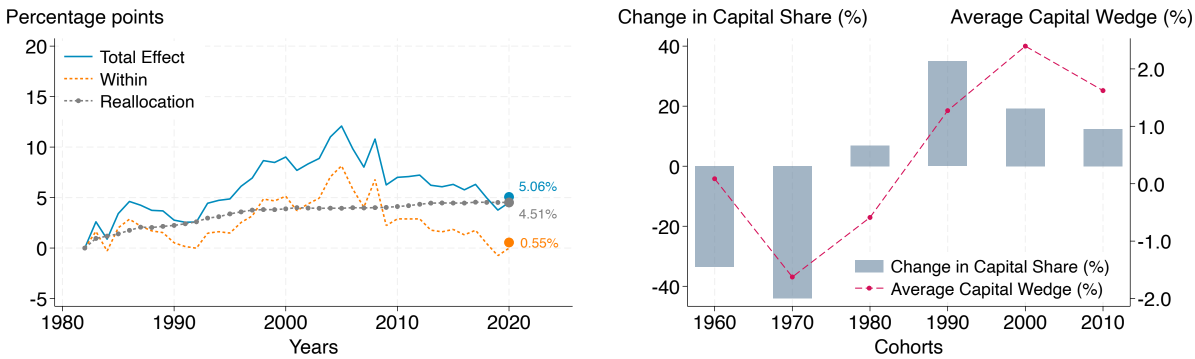
$$\Delta\boldsymbol{\tau}_t = \underbrace{\sum_c \omega_{c,t-1}\,\Delta\boldsymbol{\tau}^{\text{adj}}_{c,t}}_{\Delta\text{within}} + \underbrace{\underbrace{\sum_c \Delta\omega_{c,t}\,\boldsymbol{\tau}^{\text{adj}}_{c,t-1}}_{\Delta\text{between}} + \underbrace{\sum_c \Delta\omega_{c,t}\,\Delta\boldsymbol{\tau}^{\text{adj}}_{c,t}}_{\Delta\text{interaction}}}_{\Delta\text{reallocation}}, \tag{38}$$

where $\tau^{\text{adj}}_{c,t} := \frac{\sum_{i\in\mathcal{I}^c}\omega_{it}\tau^{\text{adj}}_{it}}{\sum_{i\in\mathcal{I}^c}\omega_{it}}$, $\omega_{c,t} := \sum_{i\in\mathcal{I}^c}\omega_{it}$, and $c$ indexes cohorts. Although we focus here specifically on capital wedges, the primary driver of the divergence, Appendix D.2 presents a comparable analysis for the other components in equation (28).

Figure 12 presents the results of the cohort-level decomposition in equation (38) for the period 1982–2020 and establishes our fourth main finding.

**Fact 4:** *The increase in capital wedges is driven by the reallocation of capital toward newer cohorts with higher capital wedges.*

**Figure 12: Cohort-Level Decomposition of the Return on Capital and Risk-Free Rate Gap**



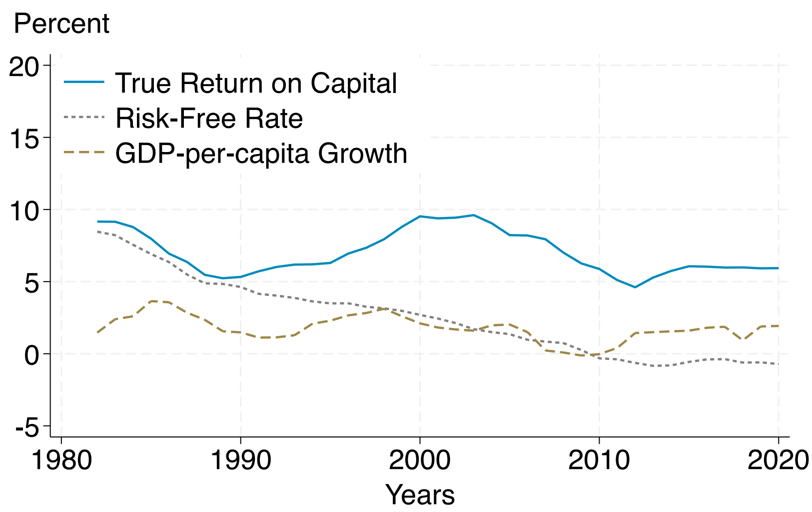

**(a) Cohort effects** **(b) Reallocation Across Cohorts**

Note. Figure 12a presents the results of the cohort-level decomposition in equation (38) for the period 1982–2020. The solid blue line shows the evolution of the capital wedge, the dotted orange line represents the $\Delta$within component, and the grey dotted line with circles depicts the $\Delta$reallocation component. Dots indicate the averages for each variable over 2015–2020. Figure 12b reports changes in capital share on the left y-axis as bars and average capital wedges on the right y-axis. Each grey bar represents the change in capital share by cohort, while the dashed line with circles shows the corresponding average capital wedge..

Figure 12a shows that $\Delta$reallocation accounts for most of the divergence between the return on capital and the risk-free rate, while $\Delta$within makes only a modest contribution. This result holds even when decomposing $\Delta$reallocation into its $\Delta$between and $\Delta$cross-term components, with the former driving the entire increase and the latter contributing nothing. Overall, these findings suggest that the rise in the capital wedge is driven by the reallocation of capital across cohorts.

Figure 12b further shows that this reallocation has been directed toward cohorts with higher average capital wedges—particularly younger cohorts born between 1990 and the 2000s.

**Figure 13: True Return on Capital: 1982-2020**




Note. Figures 13 illustrate the evolution of the true return on capital–that is, the measured return net of profits and measurement error–, the risk-free rate, and the growth rate of GDP per-capita. These series are smoothed using a 5-year rolling window.

This pattern underlies the dominant role of reallocation across cohorts in driving the rise in the capital wedge in equation (38).

# 6 Aggregate Implications

This section presents two aggregate implications. Section 6.1 provides the evolution of the true aggregate return on capital. Section 6.2 analyzes the effects of excess dispersion in return on capital on allocative efficiency.

## 6.1 True Return on Capital

Figure 13 shows the evolution of the true return on capital, defined as the measured return net of profits and measurement error. In contrast to the measured return, the true return has clearly trended downward, falling from approximately 9 percent at the beginning of the period to about 6 percent by 2020.

Despite this decline, the estimated return on capital remains above key benchmarks: it exceeds the average U.S. GDP per capita growth rate, which has remained below 2 percent over the past decade, and it is well above the risk-free rate, which has hovered near zero since the Great Recession. These findings confirm the observation by Piketty (2014) that capital returns have exceeded economic growth—and, at least in theory, wage growth. This finding also reinforces the concern raised by Reis (2022) about the dilemma central banks face in deciding whether to anchor policy rates to the risk-free rate or to the return on capital–especially given the sizable and persistent gap between the two.

## 6.2 Excess Dispersion and Aggregate Productivity

This section examines the aggregate consequences of excess dispersion in the cost of capital for allocative efficiency and overall productivity.

**Excess dispersion in the cost to capital.** Table 2 reports the variance in the cost of capital, defined as $R^k_{it} + \delta_{it}$, after demeaning by sector–year fixed effects, following standard practice. In the full sample, the variance is 0.46 (Column 1, Row 1). Imposing a zero adjusted capital wedge reduces this variance to 0.13 (Column 2, Row 1)—approximately 72% lower than its original value—indicating that capital wedges may exert sizable effects on aggregate productivity. In the subsample of firms with available proxies for frictions—the sample used in Section 4.3.4 for regression (36)—the variance is 0.36 (Column 1, Row 2). Setting to zero only the predicted component of the wedge from equation (36), i.e., $\beta\Upsilon_{it} = 0$, lowers the variance to 0.30 (Column 3, Row 2)—a reduction of about 14%.[13]

**Table 2: Excess Dispersion in the Cost of Capital**

| | $\mathbb{V}(R^k_{it} + \delta_{it})$ | $\mathbb{V}(R^k_{it} + \delta_{it} \,\vert\, \boldsymbol{\tau}^{\text{adj}}_{it} = 0)$ | $\mathbb{V}(R^k_{it} + \delta_{it} \,\vert\, \beta\Upsilon_{it} = 0)$ |
|---|---|---|---|
| Full sample | 0.46 | 0.13 | – |
| Subsample | 0.35 | 0.11 | 0.30 |

Note. This table reports the variance in the cost of capital under different counterfactual scenarios. $\mathbb{V}(R^k_{it} + \delta_{it})$ is the observed variance in the cost of capital. $\mathbb{V}(R^k_{it} + \delta_{it} \,|\, \boldsymbol{\tau}^{\text{adj}}_{it} = 0)$ is the variance when the adjusted capital wedge is set to zero. $\mathbb{V}(R^k_{it} + \delta_{it} \,|\, \beta\Upsilon_{it} = 0)$ is the variance when the predicted component of the capital wedge from regression (36) in Section 4.3.4 is set to zero. The full sample is the baseline dataset used throughout the paper, while the subsample includes only firms with the necessary predictors to estimate regression (36).

**Aggregate productivity.** To infer aggregate productivity losses for the U.S. from the observed excess dispersion in the cost of capital, we impose additional structure on the representative household's demand as compared to the framework in Section 3. Specifically, we

[13]The lower overall variance in this subsample reflects its composition, which consists primarily of larger firms that are less constrained and likely closer to their optimal size.

assume a standard CES demand aggregator given by:

$$\mathcal{D}(\{c_{it}\}) = \left( \sum_{i \in \mathcal{I}} c_{it}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{39}$$

where $\sigma$ denotes the elasticity of substitution across products. On the firm side, we assume the same production function used throughout the empirical analysis, given by:

$$q_{it} = z_{it} k_{it}^{\alpha} \ell_{it}^{1-\alpha}. \tag{40}$$

Moreover, firms face a heterogeneous cost of capital, $R_{it}^k + \delta_{it}$, as in Section 3. Given that the CES demand structure in equation (39) implies constant, homogeneous markups, to maintain consistency with the original framework and the empirical analysis, we introduce a firm-specific output tax, $(1 + \tau_{it}^q)$, which is observationally equivalent to allowing for heterogeneous markups across firms.

Thus, we can compute the total factor revenue productivity revenue ($TFPR$) that summarizes the distortions faced by the firms as follows:

$$TFPR_i = \left(\frac{1}{\alpha}\right)^{\alpha} \left(\frac{1}{1-\alpha}\right)^{1-\alpha} \underbrace{\frac{\sigma}{\sigma - 1} \frac{1}{(1 - \tau_{it}^q)}}_{:=\mu_{it}} \left(R_{it}^k + \delta_{it}\right)^{\alpha} (W_t)^{1-\alpha} \tag{41}$$

In our context, there are two sources of dispersion in $TFPR$: heterogeneous markups across firms, $\mu_{it}$, and heterogeneous costs of capital, $R_{it}^k + \delta_{it}$. In the absence of such distortions, $TFPR$ would be equalized across firms. Therefore, cross-firm variation in the cost of capital leads to deviations from this benchmark and reduces aggregate productivity.

Assuming the joint log-normality of $\{z_{it}, \tau_{it}^q, R_{it}^k + \delta_{it}\}$, aggregate productivity losses resulting from changes in dispersion in the cost of capital can be summarized as

$$\Delta \log TFP \approx \ -\left( \frac{\sigma \alpha^2}{2} + \frac{\alpha (1-\alpha)}{2} \right) \Delta \mathbb{V}(\log(R_{it}^k + \delta_{it})). \tag{42}$$

which can be used to quantify the aggregate productivity loss resulting from excess dispersion in the cost of capital.[14]

[14]The aggregate loss formula is an approximation, as it omits the covariance term $-\sigma\alpha\Delta\mathbb{C}(\log(R_{it}^k + \delta_{it}), \log \tau_{it}^q)$. This is a simplification to keep everything else constant and isolating the pure effect of changes in variance of the cost of capital. We also checked the covariance of $R_{it}^k + \delta_{it}$ and $\tau_{it}^q$ in different counterfactual scenarios, which we found to moderately decline. Thus, our results can be

The aggregate productivity loss is pinned down by counterfactual changes in the variance in the cost of capital that are equal to the following:

$$\Delta\mathbb{V}(\log(R^k_{it} + \delta_{it})) = \mathbb{V}(\log(R^k_{it} + \delta_{it})) \times \gamma_{\text{excess}} \tag{43}$$

where $\gamma_{\text{excess}}$ is the excess dispersion in percent in the cost of capital measure. From Table 2 $\gamma_{\text{excess}}$ is between -0.72 and -0.14, with the former calculated as the counterfactual variance obtained by shutting down wedges ((0.13-0.46)/0.46 from Table 2), while the latter is recovered as the counterfactual decrease in the variance from shutting down only the predicted part of the wedges ((0.30-0.35)/0.35 from Table 2). We set the elasticity of substitution between products in a sector, $\sigma$, to 3 in our baseline calibration, in line with Broda and Weinstein (2006). We set $\alpha$ equal to 0.27, which is the average estimate from our empirical analysis.

The baseline estimate of aggregate productivity losses, reported in Table 3, is 10.78%, based on the excess dispersion in the adjusted capital wedge from Table 2. When using the dispersion measure constructed from proxies for firm-level frictions, the estimated loss falls to 1.81%. Higher elasticities of substitution lead to markedly larger losses, as shown in Rows 2 and 3, because greater substitutability across firms expands the scope for reallocation from high-friction to low-friction firms, thereby amplifying the gains from removing such distortions. Overall, these results suggest that excess dispersion in the cost of capital, driven by capital wedges, can have sizable negative effects on aggregate productivity.

**Table 3: Aggregate Productivity Losses from Excess Dispersion in the Cost of Capital**

| | $\gamma_{\text{excess}} = 72\%$ | $\gamma_{\text{excess}} = 14\%$ |
|---|---|---|
| $TFP$ Loss (baseline, $\sigma = 3$) | 10.78% | 1.81% |
| $TFP$ Loss ($\sigma = 4$) | 12.06% | 2.03% |
| $TFP$ Loss ($\sigma = 5$) | 13.35% | 2.22% |

# 7 Conclusion

This paper develops a closed-form dynamic general equilibrium framework for disaggregated economies that decomposes the return on capital into firm-level contributions from markups, capital gains, risk premia, and capital wedges. Investigating why the return on capital has not

considered as the lower bound of the overall effect.

declined in line with the risk-free rate, we confirm the important role of profits. However, a key novel finding is that—contrary to much of the existing literature that emphasizes risk premia—rising capital wedges, driven by the reallocation of capital toward newer cohorts that exhibit high capital wedges, have been the primary force behind this phenomenon.

Our findings have important implications. First, after accounting for profits and measurement error, we find that the return on capital has declined, though not sufficiently to converge to the risk-free rate, and remains well above per capita output growth. In addition, capital wedges that have prevented a further decline in the aggregate return on capital may have reduced aggregate productivity by an estimated 2–13 percent.

This paper raises several challenging, albeit important, questions for future research. First, it identifies the proximate causes of the divergence between the return on capital and the risk-free rate, emphasizing the roles of markups, risk premia, and capital wedges. Although we do not address the fundamental sources of these components, future research aiming to do so must be guided by–and consistent with–the findings we highlight. While our decomposition cleanly separates profits, capital wedges, and risk premia, in practice, these forces may be jointly determined. Finally, although we applied this framework to the divergence between the return on capital and the risk-free rate within the U.S., a promising extension is to explore how markups, risk premia, and frictions contribute to cross-country differences in capital returns.

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# The Divergence Between the Return of Capital and the Risk-Free Rate: A Micro-Anatomy

Andrea Chiavari, Julia Faltermeier, and Sampreet S. Goraya

*Online Appendix*

# Contents

# A Additional Evidence on the Return on Capital and Risk-Free Rate Divergence

Here, we explain how the return on capital is calculated in the main text, present its historical evolution in comparison to the risk-free rate, and demonstrate that the divergence between risk free rate and return on capital remains robust across various measures of both return on capital and the risk-free rate.

**Measurement of return on capital.** To measure the aggregate return on capital in the national accounts, we follow equation (2). For aggregate measures, we follow Koh et al. (2020). In practice, our baseline measure of the return on capital is calculated as follows:

$$\mathcal{R}^k = \frac{NOS - CE - PI - DEP}{K}, \tag{A.1}$$

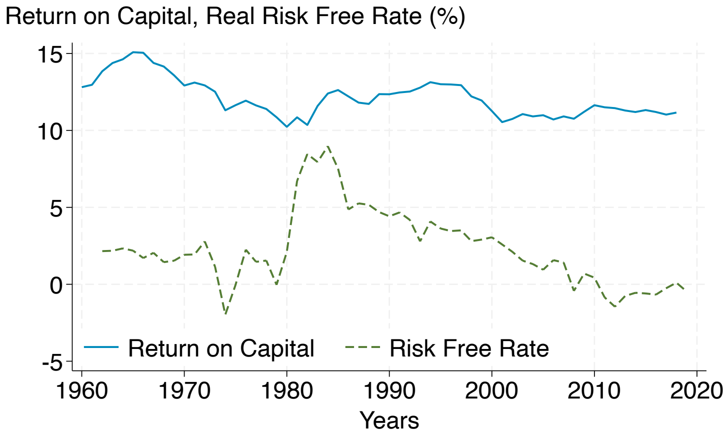
where $NOS$ is the net operating surplus, $CE$ represents compensation for employees (from NIPA Table 1.12), $PI$ refers to proprietors' income (also from NIPA Table 1.12), $DEP$ stands for depreciation (from the Fixed Assets Accounts Tables), and $K$ represents the fixed assets as defined by the BEA. This includes all non-residential structures, equipment, and intellectual property products (IPP).

**Historical evolution of return on capital versus the risk-free rate.** Figure A.1 presents the evolution of the return on capital and the risk-free rate since the 1960s. We find that the return on capital remains relatively flat over these six decades, consistent with the findings of Gomme et al. (2011) and Reis (2022). In contrast, the risk-free rate follows an inverted U-shaped pattern, in line with Rachel and Summers (2019).

**Additional measures of the return on capital and the risk-free rate.** Figures A.2a and A.2b show the evolution of alternative measures of the return on capital and the risk-free rate since the 1980s.

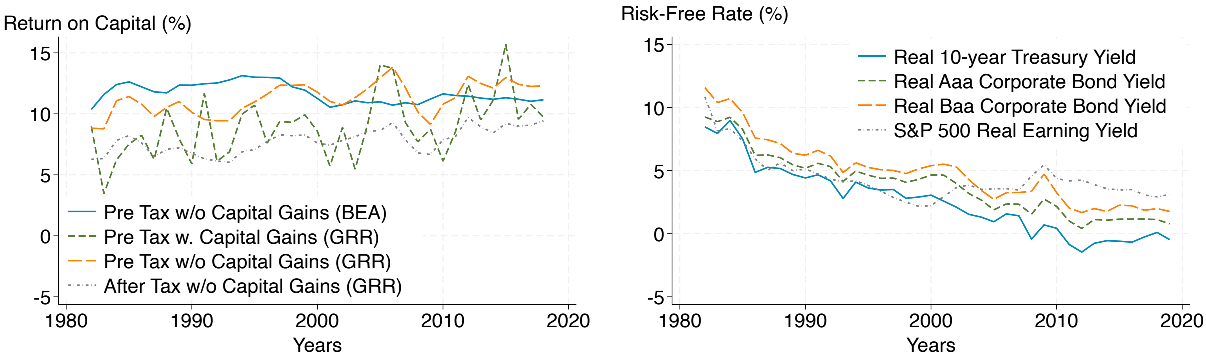
Figures A.2a illustrates the evolution of several alternative measures of the return on capital from Gomme et al. (2011). These measures focus on the business sector, thus excluding housing, and explicitly account for taxation and capital gains. While the inclusion of taxation and capital gains has only a modest impact on the level of the return on capital, it does

**Figure A.1: Historical Evolution of the Return on Capital and Risk-Free Rate**




Note. Figure A.1 shows the evolution of the return on capital and the risk-free rate, measured in percent, since 1960. The return on capital is measured using equation (2) with BEA data. The risk-free rate is the market yield on U.S. Treasury securities with a 10-year constant maturity net of expected inflation from Michigan.

**Figure A.2: Alternative Measures of Return on Capital and Risk-Free Rate Over Time**




**(a) Return on Capital** **(b) Risk-Free Rate**

Note. Figure A.2a presents the evolution of alternative measures of the return on business capital from Gomme et al. (2011), both before and after tax, and with and without capital gains. Figure A.2b displays alternative measures of the risk-free rate, as reported in Rachel and Summers (2019).

not affect its remarkable stability over time. This robustness to various adjustments is also documented in Reis (2022).

Figure A.2b presents the evolution of several alternative measures of the risk-free rate, similar to those used in Rachel and Summers (2019). Specifically, it shows the real AAA Corporate Bond yield, the real BBB Corporate Bond yield, and the S&P 500 Real Earnings yield, all of which exhibit a notably similar decline over time.

# B Microfounded Structural Decomposition

## B.1 Microfoundations for the Firms' Problem

In this section, we present alternative microfoundations for the capital wedge $\boldsymbol{\tau}$, as used in the main text. Specifically, we demonstrate that these wedges can be interpreted as financial frictions, adjustment costs, or measurement error.

**Financial frictions.** Assuming the presence of time-varying firm $i$ specific capital constraints $\kappa_{it}$, capturing the flexible presence of financial friction constraining capital expansions of the firm, then the Lagrangian objective function associated with the firm's cost minimization problem can be expressed as:

$$\mathcal{L}(\ell_{it}, k_{it}, \tau_{it}, \xi_{it}) = W_t \ell_{it} + R_{it} P_t^k k_{it} + f_{it} - \tau_{it} \left( \kappa_{it} - P_t^k k_{it} \right) - \xi_{it} \left( q(\cdot) - q_{it} \right), \tag{B.2}$$

where all variables are defined as in the main text, except that $\tau_{it}$ now represents the Lagrange multiplier associated with the constraint. The first-order conditions for both types of capital, along with the complementary slackness condition, are given by:

$$R_{it} + \tau_{it} = \frac{\xi_{it}}{P_t^k} \frac{\partial q(\cdot)}{\partial k_{it}} \tag{B.3}$$

$$\left( \kappa_{it} - P_t^k k_{it} \right) \geq 0 \tag{B.4}$$

$$\tau_{it} \left( P_t^k k_{it} - \kappa_{it} \right) = 0. \tag{B.5}$$

Note that equation (B.3) is isomorphic to equation (13) in the main text, as the right-hand side is exactly equal to $\mu_{it}^{-1} \frac{MRPK_{it}}{P_t^k}$.

**Adjustment costs.** Assuming that firms face capital-specific adjustment frictions, $\boldsymbol{\tau}(k_{it})$, the Lagrangian objective function for the firm's cost minimization problem can be expressed as:

$$\mathcal{L}(\ell_{it}, k_{it}, \xi_{it}) = W_t \ell_{it} + R_{it} P_t^k k_{it} - P_t \tau(k_{it}) + f_{it} - \xi_{it} \left( q(\cdot) - q_{it} \right). \tag{B.6}$$

The first-order conditions for both types of capital are given by:

$$R_{it} + \tau_{it} = \frac{\xi_{it}}{P_t^k} \frac{\partial q(\cdot)}{\partial k_{it}}, \tag{B.7}$$

where $\tau_{it} \equiv \partial\tau(k_{it})/\partial k_{it}$. Again, note that equation (B.7) is isomorphic to equations in the main text, as the right-hand side is exactly equal to $\mu_{it}^{-1} \frac{MRPK_{it}}{P_t^k}$.

## B.2 Proofs

### B.2.1 Proofs of Proposition 1

Equating capital supply (9) and capital demand (13) yields the following equation:

$$\frac{1}{\mu_{it}} \frac{MRPK_{it}}{P_t^k} - \tau_{it} = r_t + \delta_{it} - (1-\delta_{it}) \left( \frac{P_{t+1}^k}{P_t^k} - 1 \right) + \left( \frac{\mathbb{C}_{t-1}\left[ M_t, \frac{1}{\mu_{it}} \frac{MRPK_{it}}{P_t^k} - \tau_{it} \right]}{\mathbb{V}_{t-1}\left[ M_t \right]} \right) \left( -\frac{\mathbb{V}_{t-1}\left[ M_t \right]}{\mathbb{E}_{t-1}\left[ M_t \right]} \right) + \varepsilon_{it}. \tag{B.8}$$

Rearranging yields the following equation:

$$\frac{MRPK_{it}}{P_t^k} = r_t + \delta_{it} - (1-\delta_{it}) \left( \frac{P_{t+1}^k}{P_t^k} - 1 \right) + \left( 1 - \frac{1}{\mu_{it}} \right) \frac{MRPK_{it}}{P_t^k} + \tau_{it} + \varepsilon_{it} + \left( \frac{\mathbb{C}_{t-1}\left[ M_t, \mu_{it}^{-1} \frac{MRPK_{it}}{P_t^k} \right]}{\mathbb{V}_{t-1}\left[ M_t \right]} \right) \left( -\frac{\mathbb{V}_{t-1}\left[ M_t \right]}{\mathbb{E}_{t-1}\left[ M_t \right]} \right), \tag{B.9}$$

where, by construction, $\mathbb{C}_{t-1}[M_t, \tau_{it}] = 0$, since $\tau_{it}$ is defined as the residual component of the marginal product of capital that is orthogonal to the risk premium, and hence to the stochastic discount factor.[15]

Now define $\boldsymbol{\varrho}_{it} := (1-\delta_{it}) \left( \frac{P_{t+1}^k}{P_t^k} - 1 \right)$ as capital gains, $\boldsymbol{\mu}_{it} := \left( 1 - \frac{1}{\mu_{it}} \right) \frac{MRPK_{it}}{P_t^k}$ as the markup wedge, $\boldsymbol{\tau}_{it} := \tau_{it} + \varepsilon_{it}$ as the adjusted capital wedge, and $\boldsymbol{\zeta}_{it} := \boldsymbol{\beta}_{it} \boldsymbol{\lambda}_t$ as the risk premium, with $\boldsymbol{\beta}_{it} := \frac{\mathbb{C}_{t-1}\left[ M_t, \mu_{it}^{-1} \frac{MRPK_{it}}{P_t^k} \right]}{\mathbb{V}_{t-1}[M_t]}$ and $\boldsymbol{\lambda}_t := -\frac{\mathbb{V}_{t-1}[M_t]}{\mathbb{E}_{t-1}[M_t]}$.

Substituting these definitions delivers the generalized CAPM stated in Proposition 1. ■

[15] An alternative, though isomorphic, formulation would be to later define $\boldsymbol{\tau}_{it} := \tau_{it} + \varepsilon_{it} + \left( \frac{\mathbb{C}_{t-1}[M_t, \tau_{it}]}{\mathbb{V}_{t-1}[M_t]} \right) \left( -\frac{\mathbb{V}_{t-1}[M_t]}{\mathbb{E}_{t-1}[M_t]} \right)$, rather than simply $\boldsymbol{\tau}_{it} := \tau_{it} + \varepsilon_{it}$.

### B.2.2 Proof of Proposition 2

We begin with the definition of the measured firm-level return on capital:

$$\mathcal{R}_{it} := \frac{p_{it}q_{it} - f_{it} - \delta_{it}P_t^k k_{it} - W_t\ell_{it}}{P_t^k k_{it}}. \tag{B.10}$$

Next, we substitute the first-order conditions of the firm, given in equations (12) and (13), together with the generalized CAPM in equation (14). This gives the following expression:

$$\mathcal{R}_{it} = r_t - \boldsymbol{\varrho}_{it} + \boldsymbol{\zeta}_{it} + \boldsymbol{\tau}_{it} + \frac{p_{it}q_{it} - f_{it} - \mu_{it}^{-1}\mathcal{E}_\ell p_{it}q_{it} - \mu_{it}^{-1}\mathcal{E}_k p_{it}q_{it}}{P_t^k k_{it}}, \tag{B.11}$$

where $R_{it}^k := \mu_{it}^{-1}\frac{MRPK_{it}}{P_t^k} - \delta_{it} = r_t - \boldsymbol{\varrho}_{it} + \boldsymbol{\zeta}_{it} + \boldsymbol{\tau}_{it}$ is the true return on capital and $\boldsymbol{\pi}_{it} := \left(1 - \frac{\mathcal{E}_k + \mathcal{E}_\ell}{\mu_{it}}\right)\frac{p_{it}q_{it}}{P_t^k k_{it}} - \frac{f_{it}}{P_t^k k_{it}}$ is the profit wedge.

This establishes the decomposition stated in Proposition 2. ■

### B.2.3 Proof of Theorem 1

We begin with the definition of the aggregate measured return on capital:

$$\mathcal{R}_t = \frac{Q_t - \delta_t K_t - W_t L_t}{K_t}. \tag{B.12}$$

Expressing aggregate output and factor payments in terms of firm-level components, we obtain the following expression:

$$\mathcal{R}_t = \sum_{i \in \mathcal{I}} \left(\frac{P_t^k k_{it}}{\sum_{j \in \mathcal{I}} P_t^k k_{jt}}\right)\left(\frac{p_{it}q_{it} - f_{it} - \delta_{it}P_t^k k_{it} - W_t\ell_{it}}{P_t^k k_{it}}\right). \tag{B.13}$$

Noting that the second term inside the parentheses corresponds to the measured firm-level return on capital $\mathcal{R}_{it}$, equation (B.13) can be written as follows:

$$\mathcal{R}_t = \sum_{i \in \mathcal{I}} \left(\frac{P_t^k k_{it}}{\sum_{j \in \mathcal{I}} P_t^k k_{jt}}\right)\mathcal{R}_{it}. \tag{B.14}$$

Finally, substituting the firm-level decomposition from Proposition 2 into (B.14) yields the following decomposition

$$\mathcal{R}_t = \sum_{i \in \mathcal{I}} \omega_{it} \left( r_t - \boldsymbol{\varrho}_{it} + \boldsymbol{\zeta}_{it} + \boldsymbol{\tau}_{it} + \boldsymbol{\pi}_{it} \right), \tag{B.15}$$

where $\omega_{it} := \frac{P_t^k k_{it}}{\sum_{j \in \mathcal{I}} P_t^k k_{jt}}$ denotes the share of firm $i$ in the aggregate capital stock.

This completes the proof of Theorem 1. ■

# C Data and Measurement

## C.1 Data Cleaning and Summary Statistics

Here, we explain the data cleaning process. For data quality purposes, we interpret values for `sale`, $k$, `cogs`, or `xsga` as errors if they are zero, negative, or missing, and we exclude those observations. If `xrd`, `intano`, or `am` are negative or missing, we treat them as zeros. Finally, we winsorize `sale`, $k_{it}$, `cogs`, and `xsga` at the 0.5 percent level. Table C.1 provides summary statistics for these variables.

**Table C.1: Summary Statistics**

| | Sale | Cost of Goods Sold | Capital Stock | SG&A |
|---|---|---|---|---|
| Mean | 1,312.0 | 857.3 | 1,282.9 | 151.3 |
| p25 | 27.2 | 14.3 | 25.7 | 4.7 |
| p50 | 137.3 | 77.1 | 109.5 | 17.5 |
| p75 | 665.9 | 395.4 | 549.4 | 75.5 |
| No. Obs. | 186,416 | 186,416 | 186,416 | 186,416 |

Note. Summary statistics of the cleaned Compustat dataset between 1982 and 2020. All variables are in millions of USD. Capital stock is the sum of tangible and intangible capital. SG&A is the selling, general and administrative expenses.

## C.2 Production Function Estimation and Markups

**Production function estimation without first stage.** Relative to the benchmark production function, we follow production function estimation using Blundell and Bond (1998), which does not include the first stage.

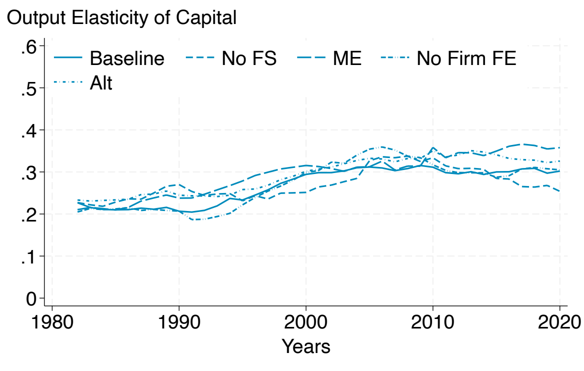
**Production function estimation with measurement error.** Following the methodology developed by Collard-Wexler and De Loecker (2021), we allow classical measurement error in the capital stock, and re-estimate the production function elasticities.

**Production function estimation a la Ackerberg and De Loecker (2024).** Here, we do not allow for firm fixed effects; therefore, we do not adopt the system GMM, but instead rely on the standard orthogonality conditions commonly used in the production function literature.

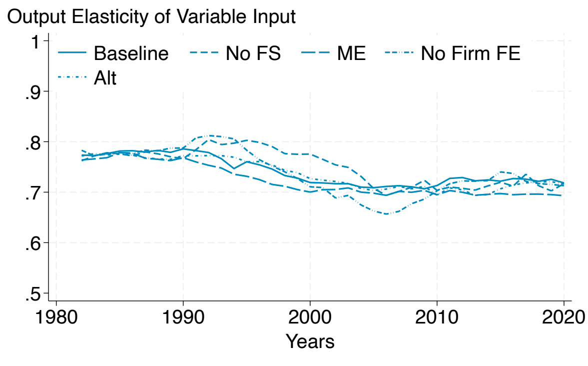
**Production function estimation with an alternative measure of intangible capital.** Here, instead of assuming that the first period intangible capital stock is zero, we assume that it is the ratio of the first year's investment in intangible capital over the depreciation rate.

**Results.** We plot the output elasticity of capital and labor for all these alternative estimation strategies in Figure C.3a and C.3b. The results are very similar regardless of the methodology applied. The output elasticity of capital has increased over time, in line with the findings of Chiavari and Goraya (2025). In contrast, output elasticity of variable input has declined in line with the findings of De Loecker et al. (2020). As our variable input includes wagebill, this finding is in line with a broader literature on the decline of the labor share at the firm-level.

**Figure C.3: Alternative Production Functions**




**(a) Capital Elasticity**

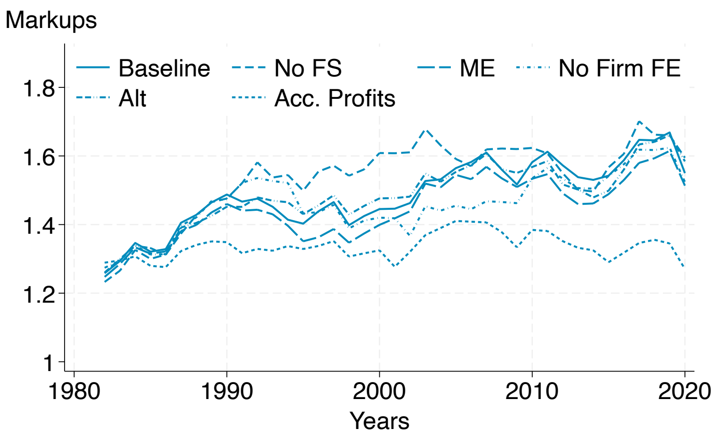



**(b) Variable Cost Elasticity**

Note. Figures C.3a, and C.3b show the evolution of elasticities for capital and variable costs across different production function estimation specifications. Each specification is explained in detail in Section C.2. Baseline: primary specification used in the paper (benchmark). No FS: variant that omits the first-stage correction used in the baseline identification. ME: baseline specification augmented with measurement error in the capital stock. No Firm FE: estimation a la Ackerberg and De Loecker (2024) without firm fixed effects and with standard moment conditions. Alt: production function elasticity estimates when the alternative measure of intangible inputs is used.

Figure C.4 presents the evolution of the various markup measures for all the production function estimation techniques. In addition, we also apply the accounting profit approach, following Baqaee and Farhi (2020), where markups are calculated as the ratio of sales to total costs. Overall, we find that the alternative markups are broadly consistent, displaying comparable trends over time, albeit with some differences in levels, as already noted in the literature (e.g., De Ridder et al., 2024).

**Figure C.4: Alternative Markups Measures**




Note. Figure C.4 presents the evolution of the various alternative markup measures. Markups are presented as simple averages. Baseline: primary specification used in the paper (benchmark). No FS: variant that omits the first-stage correction used in the baseline identification. ME: baseline specification augmented with measurement error in the capital stock. No Firm FE: estimation a la Ackerberg and De Loecker (2024) without firm fixed effects and with standard moment conditions Alt: markup estimates when an alternative measure of intangible inputs is used. Acc. Profits: markups computed using a standard accounting-based estimator as in Baqaee and Farhi (2020).

To further assess the similarity across different markup measures and move beyond simple mean comparisons, Tables C.2 and C.3 present the distribution of markups for the various alternative measures, along with their correlations. We find that the different markup measures exhibit surprisingly similar distributions across several moments and are highly and positively correlated. This is not entirely unexpected, as while there is some disagreement regarding the preferred method for estimating markups, there is broad consensus that most alternative measures display a positive trend and share comparable properties (e.g., Syverson, 2024). In conclusion, since the different measures exhibit very similar trends and only slight variations in their initial levels—differences that are not central in our methodology that focuses on trends relative to initial year–we conclude that neither the choice of markup measures nor the production function estimation methods significantly impact our results.

**Table C.2: Summary Statistics for Alternative Markup Estimates**

| | Mean | p10 | p50 | p90 | sd |
|---|---|---|---|---|---|
| Baseline | 1.523 | 0.834 | 1.204 | 2.409 | 1.125 |
| Alter. Intangible Measure | 1.521 | 0.829 | 1.199 | 2.413 | 1.134 |
| No Firm FE | 1.503 | 0.808 | 1.201 | 2.386 | 1.088 |
| Baseline + ME | 1.485 | 0.805 | 1.177 | 2.347 | 1.103 |
| No First-Stage | 1.561 | 0.817 | 1.223 | 2.478 | 1.248 |
| Accounting Approach | 1.221 | 0.879 | 1.169 | 1.660 | 0.390 |

*Note.* This table reports summary statistics for alternative estimators and specification choices used to compute firm-level markups. Columns show the cross-sectional mean, the 10th percentile (p10), the median (p50), the 90th percentile (p90), and the standard deviation (sd) of the markup distribution (firm–year observations) for each specification listed in the rows. Each specification is explained in detail in Section C.2. Baseline: primary specification used in the paper (benchmark). Alter. Intangible Measure: markup estimates when an alternative measure of intangible inputs is used. No Firm FE: baseline estimation without firm fixed effects. Baseline + ME: baseline specification augmented with measurement error in the capital stock. No First-Stage: variant that omits the first-stage correction used in the baseline identification (see text). Accounting Approach: markups computed using a standard accounting-based estimator as in Baqaee and Farhi (2020).

## C.3 Additional Results on Profit Wedge

**Profit wedge break down.** Here, we break down the evolution of profit wedge to highlight the roles of markups and fixed costs separately. Figure C.5 illustrates this relationship, showing that the upward trend of the profit wedge after 2000 is entirely driven by the increase in markups.

Next, we compare the profit wedge defined in the main text with the profit rate presented in De Loecker et al. (2020) defined as follows:

$$\pi_t^r := \sum_{i\in\mathcal{I}} \left(\frac{p_{it}q_{it}}{\sum_{i\in\mathcal{I}} p_{it}q_{it}}\right)\left(1 - \frac{\mathcal{E}_\ell}{\mu_{it}} - \frac{f_{it}}{p_{it}q_{it}} - \frac{(r+\delta)k_{it}}{p_{it}q_{it}}\right) \tag{C.16}$$

Thus, the profit wedge and the profit rate capture distinct concepts that serve different theoretical purposes: the former measures profits per unit of capital, while the latter measures profits per unit of sales.

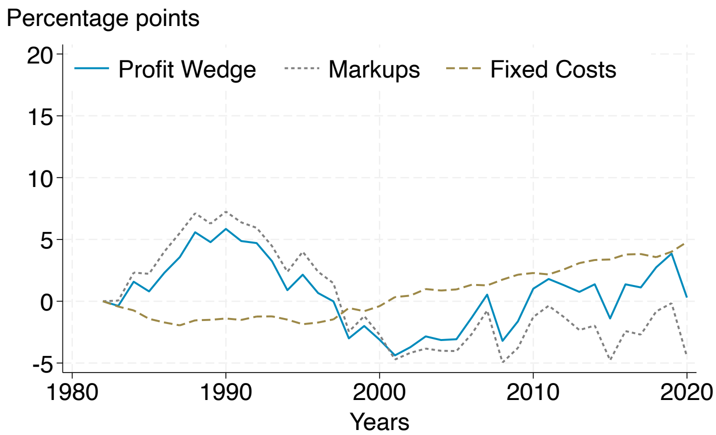
Figure C.6 plots our baseline profit wedge (solid blue line) alongside the profit rate se-

**Table C.3: Correlations for Alternative Markup Estimates**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Baseline | 1.000 | | | | | |
| No First-Stage | 0.970 | 1.000 | | | | |
| Baseline + ME | 0.997 | 0.978 | 1.000 | | | |
| No Firm FE | 0.993 | 0.958 | 0.989 | 1.000 | | |
| Alter. Intangible Measure | 0.999 | 0.971 | 0.997 | 0.991 | 1.000 | |
| Accounting Approach | 0.571 | 0.565 | 0.570 | 0.567 | 0.570 | 1.000 |

*Note.* This table reports pairwise correlations between markup estimates computed under alternative specifications (firm–year observations). The row and column order is identical. Each specification is explained in detail in Section C.2. Baseline: primary specification used in the paper (benchmark). Alter. Intangible Measure: markup estimates when an alternative measure of intangible inputs is used. No Firm FE: baseline estimation without firm fixed effects. Baseline + ME: baseline specification augmented with measurement error in the capital stock. No First-Stage: variant that omits the first-stage correction used in the baseline identification (see text). Accounting Approach: markups computed using a standard accounting-based estimator as in Baqaee and Farhi (2020).

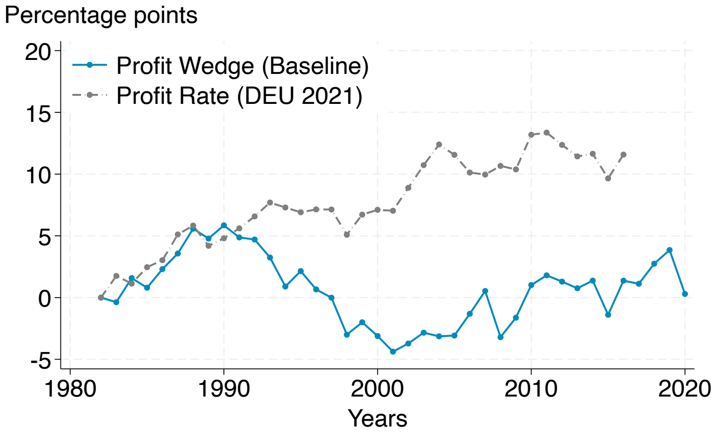
**Figure C.5: Profit wedge, Markups, and Fixed Costs**




Note. Figure C.5 displays the evolution of the profit wedge over time, breaking down its overall profit evolution into the contributions of markups and fixed costs.

ries from De Loecker et al. (2020) (dashed grey line, "RMP"). Two features stand out. First, the profit rate increases steadily, whereas the increase in the profit wedge is much smaller in magnitude. Second, the two series diverge sharply after the early 1990s: the profit rate continues its upward trend, while the profit wedge peaks in the early 1990s and then declines, turning negative around 2000 before partially recovering in the 2010s.

**Figure C.6: Profits Wedge Vs Profit Rate**




Note. Figure C.6 displays the progression of profits over time, breaking down the overall profit wedge as in our framework and the profit rate as defined in De Loecker et al. (2020).

## C.4 Additional Validations and Measurements of Capital Gains

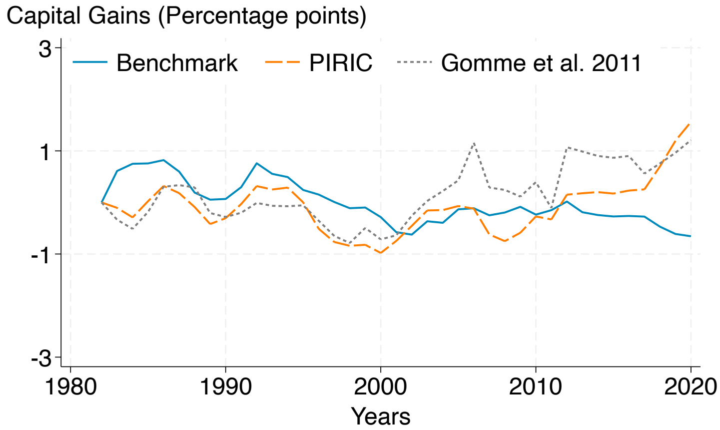
Figure C.7 shows that the documented evolution of capital gains is robust to alternative measures, whether based on the relative price of investment goods (PIRIC, FRED) or on the capital gains series from Gomme et al. (2011). The alternative series display only modest deviations from the baseline in the later part of the sample and—importantly—these deviations would imply an equal or larger increase in the capital wedge relative to our baseline measure, as capital gains enter negatively in the measurement of capital wedges. Hence, our benchmark estimate of capital gains can be interpreted as yielding a conservative lower bound on the rise in capital wedges.

## C.5 Additional Validations and Measurements of Risk Premium

Here, we present additional validations of our firm-level risk premium measure, demonstrating that it aligns well with standard theoretical predictions. We then show that alternative measures of firm-level risk premia exhibit a similar evolution over time, supporting the robustness of our conclusions.

**Validations.** To validate our estimates of firm-level risk premia, we examine their correlation with firm-level equity returns, capital used in production, and the ratio of capital to variable costs. Theory predicts that firms with higher capital risk premia should exhibit

**Figure C.7: Evolution of Capital Gains**




Note. Figure C.7 shows the evolution of the capital gains component 1982 to 2020 for different measures of the price of capital goods. The blue solid line represents the benchmark measure, the orange dashed line shows the evolution of capital gains with relative price of investment goods (PIRIC, FRED) and the grey dotted line shows capital-gains series from Gomme et al. (2011).

higher equity returns (David et al., 2022), lower levels of capital due to a higher user cost of capital, and a lower ratio of capital to variable costs, as risk premia affect the user cost of capital inputs but not of variable inputs.

**Table C.4: Correlations Between Risk Premia and Other Firm-Level Variables**

| *Dependent Variable* | $r^e$ (1) | $k$ (2) | $k/\ell$ (3) |
|---|---|---|---|
| Risk Premium, $\zeta$ | 0.149** | -0.346*** | -1.569*** |
| | (0.069) | (0.053) | (0.068) |
| *Fixed Effect* | | | |
| Firm | ✓ | ✓ | ✓ |
| Sector × Year | ✓ | ✓ | ✓ |
| *Controls* | | | |
| Age$^2$ | ✓ | ✓ | ✓ |
| Observations | 94,478 | 94,478 | 94,478 |

Note. All dependent variables except the equity return $r^e$ are in logs. $k$ is total capital (sum of tangible and intangible capital). $k/\ell$ is the ratio of total capital to the number of employees. Standard errors are clustered at the industry-year level and reported in parentheses. *, **, and *** denote 10, 5, and 1% statistical significance respectively.

Table C.4 presents the correlations between our firm-level risk premium on capital and firm-level equity returns, capital used in production, as well as the ratio of capital to variable costs. All specifications include firm and sector-year fixed effects and control for age-squared.

Standard errors are clustered at the sector-year level. We find that all correlations are statistically significant and align with standard theoretical predictions. In particular, the regression confirms that firms with higher estimated risk premia $\zeta$ earn higher equity returns, but systematically hold less capital and are substantially less capital intensive.

To further validate our measure, we test an additional prediction highlighted by David et al. (2022). Sectors with more dispersed risk premia are expected to exhibit higher proxies of misallocation, given by a greater dispersion in revenue-based marginal products of capital ($MRPK$) and in revenue total factor productivity ($TFPR$). This is the case because dispersion in risk premia implies dispersion in the user cost of both types of capital. Table C.5 tests and confirms these predictions in the data, showing that dispersion in risk premia is positively and statistically significantly associated with the dispersion of proxies for misallocation used in the literature. Overall, this evidence, along with the findings presented above, suggests that our risk premia measure captures many desirable properties of a good risk premium measure.

**Table C.5: Risk Premia Dispersion and (Mis)Allocation — $MRPK$ and $TFPR$**

| *Dependent Variable* | $\boldsymbol{\sigma(MRPK)}$ (1) | $\boldsymbol{\sigma(TFPR)}$ (2) |
|---|---|---|
| Std. Risk Premium, $\sigma(\boldsymbol{\zeta})$ | 1.446*** | 0.075 |
| | (0.180) | (0.054) |
| *Fixed Effects* | | |
| Sector | ✓ | ✓ |
| Year | ✓ | ✓ |
| Observations | 7,743 | 7,743 |

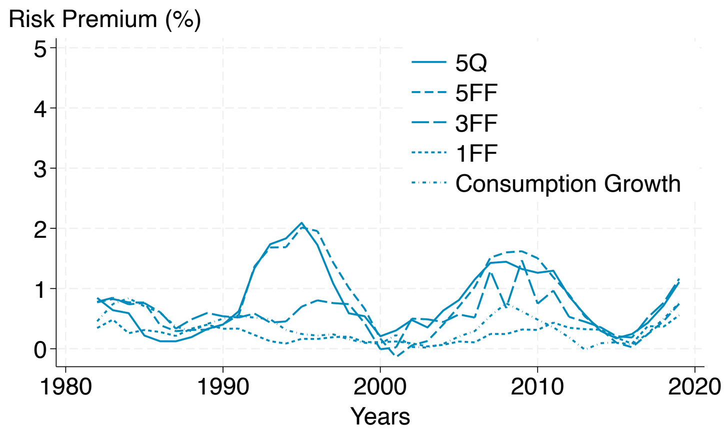
Note. Each column reports the coefficient from regressing the sector–year dispersion measure on the standard deviation of the firm-level risk premium, $\sigma(\boldsymbol{\zeta})$. Column (1)—$\sigma(MRPK)$—is the cross-sectional standard deviation of $\log(MRPK)$ across firms within a sector–year. Column (2)—$\sigma(TFPR)$—is the cross-sectional standard deviation of $\log(TFPR)$, where

$$\log(TFPR) = \log(p_{it}q_{it}) - \mathcal{E}_\ell \log(\ell_{it}) - \mathcal{E}_k \log(k_{it}),$$

and $\mathcal{E}_n$ and $\mathcal{E}_k$ are the input shares from production function estimation. All regressions include sector and year fixed effects. Standard errors clustered at the industry-year level are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

**Robustness.** Here, we present the evolution of the risk premium obtained using alternative factor models commonly found in the literature, including the 5-factor, 3-factor, and

**Figure C.8: Alternative Risk Premium Measures**




Note. Figure C.8 illustrates the evolution of the average capital-weighted risk premium across various factor models, including the baseline model, the Fama-French 5-factor model, the Fama-French 3-factor model, the Fama-French 1-factor model, and the consumption CAPM.

1-factor models from Fama and French (2023), as well as the consumption CAPM. Figure C.8 illustrates the evolution of the risk premium derived from these different factor models. Overall, they exhibit a quantitatively similar trend in the average capital-weighted risk premium over time compared to the model proposed by Hou et al. (2015), suggesting that the specific asset pricing model employed does not significantly influence the trend of the risk premium.

Additionally, to further validate the robustness of our results, we demonstrate in Table C.6 that the various firm-level risk premia derived from different asset pricing models are positively and highly correlated. This suggests that, despite some differences, they all capture a similar source of underlying firm risk, beyond just their average evolutionary trends.

**Table C.6: Correlation Matrix for Risk Premiums**

| | **MAIN** | **5FF** | **3FF** | **1FF** | **CCAPM** |
|---|---|---|---|---|---|
| 5Q (Baseline) | 1.00 | 0.75 | 0.63 | 0.37 | 0.54 |
| 5FF | 0.75 | 1.00 | 0.66 | 0.38 | 0.57 |
| 2FF | 0.63 | 0.66 | 1.00 | 0.51 | 0.59 |
| 1FF | 0.37 | 0.38 | 0.51 | 1.00 | 0.59 |
| CCAPM | 0.54 | 0.57 | 0.59 | 0.59 | 1.00 |

Note. This table reports pairwise correlations between risk premium computed under various specifications, including the 5Q (Baseline) model as in Hou et al. (2015), the Fama-French 5-factor model, the Fama-French 3-factor model, the Fama-French 1-factor model, and the consumption CAPM.

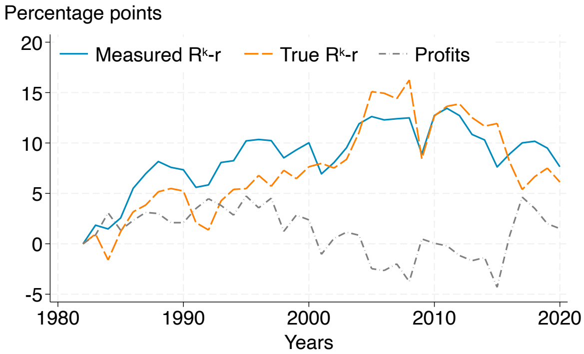
# D Robustness on Aggregate Trends

## D.1 Robustness Exercises of Section 5.1

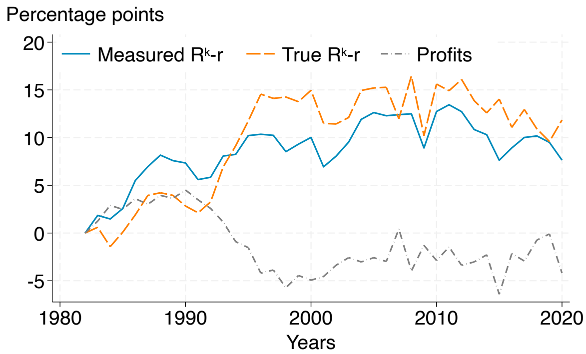
**Decomposition of measured aggregate return on capital.** Figures D.9a-D.9d show the decomposition of the measured aggregate return on capital into the profit wedge and the true return on capital for different robustness exercises. In Figure D.9a, we estimate the production function without the first stage. In Figure D.9b, we estimate a production function with measurement error. In Figure D.9c, we estimate a production function without firm fixed effects using standard moment conditions, instead of those used for system GMM, following Ackerberg et al. (2015). In Figure D.9d, we measure the production function with an alternative measure of intangible capital as explained in Section C.2. All figures show a very similar trajectory of each component showing that the robustness of the results to the different production function estimation techniques.

**Decomposition of true return on capital.** Figure D.10a-D.10d presents four robustness checks for our decomposition of the true gap between the true return on capital and the risk-free rate into its components: the capital wedge, measurement error, the risk premium, and capital gains. Each panel repeats the decomposition under the different alternative specifications mentioned before. Across the four panels, the qualitative patterns are similar, with capital wedges accounting for most of the divergence.

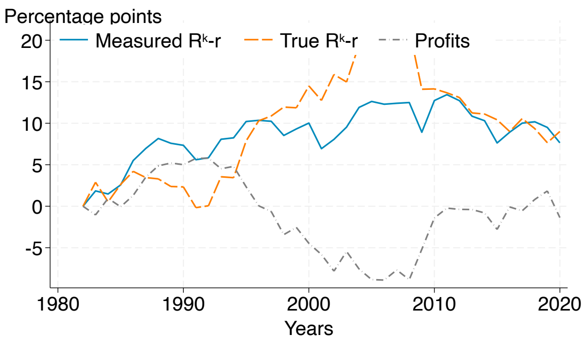
## Figure D.9: Robustness Figure 9



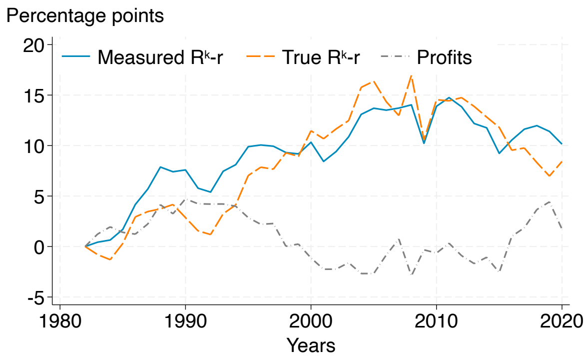

**(a) Baseline without First Stage**




**(b) Measurement Error in Capital**



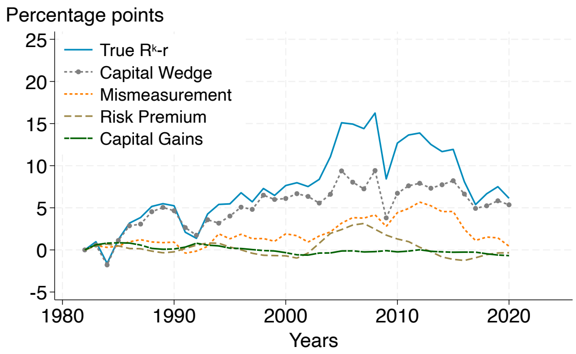

**(c) Baseline without Firm FE**



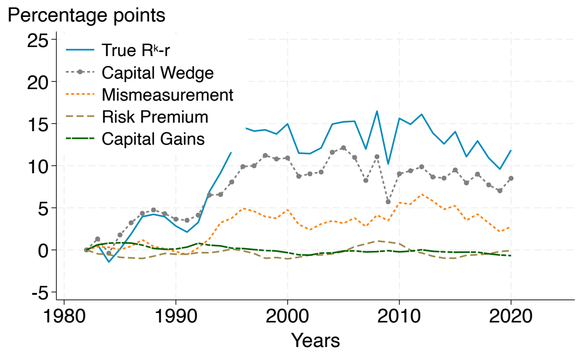

**(d) Baseline with Alt. Intangible Measure**

Note. Figures D.9a-D.9d show the decomposition of the measured return on capital into the profit rate and the true return on capital for different robustness exercises. In Figure D.9a, we estimate the production function without the first stage. In Figure D.9b, we estimate a production function with measurement error. In Figure D.9c, we estimate a production function without firm fixed effects. In Figure D.9d, we measure the production function with an alternative measure of intangible capital as explained in section C.2.

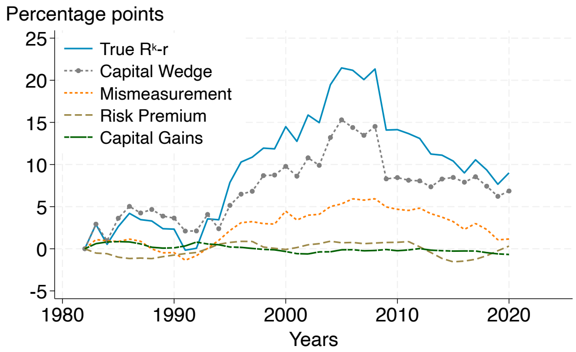
## Figure D.10: Robustness Figure 10



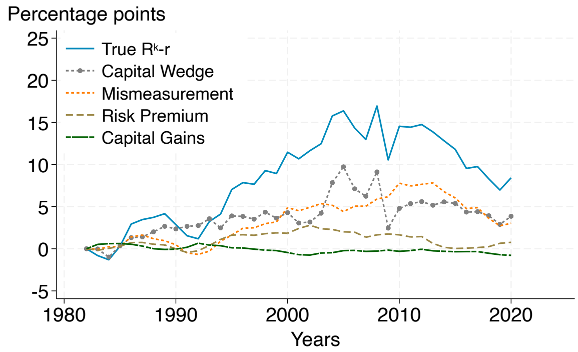

**(a) Baseline without First Stage**




**(b) Measurement Error in Capital**




**(c) Baseline without Firm FE**



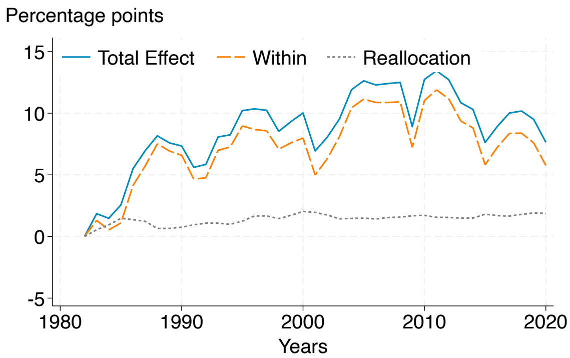

**(d) Baseline with Alt. Intangible Measure**

Note. Figures D.10a-D.10d show the decomposition of the true return on capital into risk premium, capital wedge and capital gains for different robustness exercises. In Figure D.10a, we estimate the production function without the first stage. In Figure D.10b, we estimate a production function with measurement error. In Figure D.10c, we estimate a production function without firm fixed effects. In Figure D.10d, we measure the production function with an alternative measure of intangible capital as explained in section C.2.

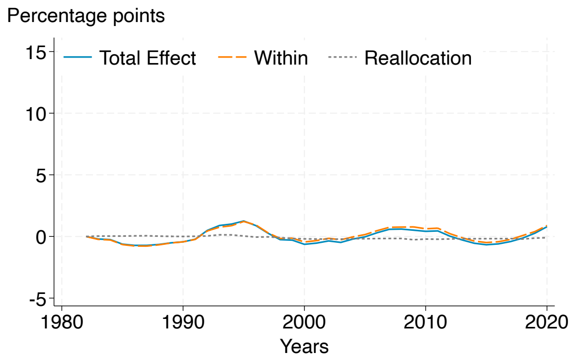
## D.2 Additional Findings of Sectoral Decomposition

Figures D.11a–D.11d illustrate the sectoral decomposition of the deviation $R^k - r$, the risk premium, profits, and capital gains, respectively. Overall, we find that the within component of the sector-level decomposition is the primary driver of the evolution of all these components over time.

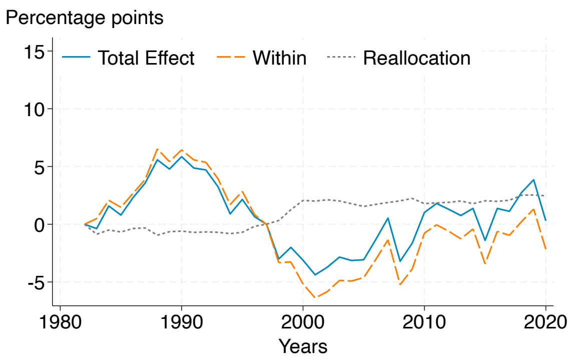
**Figure D.11: Sectoral Decomposition**



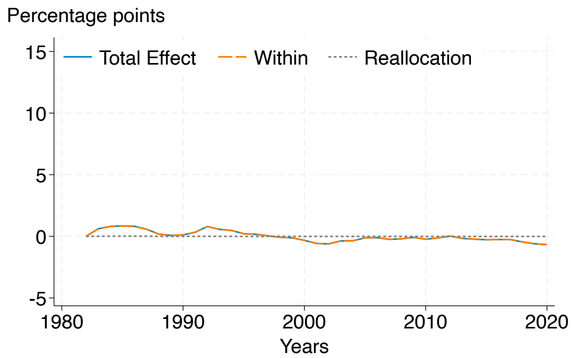

**(a) Deviation $R^k - r$**




**(b) Risk Premium**




**(c) Profits**




**(d) Capital Gains**

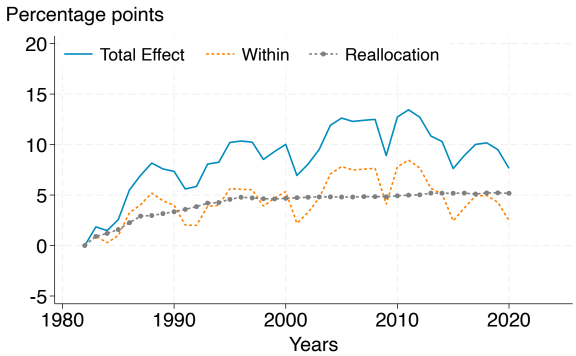
Note. Figures D.11a, D.11b, D.11c, and D.11d show the sectoral decomposition as in equation (37) of the overall difference between the return on capital and risk-free rate, profits, markups, and capital gains, respectively. The solid blue line represents the evolution of the overall effect, while the long dashed orange line depicts the evolution of the $\Delta$within component. The short dashed grey line shows the evolution of the $\Delta$reallocation component.

## D.3 Additional Findings of Cohort-Level Decomposition

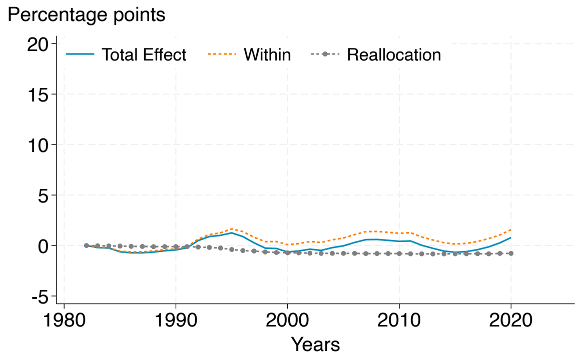
In the main text, we presented a cohort-level decomposition of the capital wedge. Here, we extend this analysis to provide a cohort-level decomposition for other variables in our model. Figures D.12a–D.12d show the cohort-level decomposition of the deviation $R^k - r$, the risk premium, profits, and capital gains, respectively. Several patterns emerge. First, the long-run gap between the return on capital and the risk-free rate $R^k - r$ is predominantly driven by reallocation between cohorts. This result corroborates our previous finding: the principal driver of the deviation $R^k - r$ is the reallocation of capital to (newer) cohorts with larger capital wedges. In contrast, the within-firm component is relatively more important for short-run, year-to-year fluctuations in the deviation $R^k - r$.

Second, the increase in the profits wedge–most pronounced after the 2000s–is mainly a within-cohort phenomenon: cohorts across the board have become more profitable over time rather than the effect being concentrated in a few cohorts. Finally, both the risk premium and capital gains exhibit little secular change; their contributions to the within and reallocation components are small and economically negligible. Overall, these results point to reallocation towards cohorts with high capital wedges and to a lesser extent within-cohort profit increases as the key drivers of the observed dynamics, with risk premia and capital gains playing only a minor role.

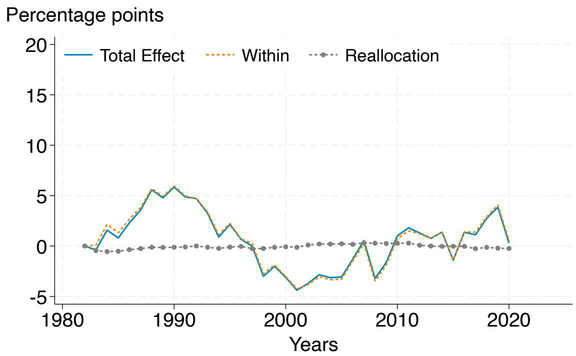
## Figure D.12: Cohort-Level Decomposition



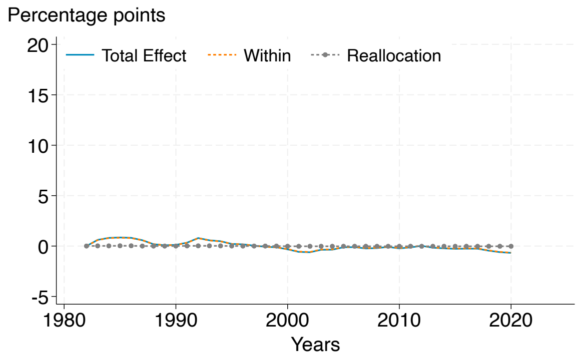

**(a) Deviation $R^k - r$**




**(b) Risk Premium**




**(c) Profit Wedge**




**(d) Capital Gains**

Note. Figures D.12a, D.12b, D.12c and D.12d show the cohort-level decomposition as in equation (38) of the deviation $R^k - r$, risk premium, and profits, respectively. The solid blue line shows the evolution of the capital wedge, the dotted orange line represents the $\Delta$within component, and the grey dotted line with circles depicts the $\Delta$reallocation component.