Do Productivity Shocks Cause Inputs Misallocation?

EEA Rotterdam 2024

Davide Luparello
Penn State University

August 21, 2024

Impact of Productivity on Firm Decisions

- **Firm productivity:** central to operational and investment decisions.
- High productivity expectations:
  - Increase orders for manufacturing inputs.
  - Expand staff and facilities.
  - Allocate more funds to R&D.
- Low productivity expectations:
  - Adopt conservative strategies.
  - Focus on cost reduction and profitability maintenance.

Productivity Uncertainty, Heterogeneity, and Misallocation

- **Dynamic uncertainty:**
  - ▶ Forecasting productivity is inherently uncertain.
  - ▶ Productivity shocks are unpredictable, causing gaps between anticipated and actual productivity.
  - → Unexpected productivity changes over time result in ex-post misallocation despite ex-ante optimal decisions.
- **Intra-industry productivity variability:**
  - ▶ Firms show diverse productivity levels, even within narrowly defined industries.
  - → Cross-firm productivity differences associated with input misallocation due to correlated distortions (e.g., financial frictions, firing costs).

Research Questions

1. **Productivity uncertainty and heterogeneity:**
   - How do these factors influence misallocation *for all* production inputs?
2. **Productivity shocks timing:**
   - How do shocks *at different stages of the input decision timeline* affect input misallocation?

- **A note on misallocation:**
  - I use the dispersion of marginal revenue product (MRP) across firms as a measure, aligning with established methods.
    (Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009)
- **Why should we care?**
  - Although some uncertainty is unavoidable, policies can help mitigate the uncertainties firms face, reducing misallocation.
  - Accurate measurement is crucial to avoid misattributing the impact of these factors and proposing misguided policy prescriptions.

What I Do

1. **Heterogeneous firms non-parametric production model:**
    - Accounts for various types of distortions, with productivity uncertainty as the sole explicitly modeled friction.
    - Considers productivity shocks at various stages of the input allocation.
    - Estimated using firm-level panel data (2000-2017) across Europe.
    - Yields micro-estimates of productivity and its components and MRPs.

2. **Estimate correlation between MRP and productivity dispersions:**

    → Reveals a positive association, for all inputs.

3. **Decomposition of productivity and associations with MRP dispersion:**

    → Productivity shocks primarily drive MRP dispersion, for all inputs.

4. **Comparison with standard factor shares approach to estimate variables and correlations of interest:**

    → Shows large bias compared to the baseline.

Literature Review and Contributions

- **Marginal products dispersion and misallocation**
  Restuccia and Rogerson (2008), Hsieh and Klenow (2009), Bartelsman, Haltiwanger, and Scarpetta (2009), Bartelsman, Haltiwanger, and Scarpetta (2013), Restuccia and Rogerson (2013), Asker, Collard-Wexler, and De Loecker (2014), David, Hopenhayn, and Venkateswaran (2016), Foster, Grim, Haltiwanger and Wolf (2017), Restuccia and Rogerson (2017), Gopinath et al. (2017), Bento and Restuccia (2017), Haltiwanger, Kulick, and Syverson (2018), David and Venkateswaran (2019), Bento and Restuccia (2021), Gollin and Udry (2021), Bils, Klenow, and Ruane (2021), Blackwood, Foster, Grim, Haltiwanger and Wolf (2021), Yang (2021), Ben Zeev (2023)

→ First paper that disaggregates productivity shocks by timing and analyzes their distinct effects on input misallocation across all production inputs.

- **Production function estimation**
  Olley and Pakes (1996), Levinsohn and Petrin (2003), Syverson (2004), Ackerberg, Caves and Frazer (2015), Gandhi, Navarro, and Rivers (2020), De Loecker, Eeckhout and Unger (2020), De Loecker and Syverson (2021)

→ This paper highlights the biases in the factor shares approach and suggests the use of models with richer dynamics to better analyze productivity evolution and its effects.

The Baseline Model

- The baseline production model builds on Gandhi, Navarro, and Rivers (2020) (GNR).

- A firm with productivity (TFPR) ν produces revenue using capital, labor, and material inputs:

$$y_{jt} = f(k_{jt}, l_{jt}, m_{jt}) + \nu_{jt}$$

- Firm's TFPR is composed of a persistent component, ω, and a shock component, ε, observed only at the end of period t:

$$\nu_{jt} = \omega_{jt} + \varepsilon_{jt}$$

- In turn, ω can be decomposed in past values, $m(\omega_{jt-1})$, known at the beginning of time t, and a forecast error, η, learned during period t:

$$\omega_{jt} = m_t(\omega_{jt-1}) + \eta_{jt}$$

- The firm is a price-taker in the input and output market, and prices are heterogeneous.

The Allocation Decisions

1. At the end of period $t-1$, the firm knows the TFPR, ν_{jt-1}, and observed revenue.

2. Using this information, the firm decides on labor L_{jt} and capital K_{jt} for period t, given input prices.

3. At the start of period t, the firm observes a productivity shock, η_{jt}, and updates its TFPR expectation.

4. The firm then decides on materials allocation M_{jt} to maximize value-added, based on the updated productivity information and input prices.

5. Before period t ends, the firm observes the final shock, ε_{jt}, and determines the TFPR ν_{jt} and revenue.

- I refer to η_{jt} as the *ex-ante productivity shock* and ε_{jt} as the *ex-post productivity shock*, relative to the material inputs allocation.

How Productivity Shocks Cause Misallocation

- The theoretical framework predicts that the total change in firm-time level MRP for input X due to variation in each TFPR component can be specified as:

$$\frac{dmrp_{jt}^X}{d\theta} = \frac{dy_{jt}}{d\theta} - \frac{dx_{jt}}{d\theta} + \frac{d\log \text{elas}_{jt}^X}{d\theta} \quad \forall \theta \in \{\omega_{jt-1}, \eta_{jt}, \varepsilon_{jt}\}$$

- Combined, these effects yield the total impact of TFPR variations on an input's MRP.

Rationale:

- Past productivity levels influence expected returns and input allocations through correlated distortions.
- Ex-post shocks affect final observed revenue but not input allocations.
- Ex-ante shocks result in changes in material allocation and affect observed revenue and its elasticity to inputs.

Data and Empirical Approach

- European manufacturing firms' annual balance sheet panel data (unbalanced) sourced from MICROPROD dataset (Altomonte and Coali 2020).

  France (2000-2017), Germany (2004-2017), Italy (2000-2017), Poland (2004-2017), Romania (2004-2017), Spain (2000-2017)

- Key information collected: *Operating Revenue*, *Number of Employees*, *Cost of Materials*, *Total Fixed Assets*, *Cost of Employees*.

- 2-digit Industry deflators for intermediate inputs and gross output from EU-KLEMS.

Empirical approach for the baseline model:

- Model estimated in two steps using GMM (country-industry by country-industry)

Factor Shares (FS) Method: Partially Nested in GNR

- **More assumptions:**
  - Constant returns to scale.
  - Labor and materials are flexible inputs allocated after observing productivity.
- **Revenue elasticity:**
  - For labor and materials: matches the proportion of input's expenditure in revenue.
  - For capital: retrieved via constant returns to scale (CRS).
- **TFPR estimation:**
  - Using a first-order Taylor Series expansion of the log revenue function:

$$\nu_{jt}^{FS} = y_{jt} - \text{elas}_{jt}^{K_{FS}} k_{jt} - \text{elas}_{jt}^{L_{FS}} l_{jt} - \text{elas}_{jt}^{M_{FS}} m_{jt}$$

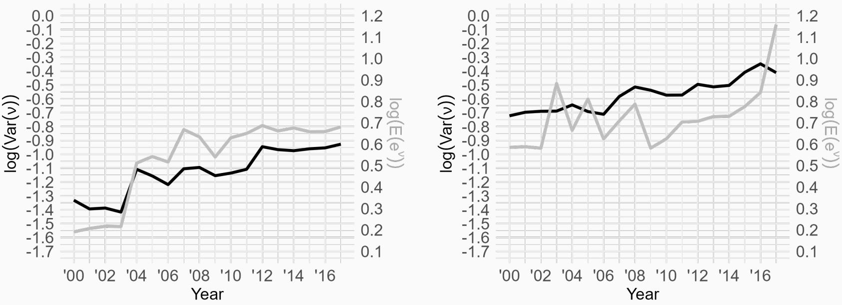
- **TFPR decomposition:**
  - Decomposes TFPR into two additive components:

$$\nu_{jt}^{FS} = \nu_{jt-1}^{FS} + \left(\nu_{jt}^{FS} - \nu_{jt-1}^{FS}\right)$$

  - The second component is referred to as the *shock* component.

Production Function Estimates: A Comparison

Figure 1: TFPR Dispersion and Mean Evolution

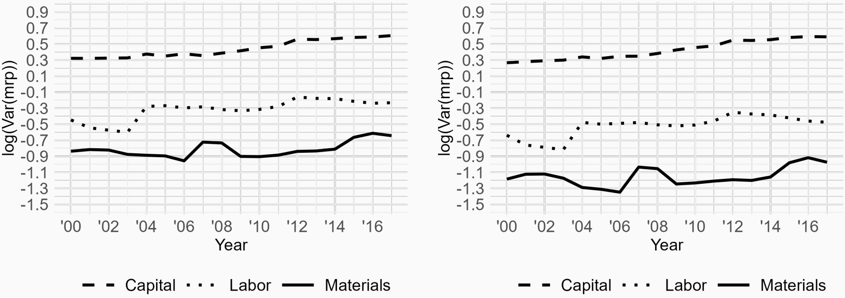


(a) Baseline - GNR **(b)** Factor Shares

- The FS approach shows comparable trends to the baseline-GNR approach.
- The FS method consistently overestimates the aggregate mean and variance.

Production Function Estimates: A Comparison

Figure 2: Inputs MRP Dispersion Evolution



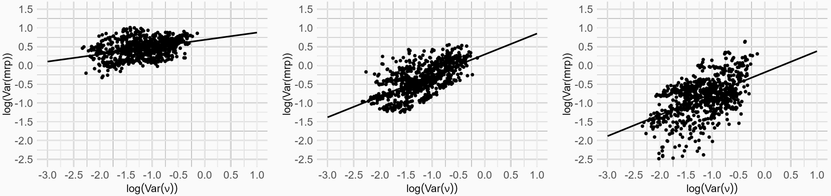
(a) Baseline - GNR

(b) Factor Shares

- FS approach shows similar capital MRP dispersion evolution as baseline.
- FS method underestimates MRP dispersion: 30% for labor, 40% for materials. Comparable temporal dynamics.

Inputs MRP and TFPR Dispersions

Figure 3: TFPR - MRP Correlation (Baseline-GNR)



(a) Capital **(b)** Labor **(c)** Material

- Scatterplot of the log variance (country-industry-time level) of log MRP (y-axis) against the log variance of TFPR (x-axis), slope 0.19 (K), 0.56 (L), 0.56 (M).

Inputs MRP and TFPR Dispersions

- Estimated the relationship between MRP dispersion and TFPR variability using the following linear model:

$$\log(\text{Var}_{cst}(\text{mrp}_{jt}^{X})) = \iota_{cs} + \iota_{ct} + \beta \log(\text{Var}_{cst}(\nu_{jt})) + e_{jt}$$

- $\text{Var}_{cst}(\text{mrp}_{jt}^{X})$: Variance of the (log) MRP for input X at the country-sector-time level.

- The coefficient β estimates the average elasticity of MRP dispersion with respect to TFPR variance.

- $\text{Var}_{cst}(\nu_{jt})$: Dispersion of TFPR at the same level of aggregation.

- ι_{cs} and ι_{ct}: Country-industry and country-time fixed effects.

- Observations weighted by the industry revenue share of the country's annual manufacturing revenue.

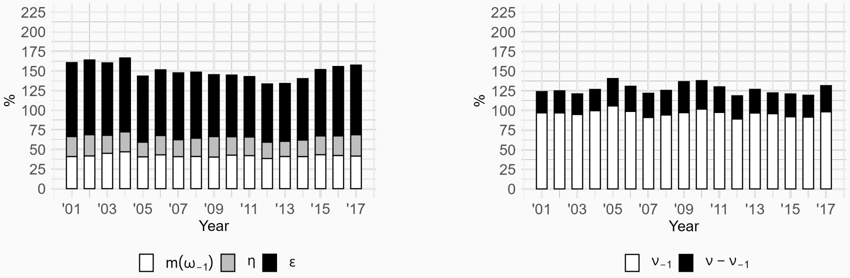
Inputs MRP and TFPR Dispersions

	Capital		Labor		Materials	
	Baseline - GNR	Factor Shares	Baseline - GNR	Factor Shares	Baseline - GNR	Factor Shares
β	0.298	0.283	0.409	0.286	0.550	1.083
	(0.038)	(0.054)	(0.033)	(0.097)	(0.078)	(0.143)
N	768	768	768	768	768	768
R^2	0.950	0.943	0.967	0.965	0.908	0.922
RMSE	0.061	0.061	0.078	0.082	0.175	0.197
Industry/Year FE	YES	YES	YES	YES	YES	YES

- Bootstrapped standard errors.
- Baseline-GNR estimates show a significant, positive average elasticity of MRP dispersion with respect to TFPR variance.
- The FS approach underestimates elasticities for capital and labor, while overestimating for materials.
- Overall, productivity dispersion is strongly associated with MRP dispersion across all inputs, confirming and extending previous findings.

Inputs MRP and TFPR Components Dispersions

Figure 4: Component Shares of TFPR Variance



(a) Baseline - GNR

(b) Factor Shares

- This figure illustrates the annual weighted average share of country-industry-year TFPR variance attributable to each TFPR component.
- Both figures indicate non-zero covariances between TFPR components.
- The FS approach overestimates the weight of past productivity and underestimates the weight of shock dispersion.

Inputs MRP and TFPR Components Dispersions

- Estimated the relationship between MRP dispersion and TFPR components (Baseline-GNR estimates) variability using the following linear models:

$$\log(\text{Var}_{cst}(\text{mrp}^X_{jt})) = \iota_{cs} + \iota_{ct} + \beta_{\omega_{-1}} \log(\text{Var}_{cst}(\omega_{jt-1})) + \beta_{\eta} \log(\text{Var}_{cst}(\eta_{jt})) \\ + \beta_{\varepsilon} \log(\text{Var}_{cst}(\varepsilon_{jt})) + \sum_{z \in \{(\omega_{-1},\eta),(\omega_{-1},\varepsilon),(\eta,\varepsilon)\}} \beta_z \log(1 + \rho_{z,cst}) + e_{jt}$$

- The coefficient β estimates the average elasticity of MRP dispersion with respect to TFPR component variance.

- $\text{Var}_{cst}(\theta_{jt})$: Country-sector-time level dispersion of TFPR component.

- To avoid omitted variable bias, I include log transformations of Pearson correlation coefficients between TFPR components at the industry-time level: $\rho_{(\omega_{-1},\eta),st}$, $\rho_{(\omega_{-1},\varepsilon),st}$, and $\rho_{(\eta,\varepsilon),st}$.

Inputs MRP and TFPR Components Dispersions

	Capital	Labor	Materials
$\beta_{\omega_{-1}}$	0.051	0.061	0.022
	(0.033)	(0.031)	(0.049)
β_{η}	0.058	0.027	0.025
	(0.019)	(0.021)	(0.028)
β_{ε}	0.143	0.214	0.689
	(0.032)	(0.038)	(0.059)
N	720	720	720
R^2	0.945	0.965	0.955
RMSE	0.063	0.080	0.122
Industry/Year FE	YES	YES	YES

- Bootstrapped standard errors.
- Ex-post shock (ε) shows the highest sensitivity for all inputs.
- Pre-existing productivity (ω_{-1}) and ex-ante shock (η) have milder effects.

Summary and Implications

- **Key Contributions:**
  - First paper to analyze the link between different sources of productivity shocks and input misallocation across all production inputs.
    - → Positive association between MRP dispersion and TFPR variability for all inputs.
    - → Productivity shocks primarily drive MRP dispersion.
  - Highlights the importance of detailed productivity dynamics for understanding input misallocation.
    - → FS approach has limitations in studying the effects of productivity evolution.
- **Policy Implications and Future Research Directions:**
  - Policies promoting stability and efficiency can mitigate misallocation.
  - Accurate measurement and accounting for productivity heterogeneity and uncertainty is crucial.
  - Important to examine specific policies or misallocation drivers (e.g., taxes, subsidies, financial frictions) to disentangle MRP dispersion due to firm heterogeneity from correlated frictions.

Thank you!