Productivity and Organization in Portuguese Firms

Lorenzo Caliendo, *Yale University*
Giordano Mion, *ESSEC and University of Nottingham*
Luca David Opromolla, *NCSU*
Esteban Rossi-Hansberg, *Chicago University*

Nottingham Lectures
March 2024

Introduction

- Firms are very heterogeneous in size, set of products, and organizational characteristics
  - Recent work in economics has underscored these differences to explain a variety of observed phenomena

  ...but little is known about the sources of this heterogeneity
  - Part of it can probably be safely treated as exogenous
    - ★ e.g. original or random inventions or improvements
  - Part of it is endogenous due to investments or organizational change
    - ★ A response to exogenous firm or economy-wide changes (e.g. a trade liberalization)
    - ★ Within-firm responses can have aggregate consequences
- Goal is to understand and measure these within-firm responses and their consequences

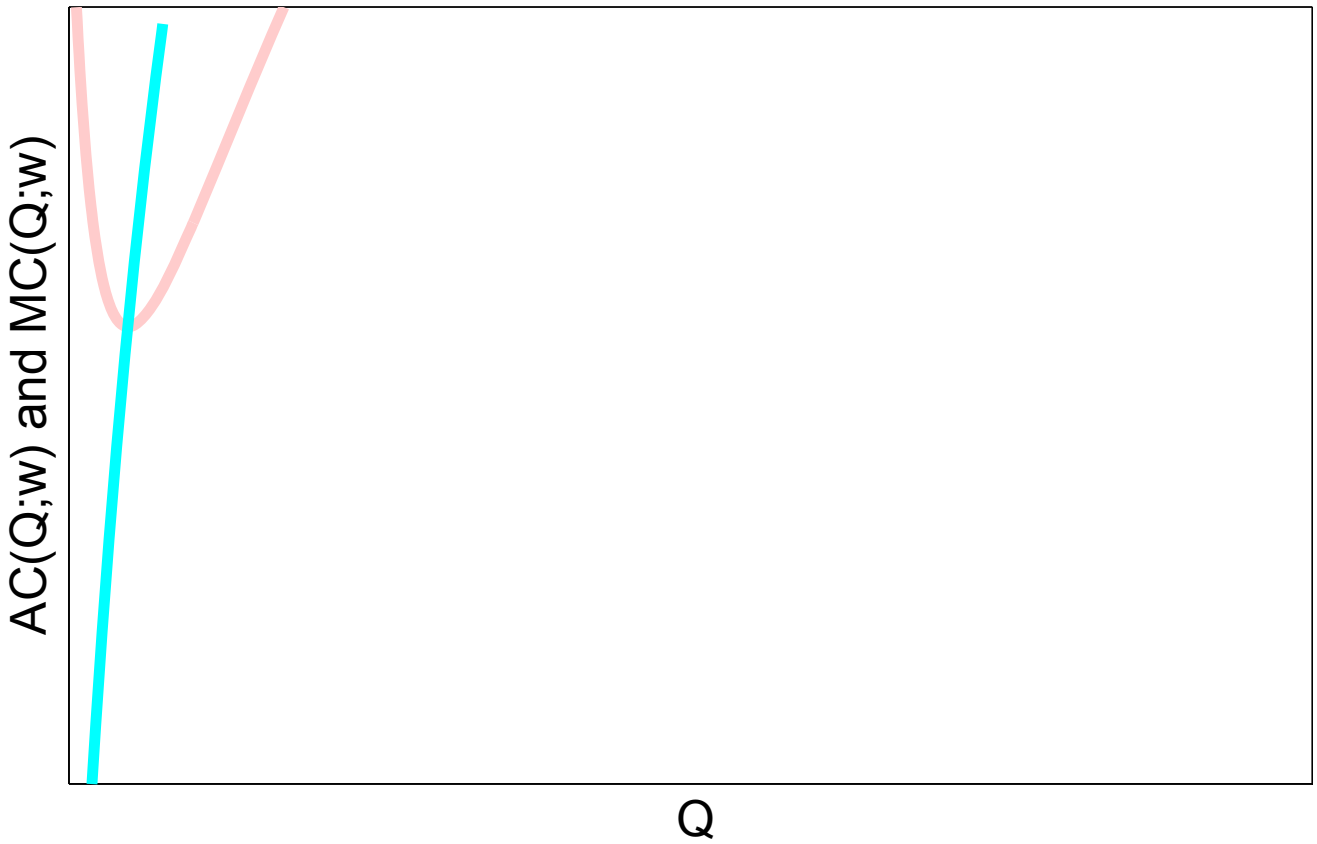
Introduction

- Consider a sudden increase in demand due to a product becoming fashionable
  - Firm can expand by adding a plant, a more complex management structure, a new division, etc.
- Suppose the firm decides to add a layer of management (a new division with a CEO that manages the whole firm)
  - The new organization is suitable for a larger firm which increases quantity-based productivity
  - Moreover, organizational structure fitted for a larger firm reduces marginal cost
    - ★ Leads to higher quantities and lower prices, which reduces revenue-based productivity

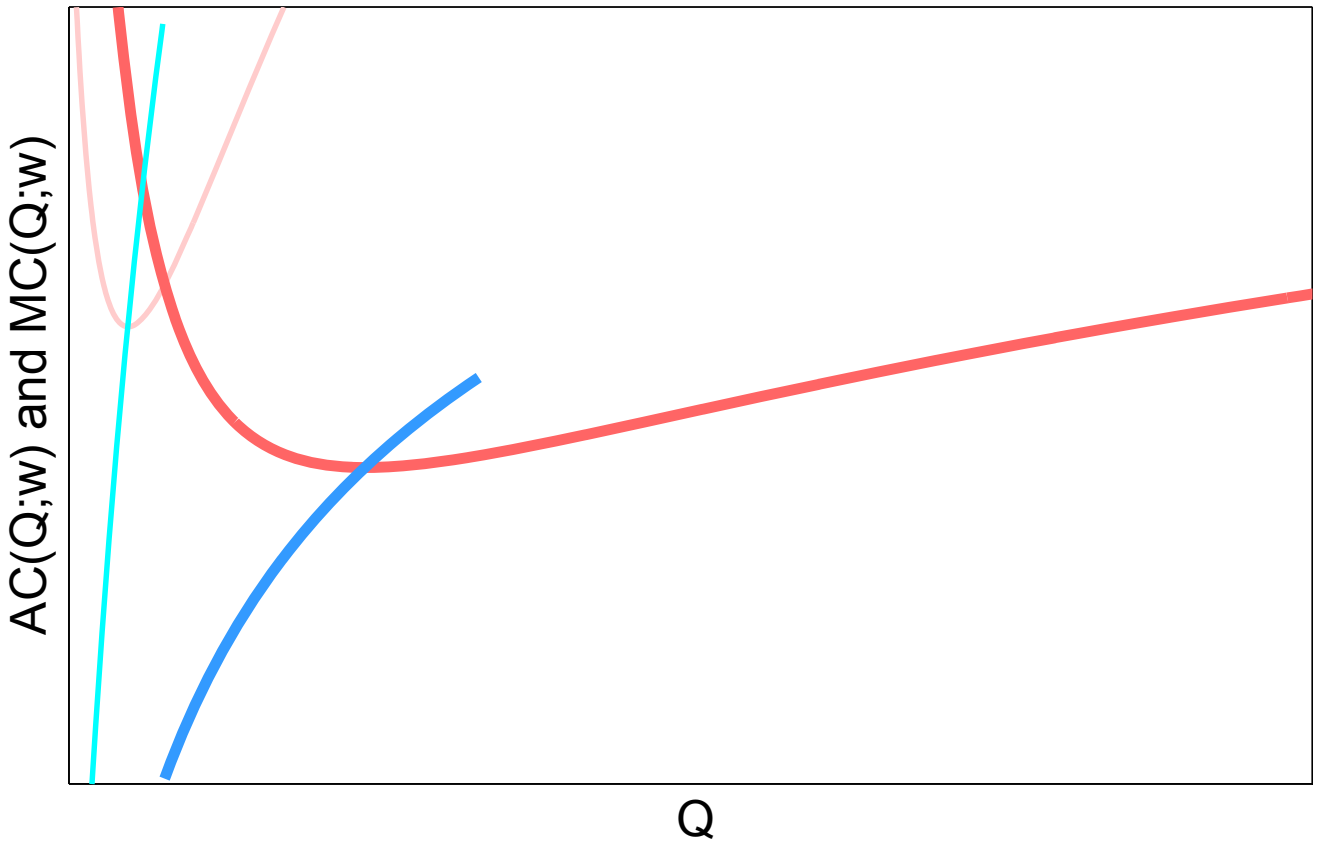
Introduction

- In this paper we explore the role that organization plays in determining firm productivity
  - We use the theory of knowledge-based hierarchies as a guiding tool as in Rosen (1982) and Garicano (2000)
    - ★ In particular the version in Caliendo and Rossi-Hansberg (2012)
  - Measure organization using the occupational composition of employment within firms
    - ★ As in Caliendo, Monte, and Rossi-Hansberg (2015)
  - Use detailed Portuguese firm-level and firm-product-level data to measure revenue-based and quantity-based productivity
    - ★ Need a flexible method that can incorporate demand shocks and organizational variables (Forlani et al., 2015)
  - Relate organization to revenue-based and quantity based productivity

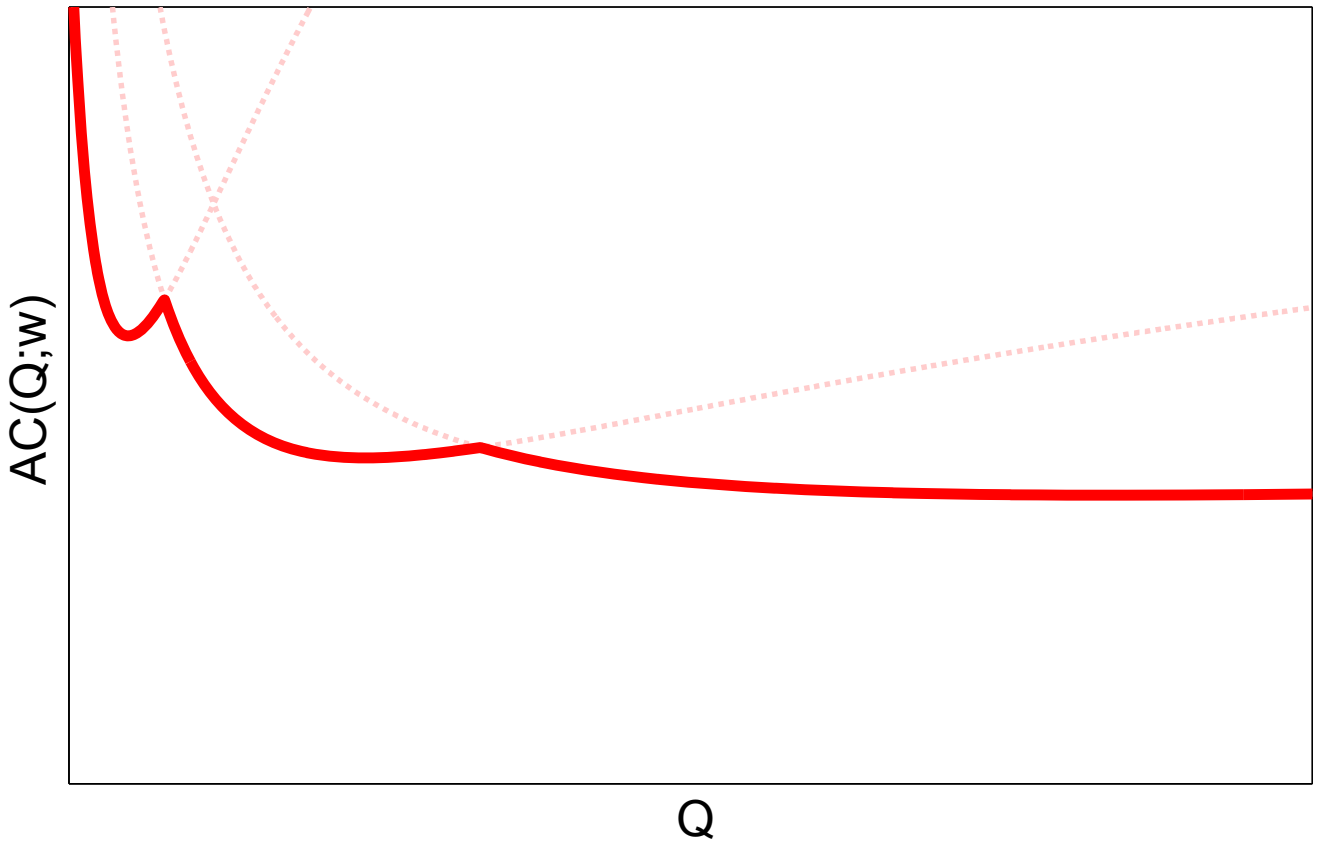
Sketch of the Theory - Marginal and Average Costs



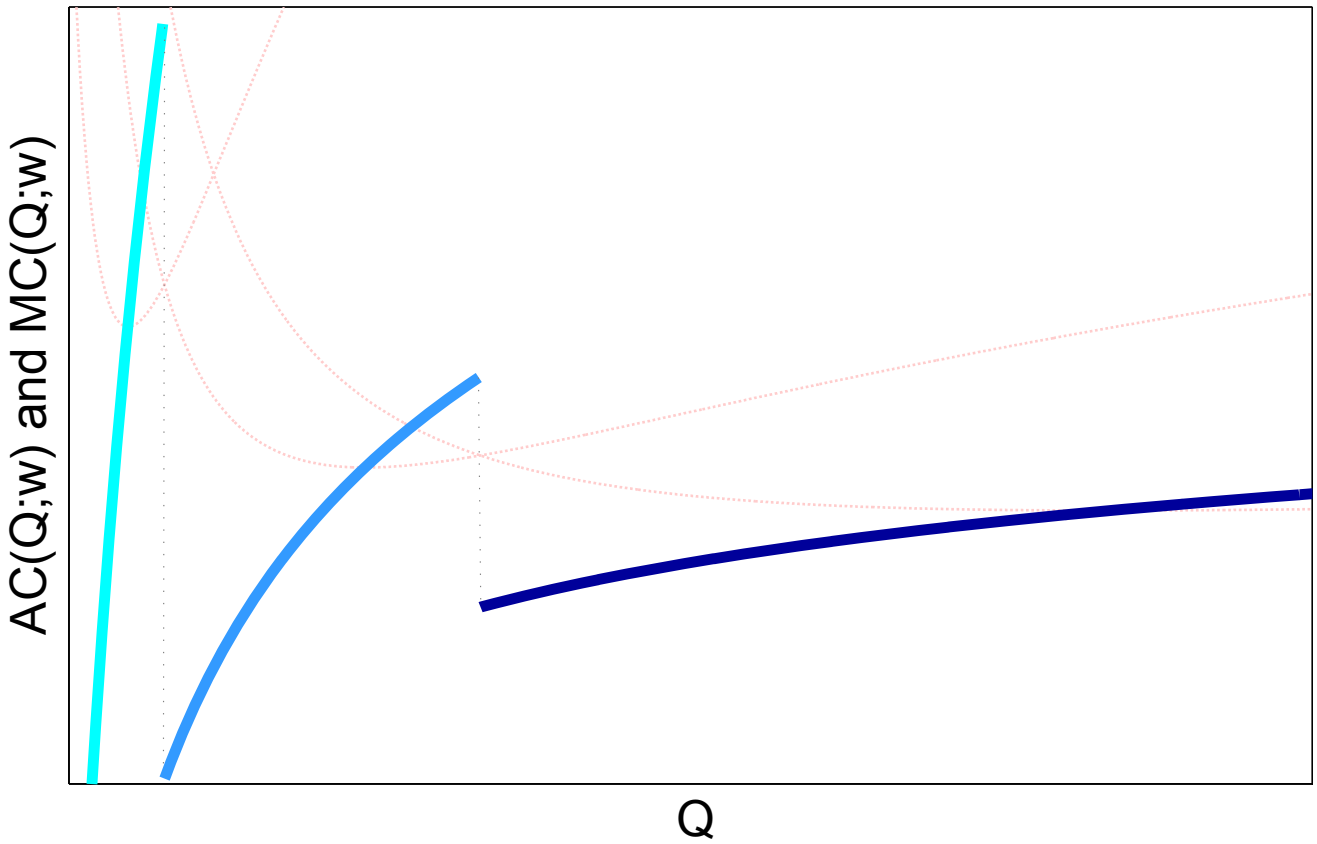
Sketch of the Theory - Marginal and Average Costs



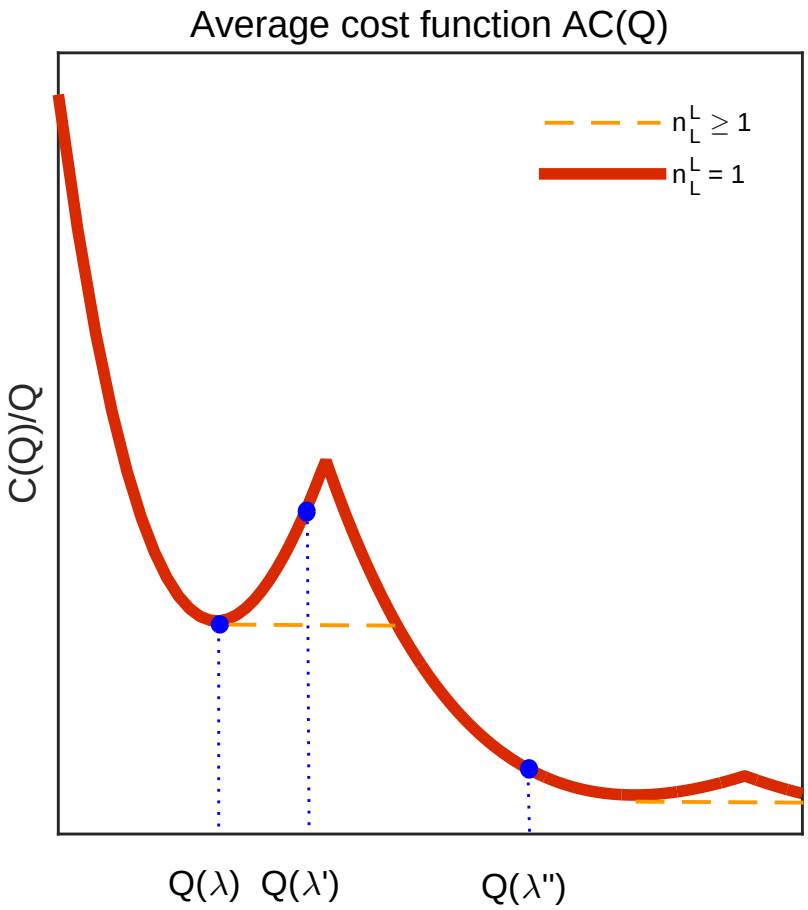
Sketch of the Theory - Average Costs

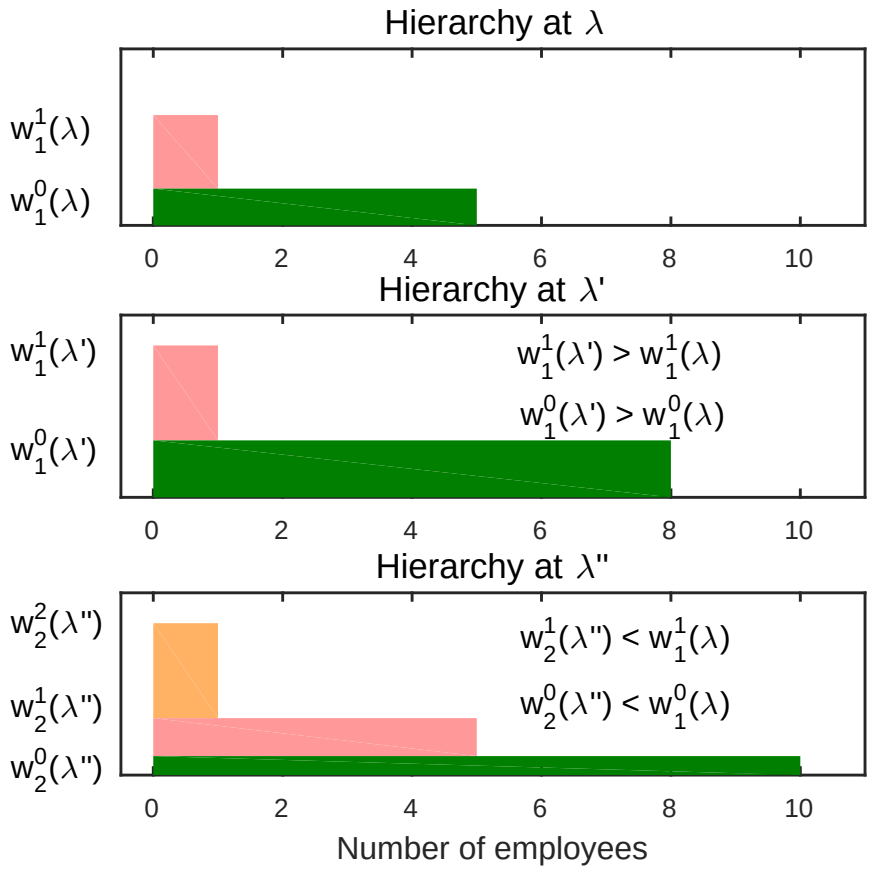


Sketch of the Theory - Marginal Costs



The Effect of Revenue Shocks





Implications of a Revenue Shock on Productivity

- Firms that add layers as a result of a marginal revenue shock increase their quantity discontinuously
- New organization is more productive at the new scale
  ...but quantity expansion decreases price and revenue-based TFP

- *Proposition 1: If firms face fixed costs and prices are increasing in marginal costs, a positive revenue shock that results in additional layers*
  - *Increases quantity-based productivity*
  - Decreases *revenue-based productivity*

Data Description

- Three datasets for Portuguese manufacturing firms (1995-2005):
  - Quadros de Pessoal (QP): matched employer-employee data
    - ★ Measure layers (maximum 4), employment, revenue and wages
  - Balance sheet data (BS): capital and materials
    - ★ Needed to compute revenue-based TFP measures
  - Prodcom data (PC): quantity produced at the firm-year-product level
    - ★ Products recorded at the Prodcom 8 digit level and the unit of measurement (Kg, liters, etc.) depends on the specific product
    - ★ We aggregate products at the 2-digits-unit of measurement pairs
    - ★ We split multi-products firms into several single product firms using products revenue shares as weights

Different Forms of Reorganizations: Three Examples

- Small firm, "Manufacture of articles of cork, straw & plaiting material"
  - Growth spell 2004-5: value-added ↑ 3%, qty sold ↑ 28%, prices ↓ 6%
- Reorganization:
  - Add a top layer of management (production & operations dept.)
  - (Net) Reinforcement of "wood treaters" and lower wages in pre-existing layers

Table 4: Cork Firm Reorganization, Nace 2052 Example

Occupation	Layer 0	Layer 1	Layer 2	Layer 3
Firm with 1 Layer (2004)				
Managers				
Clerks		1		
Crafts Workers	8	1		
Firm with 2 Layers (2005)				
Managers			2	
Clerks		1		
Crafts Workers	9			

Notes: Occupations correspond to ISCO-88 1-digit major groups.

- Productivity: TFPQ ↑ 6%, TFPR ↓ 28%

Example 2: Downsizing, core tasks, imported inputs

- Small-medium firm, "Knitted and crocheted pullovers, cardigans..."
- **Shock**: China's entry in the WTO in 2000 $\rightarrow$ **removal of EU quotas**
  - Downsized heavily: From 37 to 10 employees. Qty sold $\downarrow$ 50%, prices $\uparrow$ 30%. Imported intermediate inputs double.

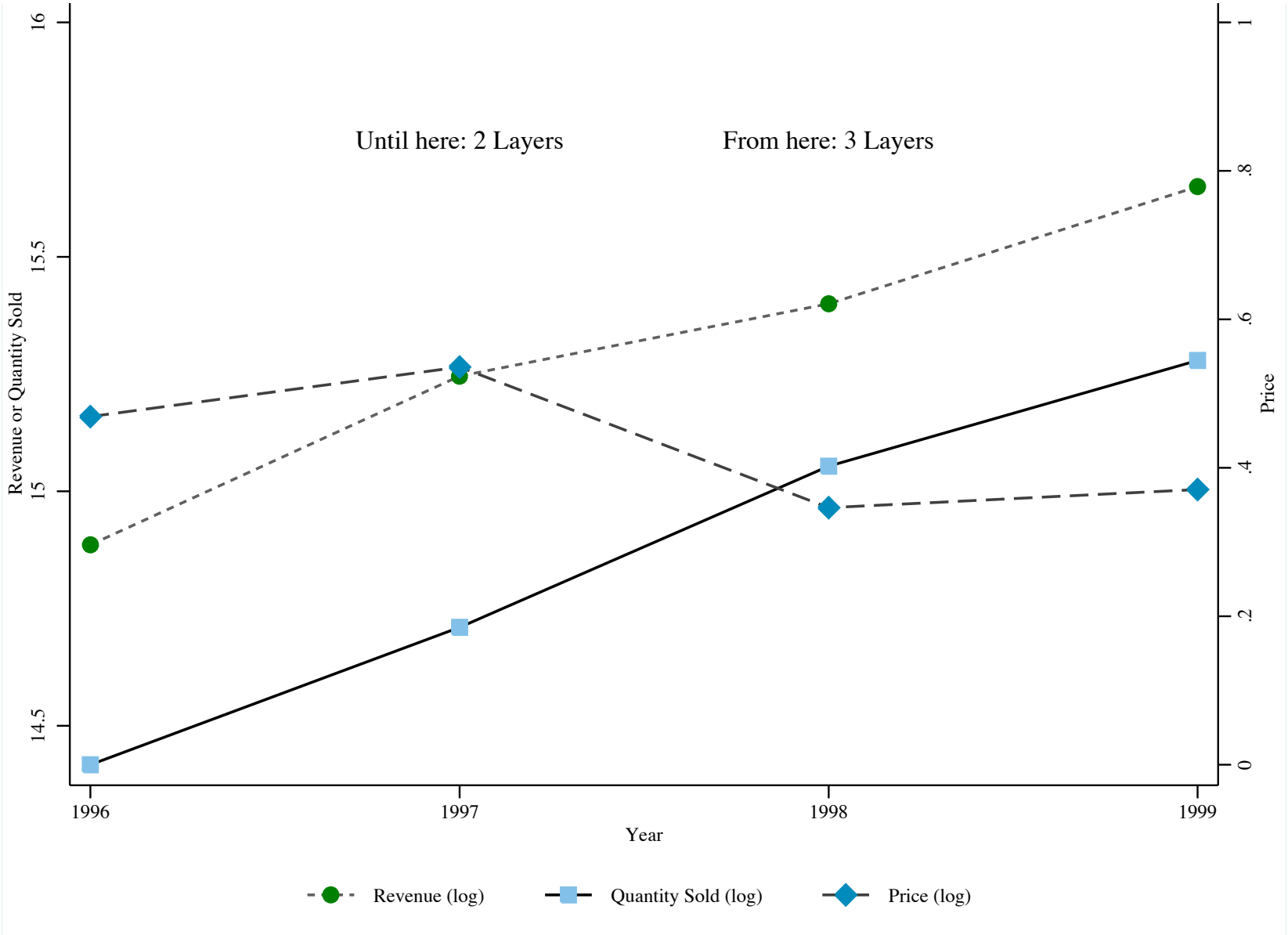
Table 1: Textile and Apparel Firm Reorganization, Nace 1772 Example

Occupation	Layer 0	Layer 1	Layer 2	Layer 3
Firm with 3 Layers (2004)				
Managers			1	2
Technicians and Assoc. Professionals		1		
Clerks	2			
Crafts Workers	15		4	
Plant and Machine Operators	11			
Elementary Occupations	1			
Firm with 2 Layers (2005)				
Managers				
Technicians and Assoc. Professionals		1	1	
Clerks		1		
Crafts Workers	4			
Plant and Machine Operators	1		1	
Elementary Occupations	1			

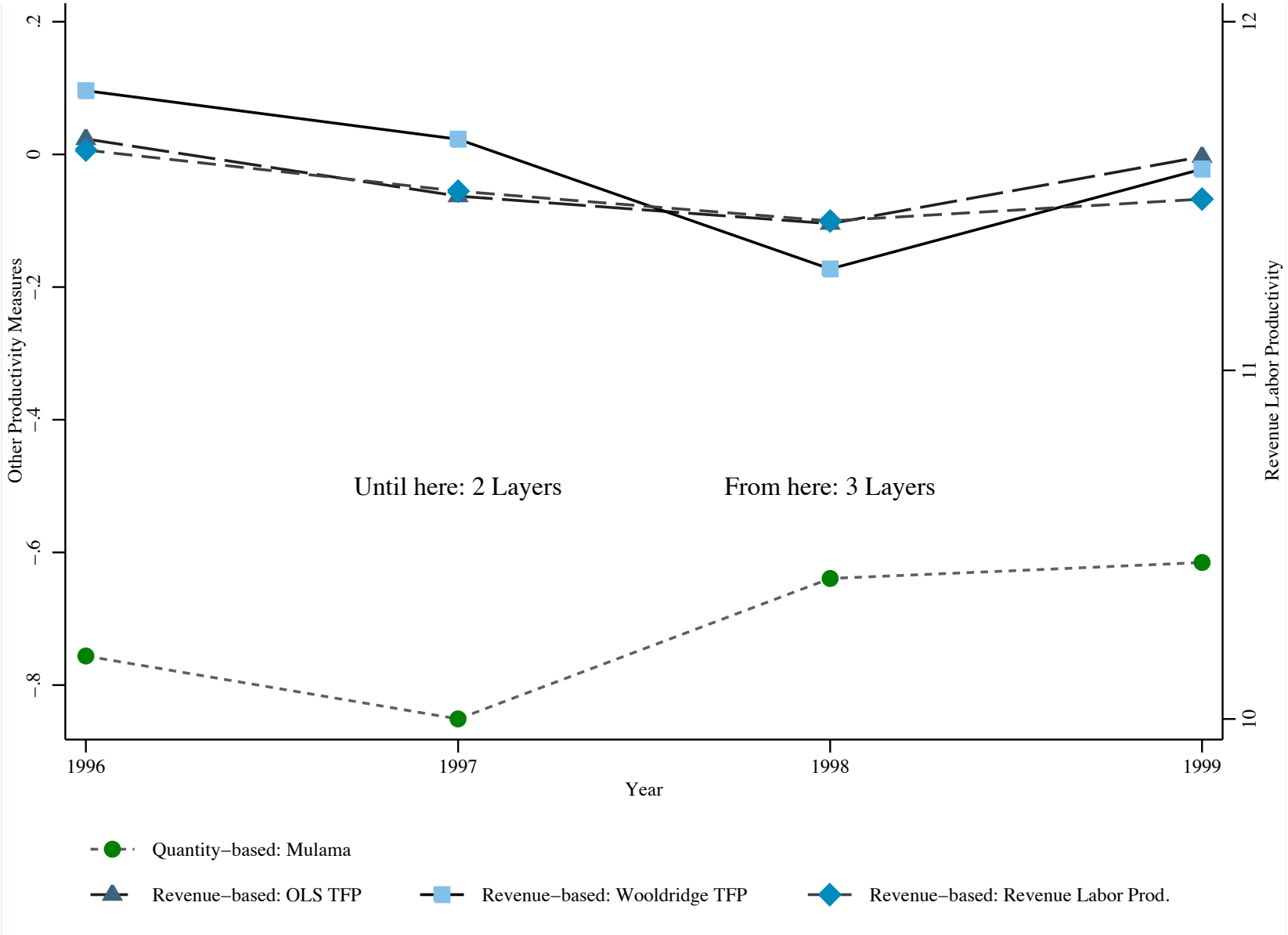
Notes: Occupations correspond to ISCO-88 1-digit major groups.

- Wages $\uparrow$. Productivity: TFPQ $\downarrow$ 53%, TFPR $\uparrow$ 9.2%

Example 3: Aluminium Cookware Firm



Example 3: Aluminium Cookware Firm



Structural Estimation - Assumptions

- **Production Function** for firm i

$$Q_{it} = A_{it} O_{it}^{\alpha_O} M_{it}^{\alpha_M} K_{it}^{(\gamma - \alpha_M - \alpha_O)}$$

  - Timing: K_{it}, and L_{it} chosen prior to t $(O_{it}^* = O_{it}|_{L_{it}})$
  - Use $O_{it}^* = C\left(O_{it}^*; w_t\right) / AC\left(O_{it}^*; w_t\right)$, then in logs

$$q_{it} = \tilde{a}_{it} + \alpha_O \ln C\left(O_{it}^*; w_t\right) + \alpha_M m_{it} + (\gamma - \alpha_M - \alpha_O) k_{it}$$

    - ★ Where $\tilde{a}_{it} = a_{it} - \alpha_O \ln AC\left(O_{it}^*; w_t\right) = a_{it} + \beta L_{it}$ (from CRH)

- **Demand** (CES)

$$r_{it} = (1/\mu_{it})\left(q_{it} + \lambda_{it}\right)$$

where μ_{it} is the markup, λ_{it} is a demand shifter

Structural Estimation - Assumptions

- **Stochastic processes**

$$\tilde{a}_{it} = \begin{cases} \alpha_i + \delta_t + \phi_a \tilde{a}_{it-1} + \nu_{ait} & \text{if } \Delta L_{it} = 0 \\ \alpha_i + \delta_t + \phi_a \tilde{a}_{it-1} + \phi_L \Delta L_{it} + \nu_{ait} & \text{if } \Delta L_{it} \neq 0 \end{cases}$$

and

$$\lambda_{it} = \delta_t^{\lambda} + \phi_\lambda \lambda_{it-1} + \nu_{\lambda it}$$

  - ν_{ait} and $\nu_{\lambda it}$ are iid idiosyncratic productivity and demand shocks
  - ν_{ait} and $\nu_{\lambda it}$ are uncorrelated with past values of $\tilde{a}_{it}$ and λ_{it}

- **Estimating Strategy**

  - First, estimate the parameters of the production function $(\gamma, \alpha_M, \alpha_O)$
  - Second, obtain quantity productivity,
    $\tilde{a}_{it} = q_{it} - \alpha_O \ln C\left(O_{it}^*; w_t\right) - \alpha_M m_{it} - (\gamma - \alpha_M - \alpha_O) k_{it}$
  - Third, use the process of $\tilde{a}_{it}$ to estimate ϕ_L and ϕ_a including firm-time-fixed effects

Quantity-based Productivity Results

Table: Quantity TFP. Firm-product-sequence FE. Dynamic panel data estimator

VARIABLES	(1) Increasing	(2) Decreasing	(3) Constant	(4) All
QTFP t-1	0.912[a]	0.880[a]	0.926[a]	0.910[a]
	(0.012)	(0.018)	(0.014)	(0.008)
Change in layers	0.037[b]	0.052[b]		0.062[a]
	(0.017)	(0.023)		(0.016)
Constant	-0.014	0.127	0.211[a]	0.116[a]
	(0.016)	(0.123)	(0.042)	(0.031)
Observations	4,141	2,829	3,031	10,001
Number of fixed effects	1,663	1,274	1,290	4,227
AR(2) Test Stat	0.468	0.117	2.443	1.980
P-value AR(2)	0.640	0.907	0.015	0.048

Firm-level clustered standard errors in parentheses. Year and Industry dummies are included in the estimations. [a] p<0.01, [b] p<0.05, [c] p<0.1

- Instrument ΔL_{it} : λ_{it-1}, μ_{it-1}, L_{it}, K_{it}, r_{it-1}, q_{it-1}, $\tilde{a}_{it-2}$, as well as all of these variables lagged to the first available year

Revenue-based Productivity Results

- Revenue-based TFP is given by

$$\tilde{a}_{it} = \bar{a}_{it} - p_{it}$$

- Issue: prices are functions productivity, use FOC to get

$$\bar{a}_{it} = \bar{\alpha}_i + \bar{\delta}_t + \bar{\phi}_a \bar{a}_{it-1} + \bar{\phi}_L \Delta L_{it} + \bar{\phi}_R X_{it} + \nu_{\bar{a}it},$$

where $X_{it} = [\lambda_{it-1}, p_{it-1}, \ln(\mu_{it}), k_{it}]$

- In addition of instrumenting for ΔL_{it} we have to instrument for $\ln(\mu_{it})$ in X_{it} since it is endogenous
  - We can use the same instruments

Revenue-based Productivity Results

Revenue TFP. Firm-product-sequence FE. Dynamic panel data estimator

VARIABLES	(1) Increasing	(2) Decreasing	(3) Constant	(4) All
RTFP t-1	0.935[a]	0.956[a]	0.967[a]	0.953[a]
	(0.014)	(0.019)	(0.016)	(0.009)
Change in layers	-0.018[b]	-0.035[a]		-0.025[a]
	(0.008)	(0.011)		(0.009)
Demand t-1	-0.006	-0.008[a]	-0.008[c]	-0.006[a]
	(0.003)	(0.002)	(0.004)	(0.002)
Price t-1	-0.007	-0.011[c]	-0.001	-0.006[c]
	(0.005)	(0.006)	(0.006)	(0.003)
Log Markup	0.075	0.059	0.074	0.049
	(0.070)	(0.046)	(0.081)	(0.042)
Capital	0.001	0.002	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.001)
Constant	-0.027[a]	0.079	0.000	-0.014[b]
	(0.009)	(0.051)	(0.000)	(0.006)
Observations	4,141	2,829	3,031	10,001
Number of fixed effects	1,663	1,274	1,290	4,227
AR(2) Test Stat	0.043	1.352	1.548	1.805
P-value AR(2)	0.966	0.177	0.122	0.071

Firm-level clustered standard errors in parentheses. Year and Industry dummies are included in the estimations. [a] p<0.01, [b] p<0.05, [c] p<0.1

Case Study: Textile & Apparel: China's Entry into WTO

- Removal of EU quotas to China in 2000 (China's entry into the WTO)
- Quotas were applied only to some textile & apparel products
  - Firm-specific instrument capturing the exposure to the quotas
- Underlying identifying assumption: unobserved demand/technology shocks are uncorrelated with the strength of quotas in 2000
  - Quotas were built up from the 1950s, and their phased abolition negotiated in the late 1980s in preparation for the Uruguay Round
- Bloom, Draca, and Van Reenen (2016) calculate that the reduction in quotas created a 240% increase in Chinese imports in that industry
  - In our data, firms that produced products that were protected by a quota, experienced a 24% negative demand shock, an 11% reduction in actual sales, and an 11% reduction in employment (all significant at the 1% level). These firms also reduced the numbers of layers

Case Study: Textile & Apparel: China's Entry into WTO

Textile and Apparel: OLS, and IV estimates

VARIABLES	TFPR OLS	TFPR IV	TFPQ OLS	TFPQ IV
RTFP t-1	0.834[a]	0.827[a]		
	(0.040)	(0.042)		
QTFP t-1			0.865[a]	0.864[a]
			(0.030)	(0.030)
Change in layers	-0.014	-0.026	0.085[a]	0.147[b]
	(0.014)	(0.018)	(0.028)	(0.066)
Demand t-1	-0.011[a]	-0.008[a]		
	(0.002)	(0.003)		
Price t-1	0.004	0.002		
	(0.008)	(0.008)		
Log Markup	0.145[a]	0.097[c]		
	(0.033)	(0.058)		
Capital	0.003[c]	0.002		
	(0.002)	(0.002)		
Observations	554	554	554	554
Adjusted R^2	0.666	0.660	0.729	0.725
Kleibergen-Paap stat.		32.50		42.03

Firm-product-level clustered standard errors in parentheses. Year dummies are included in the estimations. [a] p<0.01, [b] p<0.05, [c] p<0.1

More in the paper

- Study the aggregate effects
  - Reorganizations account for about half of all of the aggregate growth in quantity-based productivity
- Study the direct impact in prices
- Study the cost-pass through implied
- Similar results using a host of different measures of revenue productivity
  - From value-added per worker to Olley and Pakes, 1996, Wooldridge, 2009, and De Loecker and Warzinsky 2012

Conclusion

- The productivity of firms is, at least partly, determined by a firm's actions and decisions
- Using detailed employer-employee matched data and firm production quantity and input data for Portuguese firms, we study the endogenous response of TFPR and TFPQ to a change in layers: a firm reorganization
- We find that as a result of an exogenous demand or productivity shock that makes the firm reorganize and add a layer, TFPQ increases by about 6%, while TFPR drops by around 3%
- These effects are large
  - Reorganizations account for about half of all of the aggregate growth in quantity-based productivity
- The ability to reorganize is therefore essential for firms to growth
  - The inability of firms to grow in developing countries could be related to the inability to reorganize efficiently
    - ★ Reorganization requires a market for talent and delegation