

# Communication and the organization of firms across space

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# Motivation

Largest firms are **multi-establishment firms**

- ▶ Benefits: lower wages, land prices, etc.

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However: **negative impact of distance on firm performance**

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**Optimal hierarchical organization** may mitigate geographic frictions

**Little systematic study** of impact of firm geography on organization

- ▶ Anecdotal evidence: Singer Sewing machine, Philips

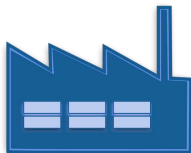
# Research Question

How does **expansion across space**  
affect the **optimal hierarchical organization**?

# Middle managers mitigate geographic frictions



CEO



HQ in Munich

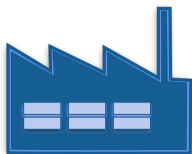


Subordinate establishment  
in East Germany

# Middle managers mitigate geographic frictions



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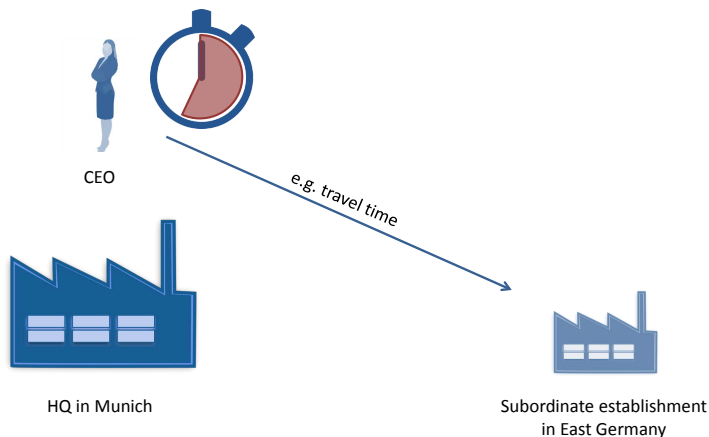


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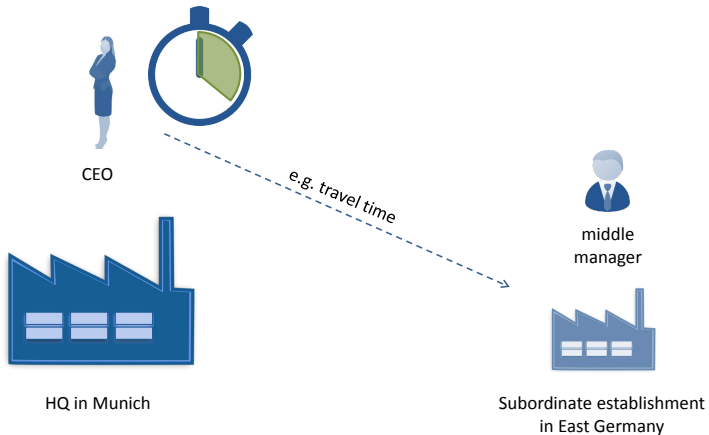
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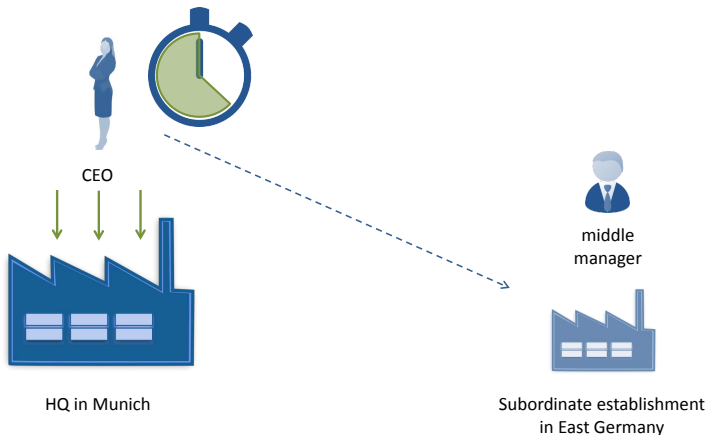




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# This paper

## Part 1: **Novel facts using linked firm-establishment-employee data**

1. ME firms have more management layers than same-size SE firms
2. Number of management layers increases with distance
3. ME firms reorganize layers establishment by establishment

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## Part 2: **Model to explain facts based on CEO as limited resource**

- ▶ ME firms optimally add layer at 1 establishment at lower size than SE firms
- ▶ Reorganization of one establishment has **implications for whole firm**

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- ▶ Reorganization of one establishment has **implications for whole firm**

## Part 3: **Identify impact of geographic frictions on firm organization** (in progress)

- ▶ Exogenous introduction of high-speed trains reducing travel time by 50%

# Contribution

- **Firm geography** as determinant of hierarchical organization
- Insights on determinants of multi-establishment **firm performance**
- **New data**: link firms, establishments and employees

→ Literature on multi-establishment and multinational firms

e.g. Antràs & Yeaple, 2014; Charnoz, Lelarge & Trevin, 2015; Giroud, 2013; Irarrazabal, Moxnes & Opromolla 2013; Kalnins & Lafontaine, 2013

Literature on knowledge hierarchies

e.g. Caliendo & Rossi-Hansberg, 2012; Caliendo, Monte & Rossi-Hansberg, 2015; Caliendo, Mion, Opromolla & Rossi-Hansberg, 2016; Friedrich, 2016; Garicano, 2000; Garicano & Rossi-Hansberg, 2015; Gumpert, 2017

## Data with unique level of detail

### **Linked firm-establishment-employee data** including

- ▶ occupation, education, age, gender, wages of employees;
- ▶ sector, county, ownership history of establishment;
- ▶ sales, value added of firms

Sources: German Social Security Records; ORBIS (Bureau van Dijk)  
combined via record linkage

### Panel for **1998-2014**

2012: 6.4 M employees ( $\approx$  one fifth of German employment)

109 k firms

144 k establishments

[Details](#)[Σ statistics](#)

## Organizational structure

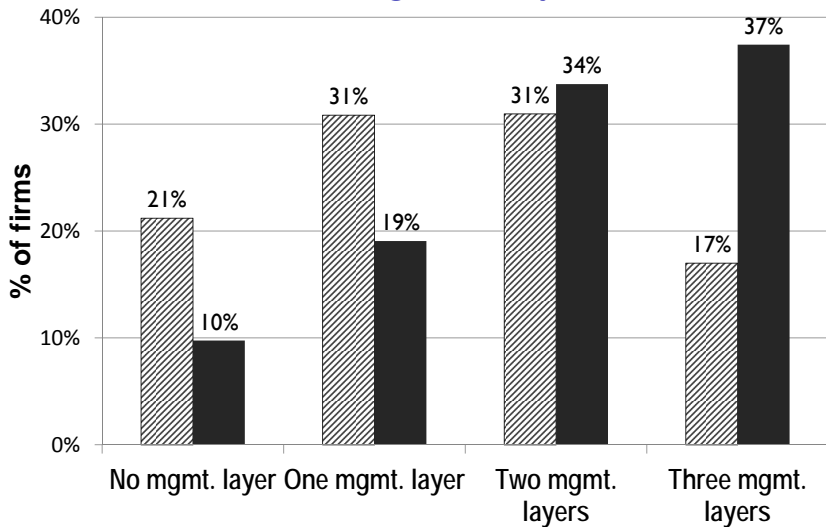
**Hierarchical layers:** four layers based on occupation (Caliendo et al., 2015)

Layer 3	CEOs, managing directors
Layer 2	Senior experts, middle managers
Layer 1	Supervisors, engineers, technicians, professionals
Layer 0	Clerks, operators, production workers

Management layers: layers above lowest layer



## ME firms have more management layers than SE firms



Firms with at least 10 employees.  
Cross-section for 2012.

▨ single-establishment firms

■ multi-establishment firms

Cons

# ME firms have more mgmt. layers than same size SE firms

$$\# \text{ mgmt. layers}_i = \exp(\beta_0 + \beta_1 D_{\text{ME firm},i} + \beta_2 \text{size}_i + \alpha_l + \alpha_n + \alpha_s)$$

with  $i$ : firm,  $l$ : legal form,  $n$ : county of HQ,  $s$ : HQ sector

# mgmt. layers, Poisson	(1)	(2)	(3)
$D_{\text{multi-establishment firm}}$	0.144*** (0.006)	0.061*** (0.007)	0.063*** (0.007)
Log # non-managerial employees	0.143*** (0.002)		-0.005 (0.003)
Log sales		0.179*** (0.002)	0.182*** (0.003)
# firms	105,948	53,566	53,566

Legal form, HQ county, HQ sector fixed effects. \*\*\*  $p < 0.001$ . Robustness by legal form

⇒ Being multi-establishment  $\approx$  **doubling** # non-mang. employees

## Number of mgmt. layers increases with distance

$$\# \text{ mgmt. layers}_i = \exp(\beta_0 + \beta_1 \max \log \text{dist.HQ}_i + \beta_2 \text{size}_i + \alpha_l + \alpha_n + \alpha_s)$$

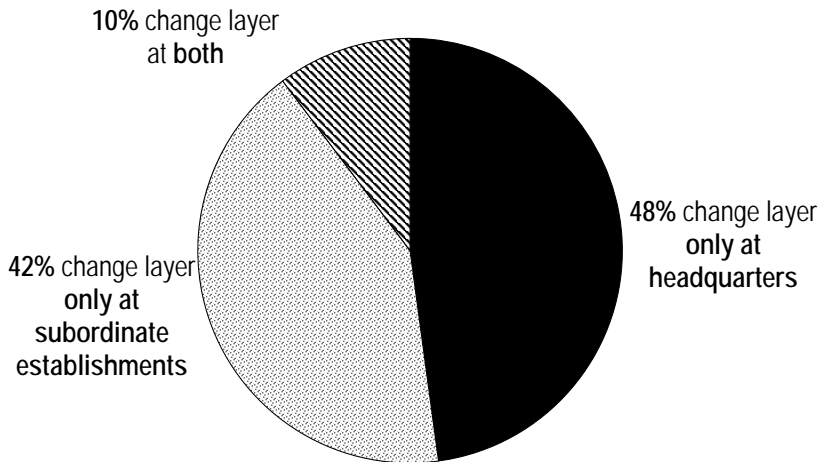
with  $i$ : ME firm,  $l$ : legal form,  $n$ : county of HQ,  $s$ : HQ sector

# mgmt. layers, Poisson	(1)	(2)	(3)
Maximum log distance to HQ	0.021*** (0.003)	0.011*** (0.004)	
Log area spanned by establishments			0.012*** (0.002)
Log # non-managerial employees	0.115*** (0.003)		0.090*** (0.005)
Log sales		0.115*** (0.004)	
# firms	9,287	5,039	3,320

Legal form, HQ county, HQ sector fixed effects. \*\*\*  $p < 0.001$ .

## ME firms reorganize establishment by establishment

Multi-establishment firms that reorganize from  $t$  to  $t + 1$ , 1998-2010



## ME firms reorganize establishment by establishment

# mgmt.lyrs,  $HQ_i = \exp(\beta_0 + \beta_1 D_{ME \text{ firm},i} + \beta_2 \text{size}_i + \alpha_t + \alpha_l + \alpha_n + \alpha_s)$   
 with  $i$ : firm,  $l$ : legal form,  $n$ : county of HQ,  $s$ : HQ sector,  $t$ : year

# mgmt. layers, HQ, Poisson	(1)	(2)	(3)
$D_{ME \text{ firm}}$	-0.093*** (0.004)	-0.097*** (0.006)	0.228*** (0.011)
Log # non-mg. employees	0.321*** (0.001)	0.275*** (0.002)	0.336*** (0.001)
$D_{ME \text{ firm}} \times$ Log # non-mg. employees			-0.079*** (0.003)
Legal form/ sector/ county FE	Y	N	Y
Firm fixed effects	N	Y	N
# observations	747,338	1,150,120	747,338

Year fixed effects included. \*\*\*  $p < 0.001$ .

## Part 1: Facts

### Firm geography affects hierarchical organization

1. ME firms **have more management layers** than SE firms given firm characteristics.
2. **Distance to headquarters increases** number of management layers given ME firm characteristics.
3. ME firms add and drop layers **establishment by establishment**.

## Set-up

World with two locations,  $j = \{0, 1\}$

Single product market; separate labor markets: local wages  $w_0 \geq w_1$

Entrepreneur (CEO) in  $j = 0$  with one unit of time

Exogenous production quantity  $\tilde{q}$

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**Knowledge hierarchy** framework  $\rightarrow$  production  $\equiv$  **problem solving**:

Labor generates problems, knowledge  $z$  solves problems

$\Rightarrow$  Output per labor unit

$$q = 1 - e^{-\lambda z}$$

i.e. positive and decreasing marginal product of knowledge



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Employees communicate problems for  $\theta_{jk}$  units of time with  $\theta_{10} \geq \theta_{00}$

Employees' remuneration increasing in knowledge:  $w_j(1 + cz_j)$

# Optimization problem

**Objective: minimize production costs**

Choice variables:

- **Organizational structure:**

- ▶ Number of establishments
- ▶ Number of layers per establishment

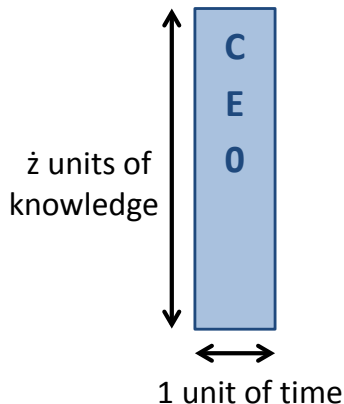
- **Firm level:**

- ▶ CEO knowledge
- ▶ If multi-establishment: allocation of CEO time, production quantity

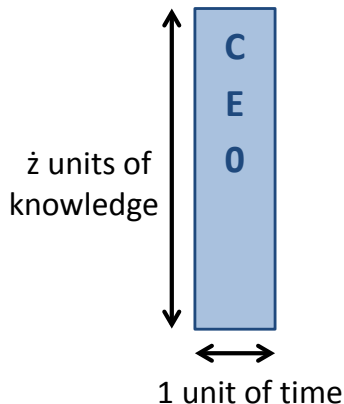
- **Establishment level:**

Number and knowledge of employees per layer

# Impact of growth on SE firm organization



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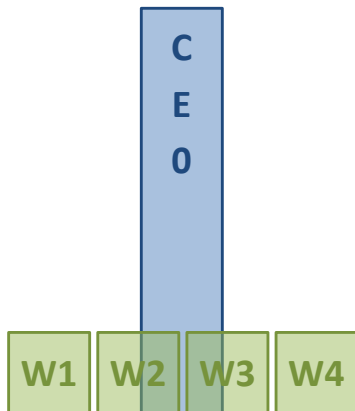


CEO on his own quantity constrained:

$$q = 1 - e^{-\lambda \bar{z}}$$

# Impact of growth on SE firm organization

CEO +  $n_0^0$  workers w/ knowledge  $z_0^0$



- Production quantity:

$$q = n_0^0(1 - e^{-\lambda \bar{z}}) = 4(1 - e^{-\lambda \bar{z}})$$

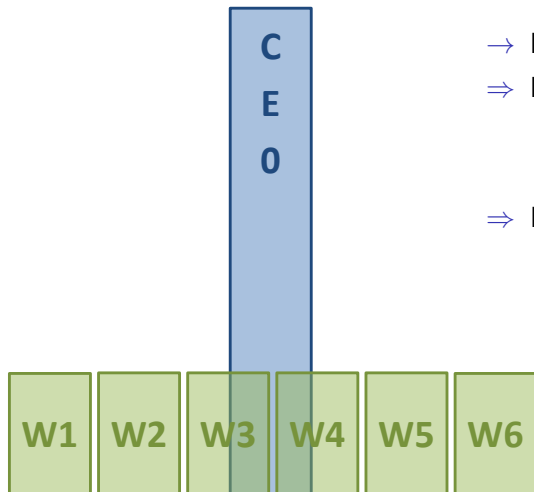
- Workers solve part of problems due to CEO time constraint:

$$e^{\lambda z_0^0} = n_0^0 \theta_{00} = 4\theta_{00}$$

- Marginal costs increase with workers' knowledge:

$$\xi_0 = \frac{w_0(1 + z_0^0 + \frac{1}{\lambda})}{1 - e^{-\lambda \bar{z}}}$$

# Impact of growth on SE firm organization



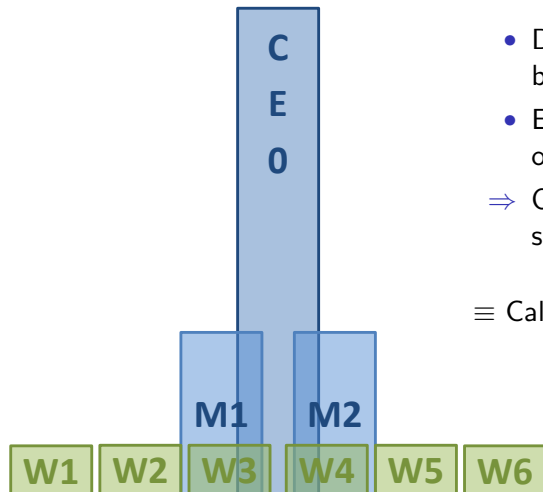
CEO and more employees

- Higher production quantity
- ⇒ Employees solve more problems

$$e^{\lambda z_0^0} = n_0^0 \theta_{00} = 6\theta_{00}$$

- ⇒ Marginal costs increase

# Impact of growth on SE firm organization



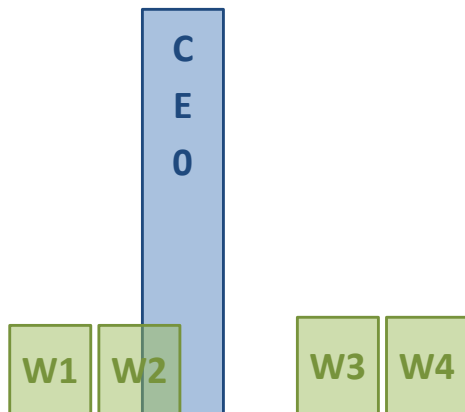
## Middle managers

- Decrease marginal costs because workers know less
  - Entail quasi-fixed costs because of managerial remuneration
- ⇒ Only useful for firms of sufficiently large size

≡ Caliendo & Rossi-Hansberg ('12)

## Multi-establishment firm organization

CEO allocates time (quantity)  
to equate marginal benefit (costs)

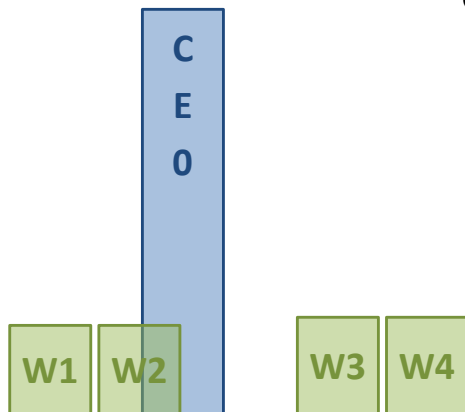




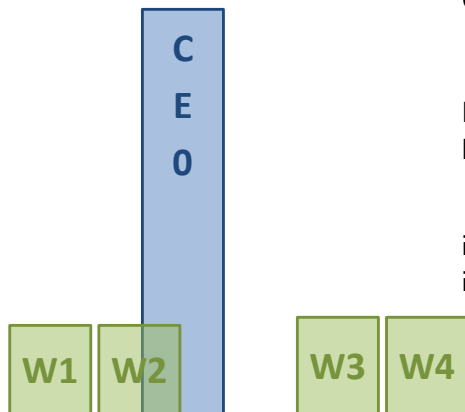
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Communication costs  $\theta_{10} > \theta_{00}$   
 $\Rightarrow$  Knowledge of distant workers  $\uparrow$



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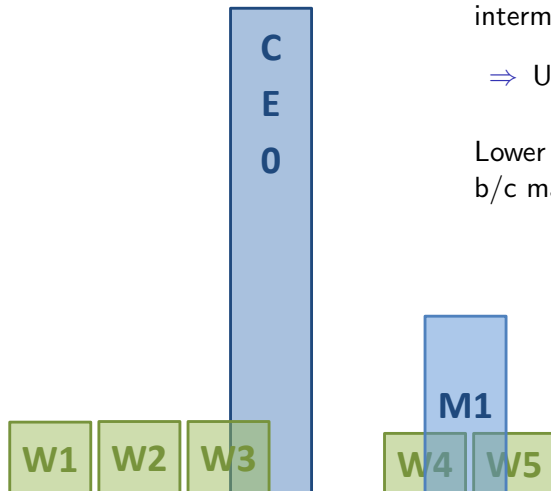
Communication costs  $\theta_{10} > \theta_{00}$   
 $\Rightarrow$  Knowledge of distant workers  $\uparrow$

Decreasing marginal product of  
knowledge

$\Rightarrow$  Knowledge of close workers  $\uparrow$

i.e. organization of establishments  
interdependent

# Impact of growth on ME firm organization (I)



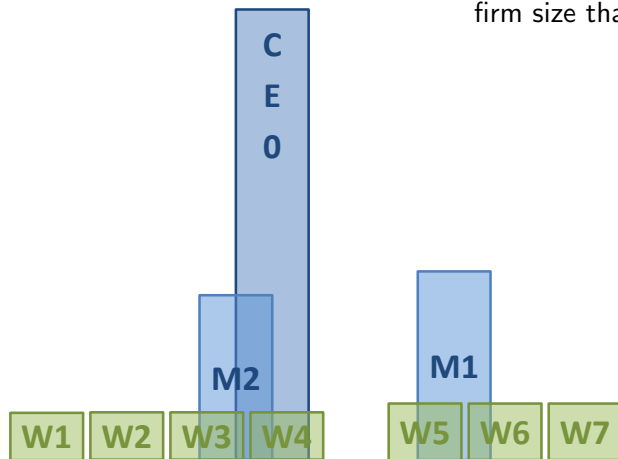
Lower quasi-fixed costs of intermediate managers

⇒ Useful for firms of smaller size

Lower marginal costs at **both** est.  
b/c managers **release CEO time**

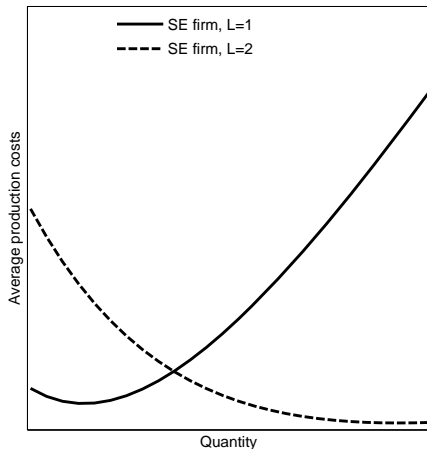
## Impact of growth on ME firm organization (II)

Consequence: additional layer at other establishment only at larger firm size than in SE case

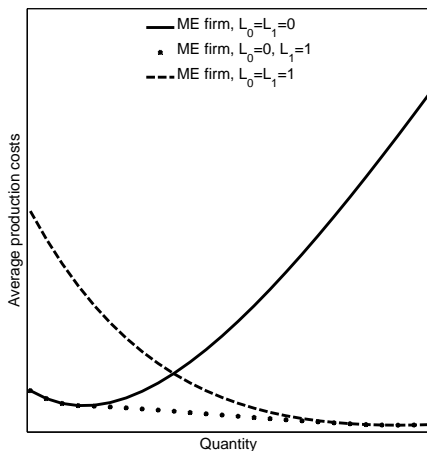


# Impact of growth on ME firm organization: formally

## Single-establishment firm



## Multi-establishment firm



Full symmetry, i.e.  $w_0 = w_1, \theta_{10} = \theta_{00}$ .

## Summary

Lower quasi-fixed costs of managerial layer

- ⇒ ME firms **add layer at lower firm size** than SE firms:  
Explains higher # of mgmt. layers in ME firms

Additional layer decreases marginal costs at **both** establishments

- ⇒ ME firms add layer at other establishments at **larger firm size**:  
Explains reorganization establishment by establishment

Higher communication costs with distant establishment

- ⇒ **Higher knowledge** at **both** locations
- Extension with transport frictions explains positive impact of distance on number of layers

## Outlook:

Identify impact of geographic frictions on firm organization

New **high-speed trains** exogenously decrease communication costs between establishments

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### Identify impact of geographic frictions on firm organization

New **high-speed trains exogenously decrease communication costs** between establishments

**Treatment = faster travel between HQ and (any) establishment**

- ▶ Frankfurt - Cologne: 2h14 ↘ **1h11**
  - opened summer 2002
  - > 2h by car
- ▶ Ingolstadt - Nuremberg: 1h08 ↘ **33min**
  - opened summer 2006
  - > 1h by car

Preliminary results consistent with model predictions



# Summary

## How does expansion across space affect optimal hierarchical organization?

### Our project

- documents that **firm geography** matters for hierarchical organization;
- explains **organizational differences between ME and SE firms** based on efficient use of CEO time;
- works on **identification** of impact of communication costs on firm organization.