

# MIT 14.662 Spring 2018: Lecture 7 – Organizational Structure and Market Structure

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February 28, 2018

# Agenda

- 1 Mass Production, Interchangeability, and the Division of Labor**
- 2 Limits on the Division of Labor: Extent of Market
- 3 Limits on the Division of Labor: Coordination costs
- 4 Limits on the Division of Labor: Adaptation
- 5 Quality of Management

Adam Smith, Wealth of Nations, 1776

*“The greatest improvement in the productive powers of labor, and the greater part of the skill, dexterity, and judgement with which it is anywhere directed or applied, seem to have been the effects of the division of labor.”*

# Frederick Winslow Taylor, The Principles of Scientific Management, 1911

## *The Principles of Scientific Management*

BY  
FREDERICK WINSLOW TAYLOR, M.E., Sc.D.  
PAST PRESIDENT OF THE AMERICAN SOCIETY OF  
MECHANICAL ENGINEERS



## The Principles of Scientific Management

“One of the first pieces of work undertaken by us, when the writer started to introduce scientific management into the Bethlehem Steel Company, was to handle pig iron on task work. . . . The Bethlehem Steel Company had five blast furnaces, the product of which had been handled by a pig-iron gang for many years. This gang, at this time, consisted of about 75 men. . . .”

## The Principles of Scientific Management

“We found that this gang were loading on the average about  $12 \frac{1}{2}$  long tons per man per day. We were surprised to find, after studying the matter, that a first-class pig-iron handler ought to handle between 47 and 48 long tons per day. . . It was our duty to see that the 80,000 tons of pig iron was loaded on to the cars at the rate of 47 tons per man per day. . . ”

## The Principles of Scientific Management

“And it was further our duty to see that this work was done without bringing on a strike among the men, without any quarrel with the men, and to see that the men were happier and better contented. . . . The task before us, then, narrowed itself down to getting Schmidt to handle 47 tons of pig iron per day and making him glad to do it. This was done as follows. Schmidt was called out from among the gang of pig-iron handlers and talked to somewhat in this way. . . . ”

## The Principles of Scientific Management

“Schmidt, are you a high-priced man?”

“Vell, I don't know vat you mean.”

“Oh yes, you do. What I want to know is whether you are a high-priced man or not.”

“Vell, I don't know vat you mean.” . . .

“Oh, you're aggravating me. . . Now come over here. You see that pile of pig iron? “

“Yes.”

“You see that car?”

“Yes.”



## The Principles of Scientific Management

“Well, if you are a high-priced man, you will load that pig iron on that car tomorrow for \$1.85. . . Tell me whether you are a high-priced man or not.”

“Vell — did I got \$1.85 for loading dot pig iron on dot car tomorrow?”

“Yes, of course you do. . . .”

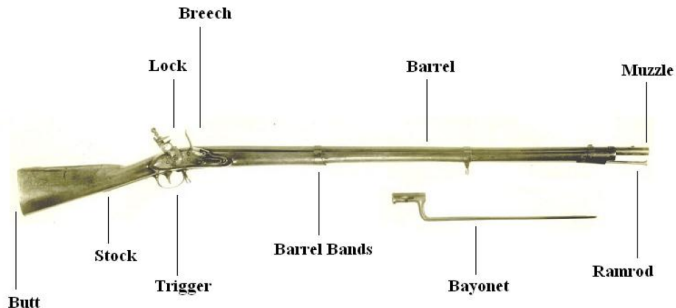
“Vell, dot’s all right. I could load dot pig iron on the car tomorrow for \$1.85, and I get it every day, don’t I? . . . Vell, den, I vas a high-priced man.”

## The Principles of Scientific Management

“This seems to be rather rough talk. And indeed it would be if applied to an educated mechanic, or even an intelligent laborer. With a man of the mentally sluggish type of Schmidt it is appropriate and not unkind, since it is effective in fixing his attention on the high wages which he wants and away from what, if it were called to his attention, he probably would consider impossibly hard work.”

## But What About Technological Progress?

### Parts of a musket



## Eli Whitney Unsuccessfully Mass-Produced Muskets for the U.S. Military, 1798 – 1809



# Magneto Assembly on the Ford Motor Co. Assembly Line, 1913



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- ② Limits on the Division of Labor: Extent of Market
- ③ Limits on the Division of Labor: Coordination costs
- ④ Limits on the Division of Labor: Adaptation
- ⑤ Quality of Management

## Adam Smith, Wealth of Nations, 1776

*“As it is the power of exchanging that gives occasion to the division of labour, so the extent of this division must always be limited by the extent of that power, or, in other words, by the extent of the market. When the market is very small, no person can have any encouragement to dedicate himself entirely to one employment. . . .”*

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## Becker and Murphy (1992), “The Division of Labor, Coordination Costs, and Knowledge”

*“If each historian specialized in the events of only a few years, they would become more expert on developments during these shorter time periods. But since events over a few years are not isolated from those in prior and subsequent years, each one would then have to coordinate his research with that of several other specialists.”*

## Becker and Murphy (1992), “The Division of Labor, Coordination Costs, and Knowledge”

*“Most pediatricians in a city, or even in a single HMO, do not specialize in particular childhood diseases. . . Parents often do not know what is wrong with their children, and would need to see several pediatricians to get adequate care if each were highly specialized. Yet we would expect to find, and do observe, more specialization in childhood diseases that require extensive knowledge to detect and treat, such as liver diseases and cancers.”*

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# Tradeoff btwn Fordist/Taylorist vs Artisanal Organizational Forms

## ① Fordist/Taylorist

- Efficiency *gains* from specialization – Smithian gains
- Efficiency *losses* from coordination breakdowns – Beckerian/Murpharian losses

## ② Artisanal work organization

- Efficiency *losses* from breadth of tasks – Smithian losses
- Efficiency *gains* from successful coordination – Beckerian/Murpharian gains

## ③ Element not in either model: Flexibility/customization

- Dessain and Santos '07
- Flexibility – Ability to respond dynamically to 'local' information
- If workers have flexibility, coordination becomes more important, coordination failures more likely

# Demand for Flexibility

## Squaring the circle—coordination mechanism is part of job design

### ① “Ex ante coordination”

- Narrow jobs. High task efficiency. *Smithian gains*
- Due to risk of coordination failures, *limit worker discretion*
- This inflexibility forgoes gains from *customization*

### ② “Ex post coordination”

- Permit *discretion*—allowing workers to take advantage of local information
- Flexibility permits gains from *customization*
- May want to *bundle* tasks to reduce coordination failures
- This foregoes gains from specialization. *Smithian losses*

## Which approach dominates?

- Flexibility important when local information may affect quality

## Dessain and Santos: Setup

There  $N$  primary tasks and  $N^2 - N$  complementary (dependent tasks) to be performed to produce output

- Performance of each task is *optimized* through two actions
  - ① Adaptation—Tailoring each task  $n$  to local information
  - ② Coordination—Ensuring that dependent tasks are synchronized

### Firms' decision problem

- Choose optimal number of tasks  $T$  to assign to each worker

## Visualize Structure of Production as an $N \times N$ Task grid

Division of labor is  $T$ : Workers are assigned  $N \geq T \geq 1$  rows each

Coordination $\updownarrow$	$a^{11}$	$a^{12}$	$a^{13}$	...	$a^{1n}$
	$a^{21}$	$a^{22}$	$a^{23}$	...	$a^{2n}$
	$a^{31}$	$a^{32}$	$a^{33}$	...	$a^{3n}$
	...	...	...	...	$a^{4n}$
	$a^{n1}$	$a^{n2}$	$a^{n3}$	...	$a^{Nn}$
Division of labor $\leftrightarrow$					

- **Local information** is a random variable  $\theta^i$  with mean  $\hat{\theta}^i$  and common variance  $\sigma_{\theta}^2$ , realization of  $\theta^i$  is independent across tasks.
- **Adaptation:** Perfect adaptation, the primary action  $a^{ii}$  should be equal to  $\theta^i$  by worker who owns row  $i$
- **Coordination:** Perfect coordination between tasks  $i$  and  $j$ , action  $a^{ij}$  of task  $i$  should be set equal to the primary action
- **Who does what:** Worker in **row**  $i$  coordinates complementary actions in **column**  $i$  in **rows**  $j \neq i$ , possibly owned by other workers

# Environment

## Local information

- Variability of local information:  $\sigma_{\theta}^2 \geq 0$
- Adaptation:  $\phi \geq 0$  is cost of adaptation failure
- Coordination:  $\beta \geq 0$  is cost of coordination failure

## Task assignments

- $L$  workers
- $T \in \{1, 2, \dots, n\}$  is number of tasks assigned to each worker  $i$
- Assignments symmetric, so  $t_i = T = N/L$

## Communications

- Probability of successful coordination *across* workers is  $\rho \in [0, 1]$
- Probability of successful coordination *within* workers is 1

## Gains from specialization (diseconomies of scope)

- Cost per task executed is  $h(T) > 0$  with  $h'(T) > 0$  and  $h''(T) > 0$



## Sequence

- 1 Firm chooses  $T$ , the number of task per worker
- 2 Local circumstances  $\theta^i$  for each primary tasks  $i = 1, 2, \dots, N$  are realized and observed by *only* worker(s) in charge of task  $i$ .  
 $E[\theta^i] = \bar{\theta} \forall i$  with  $V(\theta) = \sigma_{\theta}^2$
- 3 Workers communicate the realizations of local information  $\theta^i$ 
  - Each attempt at communication succeeds with probability  $\rho$
  - Workers *cannot* determine whether communication was successful
- 4 For each row  $i$ , the employee in charge of  $i$  chooses complementary actions  $a^{ij}$ , where  $a^{ij}$  chosen to maximize the objective function given his information
- 5 Profits are realized given the realization of local information, the success of communication, and the chosen values of all tasks

## Visualize Structure of Production as an $N \times N$ Task grid

Division of labor is  $T$ : Workers are assigned  $N \geq T \geq 1$  rows each

Coordination $\updownarrow$	$a^{11}$	$a^{12}$	$a^{13}$	...	$a^{1n}$
	$a^{21}$	$a^{22}$	$a^{23}$	...	$a^{2n}$
	$a^{31}$	$a^{32}$	$a^{33}$	...	$a^{3n}$
	...	...	...	...	$a^{4n}$
	$a^{n1}$	$a^{n2}$	$a^{n3}$	...	$a^{Nn}$
Division of labor $\leftrightarrow$					

- **Local information** is a random variable  $\theta^i$  with mean  $\hat{\theta}^i$  and common variance  $\sigma_{\theta}^2$ , realization of  $\theta^i$  is independent across tasks.
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## Loss function

Visualize as production on an  $N \times N$  task grid

$a^{11}$	$a^{12}$
$a^{21}$	$a^{22}$

Losses from  $\beta$  and  $a$  in  $N = 2$  case

$$\mathcal{L} = \phi \left[ (a^{11} - \theta^1)^2 + (a^{22} - \theta^2)^2 \right] + \beta \left[ (a^{12} - a^{22})^2 + (a^{21} - a^{11})^2 \right]$$

## Profit function

$$\begin{aligned}\pi &= - \sum_{i=1}^N C^i (a^{1i}, a^{2i}, \dots, a^{Ni}, T | \theta^i) \\ &= - \sum_{i=1}^N \left[ \phi (a^{ii} - \theta^i)^2 + \sum_{j \notin T(i)}^N \beta (a^{ji} - a^{ii})^2 \right] - N \times h(T)\end{aligned}$$

- Profit function is a loss function that the firm wants to minimize
- If you prefer, write  $\pi^* = P + \pi$ , where  $P$  is the market price of a perfectly produced unit of output and  $\pi$  is the reduction in quality incurred by imperfections in adaptation and coordination during production

## Optimal Choice of Primary Actions

One can show that employees optimally choose the following primary actions

$$a^{ii}(T) = \bar{\theta}^i + \left[ \frac{\phi}{\phi + \beta(N - T)(1 - \rho)} \right] (\theta^i - \bar{\theta}^i).$$

- Notice that degree of adaption is
  - increasing in  $\phi$
  - decreasing in  $\beta$
  - increasing in the quality of communication  $\rho$
  - increasing in task bundling  $T$

Complementary actions are chosen as

$$a^{ji}(t) = \begin{cases} a^{ii(t)} & \text{when task } j \text{ learns } \theta^i \\ \bar{\theta}^i & \text{when task } j \text{ does not learn } \theta^i \end{cases}$$

## How Much Discretion in Equilibrium?

Covariance between local  $\theta^i$  circumstances and the primary action are

$$\sigma_{a\theta}(T) = \text{Cov}[a^{ii}(t), \theta^i] = \left[ \frac{\phi}{\phi + \beta(N - T)(1 - \rho)} \right] \sigma_{\theta}^2$$

Notice that  $\sigma_{a\theta}(t)$  is increasing in

- 1 Variability of local circumstances (in addition to the other comparative statics above)
- 2 Task bundling

$$\sigma_{a\theta}(N) > \sigma_{a\theta}(1)$$

## Optimal $T^*$

Given  $T$ , expected profits are

$$\Pi(T) = N\phi [\sigma_{a\theta}(T) - \sigma_{\theta}^2] - N \times h(T),$$

$$T^* = \arg \max_{t \in N} \Pi(T),$$

as a function of  $\phi, \alpha, \sigma_{\theta}^2, \beta$  and  $\rho$

### Specialization

- Task specialization is *decreasing* in the importance of adaption,  $\phi$ , and the variance of local circumstances  $\sigma_{\theta}^2$ , but increasing in diseconomies of scope  $h'(T)$

# Relationship Between Coordination Costs and Specialization

How does a rise in  $\beta$ , i.e., coordination costs, affect task bundling?

- Becker-Murphy: Higher  $\beta$  will *increase* bundling, i.e., reduce specialization
- In DS, depends on the importance of adaptation  $\phi$ 
  - ① **Higher  $\beta$  can lead to greater bundling:** Holding worker flexibility/adaptation constant, a rise in  $\beta$  makes it more important to improve coordination, which leads to *increased bundling*
  - ② **But higher  $\beta$  can lead to reduced flexibility:** Rise in  $\beta$  may also spur the organization to reduce employee flexibility (lower  $T$ ) and become less adaptive. Reduces the need for task bundling



# Optimal Task Bundling as a Function of Coordination Costs $\beta$

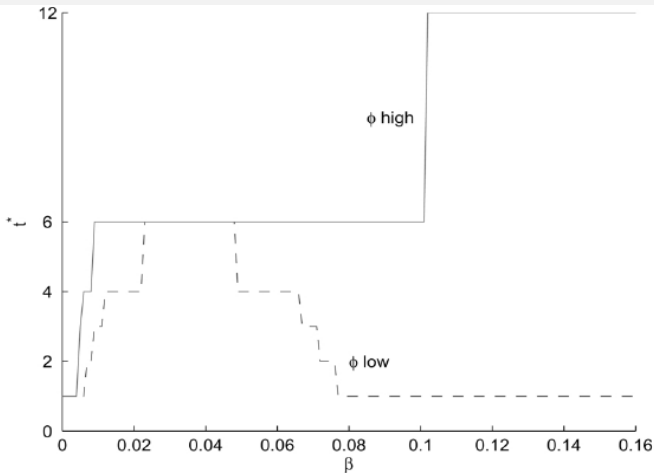


FIG. 1.—Optimal task bundling  $t^*$  as a function of the importance of coordination,  $\beta$ , for the case considered in example 1. The continuous line, denoted  $\phi$  high, shows  $t^*$  when the importance of adaptation is high,  $\phi > \phi_c$ , where  $\phi_c$  is given in proposition 4; the dashed line, denoted  $\phi$  low, shows  $t^*$  as a function of  $\beta$  when the importance of adaptation is low,  $\phi < \phi_c$ .

# Relationship Quality of Communication and Specialization

## Improving communications: $\rho$ rises

- Intuition would suggest that one would see more specialization as communication improves ( $\rho$  rises) since coordination gets easier

## But relationship is non-monotone

- ① When communication channels are very poor
  - Task bundling often increases as communication technology improves
  - Firms go from being extremely inflexible to somewhat more adaptive
  - Here, communications and bundling are *complements*
- ② But when communications become good enough
  - Further rise in  $\rho$  allows for unbundling and remaining adaptive
  - Communications and bundling are *substitutes*

# Optimal Task Bundling as a Function of Communication Quality $\rho$

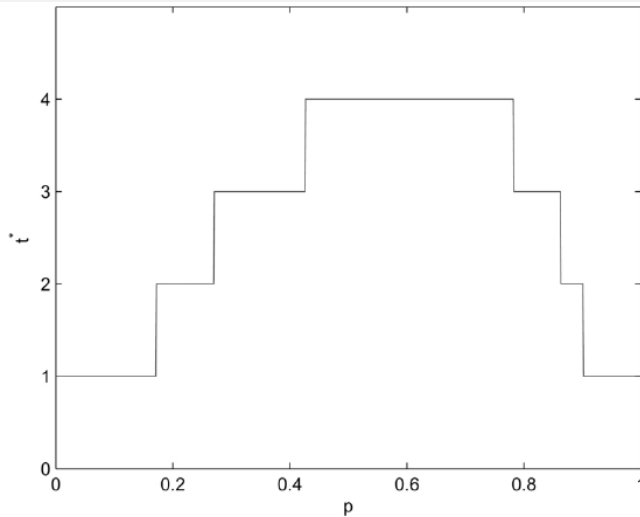


FIG. 2.—Optimal task bundling,  $t^*$ , as a function of the quality of communication,  $\rho$ , for the case considered in example 2.

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# Example Questions from Management and Organizational Practices Survey (MOPS)

## Section A - Management Practices

- 1** In 2005 and 2010, what best describes what happened at this establishment when a problem in the production process arose?

Examples: Finding a quality defect in a product or a piece of machinery breaking down.

*Check one box for each year*

	2005	2010
We fixed it but did not take further action . . . . .	<input type="checkbox"/>	<input type="checkbox"/>
We fixed it and took action to make sure that it did not happen again . . . . .	<input type="checkbox"/>	<input type="checkbox"/>
We fixed it and took action to make sure that it did not happen again, and had a continuous improvement process to anticipate problems like these in advance . . . . .	<input type="checkbox"/>	<input type="checkbox"/>
No action was taken . . . . .	<input type="checkbox"/>	<input type="checkbox"/>

- 2** In 2005 and 2010, how many key performance indicators were monitored at this establishment?

Examples: Metrics on production, cost, waste, quality, inventory, energy, absenteeism and deliveries on time.

*Check one box for each year*

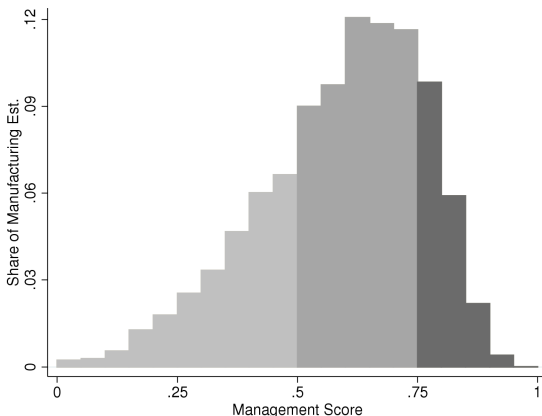
	2005	2010
1-2 key performance indicators . . . . .	<input type="checkbox"/>	<input type="checkbox"/>
3-9 key performance indicators . . . . .	<input type="checkbox"/>	<input type="checkbox"/>
10 or more key performance indicators . . . . .	<input type="checkbox"/>	<input type="checkbox"/>
No key performance indicators (If no key performance indicators in both years, SKIP to <b>3</b> ) . . . . .	<input type="checkbox"/>	<input type="checkbox"/>

- 11** In 2005 and 2010, what were **managers'** performance bonuses usually based on? *Mark all that apply*

	2005	2010
Their own performance as measured by production targets . . . . .	<input type="checkbox"/>	<input type="checkbox"/>
Their team or shift performance as measured by production targets . . . . .	<input type="checkbox"/>	<input type="checkbox"/>
Their establishment's performance as measured by production targets . . . . .	<input type="checkbox"/>	<input type="checkbox"/>
Their company's performance as measured by production targets . . . . .	<input type="checkbox"/>	<input type="checkbox"/>
No performance bonuses (If no performance bonuses in both years, SKIP to <b>12</b> ) . . . . .	<input type="checkbox"/>	<input type="checkbox"/>

# Structured Management

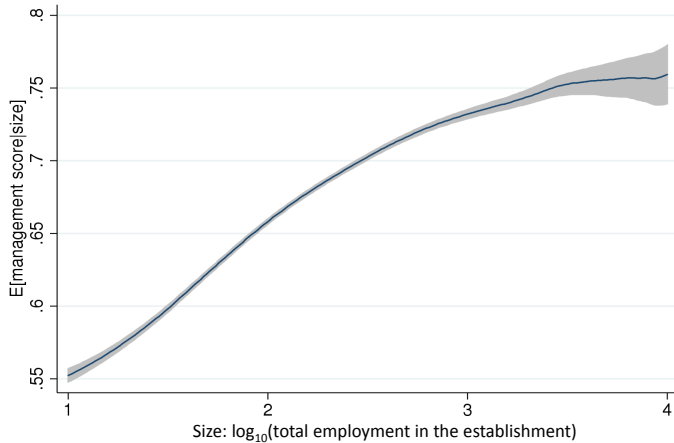
Figure 2: The Wide Spread of Management Scores Across Establishments



**Note:** The management score is the unweighted average of the score for each of the 16 questions, where each question is first normalized to be on a 0-1 scale. The sample is all MOPS observations with at least 11 non-missing responses to management questions and a successful match to ASM, which were also included in ASM tabulations, and have positive value added, positive employment and positive imputed capital in the ASM. Figures are weighted using ASM weights.

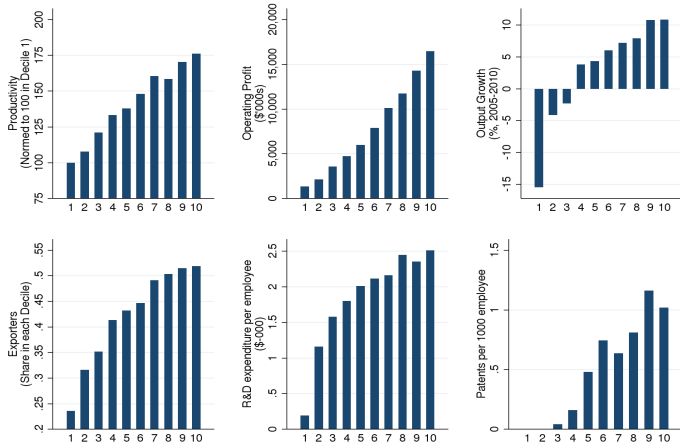
# Structured Management

Figure 6: Average Management Score Rises with Establishment Size



# 'Structured Management' and Plant Performance

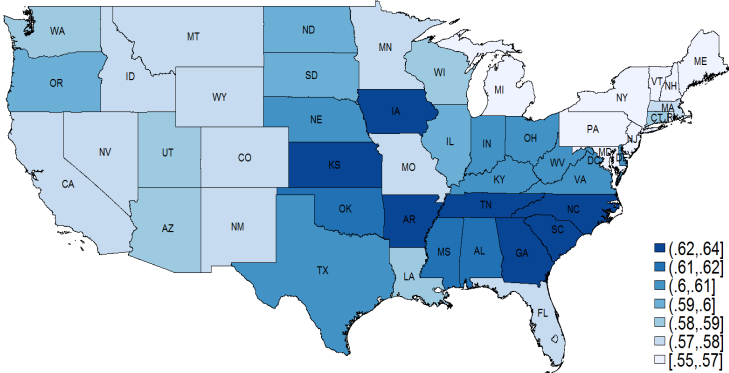
Figure 1: Plant Performance is Associated With More Structured Management





# Structured Management

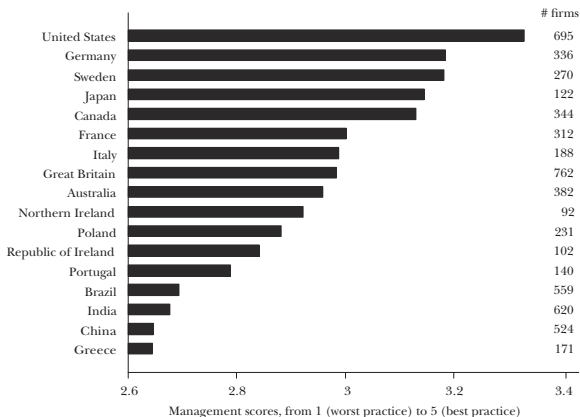
Figure 4: Average Management Scores vary Across States



Bloom et al., 2013

# Average Management Scores across Countries

Management Scores across Countries

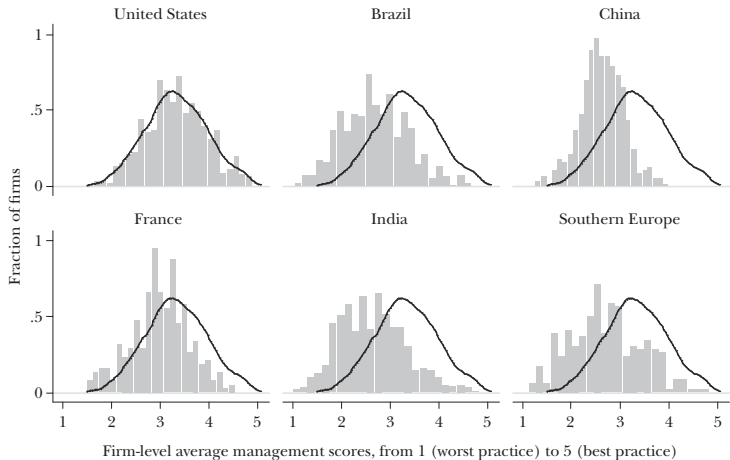


Source: Bloom, Genakos, Sadun, and Van Reenen (2009).

Notes: Averages are taken across all firms within each country. There are 5,850 observations in total. Firms per country are in the right column.

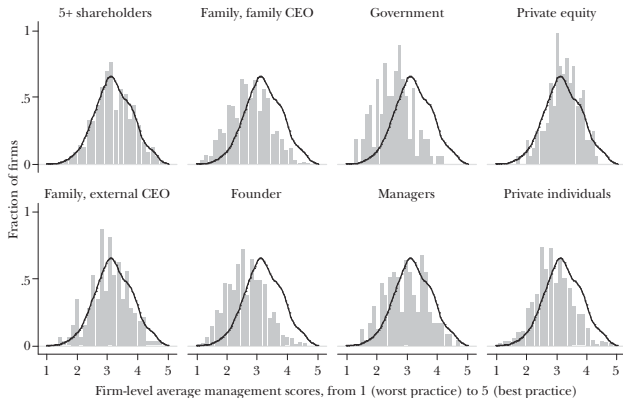
# Dist'n of Management Scores across Countries

## Management Practice Scores across Firms



# Ownership Types and Management Scores

## Ownership and Management Scores



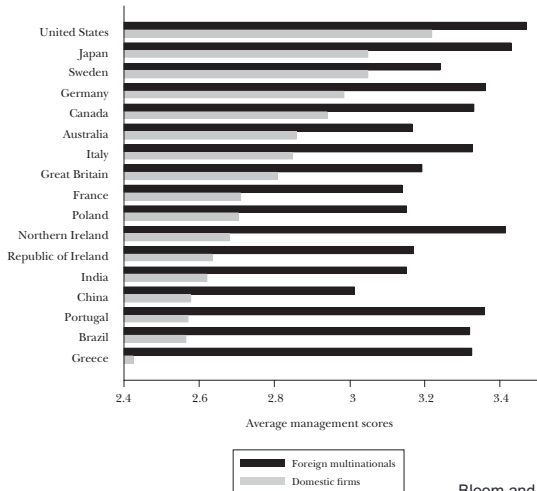
Source: Bloom, Genakos, Sadun, and Van Reenen (2009).

Notes: Graphs show the distribution of firm management scores for firms with different types of management. The overlaid line is the kernel density for dispersed shareholders, the most common U.S. ownership type.

Bloom and Van Reenen, 2010

# Multinationals Are Consistently “Well-Managed”

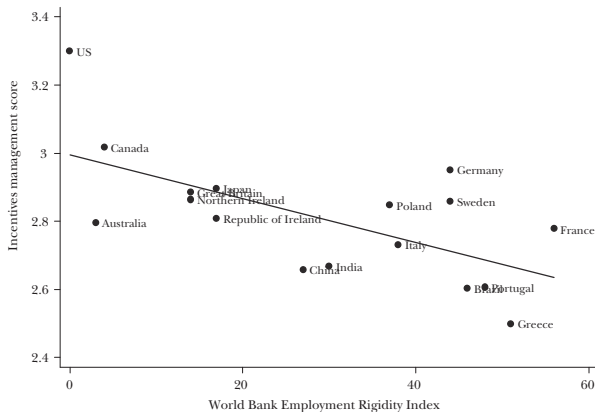
Multinationals Are Well Managed in All Countries



Bloom and Van Reenen, 2010

# Labor Market Regulations and Incentives Management

## Labor Market Regulation and Incentives Management



Source: Bloom, Genakos, Sadun, and Van Reenen (2009).

Note: World Bank index from the Doing Business database, (<http://www.doingbusiness.org/ExploreTopics/EmployingWorkers/>).

Bloom and Van Reenen, 2010