Expertise Overlap and Team Productivity: Evidence from the Hospital Industry

Danyelle Branco  
Sao Paulo School of Economics-FGV

Bladimir Carrillo  
Sao Paulo School of Economics-FGV

Di Fang  
University of Florida

Wilman Iglesias  
Vocational Economics

July 27, 2023
Motivation and Question

How to organize teams to achieve higher productivity?

• Why important? Many organizations use teamwork

• Our focus: should teams consist of heterogeneous specialists or members with similar expertise?
Diversity or shared expertise?

Members with different expertise $\Rightarrow$ productive complementarities

- Adam Smith (1776)
  - The most dissimilar geniuses are of use to one another

But $\uparrow$ coordination costs

- Becker and Murphy (1992):
  - poorer coordination of tasks in teams with more separate specialists
What we do?

Teamwork in the context of a heart procedure in Brazil

• Effects of expertise overlap on patient mortality

• **Expertise overlap**: share of overlapping medical specialties between doctors

• Policy relevant context:
  ▶ Healthcare is teamwork-intensive
  ▶ common procedure with high mortality and significant spending
What is new here?

- **Theory of team composition:** Groves (1973), Becker and Murphy (1992), Lazear (1999), Che and Yoo (2001), among others.
  - We empirically investigate some of these ideas

- **Cultural and ethnic diversity:** (Hjort, 2014; Lyons, 2017; Marx et al 2021)
  - demographic diversity ≠ skill or specialized knowledge diversity

- **Variation in the quality and cost of care:** financial incentives (Clemens and Gottlieb, 2014), medical skill (Chan, Gentzkow, and Yu, 2019), team-specific human capital (Chen, 2021)
  - our paper: variation in expertise among team members
Background
Brazil’s unified health system — (SUS)

- Universal health system:
  - largest public health care system in the world
    - covering over 150 million people
    - more than 75% of Brazil’s population (SUS, 2021)
    - annual spending is around R290 billion (or USD 58 billion)

- Hospital care through public and affiliated private health hospitals:
  - Reimbursement system
    - per procedure
    - standardized nationwide fees
Specialties

- There are about 60 specialties in Brazil
- Doctors complete more than one specialty
  - On average, 2-3
- Some specialties are pre-requisite for others
Percuntaneous Coronary Intervention (PCI)

- Nonsurgical technique to restore the blood flow through the blocked arteries.
  - catheter with a tiny balloon and stent to widen the diseased artery
  - the most recommended procedure for patients with severe clinical conditions
    - e.g., heart attacks ($\approx$50% of all cases)
  - length of stay is $\approx$ 5 days, depending on the case
Percutaneous Coronary Intervention (PCI)

1. Build up of cholesterol partially blocking blood flow through the artery.

2. Stent with balloon inserted into partially blocked artery.

3. Balloon inflated to expand stent.

4. Balloon removed from expanded stent.
PCI teams

The team consists of one proceduralist and one or more physicians:

- **Proceduralist**: a PCI-operator who executes the procedure.
- **Physicians**: provide pre/post-procedure hospital visits

Communication before/after procedure:

- before procedure $\implies$ decision about timing and strategy
  - require inputs from physicians
- after procedure $\implies$ management of complications
Assignment of Physicians to Teams

- **Assignment rule 1:** availability
  - limited sorting
    - doctor schedules set well in advance

- **Assignment rule 2:** need
  - Example: heart attack patients with a history of cancer $\Rightarrow$ oncologist
  - We observe the specialty that motivated the assigned of each physician to cases—focal specialty
Data and Identification
New Dataset on Health Care

Monthly data on doctor background:
- Universe of health professionals (with unique identifiers)
- All specialties are observed
- Hospital affiliations

Hospital data on patients:
- Dates of admissions and discharges
- All medical procedures
- Identity of all health professionals (with unique identifiers)
- Background information (age, gender, race, etc)
- 30-day mortality

Period: 2009-2020
Measuring Expertise Overlap

Expertise overlap between proceduralist $j$ and physician $k$ treating patient $i$:

$$z_{ijk} = \frac{\text{#overlapping specialties}}{\text{#specialties}}$$  \hspace{1cm} (1)

Example:

**Proceduralist:** cardiology, and oncology

**Physician:** cardiology, and general surgery

Specialties: 3 (cardiology, oncology, general surgery)

Overlapping specialties: 1 (cardiology)

$$z_{ijk} = \frac{1}{3} = 0.33$$
Measuring Expertise Overlap

when multiple physicians:

\[
\text{Expertise overlap}_{ij} \equiv Z_{ij} = \sum_{k \in \mathcal{K}(i)} \left( \frac{q_k}{\sum_{k \in \mathcal{K}(i)} q_k} \right) \times \underbrace{z_{jk}}_{\text{share of visits by physician } k} \quad \underbrace{\text{proceduralist-physician } (j, k)}_{\text{expertise overlap}}
\]

(2)

It is a weighted mean, where the number of hospital visits by physicians is used as weights.
Within-proceduralist approach — proceduralist-time fixed effects:

- Patients treated by the same proceduralist but by different physicians
- Sample limited to emergency health conditions
- Conditioning on focal specialty fixed effects
Identification

Overview - II

Variation caused by institutional features:

- Residency programs: limited supply
- Multiple paths to specialize in a given area. Example:
  - Pediatrics $\implies$ intensive care medicine; or
  - general surgery $\implies$ intensive care medicine; or
  - Anesthesiology $\implies$ intensive care medicine; or
  - Among others $\implies$ intensive care medicine; or
- Pre-requisites can differ across institutions (and regions)
  - Some institutions could have zero pre-requirements for some specialties

What does this mean?

- Idiosyncratic variation in expertise overlap
  - Identical individuals could follow different paths for a same specialty
Identifying Variation

Panel A. Histogram of the residualized expertise overlap
Estimating Equation

\( Y_{ijt} = \alpha + \beta \text{Expertise overlap}_{ijt} + \begin{pmatrix} \tilde{X}'_{ijt} \Psi \\ \tilde{P}'_{ijt} \end{pmatrix} + \xi_{jt} + \eta_{ijt} \)  

(3)

\( i \) indexes patient, \( j \) proceduralist, and \( t \) year

parameter of interest is \( \beta \)

**OBS:** standard errors clustered by hospital
Identifying Assumptions

**Condition 1. (Independence)**
Conditional on proceduralist-time and focal specialty fixed effects, patient potential outcomes are independent of the expertise overlap.

**Condition 2. (Exclusion)**
Conditional on proceduralist-time and focal specialty fixed effects, unobserved doctor characteristics are independent of the expertise overlap.
Condition 1. Covariate Balance

(patient characteristics)

Panel A. Patient characteristics

- Male
- Age
- Age>80
- age 75-80
- Age 70-75
- Age 65-70
- Age 60-65
- Age 55-60
- Age 50-55
- Age<50
- White
- Black
- Other
- Race is missing
- Out-of-state patient
- Primary hypertension
- Diabetes complicated
- Diabetes uncomplicated
- Chronic ischemic heart disease
- Kidney disease
- HIV/AIDS
- Obesity

Standardized coefficients
Condition 1. Predicted Mortality
(based on patient characteristics)

Panel A. Binned scatter plot

coeff. = -0.0005
s.e. = (0.0006)

Predicted 30-day mortality (based on patient characteristics)
Expertise overlap (residualized)
Condition 2. Covariate Balance

(physician characteristics)
Condition 2. Predicted Mortality
(based on physician characteristics)

Panel C. Binned scatter plot

Predicted 30-day mortality (based on physician characteristics)

Expertise overlap (residualized)

Coeff. = 0.0007
S.E. = (0.0014)
Results
Main Finding

actual 30-day mortality

Panel A. Binned scatter plot

coeff. = -0.042  
s.e. = (0.011)
# Effects on Mortality

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expertise overlap</td>
<td>-0.0419</td>
<td>-0.041</td>
<td>-0.0415</td>
<td>-0.0425</td>
<td>-0.041</td>
</tr>
<tr>
<td></td>
<td>[0.0107]***</td>
<td>[0.0107]***</td>
<td>[0.0107]***</td>
<td>[0.0107]***</td>
<td>[0.0106]***</td>
</tr>
<tr>
<td>Mean of dep. variable</td>
<td>0.056</td>
<td>0.056</td>
<td>0.056</td>
<td>0.056</td>
<td>0.056</td>
</tr>
<tr>
<td>Observations</td>
<td>176108</td>
<td>176108</td>
<td>176108</td>
<td>176108</td>
<td>176108</td>
</tr>
<tr>
<td>Proceduralist × year FE</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Focal specialty FE</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hospital × time FE</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Patient characteristics</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Physician characteristics</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

*Notes:* standard errors clustered at the hospital level.

* * p < 0.1; ** p < 0.05; *** p < 0.01.

10 p.p increase in expertise overlap $\Rightarrow$ 0.41 p.p (or $\approx$ 7.3%) $\downarrow$ in mortality
Major Concerns

Two obvious concerns:

- Similarity in other individual characteristics
- Correlation with number of specialties
Concern 1: Similarity in other characteristics

Specialty overlap could be correlated with similarities in other characteristics between proceduralists and physicians:

- doctors of the same gender or of adjacent birth cohorts could be more likely to choose the same specialties
- doctors with the same specialties could come from the same training institution
- teammates with the same gender or similar ages or from the same training institution may be able to work together more efficiently

Institutional characteristics make these stories less likely:

- multiple paths to specialize; hard to get in residency programs; variation in pre-required specialties across training institutions
- individuals with identical preferences may end up with different specialties
No correlation between expertise overlap and …

Panel A. Absolute difference in age

coeff. = -1.9966
s.e. = (1.6411)
No correlation between expertise overlap and ...
No correlation between expertise overlap and ...

Panel C. Residency institution concordance

coeff. = -0.0175
s.e. = (0.0954)
Expertise overlap and number of specialties are correlated by construction.

Number of specialties could have an independent effect on patient outcomes:

- More cardiologists in the team could actually be good for patients with heart issues.

In practice, correlation is weak, negative, and only marginally significant:

- Correlation coefficient: $-0.12$
Results robust to controlling for number of specialties

<table>
<thead>
<tr>
<th>Dependent variable is 30-day mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Expertise overlap</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Mean of dep. variable</td>
</tr>
<tr>
<td>Observations</td>
</tr>
<tr>
<td>Number of specialties</td>
</tr>
<tr>
<td>Number of cardiovascular-related specialties</td>
</tr>
<tr>
<td>Basic controls</td>
</tr>
</tbody>
</table>

Notes. Standard errors are clustered at the hospital level.
* p < 0.1; ** p < 0.05; *** p < 0.01.
Other concerns

Selection into procedure

- What if patients select into procedure depending on teams?
  - No evidence that is is the case

Case severity

- What if case severity $\implies$ team composition?
  - Control for diagnosis FE

Expertise overlap or shared work experience?

- what if repeated team experience $\implies$ team composition?
  - No evidence and control for team-specific experience
Physician Availability Design
Intent-to-Treat Framework

**Idea.** Simulate team composition based on the physicians available at patient arrival

- Simulated overlap as instrument for actual overlap

**Available physicians:** Based on whether they provided any care on that date.

**Simulated overlap:**

\[ w_{kd} = \frac{h_{kd}}{\sum_{k \in \mathcal{K}(d)} h_{kd}} \times z_{jkd} \]

where \( h \) is the number of hours worked per week.
First Stage
Covariate Balance

Panel A. Patient characteristics
- Male
- Age
- Age > 80
- Age 75-80
- Age 70-75
- Age 65-70
- Age 60-65
- Age 55-60
- Age 50-55
- Age < 50
- White
- Black
- Other
- Race is missing
- Out-of-state patient
- Primary hypertension
- Diabetes complicated
- Diabetes uncomplicated
- Chronic ischemic heart disease
- Kidney disease
- HIV/AIDS
- Obesity

Panel B. Physician characteristics
- Male
- Sex is missing
- Experience
- Hours worked
- Share of ambulatory workload
- Share of hospital workload
- Number of practicing cities
- Fee-for-service physician
- Fixed-term contract
- Civil-service physician
- Practice in a community health center
- Number of hospital affiliations
- Administrative duty

Standarized coefficients

[Graph showing the standardized coefficients for patient and physician characteristics]
## Results

<table>
<thead>
<tr>
<th></th>
<th>Dependent variable is:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Expertise overlap (First Stage)</td>
</tr>
<tr>
<td>Expertise overlap</td>
<td>-0.0447 [0.0199]**</td>
</tr>
<tr>
<td>Simulated expertise overlap</td>
<td>0.5399 [0.0588]***</td>
</tr>
</tbody>
</table>

kleibergen2006generalized $F$ statistics 84.1518

<table>
<thead>
<tr>
<th>Mean of dep. variable</th>
<th>0.4288</th>
<th>0.056</th>
<th>0.056</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations</td>
<td>175349</td>
<td>175349</td>
<td>175349</td>
</tr>
</tbody>
</table>

| Patient characteristics | ✓ | ✓ | ✓ |
| Physician characteristics | ✓ | ✓ | ✓ |
| Hospital × month FE     | ✓ | ✓ | ✓ |
| Hospital × day-of-week FE | ✓ | ✓ | ✓ |
| Date-of-admission FE    | ✓ | ✓ | ✓ |
| Proceduralist FE        | ✓ | ✓ | ✓ |

*Notes. Standard errors are clustered at the hospital level. 
* p < 0.1; ** p < 0.05; *** p < 0.01.*
Mechanisms
Two classes of mechanisms:

- Increased effort
  - more motivated when working with similar "co-workers"
  - costs of engaging in moral hazard are higher

- Improved team coordination
  - better communication
  - doctors familiar with each other practice's style
No Evidence of Increased Effort

Teams with shared expertise become more productive

- Consistent with improved team coordination
Case Complexity and Expertise Overlap

more complex cases require better coordination

• higher returns to expertise overlap
Previous Team Experience and Expertise Overlap

Panel B. Low versus High Shared Work Experience

- less shared experience, higher returns to learning each other style
  - higher returns to expertise overlap
Next step

Considering other medical procedures.

- Other heart procedures:
  - Pacemaker implantation
  - Coronary Artery Bypass Graft Surgery

- Non-heart procedures:
  - Treatments for intracerebral hemoerragies
  - Emergency surgeries
Thank You!
## Potential Expertise Overlap and PCI probability

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulated expertise overlap</td>
<td>0.0338</td>
<td>0.0587</td>
<td>0.0304</td>
<td>0.0302</td>
</tr>
<tr>
<td></td>
<td>[0.0986]</td>
<td>[0.0969]</td>
<td>[0.0386]</td>
<td>[0.0385]</td>
</tr>
<tr>
<td>Mean of dep. variable</td>
<td>0.4507</td>
<td>0.4507</td>
<td>0.4507</td>
<td>0.4507</td>
</tr>
<tr>
<td>Observations</td>
<td>1847482</td>
<td>1847482</td>
<td>1847463</td>
<td>1847463</td>
</tr>
<tr>
<td>Day-of-admission FE</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hospital × (day-of-week, month, and year ) FE</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Patient characteristics</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes.** Standard errors are clustered at the hospital level. * p < 0.1; ** p < 0.05; *** p < 0.01.
## Actual Expertise Overlap and Predicted PCI Probability

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expertise overlap</td>
<td>-0.000185</td>
<td>0.000005</td>
<td>-0.0002</td>
<td>-1.3E-05</td>
<td>0.000028</td>
</tr>
<tr>
<td></td>
<td>[0.000587]</td>
<td>[0.000598]</td>
<td>[0.000140]</td>
<td>[0.000607]</td>
<td>[0.000081]</td>
</tr>
<tr>
<td>Mean of dep. variable</td>
<td>0.4529</td>
<td>0.4530</td>
<td>0.4529</td>
<td>0.4529</td>
<td>0.4530</td>
</tr>
<tr>
<td>Observations</td>
<td>174934</td>
<td>173893</td>
<td>174934</td>
<td>174934</td>
<td>173893</td>
</tr>
<tr>
<td>Proceduralist × year FE</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Physician’s case-related specialty FE</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hospital × time FE</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Patient characteristics</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Physician characteristics</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Notes.** Standard errors are clustered at the hospital level.

* p < 0.1; ** p < 0.05; *** p < 0.01.
# Accounting for Selection into PCI

Dependent variable is 30-day mortality

<table>
<thead>
<tr>
<th>Expertise overlap</th>
<th>Baseline (1)</th>
<th>Control for predicted PCI treatment</th>
<th>Control for inverse</th>
<th>Sample limited to high PCI</th>
<th>prob. patients (7)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.041</td>
<td>-0.0409</td>
<td>-0.0409</td>
<td>-0.0409</td>
<td>-0.0408</td>
</tr>
<tr>
<td></td>
<td>[0.0106]***</td>
<td>[0.0106]***</td>
<td>[0.0106]***</td>
<td>[0.0106]***</td>
<td>[0.0106]***</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean of dep. variable</th>
<th>Baseline (1)</th>
<th>Control for predicted PCI treatment</th>
<th>Control for inverse</th>
<th>Sample limited to high PCI</th>
<th>prob. patients (7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean of dep. variable</td>
<td>0.056</td>
<td>0.0555</td>
<td>0.0555</td>
<td>0.0555</td>
<td>0.0555</td>
</tr>
<tr>
<td>Observations</td>
<td>176108</td>
<td>174934</td>
<td>174934</td>
<td>174934</td>
<td>174934</td>
</tr>
<tr>
<td>Sample</td>
<td>All</td>
<td>Common diagnosis for PCI</td>
<td></td>
<td></td>
<td>36103</td>
</tr>
<tr>
<td>Basic controls</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Notes. Standard errors are clustered at the hospital level.

* p < 0.1; ** p < 0.05; *** p < 0.01.
## Controlling for Diagnosis Fixed Effects

<table>
<thead>
<tr>
<th></th>
<th>Baseline (1)</th>
<th>Controlling for patient primary diagnosis (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expertise overlap</td>
<td>-0.041</td>
<td>-0.0384</td>
</tr>
<tr>
<td></td>
<td>[0.0106]***</td>
<td>[0.0098]***</td>
</tr>
<tr>
<td>Mean of dep. variable</td>
<td>0.056</td>
<td>0.056</td>
</tr>
<tr>
<td>Observations</td>
<td>176108</td>
<td>176108</td>
</tr>
<tr>
<td>Primary diagnosis FE</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Basic controls</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Notes.** Standard errors are clustered at the hospital level.  
* p < 0.1; ** p < 0.05; *** p < 0.01.
# Team-Specific Experience

<table>
<thead>
<tr>
<th></th>
<th>Dependent variable is:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shared work experience</td>
<td>30-day mortality</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(in days)</td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Expertise overlap</td>
<td>8.8064</td>
<td>-0.041</td>
<td>-0.0364</td>
</tr>
<tr>
<td></td>
<td>[6.3490]</td>
<td>[0.0106]**</td>
<td>[0.0097]**</td>
</tr>
<tr>
<td>Mean of dep. variable</td>
<td>51.44</td>
<td>0.056</td>
<td>0.0526</td>
</tr>
<tr>
<td>Observations</td>
<td>168238</td>
<td>176108</td>
<td>168238</td>
</tr>
<tr>
<td>Basic controls</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

*Notes.*

* p < 0.1, ** p < 0.05, *** p < 0.01.