Technology Adoption and Market Allocation: The Case of Robotic Surgery

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Motivation

• Technology key driver of productivity in health care, economy in general
• Information frictions, insurance may distort adoption in health care
• Patients may have a preference for technology, use as proxy for quality
• “Medical arms race”: hospitals compete over same patients
  ➞ service duplication, increased cost

• How does tech adoption impact care utilization?
• Does adoption prompt market expansion? Business stealing?
• Who does adoption draw into treatment?
Overview

Study effect of adopting robotic surgery on prostate cancer hospitalizations

• Robot: intermediate cost (vs. cardiac cath, $\beta$ blockers)
• Leverage rapid, staggered, adoption of robot
• Assess effects at market & hospital levels
• Characterize marginal patients (Gruber et al. 1999)

Key findings

• Adoption drives large increase in volume (80-99%)
• Smaller effects at market level (market expansion and business stealing)
• Marginals relatively healthy (adoption not broadening eligibility criteria)
Robotic Adoption Over Time

![Graph showing the share of hospitals adopting robotic surgery over time, with initial FDA approval marked in 2001.](image-url)
Background: Surgical Robotics

• Intuitive Surgical da Vinci robot (only device during analysis period)
• FDA approved in 2000
• Dramatically changed prostate cancer intervention
• Relatively low barriers to entry
• Not pivotal for Medicare payment
• No RCT evidence of benefit vs. alternatives (laparoscopic, open)
• Focus of hospital advertising
Use of Robotic Surgery for Prostatectomy Over Time

- **Initial FDA Approval:**
  - Year 1999

- **Share of Prostatectomies:***
  - **Laparoscopic (Including Robotic):**
  - **Robotic:**
  - Graph shows an increase over time from 1999 to 2015.
Background: Prostate Cancer

• Second most common cancer in men, 33k deaths/year

• Key surgical treatment: prostatectomy

• Slow-growing, often not fatal (competing risks)

• Mid-2000s shift to “watch & wait” (avoid unnecessary treatment)

• 32% drop in prostatectomies during analysis period

• Rapid adoption of robots during this shift, offsetting some of decline
Data

100% Medicare hospitalization data (MEDPAR), 1998-2015

• Measure prostate cancer, prostatectomy patients
• Hospitals in “risk set” for intensive treatment (50+ patients, 5+ cancer patients annually)
• Sample: 2,261 hospitals (1,091 adopters)

Robotic Adoption

• Archives of Intuitive Surgical website, 2002-2005
• AHA survey data, 2005-2015
Methodology

\[ N_{ht} = \exp(\alpha_t + \alpha_h + \beta \cdot \text{interim}_{ht} + \gamma \cdot \text{post}_{ht}) + \varepsilon_{ht} \]

- \( N_{h,t} \) - admissions for hospital \( h \), time \( t \)
- \( \alpha_t \) - year FE, \( \alpha_h \) - hospital FE
- \( \text{interim}_{h,t} \) - adopted in \( t \)
- \( \text{post}_{h,t} \) - adopted in \( t - 1 \) or before

Also run analyses at market (HRR) level \( r \)

- \( \text{interim}_{r,t} \) - beds-weighted share adopting in \( t \)
- \( \text{post}_{r,t} \) - beds-weighted share adopting in \( t - 1 \) or before
Effects on Prostatectomy Patient Volume

Coefficient

Hospital-Level

Market-Level

1.0
0.8
0.6
0.4
0.2
0.0
-0.2

≤-3 -2 -1 0 1 2 ≥3
## Estimates of Effect of Adoption on Volume

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Robust standard errors clustered at the market level in parentheses.
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Study *who* robots bring into treatment:

- Patient Age
- Chronic conditions (22 conditions from pre-admit diagnoses)

First approach: use DD to measure volume effects for subgroups
Identifying Characteristics of Marginal Patients

Second approach: estimate characteristics of marginals (c.f. Gruber et al. 1999)

\[ N_{ht} = \exp \left( \alpha^1_{t} + \alpha^1_{h} + \beta^1 \cdot \text{interim}_{ht} + \gamma^1 \cdot \text{post}_{ht} \right) + \varepsilon^1_{ht} \]

“First stage” - same DD regression as before

\[ C_{ht} = \exp \left( \alpha^RF_{t} + \alpha^RF_{h} + \beta^RF \cdot \text{interim}_{ht} + \gamma^RF \cdot \text{post}_{ht} \right) + \varepsilon^RF_{ht} \]

“Reduced form” - use average characteristic \( C_{ht} \) as outcome

\[ \eta = \frac{\gamma^RF}{\gamma^1} \]

“Elasticity” - ratio of reduced form to first stage

\( \approx \) % effect on average characteristic from 100% increase in volume

\( \approx \) % diff between marginal & average patient (under no defiers)
### Characteristics of Marginal Patients After Adoption

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<td>Beds</td>
<td>Volume</td>
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</tr>
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CCs: chronic conditions count. Beds & volume measured at baseline (1998) levels.

Elasticity \approx \%\text{ effect on average characteristic from 100\% increase in volume}

\approx \%\text{ diff between marginal & average patient (under no defiers)}
### Characteristics of Marginal Patients After Adoption

#### Hospital-Level vs. Market-Level

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### Notes

- Elasticity ≈ % effect on average characteristic from 100% increase in volume
- ≈ % diff between marginal & average patient (under no defiers)
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Elasticity \(\approx\) % effect on average characteristic from 100% increase in volume

\(\approx\) % diff between marginal & average patient (under no defiers)
Robotic surgery expands market and moves patients across hospitals

- Gap between the market- & hospital-level: business stealing
- Marginal patients are younger and healthier
- No detected expansion of treatment to older patients (low-value)
- Signs that adoption brings patients to larger & teaching hospitals
Implications for Welfare

A socially wasteful “medical arms race”?

- Traditional view: unconstrained adoption, fixed costs, business stealing
  \[\Rightarrow\] welfare-damaging arms race

- Assumes common quality or quality uncorrelated with adoption

- Adoption that reallocates to better hospitals can be welfare-improving

- Signs patients move to bigger & teaching hospitals are encouraging
Does finding of market expansion mean welfare improved?

- Market imperfections, behavioral patients (or agents) complicate story
- Moral hazard - insurance distorts decisions
- Behavioral hazard - biased beliefs distort decisions (Baicker et al. 2015)
- But don’t find welfare-damaging expansion to poor matches to surgery
- Detailed clinical data (e.g. SEER) could give the last word
Conclusion

• Study intermediate-cost, rapidly-adopted tech in prostate cancer context
• Find adoption drives large increases in patient volume
• Effects due to market expansion and business stealing
• Small to no volume effects for poor patient matches
• Results inconsistent with most welfare-damaging stories

• Thank you for attending!