A Stitch in Time

Work Complexity and the Divergent Effects of Employee Monitoring on Productivity

Aruna Ranganathan (Stanford) & Alan Benson (Minnesota)

University of Toronto- CIRHR
Research Questions

QUESTION 1:  
Does monitoring improve or impair worker productivity?

QUESTION 2:  
Under what conditions does monitoring improve or impair productivity?
Motivation

- Conceptual
Motivation

- Conceptual
- Timeliness
Motivation

- Conceptual
- Timeliness
- Methodological
“Monitoring Improves Productivity”

- Barcodes $\rightarrow$ retail productivity
  Basker et al. (2012)

- Truck OBC $\rightarrow$ better driving
  Hubbard (2000)

- Process control $\rightarrow$ factory productivity
  Bloom and van Reenen (2006)

- Restaurant IS $\rightarrow$ server productivity & less theft
  Pierce, Snow, and McAfee (2015)
"Monitoring Improves Productivity"

- Digitization $\rightarrow$ faster growth
  - Aral et al. (2012)
  - Bryjolfsson and Hitt (2000)
“Monitoring Impairs Productivity”

- Monitoring reduces motivation
  (Deci and Ryan 1975)
“Monitoring Impairs Productivity”

- Monitoring Reduces Innovation (Bernstein 2012)
“Monitoring Impairs Productivity”

Setting
Hypothesis Development
Hypothesis Development

Works on simple product line

Works on more complex product line
Hypothesis Development

Works on simple product line

My work was boring before..I like the various buttons [on the machine] and this makes the work fun. Its nice that IE is aware of what I’m doing.

Works on more complex product line
Hypothesis Development

Works on simple product line

My work was boring before..I like the various buttons [on the machine] and this makes the work fun. Its nice that IE is aware of what I’m doing.

Works on more complex product line

My work is critical and difficult to do…so the thought of the IE manager constantly observing is [distracting]..it would make even a normally fast operator slow down.
Hypothesis Development

The machine has helped me realize my potential...I am delivering better production numbers than I ever thought I could do!

I do not like having the machine... [I] think that it has not positively impacted my production levels.
Hypothesis Development

- **Simple jobs**
  - Workers engaged in “job crafting” (Berg et al. 2010, Leana 2009)
  - Monitoring promoted gamification (Deterding et al. 2011)
  - Similar forms of job crafting long seen on factory floors (Burawoy 1979; Roy 1952, 1959; Sherman 2007)

- **Complex jobs**
  - Micromanagement appeared to reduce workers’ autonomy (Spreitzer 1996, Deci and Ryan 1975)
  - Crowded out workers’ intrinsic motivation (Manso 2011, Frey and Jegen 2011)
Research Questions

**QUESTION 1:**
Does monitoring improve or impair worker productivity?
*It depends.*

**QUESTION 2:**
Under what conditions does monitoring improve or impair productivity?
*In this case, it depends on work complexity.*
Hypotheses

- H1: Monitoring will *improve* productivity among workers performing *simple* work
- H2: Monitoring will *impair* productivity among workers performing *complex* work
Data

- Unique longitudinal, quantitative data
  - Line-level Data (5 years: 2009-2014)
    - Daily Line Productivity
  - Individual-level Data (1 year: 2012)
    - Pants Lines only
    - Daily Individual Productivity
- 1 year of ethnographic observation
Data

- **Standard Minute Values (SMV):** The number of minutes required to perform an operation, including rest time
  - SMVs are thought of as a measure of complexity
  - Complexity appears to determine how workers treat the monitoring intervention

- Percent efficiency\(_i\) = \frac{\text{Production}_i}{\text{SMV}_i}
Research Design

3 jacket lines

9 pant lines
Research Design

3 jacket lines

9 pant lines

SMV
Mean: 0.74
SD: 0.36
Research Design

3 jacket lines

9 pant lines

SMV
Mean: 0.59
SD: 0.31
Research Design

3 jacket lines

9 pant lines

SMV
Mean: 0.74
SD: 0.36

SMV
Mean: 0.59
SD: 0.31
Research Design

3 jacket lines

10/1/12

SMV
Mean: 0.74
SD: 0.36

9 pant lines

SMV
Mean: 0.59
SD: 0.31
Research Design

3 jacket lines

9 pant lines

SMV
Mean: 0.74
SD: 0.36

SMV
Mean: 0.59
SD: 0.31

12/1/12
Empirical Strategy

**Jackets (complex)**
- a: Lining to arm hole (1.49)
- b: Facing seam (0.89)
- c: Trim lapel corner (0.71)
- d: Front dart marker (0.45)
- e: Under collar gat (0.19)

**Pants (simple)**
- a: Loop bartack (1.11)
- b: Front panel ol (0.71)
- c: Fix hook (0.55)
- d: Back button hole (0.41)
- e: Wash care label (0.19)
## Threats to Validity

<table>
<thead>
<tr>
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<th>Threat to Validity</th>
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<td>Treated vs control</td>
<td>Treatment was nonrandom with respect to productivity</td>
</tr>
<tr>
<td>DID</td>
<td>Treatment was nonrandom with respect to productivity and time</td>
</tr>
</tbody>
</table>
# Balance Checks

<table>
<thead>
<tr>
<th></th>
<th>Treated Lines</th>
<th>Control Lines</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count of Workers on Same Line</td>
<td>245.9</td>
<td>242.1</td>
<td>3.770</td>
</tr>
<tr>
<td>(159.5)</td>
<td>(155.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share High Skilled</td>
<td>0.0121</td>
<td>0.0131</td>
<td>-0.001</td>
</tr>
<tr>
<td>(0.109)</td>
<td>(0.114)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share Female</td>
<td>0.933</td>
<td>0.908</td>
<td>0.024*</td>
</tr>
<tr>
<td>(0.251)</td>
<td>(0.289)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share from Karnataka</td>
<td>0.858</td>
<td>0.837</td>
<td>0.021</td>
</tr>
<tr>
<td>(0.349)</td>
<td>(0.369)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (in years)</td>
<td>28.43</td>
<td>28.40</td>
<td>0.029</td>
</tr>
<tr>
<td>(6.808)</td>
<td>(6.484)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tenure in Plant (in years)</td>
<td>1.117</td>
<td>1.013</td>
<td>0.104</td>
</tr>
<tr>
<td>(2.005)</td>
<td>(1.670)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Workers</td>
<td>579</td>
<td>1068</td>
<td></td>
</tr>
</tbody>
</table>

Standard deviations in parentheses

* p<0.1, ** p<0.05, *** p<0.01
## Summary Statistics

### Table 2: Effect of Monitoring on Line Productivity (Percent Efficiency)

<table>
<thead>
<tr>
<th></th>
<th>Before RFID Implemented</th>
<th>After RFID Implemented</th>
<th>Difference: After—Before</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SE</td>
<td>Mean</td>
</tr>
<tr>
<td>Treated</td>
<td>65.9%</td>
<td>(0.2)</td>
<td>70.0%</td>
</tr>
<tr>
<td>Control</td>
<td>59.0%</td>
<td>(0.2)</td>
<td>60.6%</td>
</tr>
<tr>
<td>Treated—Control</td>
<td>6.8%</td>
<td>(0.3)</td>
<td>9.4%</td>
</tr>
</tbody>
</table>

### Panel 1: Unconditional Analysis

1. **Across All Lines**
   - Treated: 65.9% (0.2)
   - Control: 59.0% (0.2)
   - Treated—Control: 6.8% (0.3)
   - After RFID Implemented: 70.0% (0.2)
   - Difference: After—Before: 4.2% (0.3)

### Panel 2: Analysis by Product

2a. **Simple Product Lines (Pants)**
   - Treated: 64.2% (0.2)
   - Control: 59.4% (0.2)
   - Treated—Control: 4.8% (0.3)
   - After RFID Implemented: 73.0% (0.2)
   - Difference: After—Before: 8.8% (0.3)

2b. **Complex Product Lines (Jackets)**
   - Treated: 68.8% (0.4)
   - Control: 57.5% (0.4)
   - Treated—Control: 11.2% (0.5)
   - After RFID Implemented: 63.9% (0.4)
   - Difference: After—Before: -4.9% (0.6)
## Summary Statistics

### Table 2: Effect of Monitoring on Line Productivity (Percent Efficiency)

<table>
<thead>
<tr>
<th></th>
<th>Before RFID Implemented</th>
<th>After RFID Implemented</th>
<th>Difference: After—Before</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SE</td>
<td>Mean</td>
</tr>
<tr>
<td><strong>Treated</strong></td>
<td>60.0% (1.2)</td>
<td></td>
<td>65.1% (1.2)</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>57.1% (1.2)</td>
<td></td>
<td>57.2% (0.7)</td>
</tr>
<tr>
<td><strong>Treated—Control</strong></td>
<td>2.9% (1.8)</td>
<td></td>
<td>7.9% (1.5)</td>
</tr>
</tbody>
</table>

### Panel 3: Analysis by Operation

#### 3a. Simple Operations

- **Treated**: 60.0% (1.2)  
- **Control**: 57.1% (1.2)  
- **Treated—Control**: 2.9% (1.8)

#### 3b. Complex Operations

- **Treated**: 71.6% (1.4)  
- **Control**: 65.4% (1.0)  
- **Treated—Control**: 6.2% (1.7)

*Note.* Cells represent mean percent efficiency at the line-day level (1, 2a, and 2b) and operation-day level (3a and 3b). Analysis 2a is for lines producing the product with relatively simple operations (pants), 2b is for lines producing the product with relatively complex operations (jackets), 3a is for relatively simple operations on the pant lines, and 3b is for relatively complex operations on the pant lines.
DID Regression (Production Lines)

<table>
<thead>
<tr>
<th></th>
<th>Simple Lines (Pants)</th>
<th>Complex Lines (Jackets)</th>
<th>All Lines (Pants &amp; Jackets)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Post</td>
<td>0.73</td>
<td>4.52</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td>(2.50)</td>
<td>(2.86)</td>
<td>(2.46)</td>
</tr>
<tr>
<td>Treated</td>
<td>4.80*</td>
<td>11.2***</td>
<td>4.80*</td>
</tr>
<tr>
<td></td>
<td>(2.52)</td>
<td>(0.31)</td>
<td>(2.48)</td>
</tr>
<tr>
<td>Post × Treated</td>
<td>8.06**</td>
<td>-9.42*</td>
<td>8.06**</td>
</tr>
<tr>
<td></td>
<td>(2.68)</td>
<td>(2.86)</td>
<td>(2.64)</td>
</tr>
<tr>
<td>Complex</td>
<td></td>
<td>-1.86</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.11)</td>
<td></td>
</tr>
<tr>
<td>Post × Complex</td>
<td></td>
<td>3.80</td>
<td>2.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.46)</td>
<td>(2.96)</td>
</tr>
<tr>
<td>Treated × Complex</td>
<td></td>
<td>6.42**</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.50)</td>
<td></td>
</tr>
<tr>
<td>Post × Treated × Complex</td>
<td></td>
<td>-17.5***</td>
<td>-15.7***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.59)</td>
<td>(2.90)</td>
</tr>
</tbody>
</table>

Line FE | No | Yes |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Month-Year FE</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Day of Week FE</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>N</td>
<td>12,137</td>
<td>12,137</td>
</tr>
<tr>
<td></td>
<td>4,299</td>
<td>4,299</td>
</tr>
<tr>
<td></td>
<td>16,436</td>
<td>16,436</td>
</tr>
</tbody>
</table>

Note. Observations are at the line-date level. All estimates are from OLS models.
DV: One point is one percent efficiency. Post=1 after RFID implemented.
Treated=1 for lines that received RFID. Jackets=1 for jacket lines.
Standard errors clustered by line are in parentheses.
* p<0.1, ** p<0.05, *** p<0.01
Difference in Weekly Line Productivity b/w Treated and Control Lines

Pants (Simple)

Jackets (Complex)
Counterfactual Analysis (Production Lines)

Figure 6  Placebo Analysis with Truly Nontreated Lines Indicated as Treated Lines

Note. Capped vertical lines represent 95% confidence intervals using the $T(G - L)$ distribution. Solid markers denote the nonplacebo tests.
Variation in Work Complexity

![Box plots showing variation in work complexity for jackets and pants.](image)

- **Jackets (complex)**:
  - a: Lining to arm hole (1.49)
  - b: Facing seam (0.89)
  - c: Trim lapel corner (0.71)
  - d: Front dart marker (0.45)
  - e: Under collar gat (0.19)

- **Pants (simple)**:
  - a: Loop bartack (1.11)
  - b: Front panel ol (0.71)
  - c: Fix hook (0.55)
  - d: Back button hole (0.41)
  - e: Wash care label (0.19)
## DID Regression (Individuals)

<table>
<thead>
<tr>
<th></th>
<th>Simple Operations (Within Pants)</th>
<th>Complex Operations (Within Pants)</th>
<th>All Operations (Within Pants)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Post</td>
<td>0.0952</td>
<td>-1.04</td>
<td>0.0952</td>
</tr>
<tr>
<td></td>
<td>(0.871)</td>
<td>(1.66)</td>
<td>(0.869)</td>
</tr>
<tr>
<td>Treated</td>
<td>2.93</td>
<td>6.21*</td>
<td>2.93</td>
</tr>
<tr>
<td></td>
<td>(2.63)</td>
<td>(3.17)</td>
<td>(2.62)</td>
</tr>
<tr>
<td>Post x Treated</td>
<td>4.97*</td>
<td>-4.15**</td>
<td>4.97*</td>
</tr>
<tr>
<td></td>
<td>(2.77)</td>
<td>(1.52)</td>
<td>(2.76)</td>
</tr>
<tr>
<td>Complex</td>
<td></td>
<td></td>
<td>8.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(7.33)</td>
</tr>
<tr>
<td>Post x Complex</td>
<td></td>
<td></td>
<td>-1.14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(1.80)</td>
</tr>
<tr>
<td>Treated x Complex</td>
<td></td>
<td></td>
<td>3.29</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3.98)</td>
</tr>
<tr>
<td>Post x Treated x Complex</td>
<td></td>
<td></td>
<td>-9.13***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3.11)</td>
</tr>
<tr>
<td>Line FE</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Month FE</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Day of Week FE</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>N</td>
<td>3745</td>
<td>3745</td>
<td>1618</td>
</tr>
</tbody>
</table>
Difference in Difference Estimates by Complexity Bins (Individual)
Discussion and Limitations

- Are results driven by complexity, or something correlated with complexity?
Discussion and Limitations

- Are results driven by complexity, or something correlated with complexity?
Discussion and Limitations

- Why does the effect of monitoring on productivity depend on complexity? A few theories can be ruled out because the intervention involved no rewards/punishments
  - Shirking (Shapiro and Stiglitz 1984)
  - Cheating (Pierce, Snow, and McAfee 2015)
  - Multitasking (Holmstrom and Milgrom 1991)
  - Monitoring as deterrence to innovation (Bernstein 2012)
  - Complementary practices (Brynjolfsson and Hitt 2000)
Discussion and Limitations

- What mechanisms do we rule in?
  - Fieldwork suggests gamification and crowding out was occurring
  - Social facilitation may play role, but surprising in this setting?
  - Cognitive load also may play a role, but surprising in this setting?
Conclusion

- This paper argues that work complexity moderates the effectiveness of monitoring on employee productivity.
- When work is simple, monitoring “gamifies” the work and improves productivity.
- When work is complex, monitoring micro-manages the work and is counterproductive.
Editor and reviewers are asking us to unpack the theoretical mechanism. They offer:

Mechanism may be:
(a) Assignment of workers
(b) Monitoring’s heterogeneous effect on motivation
(c) Differences in work structures and interdependence
(d) Mean reversion
Status of the Paper

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   *we’re formalizing qualitative analysis*
(c) Differences in work structures and interdependence
   *we’re thinking about across-line vs within-line results*
(d) Mean reversion
   *we find that lines start out the same then diverge*
Thank You!
bensona@umn.edu