Predictive Analytics and the Changing Manufacturing
Employment Relationship:
Plant Level Evidence from Census Data

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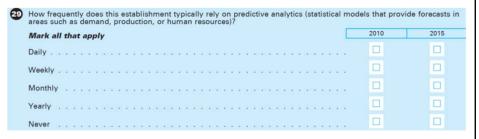
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Disclosure

What is predictive analytics?

- "Predictive analytics is the use of data, statistical algorithms and machine learning techniques to identify the likelihood of future outcomes based on historical data." (SAS)

- Census data question:

- Note that we are measuring predictive analytics usage over and above more general Information Technology and Data usage.

Motivation

- Increase in predictive analytics (PA) usage and interest over time
  - Google trend:

- Most attention (practitioner and academic) goes to plant optimization
  - Little known about how predictive analytics alters employment relationship
  - Even though practitioners understand the need to "manage" differently

Research questions

- Use US Census Bureau data on management practices to study how PA affects the manufacturing employment relationship:
    1. Delegation of decision-making between HQ and plants
    2. Intensity, design and communication of performance-based incentives
    3. Demographics / composition of workforce at plant
- We also look at characteristics of firms and plants that are more likely to increase use of PA over our time period and plant-level efficiency outcomes

US Census data

- Mandatory compliance

- Public and private firms

- CMF—Census of Manufacturers
    - Every 5 years, all establishments are "censused" (~168,000)

- ASM—Annual Survey of Manufacturers
    - In between, stratified/random sample of 51,000 are surveyed each year
    - 15,400 big plants always selected (67% of CMF activity)
    - 33,000 multi-plant firms, 18,000 single plant

- MOPS—Management and Organizational Practices Survey
    - ASM sample, 71% response rate
    - 46 questions, 45 minutes to complete
    - 2015 with recall for 2010
    - Multiple plants per firm

- From a research point of view: high quality, large dataset that allows to derive statistically and economically relevant conclusions, generalizable to all of US manufacturing

Increasing use of predictive analytics in manufacturing

- In Census Data, 30+% of manufacturers reported an increase in their use for at least one plant from 2010 through 2015
- Average plant increases frequency of PA use from quarterly to monthly
- Which firms and plants use predictive analytics in 2015?
  - Firm
    - Larger firms (payroll, multinational, multi-plant)
    - Educated management in HQ
    - More educated workforce
    - Newer firms
    - Not family run
    - More stable industries (lower growth, not tech)
  - Plant
    - Bigger plants
    - More educated workforce

Increases in PA result in increased centralization of decision-making in headquarters (HQ)

- Increased centralization of decision-making related to
  - Marketing: pricing of products, new product introductions, advertising
  - Human Resource Management: hiring, large pay increases
  - NOT CAPEX decisions
- HQ (rather than plant) also more likely to choose which data to collect
- Information Technology (IT) more generally often leads to increased decentralization as it provides local plant management with an information advantage
- Our results suggests that every IT isn't created equally: PA provides hard data that can quickly and easily be communicated to HQ

How does PA affect managerial incentives and performance measurement?

- If PA reduces delegation, intensity of incentive-based compensation reduces because
  - Local managers have less control over performance
  - Less need to rely on strong incentives to mitigate the agency problem
- Availability of hard data from plant enhances ability to closely tie incentives to performance and set accurate targets
- Hence, unclear directional effect

Increases in PA result in stronger incentives

- Increased use of performance-based bonus plans
- Speedier terminations upon observing low performance
- More meritocratic promotions
- Performance targets:
  - More long term, less short term
  - More salient: awareness of targets
  - More likely to be achieved with normal levels of effort
    - Not extremely little or extremely high effort
  - Ex post targets more likely to be achieved

Increases in PA affect workforce composition

- Managerial compensation in proportion to total value of shipments reduces
- While staff compensation in proportion to total value of shipments doesn't alter significantly
- Suggests fewer managers needed at plant-level
  - In line with decision-making authority pulled into HQ
- Changes at staff level:
  - Proportion of staff on temporary contracts increases
  - Proportion of staff working flexible hours increases
  - Proportion of staff cross-trained increases

Are these big changes to employee management worth it? Increases in PA lead to:

- Improved efficiency
  - Total Value of Shipments increases
  - While production hours worked stays constant
- Improved inventory utilization
  - Inventory $ in proportion to Total Value of Shipments
- Streamlined product offering: reduction in number of products
  - In line with product introduction decision centralized in HQ

Conclusion

- Predictive analytics increasingly pervasive in manufacturing

- Predictive analytics is associated with
    - Reduced delegation of decision-making
    - Changes in intensity, design and communication of performance-based incentives
    - Changes in the demographics of the workforce:
        - Fewer managers
        - Staff increasingly temporary, flexible and cross-functional
    - Improvements in operational efficiency

- "Uberization" of manufacturing
- Introduction of the "gig economy" in manufacturing