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

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Disclosure

This research was conducted while the authors were Special Sworn Status researchers of the U.S. Census Bureau at the Triangle Census Research Data Center and the Michigan Census Research Data Center.  
Any opinions and conclusions expressed herein are those of the authors and do not represent the views of the U.S. Census Bureau.  
All results have been reviewed to ensure that no confidential information is disclosed.
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:

![Census Data Question](image)

• 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:

![Google Trend](image)

• 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