Measuring Advanced Manufacturing and Process Innovation: Applications to Productivity and Growth

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Big picture

- The flow of this paper reminds me of Kogan, Papanikolaou, Seru, and Stoffman (2017)
  - I understand that the authors tried to link the process and product patents to aggregate economies and firm growth so to highlight the economic relevance
- However, I am looking for a "new dimension"- how can this study open a new window for the literature?
- 3 possibilities:

    1. Synergies/complementarities of being good on both ends: how two types of innovations facilitate each other

    2. Classify different types of firms: firms that focus on process (Foxconn) and firms that focus on product (Garmin); how they operate and develop?

    3. Firms' life cycles: product innovation first or process innovation first? When will the priority switch? (Utterback argued that firms first engage in product innovation and then shift to process innovation when they grow mature)

The separation of product and process innovation

- To my knowledge, the earliest seminal work in this direction can be traced to Scherer's works:
  - Scherer (1967, 1984) pointed out, about 24%-26% of R&D efforts are process-related, and the rest are product-related.
  - Similar estimates are also found in McGraw-Hill surveys (1978, 1979)
- This paper shows that the process innovation increases in ratio (30%-40%)
- Chen, Hsu, and Wang (2022) use product-related patents to measure a firm's product innovation

The separation between process and product patents

- The authors intentionally classify a patent into process innovation, a product invention, or both.
    - (0,0), (0,1), (1,0), or (1,1)
- Ganglmair, Robinson, and Seeligson (2021) analyze each independent claim of US patents and then calculate the ratio of process and product claims
    - The authors separate each title into several parts and then classify each part into process- or product-related
    - Thus, it is totally possible to consider a ratio-based analysis

Heterogeneity in patent laws and formats

- Lerner's (2002) paper posits that patent protections and systems vary across nations to a great extent

- Thus, the titles and claims of an innovation may vary across countries
  - Will such variation affect the precision of the product-process classification?
  - The authors may check PATSTAT for a same family's patent titles in different countries to see if they use the same title most of time

- Citations and references
  - This is true for the US patent system as patent applicants need to disclose all relevant prior arts
  - However, in EPO, patent applicants do NOT need to disclose all relevant prior arts – thus, forward citations in EPO means differently

Technical details: first claim vs. the rest

- The first claim is the most important one
- People said that the shorter the better (i.e., broader scope)
    1. This is a mixture of X and Y
    2. This is a mixture of X and Y under the condition Z
- The authors may consider to give some more weights to the first claim; or, just use the first claim to classify patents into process or product innovation

Technical details: hypernyms

- The authors use "hypernyms" to summarize all different names
  - For example, "animal" is the hypernym for "dog"
  - But "dog" is the hypernym for "chow-chow" and "chihuahua"
  - I am just curious how the authors handle this multi-layer issue
  - It's like the pyramid structure of ownership, do they trace 1 layer or N layers
  - Is the list of hypernyms time-invariant or yearly updated?

- The authors also wrote "expanding set of activity and physical entity hypernyms"
  - What does "expanding" mean here?
  - More details in Internet Appendix will be helpful

Technical details: priority in classification

- To help the readers to understand the algorithm (Appendixes A.1. and A.2.), the authors may list real examples and walk readers through all steps in the algorithm.

- Steps 4 and 5
  - Step 4. For each partition from last step, define it as product-related if the last word in the partition is in our <u>Product-related</u> words list or their minor variations.
  - Step 5. For each partition <u>undefined from last step</u>, define it as process-related if it contains if any word(s) is (are) in our <u>Process-related</u> words list or their minor variations.

- The above description gives priority to product-related. Does it work if we switch the order of these two steps (i.e., give more priority to process)?

Technical details: patent data in the 1800s

- Data for the U.S. prior to 1870 or 1880 is indeed sparse.

- Everything in the 1830 and 1840 is a mess.

- Claims are problematic before the late 1800s.
  - Claims became a requirement in the patent at some point in the 1870s
  - Many much earlier patents do not explicitly mention claims.
  - Ganglmair, Robinson, and Seeligson (2021) do classify all patent claims (if available) going back to 1836 and also publish the data, but they don't use them in empirical analyses due to quality concerns

Technical details: cross-validation

- How accurate is the claim classification? Some estimates may be helpful

- Did the authors cross-validate their claim classification with some patent lawyers?
  - But Bernhard Ganglmair indeed found the aggregate summary statistics in Sections 2.2 and 2.3 very consistent with his work

- Since Ganglmair, Robinson, and Seeligson (2021) publicize their data for each claim, the authors may cross-check with their claim classification (i.e., process, product, or both)

Other thoughts: Writing and Concepts

- The insignificant relation between product innovation and TFP may totally understandable – product innovation may add more to "variety", a commonly neglected component of consumers' utility
  - Human beings also pursue "variety"; all our shoes of similar quality but they look differently
  - Utility can include not just consumption quantity but also "variety"
- The statement "1850 to 2019" in the abstract seems too strong (most patent data before 1950 are only U.S. patents).

Other thoughts on empirical work

- Authors only consider one-word (Table B4) -- the literature (Arts, Hou, and Gomez, 2021 RP) has started to consider 2-gram and 3-gram
  - 2-gram: cloud comput, social media
  - 3-gram: cloud host provid

- Turnover and inventories can be considered as proxies for operating performance: process innovation is expected to be associated with higher turnover (e.g., "Just-in-time" production)

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