Comments on Rosemarie Ziedonis' When the Giants' Shoulders Are Crowded…

[Or is it: Standing on the Shoulders of Many Giants?]

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What I Like About this Paper…

- Important application of transaction cost economics to intellectual property issues
- Quantitative work informed by qualitative research
- Imaginative use of available data to measure the fragmentation of intellectual property rights
- Care in constructing data
- Interesting results
- Acknowledgement of the data limitations
- Spirit of scientific inquiry

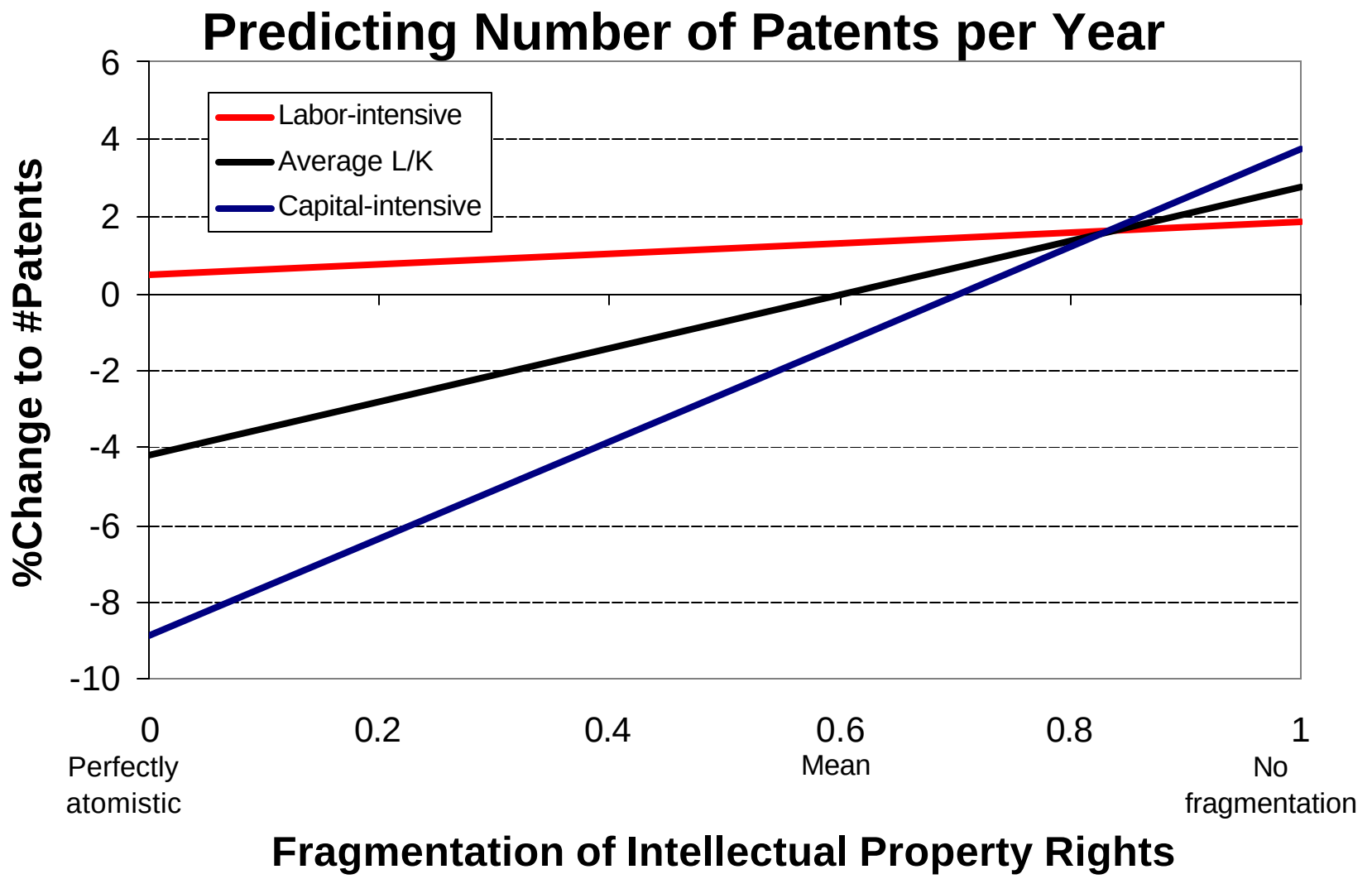
Contributions

- Theory
  Implications of a transaction cost approach to property rights.
  ⇒ Hold-up problems are more likely if:
  - Assets are not easily redeployed ("specificity" matters)
  - Property rights are highly fragmented
  - Interaction effects: Fragmentation raises the probability of hold-up, and specificity raises the stakes
  - (Enforcement of intellectual property rights mediates these effects)

- Measurement
  A new measure of the fragmentation of property rights

- Empirical Findings
  Fragmentation and specificity interact to lead firms to patent more aggressively

Results


Predicting Number of Patents per Year
%Change to #Patents
6
4
2
0
-2
-4
-6
-8
-10
Labor-intensive
Average L/K
Capital-intensive
0
0.2
0.4
0.6
0.8
1
Perfectly atomistic
Mean
No fragmentation
Fragmentation of Intellectual Property Rights

Theory

- Theory : Hold-up is a positive function of:
  - Specificity
  - Fragmented property rights; and
  - Their interaction

- Theory is:
  - Heuristically stated
  - Probably right
  - But a formal model may aid empirical implementation (more in a moment)

- Linking theory and measurement
  - *Theory* speaks to specificity and fragmentation causing "hold-up"
  - *Empirical work* examines #patents per year
  - Easily reconciled if patenting is a monotonically increasing function of "hold-up"

Mapping Theory to Measurement:
From "Hold-Up" to Patenting

- "Hostage Exchange model"
  - Greater risk of hold-up → Take more hostages (more aggressive patenting)
- But… Is it monotonic?
  Probably not:
  - Two players: Transactions costs are low → Contracting provides a solution
  - Some players: Transactions costs are problematic → Hostage exchange
  - Many players: Each firm is an atom. Need to hold infinite hostages (problematic).
- Is it increasing?
  Unclear: Standard transaction cost economics.
  If risk of hold-up is large:
  - Internalize transactions: 'make' instead of 'buy'
    In the R&D context, 'make'=invent around — Patenting ↑
  - Under-invest when risks of expropriation are high — Patenting ↓
  - *Tragedy of the anticommons* weakens demand for ideas — Patenting ↓

Capital Intensity

- Economic concepts:
  - Asset specificity
  - Redeployability
  - Appropriability
- Measurement: Capital/Labor Ratio
  - In high-tech industries, which is the more specific asset: labor or capital?
  - An analogy:
    - What if the patent office were engaged in “hold-up”, refusing to share patent data with researchers?
    - Who is more likely to be hurt?
      - » Harvard: Rich in physical capital (nice offices, fast computers etc.)
      - » Wharton: Who have Rosemarie, a researcher heavily-invested in this literature
    - Which asset is more easily redeployed: Rosemarie, or her office/computer?

Specification

- Poisson regression:

$$\#Patents_{firm\ i,year\ t} = exp[b_1 ln(Capital\ intensity_{i,t}) + b_2 Fragmentation_{i,t} + b_3 Fragmentation_{i,t} * ln(Capital\ intensity_{i,t}) + b_4 ln(Employment_{i,t}) + b_5 ln(\$R\&D/Employment) + year\ dummies]$$

- Almost equivalent to:

$$Ln(\#Patents) = b_1 ln(Capital\ intensity) + b_2 Fragmentation + b_3 Fragmentation * ln(Capital\ intensity) + year\ dummies + (b_4 - b_5) ln(Employment) + b_5 ln(\$R\&D)$$

…but it has advantages: Deals with zero patents ln(0)=? …yielding efficient estimates

- Rewriting:

$$Ln(\#Patents) - (b_4 - b_5 - b_1) ln(Employment) - b_1 ln(Capital) - b_5 ln(\$R\&D) = b_2 Fragmentation + b_3 Fragmentation * ln(Capital\ intensity)$$

- Ln(#Patents / resources)

  =f(fragmentation, fragmentation*capital intensity)

- **Potentially measuring R&D productivity (cf Theory)**
- **An unconditional regression may be more informative**

Functional Form

- The advantage of a Poisson regression is that it makes sense of company-years when zero patents are awarded
  - At the expense of:
    - Strong distributional assumptions (Are they met?)
    - Loss of transparency
- But, if #Patents=0, then *Fragmentation* is undefined
- In practice, solve this by setting fragmentation index to any number (zero in practice), and including a dummy:
  - DFRAG=(Fragmentation undefined)
  - This effectively partials out all observations with zero patents
    (Not quite: Fragmentation is a backward-looking average)

Interpreting the Conditional Regression

- Most interpretable result: (Table 5, column 3)

Ln(#Patents) -(0.7 –0.1 –0.4) ln(Employment) –0.4 ln(Capital) - 0.1 ln($R&D)
= 6.9 Fragmentation

- Cobb-Douglass Production function

Patents= tfp*($L^{0.2}$ $K^{0.4}$ $R\&D^{0.1}$)

  - Mildly decreasing returns to scale
  - Total Factor Productivity (TFP) is a positive function of fragmentation

- Productivity in the production of patents is positively related to fragmentation
  - Presumably the opposite of the transaction cost prediction(!)
  - An interpretation at odds with Rosemarie's hold-up story

Measuring Fragmentation

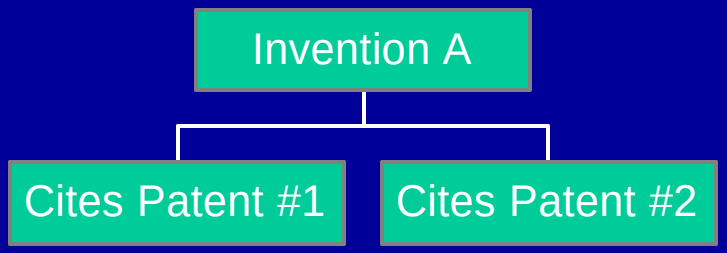
- What is the incentive to cite prior art?
  (This is the basis of subsequent measurement of fragmentation)
  - What happens if you "invent around" a patent?
  - Inventing around is one possible reason for not citing prior art.
    - Likely to be more common if property rights are highly fragmented(?)
    - Or too hard to invent around if highly fragmented…
    - Net effect uncertain…
- Fragmentation is measured as a lagged 3-year moving average:
  - Induces autocorrelation, overstating precision
  - Problems if no patents in a particular year
- Small-sample problems (Hall 2000)

Measuring Fragmentation

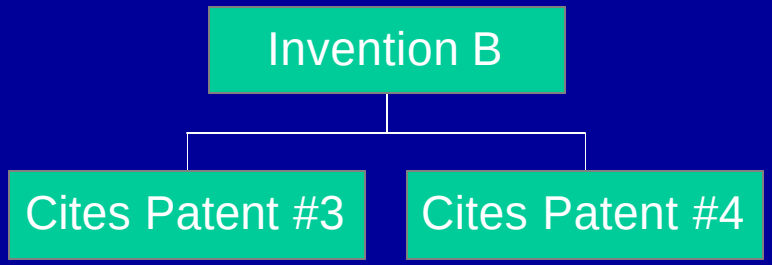
- The thought experiment:
  - *…the bargaining costs associated with negotiating 1,000 patents owned by one entity are expected to be lower than the costs associated wi th negotiating 1 patent each owned by 1,000 entities. (p.8)*
- But this is only the cost side. What of the benefits?
  - It may be that Firm A's inventions rely on 1,000 citations across 1,000 patent owners, but these generate 2,000 inventions, while Firm B's inventions rely on 1,000 citations across 1 patent owner, generating 2 inventions.
- Do more contracting links (measured by *Fragmentation*) reflect:
  - More inventions? (benefits) or
  - More fragmentation? (costs)

Measuring Fragmentation

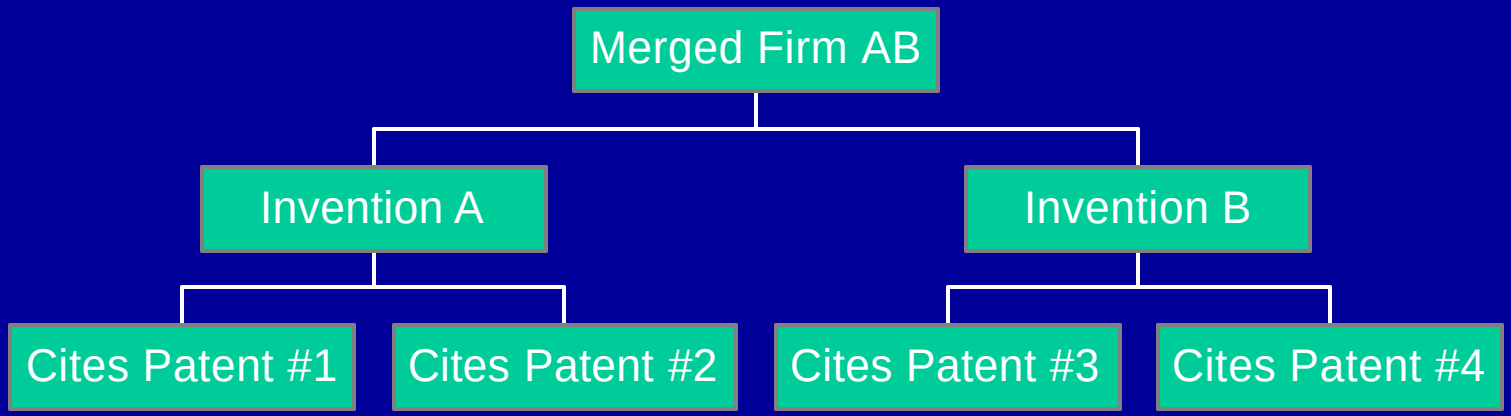
Firm A: Fragmentation=0.5



Firm B: Fragmentation=0.5



Merger: Fragmentation=0.75



Measuring Fragmentation

- The Herfindahl Index picks up:
  - ✓ Fragmentation of property rights regarding each invention
  - ✗ #Inventions

$$Fragmentation_{i,t} = 1 - \sum_{j}^{\text{Other firms}} \left(\frac{Citations_{i,j}}{\sum_{j} Citations_{i,j}} \right)^2$$

$$= 1 - \sum_{j}^{\text{Other firms}} \left(\frac{\sum_{p}^{Inventions} Citations_{i,j,p}}{\sum_{p}^{Inventions} \sum_{j} Citations_{i,j,p}} \right)^2$$

- Aggregation problem: Theory speaks to invention-level transaction costs, data are aggregated to firm*year.

Measuring Fragmentation

- If all the variation is due to #inventions, P_i
- AND all inventions cite the same number of earlier patents, C

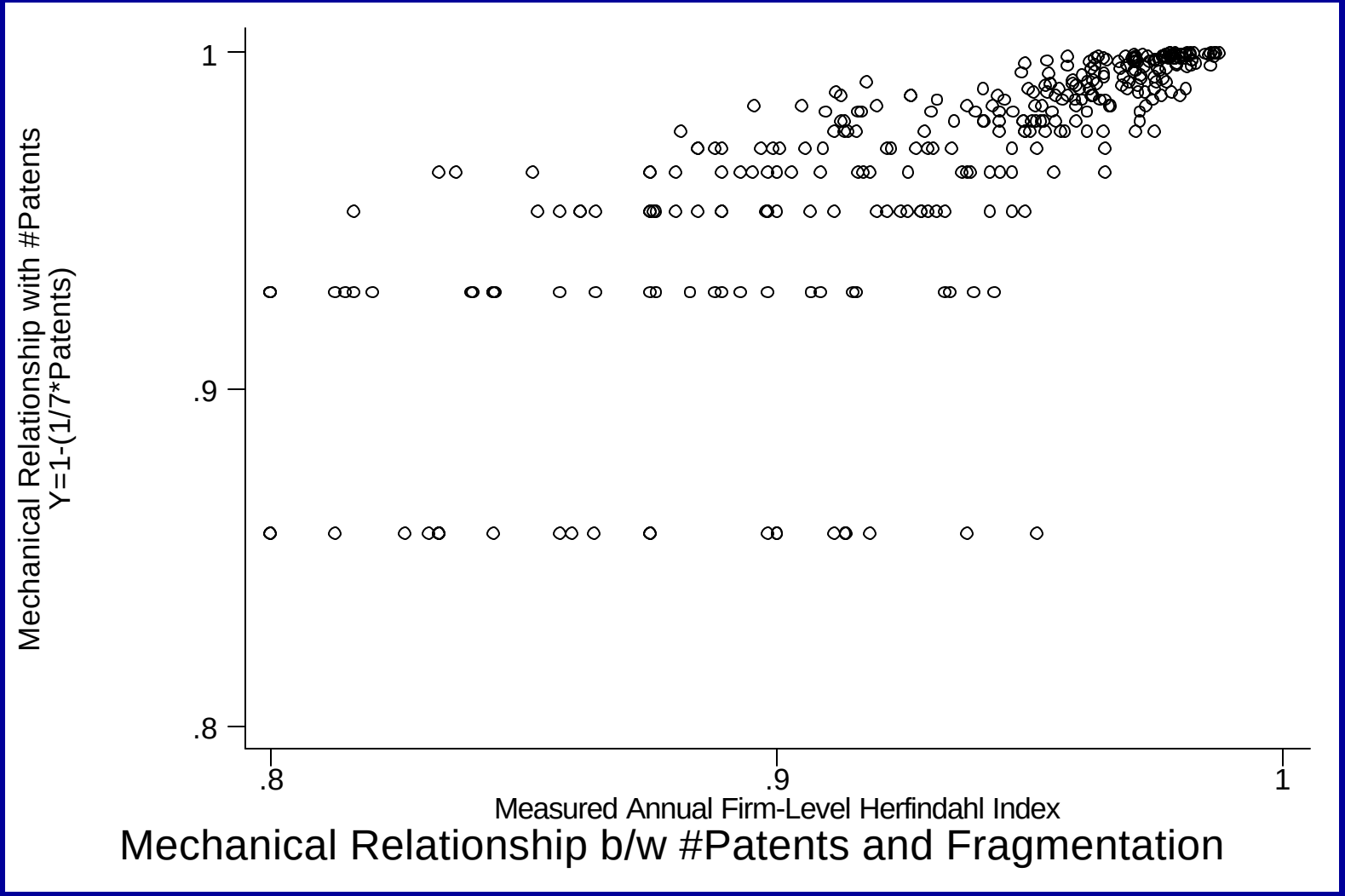
$$Fragmentation_{i,t} = 1 - \sum_{j=1..CP}^{\text{Other firms}} \left(\frac{\sum_{p=1..P}^{Inventions} Citations_{i,j,p}}{\sum_{p}\sum_{j}^{Inventions} Citations_{i,j,p}} \right)^2$$

$$= 1 - \sum_{j=1..CP}^{\text{Other firms}} \left(\frac{CP}{C^2P^2} \right)^2$$

$$= 1 - \frac{1}{CP}$$

How Important is this Mechanical Link?

- Simple simulation: Set C=7: Y=1-1/CP



Mechanical Relationship b/w #Patents and Fragmentation

Re-Interpretation

- The link between measured *Fragmentation* and Patenting behavior reflects a mechanical relationship
  - Not a behavioral relationship
- This relationship is a non-linear
  - *Patents|Measured Fragmentation* is a non-linear (possibly non-monotonic) function of *Patents*
- If Patents are a (log-)linear function of capital intensity, then #Patents|Fragmentation is a non-linear (possibly non-monotonic) function of capital intensity, leading the term Fragmentation*Capital Intensity to be misidentified.

Re-Measuring Fragmentation: Suggestions

Conceptually prefer to measure the average thickness of each firm's patent thicket:

$$Average\ Fragmentation_{i,t} = \frac{\sum_{p}^{Inventions}\left(1 - \sum_{j}^{Other\ firms}\left(\frac{Citations_{i,j,p}}{\sum_{j} Citations_{i,j,p}}\right)^2\right)}{\#\ Inventions}$$

- A Cross-check: Test a natural Placebo
  - Does the fragmentation of expired patents have any explanatory power?

By Analogy: Where else should we see this?

- Labor literature:
  - Many unions, one firm. Strikes increase
  - Capital-intensive firms. Strikes increase
  - Many unions in a capital-intensive firm: Strike increase more
- Politics:
  - Many veto points. Status quo bias
  - Specificity? Perhaps term limits. Status quo bias stronger
  - Interaction: Term limits with many veto points is worst
- Elsewhere in the business environment?

Conclusions

- Interesting insights into the patenting problem
- Transaction cost economics yields useful predictions
- Need a closer correspondence between theory and measurement