# Innovation, IP Choice, and Firm Performance

Bronwyn H. Hall
(with Christian Helmers, Vania Sena, and Mark Rogers)

## UK IPO Study

Looks at firm use of alternatives to patents

# Introduction

- Overview
  - Innovation represents 'knowledge'/intangible asset - appropriability problem
  - Where does reward for innovation come from?
  - Available options:
    1. Intellectual Property— registered and unregistered (formal)
    2. Range of "alternative" protection strategies (informal)
  - Choice among formal and informal IP protection methods is an endogenous decision by firm
    - Some can be used simultaneously, but not all



# Introduction - motivation

"Kolon Industries Inc. lost a $919.9 million jury verdict to DuPont Co. over the theft of trade secrets about the manufacture of Kevlar, an anti-ballistic fiber used in police and military gear." (Bloomberg 24 Dec 2011)

"Motorola said the R&D costs of the information in Ms. Jin's [the alleged Huawei spy] possession exceeded $600m and the company would lose substantial global revenues if it was made public." (FT July 22 2010)

"IBM has agreed to pay Compuware $400m over four years to settle claims that it stole trade secrets from the Detroit-based software company. [...] Compuware filed claims three years ago that IBM had used information obtained improperly from former employees [...]" (FT March 22 2005)

# Outline

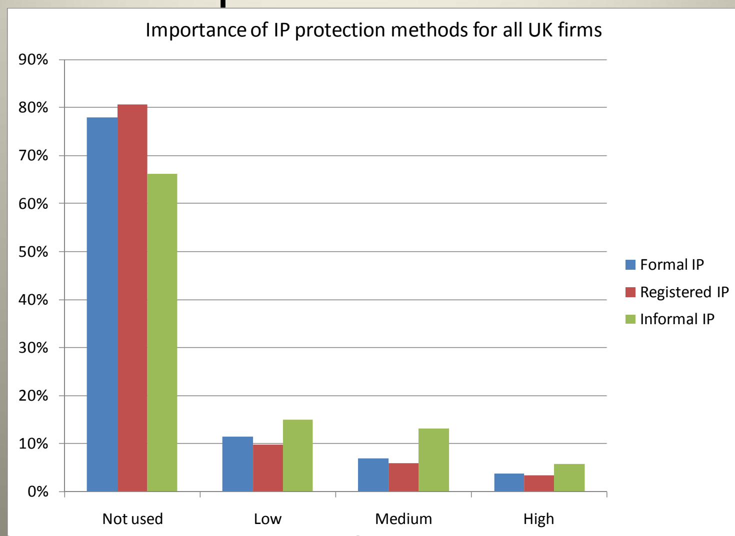
1. Introduction
   1. Types of IP considered
   2. Some facts from UK firm survey
2. Theory and evidence on IP choice
3. Impact of IP choice on performance
   a. Firm productivity and employment growth
   b. Adding IP choice to the CDM model



# Types of IP considered

- Formal IP
  – Registered:
    - Patents
    - Trademarks
    - Design rights
  – Unregistered:
    - Copyright
    - Confidentiality agreements
- Informal IP
  – Secrecy
  – Lead time
  – Complexity

# Among all firms, IP not very important; most important is informal IP



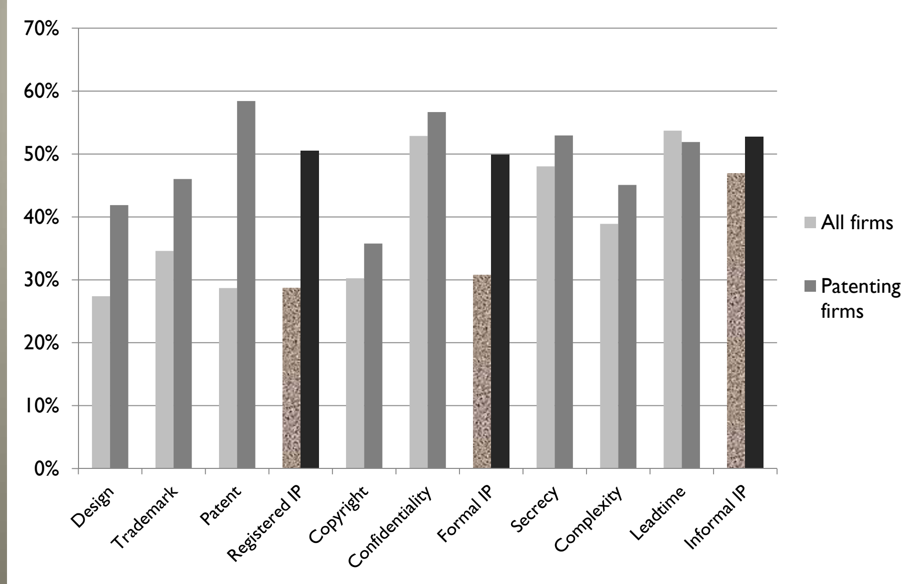




Figure 1: Share of innovating firms rating different types of IP protection as medium or highly important

# Theory: patents vs. secrecy

- Modeling of trade-off between the benefits from using registered IP and its costs
- Focus on patents vs secrecy because these are clearly substitutes, at least to some extent
  - Other informal IP mechanisms tend to complement patents
  - E.g., software: copyright, trade secrecy, & trademarks (Graham and Somaya 2004)



# Theory: costs and benefits of patenting

- Costs
  1. Direct and indirect financial expenditures for application and maintenance
  2. Disclosure of information (published 18 months after priority)
  3. Grant uncertain
  4. Enforcement uncertain
- Benefits
  1. Exclude competitors from using technology
  2. Licensing income
  3. Block competitors by restricting their freedom-to-operate
  4. Signalling of quality of invention
  5. Improved public image by conveying technological leadership
  6. Deterrence of infringement suites
  7. Increase in bargaining power in (cross)-licensing negotiations
  8. Signal to potential research collaborators expertise in specific area

## Theory: costs and benefits of secrecy

- Costs
  1. Direct and indirect financial expenditures
  2. Active knowledge management (internal secrecy policy)
  3. Need to sign confidentiality agreements
  4. Enforcement uncertain & difficult
- Benefits
  1. Protect the invention indefinitely
  2. Not limited to certain technologies
  3. Broader scope (example - customer lists)
  4. Applicable to 'work in progress'

UK IPO study

## Factors affecting the choice to patent vs keep secret

- 'Exogenous' differences in technologies
  - Process vs. product (process innovation easier to keep secret)
  - Expected commercial life of innovation
  - Expected value of innovation
  - Composition of innovation: tangible vs. intangible components
  - Complexity of research (difficult to codify knowledge may imply use of secrecy)
  - How effectively does a single patent protect the invention (reverse-engineering)?

UK IPO study

## Factors affecting the choice to patent vs keep secret

- Industry demographics/characteristics & strategic/competitive considerations
  - Strong competition for same or similar innovation may encourage patenting (e.g. a patent race)
  - Patent can act as 'strategic signal' of profitable innovation
  - Technology gap between lead innovator and imitative followers
    - Whether competition is 'neck and neck', with each firm building on others' innovations
  - Firm size
    - Large – lower cost per patent
    - Startups – helps obtain financing
  - Appropriability regime in industry



## Factors affecting the choice to patent vs. keep secret

- Institutional aspects:
  - Patent system
    - Initial fixed costs (higher initial costs reduce patent use, especially for smaller firms)
    - Maintenance and enforcement costs (higher costs reduces patent use)
    - Division and addition (ability to delay and amend patent increases their strategic value)
    - Disclosure requirements
  - Trade secrecy system
    - Costs of confidentiality agreements
    - Internal monitoring and active knowledge management
    - Enforcement issues

# Empirical challenges

- Multiple and overlapping IP use
- Impossible to determine what exactly is protected by which protection instrument
- Different protection tools may be used at different stages of the innovative process (secrecy protects work in progress)



# Empirical evidence: surveys

- Fundamental problem is 'observability' - need for survey data
- Levin et al. 1987 (Yale I survey) and Cohen et al. 2000 (Carnegie Mellon survey)
  - Firms in different industries favor secrecy and lead time over patents to protect innovation
  - Firms patent for strategic reasons (block competitors, improve reputation, gain bargaining power)
- Large number of similar surveys: CIS in Europe, similar surveys around the world…
  - Most find firms systematically regard lead-time and secrecy as more important to protect innovation than patents

# Explaining the choice

- Cross-country comparisons
  - PACE survey (Arundel et al., 1995)
  - Japan vs. US (Cohen et al., 2002)
  - PATVAL (Giuri et al., 2007)
- Impact of protection method on firm performance and knowledge diffusion
  - Hanel (2002) – increased profits
  - Hussinger (2006) – patents assoc with innov sales, but secrecy is not



# Indirect evidence on secrecy

- Moser (2005): innovations presented at two 19C world fairs in the 19th century, from countries with and without patent systems
  - Patent protection not critical to innovation
  - affects the industrial distribution of innovative activity - countries without patent protection produce in industries where secrecy effective such as textiles, food processing and watch making
- Png (2011): Assesses effect of secrecy on R&D and patenting
  - Enactment of Uniform Trade Secrets Act (UTSA) in US - exploit variation over time and across states in enactment
  - Associated with average drop of 2.4% in R&D in US manufacturing (1976-2006)
  - Differential impact across sectors: drop of 4.2% in medicinal chemicals & 4.7% in computer terminals, but no impact in pharmaceuticals and computer communications equipment
  - No overall impact on patenting, negative impact in sectors in which patenting of process innovations relatively more important/effective

# Our empirical study

- Construct database that can be used to:
  - Analyze determinants of a firm's choice between formal and informal IP
  - Analyze determinants of differences in patenting propensities across firms within and across sectors
  - Provide (tentative) empirical evidence on impact of firm's choice on performance
- New firm-level dataset combines:
  - Actual patent and trade-mark holdings
  - Self-reported innovation (with minimal information on quality) from UK Community Innovation Survey (CIS)



# Data Overview

- New firm-level dataset for UK firms - components:
  - Business Structure Database (BSD)
  - Annual Respondents Database (ARD2)
  - UK Community Innovation Survey (CIS) 3, 4, and 5
  - Patent data (UK & EPO – includes PCT)
  - Trade-mark data (UK & OHIM)
  - Business Enterprise Research & Development expenditure (BERD)
  - Code-point data
- Linked from 'scratch'—easy to reproduce, modify & update
  - Unified structures of CIS 3, 4 and 5
  - Cleaned and modified/adapted BSD, ARD2, and CIS
  - Database at enterprise level due to patent and trade-mark data
  - When necessary, aggregated local unit up to enterprise level

# Dataset structure

CIS-based firm panel (1998-2006), highly unbalanced (stratified sampling & changing sampling frame)

| # Firms | Share (%) | Sample* | CIS 3 | CIS 4 | CIS 5 |
|---|---|---|---|---|---|
| 533 | 2.0% | 109 | X | X | X |
| 436 | 1.7% | 163 | X | X | |
| 5,321 | 20.4% | 1,174 | | X | X |
| 235 | 0.9% | 81 | X | | X |
| 6,740 | 25.9% | 1,942 | X | | |
| 6,694 | 25.7% | 3,576 | | X | |
| 6,101 | 23.4% | 2,479 | | | X |
| 26,060 | 100.0 | 9,524 | | | |

*Regression sample is innovating firms only, cleaned



# Sectoral distribution (%)

| Sector | CIS 3 | CIS 4 | CIS 5 | Total |
|---|---|---|---|---|
| High-tech | 2.7 | 1.6 | 1.5 | 1.9 |
| Medium tech | 5.6 | 3.7 | 3.5 | 4.1 |
| Other manufacturing | 17.0 | 16.3 | 15.3 | 18.7 |
| Non-manufacturing | 63.9 | 76.3 | 78.9 | 74.1 |
| R&D services | 0.7 | 2.1 | 0.9 | 1.3 |

High-tech: pharma 2423; aircraft & spacecraft 353; scientific instruments 33; radio, TV , & comm eq 32; office, acctg, & comp machinery 30
Medium-tech: elec machinery 31; motor vehicles, etc. 34; rail & transport equipment 352/359; chemicals 24 (excl. 2423); machinery 29
R&D services: SIC 73
*(international SIC Rev. 3)*

## Size Distribution (%)

| Size class | CIS 3 | CIS 4 | CIS 5 | All |
|---|---|---|---|---|
| Small (11-49) | 82.4 | 81.3 | 82.1 | 81.9 |
| Medium (50-249) | 13.0 | 14.8 | 14.3 | 14.1 |
| Large (>250) | 4.6 | 3.9 | 3.6 | 4.0 |

Innovation and patenting propensity by size

| Size category | Product only (% yes) | Process only (% yes) | Product & process (% yes) | No innovation (% yes) | Patent (% yes) | TM (% yes) |
|---|---|---|---|---|---|---|
| Small | 13.65 | 4.84 | 8.06 | 73.45 | 0.71 | 1.74 |
| Medium | 18.48 | 7.31 | 12.22 | 61.99 | 2.61 | 5.36 |
| Large | 20.55 | 11.08 | 21.42 | 46.95 | 10.01 | 16.98 |
| **Total** | **14.54** | **5.39** | **9.18** | **70.89** | **1.35** | **2.86** |

## Regression Analysis

- Determinants of firm’s *decision* to patent
  - interpret firm’s decision not to patent as decision in favor of informal IP
- Determinants of firm’s *preference* for patents relative to secrecy
- Sample is product and/or process innovators only
  - Look only at firms that innovate, since they clearly have an incentive to choose some form of IP

# Regression Analysis

Patenting decision *p*:

$$p_{ijc} \sim f(\alpha + \xi rd_{ijc} + \gamma X_{ijc} + \beta fip_{jc} + \theta iip_{jc} + \delta Z_{jc} + \delta_c + \mu_j)$$

Performance equation for $y$ - innov sales share or emp. growth:

$$y_{ijc} = \tilde{\alpha} + \tilde{\beta} p_{ijc} + \tilde{\gamma} X_{ijc} + \tilde{\delta} Z_{jc} + \tilde{\delta}_c + \tilde{\mu}_j + \varepsilon_{ijc}$$

$i$=*firm*, $j$=*industry*, $c$=*year*

*fip* = 0 to 3 perception of formal IP importance in sector

*iip* = 0 to 3 perception of informal IP importance in sector

Drop SIC 50, SIC 52, SIC 55, SIC 921 and SIC 922 (not in all surveys)



# Patenting choice

| *Dependent variable* | *Has a patent* | *Impt of pat relative to secrecy* |
|---|---|---|
| New-to-mkt product innovator | 0.051 (0.006)*** | -0.13 (0.05)** |
| New-to-mkt process innovator | 0.012 (0.006)** | -0.19 (0.06)*** |
| New-to-firm product innovator | 0.013 (0.007)* | -0.15 (0.05)*** |
| New-to-firm process innovator | -0.003 (0.005) | -0.18 (0.04)*** |
| Registered IP important in the 3-digit sector | 0.011 (0.013) | 1.73 (0.14)*** |
| Informal IP important in the 3-digit sector | 0.010 (0.013) | -1.53 (0.12)*** |
| D (does R&D) | 0.062 (0.015)*** | -0.37 (0.06)*** |
| Log age | -0.000 (0.004) | 0.06 (0.03)* |
| Log employment | 0.024 (0.002)*** | 0.04 (0.01)*** |
| Observations | 11160 | 10880 |

Logit and ordered logit estimation; marginal effects shown. Robust standard errors, clustered on firm. All regressions control for year and sector effects. 11,160 observations

# Patent propensity

- Predicting patent propensity using larger model:
  + Importance attributed to patents
  o Importance attributed to secrecy or other informal methods
  + Product innovations
  + Larger firms
  + Older companies
  + Some form of R&D
  + Trademark
  + Business group
  + Employees with science and/or engineering degree
  + Exporting
  + R&D intensity
  – Market concentration



# Performance: Innovative sales share

| *Dependent variable* | *Log (Share/(1-Share))*<br>*Sales share new to the mkt* | *Log (Share/(1-Share))*<br>*Sales share new to the firm* |
|---|---|---|
| D (has EPO or UK patent) | 0.53 (0.09)*** | 0.08 (0.08) |
| Registered IP important in sector | 0.15 (0.13) | 0.02 (0.13) |
| Informal IP important in the sector | 0.33 (0.12)*** | 0.24 (0.12)** |
| D (does R&D) | 0.06 (0.08) | 0.05 (0.09) |
| Log age | -0.30 (0.04)*** | -0.39 (0.04)*** |
| Log employment | -0.07 (0.01)*** | -0.09 (0.01)*** |
| Observations | 9028 | 9225 |

Heteroskedastic-consistent standard errors clustered on enterprise are shown in parentheses.
16 sector dummies and 2 time dummies for different periods included. The excluded categories are the CIS3 and metals & machinery.

# Performance: Employment growth

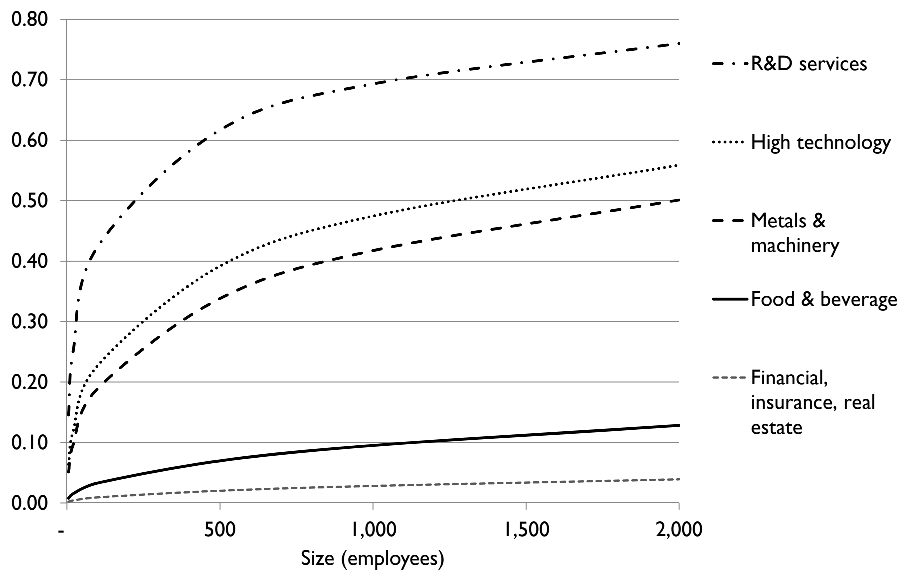
| *Dependent variable* | *Annual employment growth for available years 1998-2006* | |
|---|---|---|
| *Variable* | All sectors | Manufacturing only |
| D (has EPO or UK patent) | 0.12 (0.06)** | 0.16 (0.07)** |
| Registered IP important in sector | -0.22 (0.08)*** | -0.19 (0.08)** |
| Informal IP important in sector | 0.04 (0.08) | 0.11 (0.08) |
| D (does R&D) | 0.07 (0.04)* | 0.11 (0.03)*** |
| Log age | -0.40 (0.03)*** | -0.30 (0.05)*** |
| Log employment | -0.05 (0.01)*** | -0.08 (0.01)*** |
| Observations | 7567 | 2327 |

Heteroskedastic-consistent standard errors clustered on enterprise are shown in parentheses.
16 sector dummies and 2 time dummies for different periods included. The excluded categories are the CIS3 and metals & machinery.

# Summary (1)

- Enormous variation in patenting propensities across firms and industries explained by
  - Exogenous factors
  - Potentially endogenous factors
  - Factors associated in a robust way with firm's decision to patent vs to opt for informal methods:
    - Size (larger) – very important
    - Sector (chemicals, high tech, metals & machinery, R&D services)
    - Doing R&D
    - New to market innovation

Figure 4: Probability of patenting - Innovating, R&D-doing firms aged 20 years




# Summary (2)

- Firm’s decision to patent or to rely on informal IP:
  - Extremely low share of patentees among innovators
    - among firms conducting R&D 2% patent
  - Large differences across sectors
    - 0.4% non-manufacturing firms vs. 15% in R&D services
  - Overwhelming share of firms does not consider patents to be important
    - 2.8%–5.0% (CIS 3–CIS 5) say they are crucial
  - Within formal IP, trademarks most important
  - Informal IP mechanisms regarded as more essential

# Summary (3)

- Importance attributed to formal IP varies depending on whether firm innovates
  - 92% of non-product innovators regard patents as unimportant, but only 30% of innovators
- Share of firms regarding formal IP as important is substantially larger for patenting than for non-patenting firms
  - However, even patenting firms rely much more heavily on informal protection
- Considerable variation across sectors in importance of informal IP (top is R&D services)
- Unsurprisingly,
  - Larger firms report considerably higher reliance on any type of IP
  - Formal and informal IP used most by firms that produce innovation ‘new to the market’



# Summary (4)

- Relation between decision to patent and performance:
  - No relation between sales due to innovation ‘new to the firm’ and patents
  - Positive relation between sales due to innovation ‘new to the market’ and patents
    - Having a patent associated with 50% increase in share of sales from products new to market
  - Positive relation between employment growth and patents:
    - having a patent associated with higher employment growth (by 12%)

## Augmented CDM model

- Augment the CDM model with equations for the choice of formal and informal IP.
- For simplicity in estimation and clarity of presentation we treat process and product innovation separately.
- Sample is 7,269 observations
  - Innovators with good measures of capital, labor, and value added from business survey data
  - 43% do R&D



## Augmented CDM model

1. Usual R&D selection and R&D intensity equations, estimated by generalized tobit
2. Choice of formal IP, informal IP, and innovation estimated via trivariate probit model, separately for process and product innovation
3. Predicted probability of innovation included in production function

# Augmented CDM model

Firm innovates simultaneously with developing a preference for formal and informal methods of protecting its IP

$$\begin{pmatrix} FIP_i \\ IIP_i \\ INNO_i \end{pmatrix} = \Phi \begin{pmatrix} RD_i^*\gamma_1 + x_i\delta_1 \\ RD_i^*\gamma_2 + x_i\delta_2 \;, \Sigma \\ RD_i^*\gamma_3 + x_i\delta_3 \end{pmatrix} \quad \text{where } \Sigma = \begin{pmatrix} 1 & & \\ \rho_{12} & 1 & \\ \rho_{13} & \rho_{23} & 1 \end{pmatrix}$$

R&D input is the predicted value of R&D intensity from the model in STEP 1.

WHY?

Instruments the innovative effort in the KPF and accounts for that part of innovation activity that has not been formalized - especially important for SMEs.



# Step 1: doing R&D and R&D intensity

| *Dependent variable* | *Invests in R&D (1/0)* | | | *R&D intensity* | | |
|---|---|---|---|---|---|---|
| | *Marginal Effects* | *Standard Errors* | | *Marginal Effects* | *Standard Errors* | |
| D (foreign ownership) | -0.063 | 0.022 | *** | -0.260 | 0.053 | *** |
| Age of firm | 0.000 | 0.001 | | -0.026 | 0.003 | *** |
| D (international market important) | 0.420 | 0.022 | *** | 1.002 | 0.058 | *** |
| D (collaborates) | | | | 0.286 | 0.044 | *** |
| Formal IP importance (industry average) | 0.681 | 0.175 | *** | 1.904 | 0.380 | *** |
| Informal IP importance (industry average) | 0.720 | 0.187 | *** | 2.172 | 0.413 | *** |
| Importance of reg. & standards in sector | | | | -1.714 | 0.321 | *** |
| Source of info: competitors | 0.723 | 0.033 | *** | 0.953 | 0.110 | *** |
| Source of info: customers | 0.358 | 0.040 | *** | 0.352 | 0.106 | *** |
| Source of info: suppliers | 0.421 | 0.044 | *** | 0.657 | 0.120 | *** |
| Source of info: internal to the firm | 0.035 | 0.032 | | 0.188 | 0.078 | ** |
| Source of info: higher ed inst | 0.192 | 0.021 | *** | 0.451 | 0.050 | *** |
| D (High-tech sector) | -0.160 | 0.212 | | -0.409 | 0.471 | |

Robust standard errors clustered on firm. Industry, size, and year dummies included.
Estimated correlation between the two equation is 0.80 (0.02).

# Step 1 summary

- R&D doing and intensity associated strongly with international market participation, industries with high IP ratings of both kinds, and acquiring information from outside the firm.
- If regulation and standards are important in the sector, R&D intensity is lower.
- Unobserved determinants of doing R&D and its intensity are highly correlated, even conditioning on sector, size, and the other variables.



# Step 2: prob (product innovation)

| | *Formal IP methods* | | | *Informal IP methods* | | | *Product Innovator* | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Marginal effect* | *Standard error* | | *Marginal effect* | *Standard error* | | *Marginal effect* | *Standard error* | |
| Concentration Index | -0.108 | 0.224 | | -0.111 | 0.230 | | 0.119 | 0.229 | |
| Market Risk (1/0) | 0.339 | 0.016 | *** | | | | | | |
| R&D Intensity (predicted) | 3.897 | 0.130 | *** | 4.058 | 0.138 | *** | 3.605 | 0.129 | *** |
| Foreign owned (1/0) | -0.059 | 0.018 | *** | -0.050 | 0.018 | ** | -0.011 | 0.018 | |
| Source of Info: Internal | 0.109 | 0.025 | *** | 0.198 | 0.024 | *** | 0.270 | 0.026 | *** |
| Source of Info: Suppliers | 0.127 | 0.029 | *** | 0.374 | 0.027 | *** | 0.235 | 0.031 | *** |
| Source of Info: Customers | 0.239 | 0.033 | *** | 0.428 | 0.031 | *** | 0.401 | 0.036 | *** |
| Source of Info: Competitors | 0.175 | 0.027 | *** | 0.244 | 0.025 | *** | 0.053 | 0.028 | * |
| Source of Info: Higher Ed | -0.090 | 0.019 | *** | -0.373 | 0.019 | *** | -0.313 | 0.019 | *** |
| Financial Constraints (1/0) | 0.200 | 0.023 | *** | 0.309 | 0.023 | *** | | | |
| Product Imitator (1/0) | -0.140 | 0.026 | *** | 0.020 | 0.027 | | | | |
| Importance of reg. & standards in sector | | | | | | | 0.390 | 0.174 | ** |
| Importance of environmental concerns in sector | | | | | | | -0.250 | 0.145 | * |

Estimated correlation between equations: 0.86, 0.34, 0.41

# Step 2: prob (process innovation)

| | *Formal IP methods* | | | *Informal IP methods* | | | *Process Innovator* | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Marginal effect* | *Standard error* | | *Marginal effect* | *Standard error* | | *Marginal effect* | *Standard error* | |
| Concentration Index | 0.356 | 0.016 | *** | -0.133 | 0.235 | | -0.028 | 0.244 | |
| Market Risk (1/0) | -0.333 | 0.173 | | | | | | | |
| R&D Intensity (predicted) | 3.696 | 0.130 | *** | 3.868 | 0.138 | *** | 2.039 | 0.134 | *** |
| Foreign owned (1/0) | -0.057 | 0.018 | *** | -0.047 | 0.018 | ** | -0.001 | 0.019 | |
| Source of Info: Internal | 0.076 | 0.025 | *** | 0.163 | 0.024 | *** | 0.293 | 0.028 | *** |
| Source of Info: Suppliers | 0.121 | 0.029 | *** | 0.373 | 0.028 | *** | 0.676 | 0.037 | *** |
| Source of Info: Customers | 0.228 | 0.033 | *** | 0.421 | 0.031 | *** | 0.090 | 0.038 | ** |
| Source of Info: Competitors | 0.163 | 0.027 | *** | 0.232 | 0.026 | *** | -0.049 | 0.030 | * |
| Source of Info: Higher Ed | -0.063 | 0.019 | *** | -0.348 | 0.019 | *** | -0.206 | 0.020 | *** |
| Financial Constraints (1/0) | 0.207 | 0.024 | *** | 0.321 | 0.024 | *** | | | |
| Product Imitator (1/0) | 0.243 | 0.022 | *** | 0.456 | 0.023 | *** | | | |
| Importance of reg. & standards in sector | | | | | | | 0.517 | 0.182 | ** |
| Importance of environmental concerns in sector | | | | | | | -0.526 | 0.155 | *** |

Estimated correlation between equations: 0.84, 0.17, 0.27



# Step 2 summary

- Unobserved determinants of IP preferences are highly correlated.
- R&D intensity strongly associated with both innovation and a preference for formal *and* informal IP
- Market risk associated with formal IP in the case of product innovation
- Concentrated industries prefer formal IP in the case of process innovation
- Firms using outside sources of information rate both IP methods more highly, unless their source is the university
- If regulation and standards are important in the sector, more likely to innovate (even though lower R&D). (within 2-digit sector)

# Step 3: productivity

| | *Product Innovator* | | | *Process Innovator* | | |
|---|---|---|---|---|---|---|
| | *Coeff.* | *Standard error* | | *Coeff.* | *Standard error* | |
| Labour (log employees) | 0.655 | 0.020 | *** | 0.654 | 0.020 | *** |
| Log capital | 0.252 | 0.012 | *** | 0.252 | 0.012 | *** |
| Innovation output (predicted value) | 0.090 | 0.045 | ** | 0.081 | 0.049 | |
| Formal IP methods | 0.097 | 0.031 | *** | 0.123 | 0.029 | *** |
| Formal IP methods*Innovation (predicted) | 0.071 | 0.049 | | 0.031 | 0.050 | |
| Informal IP methods | 0.058 | 0.030 | ** | 0.054 | 0.029 | ** |
| Informal IP methods*Innovation (predicted) | -0.064 | 0.056 | | -0.047 | 0.062 | |
| Total formal IP*innovation effect | 0.258 | 0.073 | *** | 0.235 | 0.076 | *** |
| Total informal IP*innovation effect | 0.084 | 0.078 | | 0.088 | 0.084 | |
| Both*innovation effect | 0.252 | 0.118 | *** | 0.242 | 0.124 | ** |



# Summary

- Most surprising result:
  - Although firms seem to prefer informal IP as much as formal IP, the productivity contribution of innovation is associated only with the choice of formal IP protection.
  - A firm that innovates and attaches importance to formal IP achieves the same impact on its productivity as if it had doubled its capital stock.

# Conclusions

- Few UK firms patent, because most firms are SMEs or are in sectors where patenting is not important (services, for the most part).
- Firms that do patent or use other means of formal IP seem to achieve higher performance, in innovative sales, growth, and productivity
- Should more firms patent? Or is patenting associated with characteristics of successful innovation that we cannot measure?