Appendix (Not for publication)

Proof of Proposition 1

The left-hand side of (3) does not vary with L. Hence, stronger trade secrets law would reduce patenting if and only if the derivative of the right-hand side of (3) with respect to L,

$$\frac{d}{dL}\left\{[1-\varsigma(L)]\rho(L)\right\} < 0.$$

The above simplifies to

$$[1-\varsigma(L)]\frac{d\rho}{dL} - \frac{d\varsigma(L)}{dL}\rho(L) < 0,$$

or

$$\frac{1}{1-\varsigma(L)}\frac{d\varsigma(L)}{dL} > \frac{1}{\rho(L)}\frac{d\rho}{dL},$$

which resolves to (4). ■

Proof of Proposition 2

Suppose that, in stage 2, the manufacturer chooses to patent. Then, by (6),

$$G = [1-\varsigma(L)]M - c_P.$$

Differentiating (8) with respect to L,

$$\frac{\partial^2\alpha}{\partial R^2}\frac{\partial R}{\partial L}G + \frac{\partial^2\alpha}{\partial R\partial S}\frac{dS}{dL}G + \frac{\partial\alpha}{\partial R}\left\{-\frac{d\varsigma(L)}{dL}M\right\} = 0,$$

or

$$\frac{\partial^2\alpha}{\partial R^2}\frac{\partial R}{\partial L}G = -\frac{\partial^2\alpha}{\partial R\partial S}\frac{dS}{dL}G + \frac{\partial\alpha}{\partial R}\frac{d\varsigma(L)}{dL}M. \tag{A1}$$

Suppose instead that, in stage 2, the manufacturer does not patent. Then, by (6),

$$G = [1-\varsigma(L)][1-\rho(L)]M - c_S.$$

Differentiating (8) with respect to L,

$$\frac{\partial^2\alpha}{\partial R^2}\frac{\partial R}{\partial L}G + \frac{\partial^2\alpha}{\partial R\partial S}\frac{dS}{dL}G + \frac{\partial\alpha}{\partial R}\left\{-[1-\varsigma(L)]\frac{d\rho(L)}{dL} - [1-\rho(L)]\frac{d\varsigma(L)}{dL}\right\}M = 0,$$

or

$$\frac{\partial^2\alpha}{\partial R^2}\frac{\partial R}{\partial L}G = -\frac{\partial^2\alpha}{\partial R\partial S}\frac{dS}{dL}G + [1-\varsigma(L)]\frac{\partial\alpha}{\partial R}\frac{d\rho(L)}{dL}M + [1-\rho(L)]\frac{\partial\alpha}{\partial R}\frac{d\varsigma(L)}{dL}M. \tag{A2}$$

(i) Suppose that own and spillover R&D are substitutes, $\partial^2\alpha/\partial R\partial S < 0$. Consider the case where, in stage 2, the manufacturer chooses to patent. Regarding the first term on the right-hand side of (A1), stronger law reduces spillovers, $\partial S/\partial L < 0$, and the expected contribution margin, $G > 0$, hence, the first term (including the leading minus sign) is negative. Regarding the second term on the right-hand side of (A1), $\partial\alpha/\partial R > 0$, $d\varsigma(L)/dL < 0$, and $M > 0$, and so, the second term is also negative.

Substituting in (A1),

$$\frac{\partial^2\alpha}{\partial R^2}\frac{\partial R}{\partial L}G < 0.$$

Now, the probability of R&D success is concave, $\partial^2\alpha/\partial R^2 < 0$, and the expected contribution margin, $G > 0$, so, $\partial R/\partial L > 0$, which is the result.

The proof in the case where, in stage 2, the manufacturer chooses not to patent is similar. The only difference is that it analyzes (A2), and makes use of both $d\varsigma(L)/dL < 0$ and $d\rho(L)/dL < 0$. For brevity, the proof is omitted.

(ii) Suppose that R&D decreases with the strength of trade secrets law, $\partial R/\partial L < 0$. Consider the case where, in stage 2, the manufacturer chooses to patent. Recall from the proof of (i) that $\partial^2\alpha/\partial R^2 < 0$ and $G > 0$. Substituting on the left-hand side of (A1),

$$0 < -\frac{\partial^2\alpha}{\partial R\partial S}\frac{dS}{dL}G + \frac{\partial\alpha}{\partial R}\frac{d\varsigma(L)}{dL}M.$$

Recall that $\partial\alpha/\partial R > 0$, $d\varsigma(L)/dL < 0$, and $M > 0$. Substituting above,

$$0 < -\frac{\partial^2\alpha}{\partial R\partial S}\frac{dS}{dL}G.$$

Now, $dS/dL < 0$ and $G > 0$, thus, $\partial^2\alpha/\partial R\partial S > 0$, i.e., own and spillover R&D must be complements, which is the result.

The proof in the case where, in stage 2, the manufacturer chooses not to patent is similar. The only difference is that it analyzes (A2), and makes use of both $d\varsigma(L)/dL < 0$ and $d\rho(L)/dL < 0$. For brevity, the proof is omitted. ■

Data

Period of study: 1996-2006.

National variables

N1 Annual GDP deflator. Source: U.S. Bureau of Economic Analysis.

N2 Annual deflator of gross domestic private investment. Source: U.S. Bureau of Economic Analysis.

State-level variables

S1 Gross State Product. Deflated by U.S. GDP deflator. Source: U.S. Bureau of Economic Analysis.

S2 Manufacturing proportion of Gross State Product. Calculated as the ratio of manufacturing value-added to Gross State Product. Source: U.S. Bureau of Economic Analysis.

S3 R&D expenditure (corporate, federal, and other). Deflated by U.S. deflator for gross domestic private investment. Data was missing for even years between 1978-1996. Source: National Science Foundation.

S4 R&D tax credit and effective rate. Source: Wilson (2007).

S5 Numbers of graduates with bachelor, master, and doctoral degrees in science and engineering as percentage of population. Source: National Center for Education Statistics of U.S. Dept. of Education: IPEDS and HEGIS.

S6 Number of bills introduced to state legislature. Source: *The Book of the States*, various issues.

S7 Number of sitting days in state legislature. Source: *The Book of the States*, various issues.

S8 Numbers of state legislators by party – Democratic, Republican, and other. Source: *The Book of the States*, various issues.

S9 Number of trade secrets cases. Source: Lexis-Nexis, Federal and State Cases database with keyword “trade secret”.

Industry-level variables

I1 R&D intensity. Computed for each 4-digit SIC as (total R&D expenditure deflated by the deflator for gross domestic private investment over all of companies in the SIC)/(total sales deflated by the GDP deflator over all of companies in the SIC) over the entire sample period. Source: Compustat.

I2 Effectiveness of patent for appropriating returns from product innovation. From Cohen et al. (2000), Table 1. Where Cohen et al. reported industry at two- or three-digit level, e.g., "2700: Metal n.e.c.", the measure was applied to all the respective four-digit industries, except for those which Cohen et al. specifically reported, e.g., "2710: Steel". Concorded by the author to SIC using the concordance in U.S. Office of Management and Budget (1997). Source: Cohen et al. (2000), Table 1.

I3 Effectiveness of patent for appropriating returns from process innovation. From Cohen et al. (2000), Table 2. Constructed by same procedure as effectiveness of patent for product innovation. Source: Cohen et al. (2000), Table 2.

I4 High technology. Drugs and medicinals (SIC 283), office and computing equipment (SIC 357), communications equipment (SIC 366), electronics components (SIC 367), industrial measuring instruments (SIC 382), aerospace (SIC 372 and 3760), controls and instruments (SIC 382), and surgical and medical instruments (SIC 384). Sources: U.S. Department of Commerce (1983) and Brown (2009).

Company-level variables

C1 Sales (Compustat: revt). Deflated by U.S. deflator for gross domestic private investment. Source: Compustat.

C2 Market-book ratio. The ratio of market-to-book value of the company was calculated as (Total assets + (Common shares outstanding x fiscal-year closing share price) - (Common equity + balance sheet deferred taxes))/(Common equity + balance sheet deferred taxes), or in Compustat nomenclature, $(\text{at} + (\text{csho} \times \text{prcc\_f}) - (\text{ceq} + \text{txdb}))/(\text{ceq} + \text{txdb}))$ (Acharya et al. 2010). Source: Compustat.

C3 EBITDA (Compustat: ebitda). Deflated by U.S. GDP deflator. Source: Compustat.

C4 R&D expenditure (Compustat: xrd). Deflated by U.S. deflator for gross domestic private investment. Source: Compustat.

C5 Capital expenditure (Compustat: capx). Deflated by U.S. deflator for gross domestic private investment. Source: Compustat.

C6 Depreciation and amortization (Compustat: dp). Deflated by U.S. deflator for gross domestic private investment. Source: Compustat.

C7 Patent applications. Source: NBER Patent Database.