Law and Innovation:
Evidence from the Uniform Trade Secrets Act

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Abstract

Most research and policy on protecting innovation focuses on patents. Yet, almost all technology managers report secrecy to be more important than patents.

Here, I show theoretically that stronger secrecy laws could increase or reduce R&D. By reducing spillovers, secrecy laws might reduce or raise the return to R&D, depending on whether spillover and own R&D are complements or substitutes. By strengthening appropriability, secrecy laws would raise the return to R&D.

Empirically, I find that, among U.S. manufacturers between 1976 and 2006, the Uniform Trade Secrets Act (UTSA) was associated with an average 2.4% (±0.7%) reduction in R&D. This negative effect suggests that, on average, own and spillover R&D are complements. More specifically, the UTSA was associated with a negative main effect moderated by a positive effect increasing with the complexity and technology and R&D intensity of the industry, and company size. For instance, the UTSA was associated with reductions in R&D of 4.2% (±1.0%) in medicinal chemicals and botanicals, and 4.7% (±0.1%) in computer terminals, and, by contrast, no or only marginally significant increases of R&D in pharmaceuticals and computer communications equipment, which are relatively more R&D-intensive.

Further, I show theoretically that stronger secrecy laws could increase or reduce patenting depending on their relative impact on the exclusivity of the patentable innovation vis-a-vis complementary know-how. Empirically, the UTSA was associated with reduced patenting in industries where patents are relatively effective in protecting process innovations.

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1 Introduction

“Hurd will be in a situation in which he cannot perform his duties for Oracle without necessarily using and disclosing HP’s trade secrets and confidential information to others.” (Hewlett-Packard Company, September 7, 2010).

Wall Street Journal: “Is it true that the original WD-40 formula is locked in a bank vault?”
Mr. Ridge (CEO, WD-40 Company): “Absolutely. We have only ever taken it out of the vault, well, twice. Once when we changed banks. ... It’s a trade secret.”


“Google avidly protects every aspect of its search technology from disclosure, even including the total number of searches conducted on any given day.” (Nicole Wong, Associate General Counsel, Google Inc., February 17, 2006).

Innovation depends on tangible investments such as plant and equipment and intangible investments such as research and development (R&D) and marketing. In turn, commercial investment depends on formal and informal property rights. To date, policy makers and scholars of innovation have tended to focus attention on technical innovation and on patents (Jaffe and Lerner 2004; Hall 2007).

However, almost all European and American technology managers consistently report secrecy to be more important than patents as a way to appropriate the returns from technical innovation (Arundel and Kabla 1998; Cohen et al. 2000; Arundel 2001). Coca-Cola (probably the world’s most famous trade secret), WD-40, and Google’s algorithms exemplify the importance of secrecy to technical and business innovation.

Patents provide broad exclusivity but only for a fixed period of time, are limited to technical innovations that meet particular standards, and require disclosure of the innovation as well as application fees and other expenses. By contrast, trade secrets can be unlimited in time, are not limited by particular technical standards, do not require disclosure, and cost relatively little. (Secrecy does not provide protection against accidental disclosure, independent discovery, or reverse engineering.)
Moreover, the scope of trade secrecy is much broader than that of patents. While patents give protection only to completed innovations, trade secrecy is the only legal protection for work in progress. Further, trade secrecy extends beyond technical innovations to commercial innovations including business ideas, marketing concepts, and customer lists. To some extent, these can be protected through trademark and copyright. However, some fall outside the scope of trademark and copyright – an important example is customer lists, which were the subject of almost one-third of federal trade secrets cases in federal courts between 1950-2008 (Almeling et al. 2010). For such marketing investments, trade secrecy is the only available legal protection.

Like intellectual property in general, the purpose of trade secrecy is to encourage innovation and ultimately foster economic growth. In general, secrecy can affect innovation at two stages – the investment stage where the innovator decides on the amount of investment, by affecting the extent of spillovers from the innovation of others, and the exploitation stage, where the innovator decides how to commercialize and protect the innovation. Secrecy may have conflicting effects on investment in innovation. On the one hand, stronger secrecy laws would provide better assurance of exclusivity, and hence increase the innovator’s return from investment. On the other hand, stronger secrecy laws would reduce the extent to which innovators would receive spillovers from others. The impact of reduced spillovers would depend on whether spillovers are complements or substitutes for own investment in innovation.

Despite the practical importance of trade secrecy to innovation, there has been little empirical research into the impact of trade secrets law on businesses and the economy. The major issues – how trade secrets law affects innovation at the investment and exploitation stage, and how the effects depend on characteristics of the industry and business – remain open. The only work to date is indirect (focusing on patent rather than secrecy laws) and based on innovations presented at 19th century World’s Fairs. Among twelve countries, inventors specialized by industry according to whether their home country allowed patents (Moser 2005). However, in Britain and the USA, most innovations were not patented and the extent of patenting did not vary with national patent laws (Moser 2010).

Here, I use analytical modeling and a rich data set compiled from multiple sources to address the following research questions:

- How does trade secrets law affect investment in innovation?
- How does trade secrets law affect the choice between patents and secrecy as means
to protect and appropriate the returns to innovation?

• How do the effects depend on characteristics of the industry and business?

This paper makes four contributions. First, drawing on various legal authorities, I compile a chronology of U.S. state-level trade secrets laws. In the United States, patents, trademarks, and copyrights are governed by federal law. By contrast, civil rights to trade secrecy lie within state jurisdiction, and historically, trade secrets was governed by common law. Since 1979, most states have enacted the Uniform Trade Secrets Act (UTSA). My chronology of state-level trade secrets laws includes details of their legislative history and conformance with the UTSA.

Second, I develop a simple model of innovation over two stages – including the decision on R&D in the investment stage, and the decision whether to patent the innovation in the exploitation stage. I show theoretically that stronger secrecy laws could increase or reduce R&D. By reducing spillovers, secrecy laws might reduce or raise the return to R&D, depending on whether spillover and own R&D are complements or substitutes. By strengthening appropriability, secrecy laws would raise the return to R&D. The impact of secrecy laws on patenting depends on their effect on the exclusivity of the patentable innovation itself relative to their effect on complementary know-how (know-how that cannot be patented but needed to commercialize the innovation).

Third, I combine the chronology of state-level trade secrets laws with data from multiple sources including company-level data on innovation (R&D expenditure and patenting) from Compustat and the NBER Patent Database to assemble a rich data-set of U.S. manufacturers between 1976 and 2006. I use the variation across and within states in enactment of the UTSA to identify the impact of the UTSA on company-level R&D through difference-in-differences estimation. I find that the UTSA was associated with an average 2.4% (±0.7%) reduction in R&D. More specifically, the UTSA was associated with a negative main effect moderated by a positive effect increasing with complexity, and technology and R&D intensity of the industry, and company size.

I interpret the empirical findings as showing that, on average, own and spillover R&D are complements, so, the UTSA, by reducing spillovers, lowered the expected return from R&D, and so, led to less R&D. This finding was confirmed through multiple

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1 Federal law does regulate the criminal misappropriation of trade secrets. The federal Economic Espionage Act of 1996 provides criminal penalties for misappropriation of trade secrets that benefit a foreign government or that involve inter-state commerce. Some states also subject trade secrets to criminal law.
robustness checks for omission of possibly relevant variables, specification of control vis-
a-vis treatment, geographic samples, and definitions of location. In addition, the findings
were robust to multiple falsification exercises (for brevity, reported in the Appendix) that
tested the impact of the UTSA on other categories of company-level expenditure and
the impact of other uniform laws on R&D.

Fourth, I find evidence that, on average, controlling for R&D expenditure, the UTSA
had no significant impact on patenting. This finding is consistent with patents being filed
for strategic reasons not directly related to appropriating the returns from innovation, or
trade secrets law having relatively less impact on the exclusivity of the complementary
know-how vis-a-vis the innovation itself. However, the UTSA was associated with re-
duced patenting among industries in which patenting is relatively effective in protecting
process innovations. So, the UTSA matters for patenting where patenting is effective in
protecting appropriability.

I interpret these results as showing that, broadly, the principal effect of the UTSA on
innovation was to reduce spillovers at the R&D investment stage, while its effect at the
subsequent exploitation stage was limited to industries in which patenting is relatively
effective for processes. Given the importance of innovation for economic growth, my
empirical findings are significant for public policy and management practice. Policy-
makers and managers should look beyond patents, copyright, and trademarks. Trade
secrecy matters. By harnessing the property rights arising from this relatively under-
explored area of the law, nations and businesses can increase innovation, and achieve
faster economic growth and higher long-run welfare.

2 Background Literature

The prior empirical literature on trade secrecy mostly comprises analyses of litigation
and surveys of technology managers. Lerner (2006) analyzed the industry characteristics
of California and Massachusetts trade secret cases decided in state and federal courts in
the states of up to 2006. The top three industries by 3-digit Standard Industrial Class-
ification were: (i) computer programming (10.6%), (ii) miscellaneous business services
(5.9%), and (iii) insurance agents, brokers, and service (5.2%). Almeling et al. (2010)
analyzed a random sample of all trade secrets cases decided in federal courts between

While trade secrets are a state matter, federal courts have jurisdiction over cases in which plaintiffs
and defendants reside in different states and the amount at stake exceeds $75,000 (Perritt 2005: 10-3).
The top three issues were: (i) technical information and know-how (46%), (ii) customer lists (32%), and (iii) internal business information (31%).

The Lerner (2006) and Almeling et al. (2010) studies point to the importance of trade secrecy for technical innovations which cannot be patented. An innovation may be patented only if it is novel, not obvious, and has utility. Mere “know-how” might not meet these standards and so, might not be patentable, hence the innovator must rely on secrecy. Until the 1980s, the United States did not allow patenting of software, and so, software developers had to rely on copyright and secrecy. The same studies underscore the importance of trade secrecy for commercial innovation – miscellaneous business services and insurance broking (Lerner 2006) and customer lists and internal business information (Almeling et al. 2010).³

Various surveys have asked technology managers about the ways by which they appropriate the returns to innovation. European R&D managers were more likely to patent product innovations than process innovations, and the propensity to patent increased with sales and the importance of patents, but did not vary with R&D intensity (Arundel and Kabla 1998). European R&D managers generally rated secrecy as more valuable than patents, but the advantage of secrecy over patents decreased with R&D expenditure for product innovations, but not for process innovations (Arundel 2001). U.S. R&D managers cited secrecy and lead time most frequently as providing effective protection for product innovations, and cited secrecy and complementary manufacturing most frequently as providing effective protection for process innovations (Cohen et al. 2000). However, German businesses rated patents as being more important than secrecy (Hussinger 2006).

Analytical research on trade secrecy has focused on technical innovation and the choice between trade secrets and patents as alternative ways to protect innovation. Where innovators are not fully protected against imitators, the innovator may decide to patent only minor innovations and choose to keep major innovations secret (Anton and Yao 2004). This prediction is supported by evidence from France (Pajak 2009).

Denicolo and Franzoni (2004), Kultti et al. (2007) and Ottoz and Kugno (2008) analyzed the impact of changes in the patent system on the choice between patenting and secrecy, and R&D expenditure. The only extant empirical studies are based on

³The federal Economic Espionage Act of 1996 provides criminal penalties for misappropriation of trade secrets that benefit a foreign government or that involve inter-state commerce. Searle (2010) studied 95 cases filed between 1996 and 2008 and found that relatively more prosecutions involved the secrets of smaller companies.
innovations presented at 19th century World’s Fairs. Moser (2005) found that patent laws affected the direction of innovation in 12 countries. Inventors specialized by industry according to whether their home country allowed patents. Separately, Moser (2010) found that most British and U.S. innovations were not patented and that the extent of patenting did not vary with national patent laws. However, neither of Moser’s (2005 and 2010) studies addressed the impact of patent laws on the extent of innovation.

The various surveys suggest that trade secrecy plays an important role in technical innovation. However, there are no empirical studies of the impact of secrecy on investment in innovation (as distinct from appropriating the returns to innovations that have already been created). Apparently, the impact of trade secrets law on investment in innovation continues to be an open issue.

3 Model

Trade secrets law possibly affects innovation at two stages. In the first stage, where the innovator decides on investment in R&D, trade secrets law possibly affects the extent of spillovers from the R&D of others. In the second stage, where the innovator decides how to exploit the innovation, trade secrets law affects the exclusivity of the patentable innovation itself as well as complementary know-how.

Referring to Figure 1, a manufacturer faces a decision in stage 1 (investment), how much, \( R \), to invest in R&D to yield an innovation. The innovation could be either a new product that would generate additional revenues, or a new process that would reduce the costs of production. The R&D would succeed and produce the innovation with probability, \( \alpha(R, S(L)) \in [0,1] \), where \( L \) characterizes the strength of trade secrets law and \( S(L) \) represents spillovers from the R&D of other manufacturers.

The likelihood of R&D success is increasing, \( \partial \alpha / \partial R > 0 \), and concave in the investment. It is also increasing, \( \partial \alpha / \partial S > 0 \), and concave in spillovers. Own and spillover R&D are substitutes if \( \partial^2 \alpha / \partial R \partial S < 0 \) and complements if \( \partial^2 \alpha / \partial R \partial S > 0 \). Spillovers decrease with stronger trade secrets law, \( dS/dL < 0 \).

If the R&D succeeds, in stage 2 (exploitation), the manufacturer must then decide how to exploit the innovation. Exploitation involves manufacturing and marketing the product either internally or through licensing, and also protection of the innovation through intellectual property or other means. As emphasized by practitioners, the manufacturing process may involve the use of complementary know-how which is not patentable:
“Patents and trade secrets are not incompatible but dovetail: the former can protect patentable inventions, and the latter, the volumes of important, if not essential, collateral know-how associated with such inventions” Jorda (2008: 1). Moreover, the exploitation also depends on marketing and internal business knowledge such as customer lists that can only be protected by secrecy.

Accordingly, in the exploitation stage, I suppose that trade secrets law affects the manufacturer in two ways. One is through the likelihood, \( \varsigma(L) \), that the complementary know-how, protected by trade secrecy, would leak out. I assume that \( \varsigma(L) \) decreases in the strength of trade secrets law, \( d\varsigma/dL < 0 \). The other is through the likelihood that the innovation itself, if not protected by patent, would leak out.

For simplicity, I assume that, if the manufacturer chooses to patent the innovation, it would enjoy exclusive use of the innovation. In this case, the manufacturer’s net earnings would depend only on whether the complementary know-how leaks out. If the know-how does not leak out, the manufacturer would earn \( M - R - f \), where \( M > 0 \) is the contribution margin (revenue net of production costs) from the innovation, and \( f \) represents the cost of obtaining and defending the patent and also any losses arising from the revelation of information that must be published with the patent. If the know-how leaks out, I assume, for simplicity, that competition would drive down the contribution margin to zero, while the manufacturer would still incur the costs of R&D and patenting, and so, its earnings would be just \( -R - f \). Since the probability of a leak is \( \varsigma(L) \), the manufacturer’s expected profit if it does patent is

\[
\varsigma(L)[-R - f] + [1 - \varsigma(L)][M - R - f] = [1 - \varsigma(L)]M - R - f. \tag{1}
\]

However, if the manufacturer chooses not to patent the innovation, it faces the risk that either the innovation itself or the complementary know-how would leak out to competitors. The obvious way by which the innovation or complementary know-how could leak out is through reverse engineering. Trade secrets law does not protect against reverse engineering. If neither the innovation nor know-how leaks out, the manufacturer would earn profit, \( M - R \). If either innovation or know-how leaks out, the manufacturer’s contribution margin would be driven to zero, hence its profit would be \( -R \). Let the innovation leak out with probability, \( \rho(L) \), which decreases in the strength of trade secrets law, \( d\rho/dL < 0 \). Further, let the probabilities of the innovation and the complementary know-how leaking out be independent. Hence, the manufacturer’s expected profit if it does not patent is

\[
\{1 - [1 - \varsigma(L)][1 - \rho(L)]\} [-R] + [1 - \varsigma(L)][1 - \rho(L)][M - R] = [1 - \varsigma(L)][1 - \rho(L)]M - R. \tag{2}
\]
Referring to Figure 1, by (1) and (2), in stage 2 (exploitation), the manufacturer would patent the innovation if and only if 

\[ [1 - \varsigma(L)]M - R - f \geq [1 - \varsigma(L)][1 - \rho(L)]M - R, \]

or,

\[ f \leq [1 - \varsigma(L)]\rho(L)M. \]  \hspace{1cm} (3)

The parameters, \(1 - \varsigma(L)\) and \(1 - \rho(L)\), characterize the exclusivity of the complementary know-how and the innovation, if not patented, as provided by trade secrets law.

With this set-up, my first result addresses the impact of trade secrets law on patenting. Since the decision to patent arises only if the manufacturer invests in R&D and only if R&D is successful, the patenting result is conditional on R&D.  

**Proposition 1** If trade secrets law is stronger, conditional on R&D expenditure, the manufacturer would reduce patenting if and only if trade secrets law has a relatively larger impact on exclusivity of the complementary know-how than the innovation itself if not patented, specifically,

\[ \frac{\varsigma(L)}{1 - \varsigma(L)} \cdot \frac{1}{\varsigma(L)} \frac{d\varsigma(L)}{dL} > \frac{1}{\rho(L)} \frac{d\rho(L)}{dL}. \]  \hspace{1cm} (4)

Stronger trade secrets law would affect the manufacturer's choice of whether to patent the innovation in two ways. It reduces the probability, \(\rho(L)\), that the innovation itself, if not patented, would leak out. This raises the expected profit from not patenting. The stronger trade secrets law also reduces the probability, \(\varsigma(L)\), that the complementary know-how would leak out, i.e., raises the exclusivity of the complementary know-how. This raises the expected profit from both patenting as well as from not patenting. However, the marginal impact on the expected profit from patenting is relatively higher because, with patenting, the innovation itself would not leak out. By contrast, without patenting, the innovation itself might leak out, and so, the increased exclusivity of the complementary know-how would not raise the manufacturer's expected profit so much.

On balance, the manufacturer would reduce patenting on and only on condition (4). On the left-hand side of (4), the second fraction is the the elasticity of the likelihood of leak of the complementary know-how. The right-hand side is the elasticity of the likelihood of leak of the innovation itself when not patented. Accordingly, I interpret the condition as being that trade secrets law has a relatively larger impact on the exclusivity of the complementary know-how than on exclusivity of the innovation itself if not patented.

\[ \text{Please refer to the Appendix for the proofs of the two propositions.} \]
Having analyzed the impact of trade secrets law in stage 2 (exploitation), the next issue is the impact of trade secrets law in stage 1 (investment). Let $\Pi_2$ represent the manufacturer’s expected profit looking forward from stage 2,

$$\Pi_2 = \max\{[1 - \varsigma(L)]M - R - f, [1 - \varsigma(L)][1 - \rho(L)]M - R\} \quad \text{where} \quad G \equiv [1 - \varsigma(L)]M - \min\{f, [1 - \varsigma(L)]\rho(L)M\} - R = G - R, \quad (5)$$

Looking forward from stage 1, if the R&D succeeds, the manufacturer’s expected profit would be $\Pi_2$, while, if the R&D fails, its expected profit would be $-R$. Accordingly, the manufacturer’s unconditional expected profit would be

$$\Pi_1 = \alpha(R, S(L))\Pi_2 + [1 - \alpha(L)][-R] = \alpha(R, S(L))G - R, \quad (7)$$

after substituting from (5). Hence, the manufacturer would maximize profit by investing the amount $R$ given by the first-order condition, $\partial\Pi_1/\partial R = 0$, or

$$\frac{\partial\alpha}{\partial R} \cdot G = 1. \quad (8)$$

I can now prove the following result.

**Proposition 2** If trade secrets law is stronger,

(i) The manufacturer would increase R&D expenditure if own and spillover R&D are substitutes; and

(ii) The manufacturer would reduce R&D expenditure only if own and spillover R&D are complements.

The condition that own and spillover R&D be substitutes for stronger trade secrets law to result in higher R&D is clearly not necessary. If the impact of stronger trade secrets law on exclusivity (lower $\rho(L)$ and $\varsigma(L)$) is large enough, it could outweigh the complementarity of own and spillover R&D to yield a net increase in R&D.

Technology managers report greater reliance on secrecy relative to patents for process innovations as compared with product innovations (Arundel and Kabla 1998; Cohen et
al. 2000; Arundel 2001). This seems reasonable since, by their very nature, product innovations would be more exposed to outsiders than process innovations. However, my model suggests that this empirical finding should not be directly extended to the relative impact of trade secrets law on process vis-à-vis product R&D. For process innovations, leakage, \( \rho(L) \) and \( \varsigma(L) \), might be lower than for product innovations. However, by the same token, spillovers (which benefit the innovator), \( S(L) \), would also be lower. Accordingly, the net effect depends on the balance between spillovers and exclusivity.

4 Trade Secrets Law

Historically, in the United States, trade secrets were governed by common law, which originated in England. The seminal case is Peabody v. Norfolk, a Massachusetts decision in 1868 (Bone 1998). Subsequently, the Restatement (First) of Torts (1939), in its consolidation of the common law of torts, included section 757 on trade secrets.\(^5\) The Restatement (Section 757, Comment b (1939)) defined a trade secret to “consist of any formula, pattern, device or compilation of information which is used in one’s business, and which gives him an opportunity to obtain an advantage over competitors who do not know or use it”.

In 1968, the National Conference of Commissioners on Uniform State Laws appointed a committee to prepare a uniform trade secrets law. Then, in 1979, the Commissioners approved and recommended the Uniform Trade Secrets Act (UTSA) for enactment by the states. The Commissioners explained the need for a uniform trade secrets law on two grounds. Many states did not have extensive case law on trade secrets, while, even in states with substantial case law, the case law was not clear on the parameters of trade secret protection and the appropriate remedies for misappropriation.\(^6\)

However, the UTSA did go beyond codification of the existing law. Compared with the Restatement (First) of Torts, it expanded the definition of a trade secret. By contrast with the Restatement, the UTSA does not require that the secret be business related or in continuous use. Hence, under the UTSA, information that has been developed but not yet used, negative information, and one-off information can also be trade secrets (Lydon 1987: 430; Samuels and Johnson 1990: 62-63).\(^7\)

\(^5\) The Restatements of the Law are published by the American Law Institute, an organization of legal academics and practitioners, to codify the common law in specific fields. They are not binding authority. However, as the product of a respected group of lawyers, they are influential in legal cases.


\(^7\) The extent to which the UTSA expanded the law in the various states depended on the evolution of
My primary sources of information on the states’ trade secrets laws were the compendium, *Uniform Laws Annotated*, and the treatises, *Milgrim on Trade Secrets*, Perritt (2005), and Pooley (1997). I supplemented these with various law review analyses (Root and Blynn 1982; Lydon 1987; Samuels and Johnson 1990; Hutter 1999).

Table 1 presents the years when the UTSA became effective in the various states. Twelve states enacted the UTSA with effect between 1981-85, and then the pace accelerated, with a further twenty-five states enacting the UTSA with effect between 1986-90. Figure 2 shows the states with the UTSA in effect by 1990.8

A key issue is why the states enacted the UTSA. The concern for my research into the effect of the UTSA on R&D is that the states’ enactment of the UTSA might be endogenous to companies’ decisions on R&D. Such endogeneity would present a serious challenge to the interpretation of any regression of R&D on UTSA enactment.

One possible source of endogeneity is reverse causality – that the states enacted the UTSA in response to pressure from businesses that were planning to change R&D. To check for reverse causation, following Romanosky et al. (2010), I compiled the lag between enactment of the UTSA and the year in which the UTSA was first tabled in the legislature (in some states, the UTSA was tabled multiple times). In states where businesses were planning to raise R&D relatively more and would benefit relatively more from trade secrets protection, they would invest relatively more in lobbying, so the legislative lag ought to be shorter.

Figure 3 presents a scatter-plot, by state, of the lag in UTSA legislation against the growth of R&D in the previous year or the year before the previous.9 If, indeed, businesses in states which planned to increase R&D relatively more had invested more in lobbying, the legislative lag would have been shorter. In that case, the scatter-plot would slope downward from left to right, i.e., would present a negative slope. However, Figure 3 reveals no apparent relation between the legislative lag and R&D growth. Indeed, in a least squares regression, the coefficient of R&D growth, 0.0252 (±0.0222), was positive although not significant.

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8 The map was produced with the system, “Mapping: AgriLife IT”, Texas A&M University System, http://monarch.tamu.edu/ maps2/us.htm

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To further investigate possible sources of endogeneity, Table 2 reports regressions applying the Cox proportional hazard model to the effective year of the UTSA in the various states. (I excluded South Carolina, which enacted the UTSA with effect from 1992 and then, in 1997, replaced the UTSA with its own state trade secrets act (Pooley 1997: 2-30.5.).)\textsuperscript{10} As reported in Table 2, column (1), state enactment of the UTSA was negatively related to the percentage of gross state product (GSP) due to manufacturing, and positively related to the growth of GSP. However, state enactment of the UTSA was not significantly related to either the level or growth of R&D.

Besides reverse causation, endogeneity may arise from omitted variables, in particular, unobserved state-level policies affecting R&D expenditure. Various studies of R&D expenditure and financing (Wu 2005; Brown et al. 2009; Wilson 2009) mention only one state-level policy directed at R&D – the state tax credit for R&D expenditure. In 1981, the U.S. government introduced a federal tax credit for R&D expenditure, and 32 states followed with state-level tax credits (Wilson 2007).\textsuperscript{11} To supplement the prior studies, it is also worth checking for the presence of unobserved policies that affect R&D. Biderman et al. (2010) suggest to check for unobserved policies by checking for the impact of observable policies as it is likely that governments implement both observable and unobserved policies in tandem.

The ideal measure of the state-level R&D tax credit would be the effective rate of the tax credit. However, the historical effective rates are not available and only the rates for the year 2006 have been published (Wilson 2007: Table 1). Accordingly, Table 2, column (2), reports a specification including an indicator for the presence of a state-level tax credit for R&D expenditure. This was not significant, suggesting that the states’ only known policy to encourage R&D was not significantly related to UTSA enactment.\textsuperscript{12}

Besides explicit policies directed at R&D, it is also useful to check for the impact of background factors that might possibly be correlated with policies that affect R&D. Wu (2005) points to state support for higher education. Table 2, column (3), reports a specification including the numbers of master and doctoral graduates. While the number of master graduates is not significant, the number of doctoral graduates is negative and significant. Collectively, the estimates including the presence of a state R&D tax credit

\textsuperscript{10}Typically, there was some lag between introduction of the UTSA as a bill and the law taking effect. Accordingly, with respect to introduction of the legislation, this specification amounts to regressing the law with a lag.

\textsuperscript{11}New Hampshire introduced the credit in 1993 and withdrew it two years later (Wilson 2007: footnote 48).

\textsuperscript{12}In an unreported regression including the effective rate of tax credit as of 2006, the coefficient of the effective rate was negative and significant, suggesting that the model was misspecified.
and the numbers of master and doctoral graduates suggest that enactment of UTSA was not systematically related to state-level R&D policies.\textsuperscript{13}

I then turned to investigate what factors might explain enactment of the UTSA. In the only comprehensive empirical analysis of the Uniform Law Commissioners to date, Ribstein and Kobayashi (1996) showed that states with part-time legislatures and those which consider fewer bills are more likely to adopt uniform laws.

\textit{The Book of the States} publishes details, including numbers of bills, sitting days, and political composition of the state legislatures. Table 2, column (4), reports a specification including a measure of the legislative workload. The legislatures of some states meet in regular session only in alternate years. \textit{The Book of the States} reports only the total number of bills, introduced in the lower and upper houses. Accordingly, I constructed the measure of workload as the two-year moving average of the number of bills relative to the total number of legislators (lower and upper house). Table 4, column (4), reports the estimate of a specification including the legislative workload. Consistent with the findings of Ribstein and Kobayashi (1996), the coefficient was negative, suggesting that state legislatures with a higher workload were \textit{less} likely to enact the UTSA. However, the coefficient was not precisely estimated.

Table 4, column (5), reports the estimate of a specification including the length of the legislative session. The sample was substantially reduced as the states vary in their reporting of sittings. As with the measure of workload, to account for legislatures that meet only in alternate years, I specified the length of the session as a two-year moving average of the number of calendar days that the legislature was in session. Consistent with the findings of Ribstein and Kobayashi (1996), the coefficient was negative and significant, suggesting that state legislatures with longer sessions were \textit{less} likely to enact the UTSA.

Finally, laws to regulate trade secrets might reasonably be thought of as being part of a “pro-business” agenda. To the extent that the Republican Party is more “pro-business” than the Democratic Party and that the UTSA helps business, states governed by Republicans should be more likely to enact the UTSA. Table 2, column (6), reports a specification including the percent of Republicans in the lower and upper houses of the state legislature.\textsuperscript{14} Neither political measure was significant, suggesting that UTSA

\textsuperscript{13}In Table 2, column (3), the indicator for R&D tax credit was positive and marginally significant. This was the only specification in which R&D tax credit was even marginally significant.

\textsuperscript{14}Since 1937, Nebraska’s legislature had had only one chamber and legislators may not be affiliated to any party. Accordingly, the estimate excluded Nebraska.
enactment was not associated with any pro-business agenda.

In summary, enactment of UTSA was not significantly related to either the level or growth of state-level R&D. UTSA enactment was, at most, tenuously associated with the state-level R&D tax credit – being only marginally significantly related to the credit in one specification. Further, UTSA enactment was not significantly related to state politics. By contrast, consistent with prior research into uniform laws (Ribstein and Kobayashi 1996), I found evidence that UTSA enactment was influenced by a purely legislative agenda. On balance, it seems reasonable to conclude that enactment of UTSA was not related to any observed or unobserved policy to influence R&D.\(^{15}\)

## 5 Empirical Strategy and Data

My main objective was to study the impact of trade secrets laws on technical innovation, specifically, R&D expenditure and patenting. I applied an empirical strategy similar to those in recent studies of the impact on innovation of various U.S. state-level laws, including wrongful discharge laws (Bird and Knopf 2009; Acharya et al. 2010), and enforcement of non-competition covenants (Garmaise 2011; Marx et al. 2010; Samila and Sorensen 2011). Essentially, the research design is one of difference in differences (Bertrand et al. 2004).

The various states enacted the UTSA with effect in different years. Accordingly, panel estimation of the following specification implements differences in differences in a setting of multiple treatment groups over multiple years (Acharya et al. 2010):

\[
\ln Y_{ist} = \beta_i + \beta_t + \beta \cdot X_{ist} + \gamma \cdot UTSA_{st}. \tag{9}
\]

In (9), \(Y_{ist}\) represents R&D expenditure or patents, and \(X_{ist}\) represents time-varying control characteristics of company \(i\) in state \(s\) in year \(t\). Further, \(UTSA_{st} = 1\) for any

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\(^{15}\)California and New York provide further support for the view that UTSA enactment is unrelated to substantive policy considerations. Pooley (2010) represented the American Electronics Association before the California Senate when it considered the UTSA in 1982 and again in 1983. He described the process as “whimsical”. The senator who introduced the legislation appeared to be unconcerned with the subject matter of the legislation, but was probably motivated by an interest in a good record in terms of the number of bills introduced. The other members of the committee considering the bill were no more interested in the substance of trade secret law. Hutter (1999) drafted legislation to implement the UTSA in New York. His draft was introduced and passed by the state Senate, but it was blocked by the Assembly. “The reason for the Assembly’s rejection of the bill was solely the opposition of the NY State Trial Lawyer’s Association ... The Trial Lawyers donate a lot of money to the Assembly” (Hutter 2010).
year $t$ in which the UTSA was effective in state $s$ and zero otherwise. The $\beta_i, \beta_t$ are company and year fixed effects, while $\beta$ and $\gamma$ are the coefficients of the time-varying controls and the UTSA indicator respectively.

In (9), the treatment group is the companies in states which have the UTSA in effect, and the control group is the companies in states which do not yet have the UTSA in effect (but which eventually enact the UTSA) and companies in states which never enact the UTSA. Following Bertrand et al. (2004), in all estimates, the standard errors were clustered by state and industry.

Technical innovation is relatively more important in manufacturing than service industries. Accordingly, much previous research into the protection of technical innovation has focused on manufacturing (Arundel and Kabla 1998; Cohen et al. 2000; Arundel 2001). Likewise, I also focused on manufacturing and compiled company-level financial information including R&D expenditure, sales revenue, EBITDA (earnings before interest, tax, depreciation, and amortization), market value, book value, industry (SIC 4-digit), and location from Compustat for manufacturing companies.

I then matched these with information on patents from the NBER Patent Database (Hall, Jaffe, and Trajtenberg 2001; Bessen 2009). The UTSA was first enacted with effect from 1981, hence, I set the beginning of the study as 1976, being five years before the first effective date of the UTSA, and the end of the study as 2006, which was the last year covered by the NBER Patent Database. I deflated sales revenue and EBITDA by the U.S. GDP deflator, and R&D expenditure by the U.S. deflator for gross private domestic investment.

As the empirical analysis focuses on R&D and patenting, I dropped observations for which either R&D or the number of patent applications were missing. Further, I dropped extreme outliers those with negative R&D, or ratio of R&D to sales revenue exceeding the 99th percentile, or ratio of patent applications to sales revenue exceeding the 99th percentile. Collectively, these outliers amounted to 1.6% of the sample. Table 3 presents summary statistics of the data, and the Data Appendix provides details of the variables including sources and construction.
6 Results – R&D

For a preliminary appreciation of the impact of the UTSA on R&D, I constructed an event history, following the method of Jacobson et al. (1993). Using ordinary least squares, I regressed, at the company level, R&D expenditure on sales revenue, the ratio of market-to-book value (“market-book ratio”), and EBITDA, all lagged by one year, company fixed effects, year fixed effects, state-specific year trends, and indicators of the years before and after UTSA became effective in a 11-year window (from 5 years before to 5 years after) around the effective date of the trade secrets law.\(^{16}\)

In Figure 4, the solid line shows the coefficients of the indicators of years before and after the UTSA became effective, while the broken lines show 95% confidence intervals for the coefficients. Apparently, there was a slight upward trend in R&D expenditure before the UTSA became effective. From one year after the UTSA became effective, the growth path of R&D became flat. The event history suggests that the UTSA was associated with a reduction in the growth of R&D, which persisted for at least five years.

UTSA

With the event history providing an intuitive view, I then applied least squares regressions to test Proposition 2. I first regressed, at the company level, the logarithm of R&D expenditure on the following controls – sales revenue, market-book ratio, and EBITDA, all lagged by one year, company fixed effects, year fixed effects, and state-specific year trends. Sales revenue represented the scale of the company and controlled for any economies of scale in R&D, the ratio of the market-to-book value of the company controlled for other investment opportunities (Acharya et al. 2010), while EBITDA represented cash flow and controlled for the availability of investment funds. The company fixed effects accounted for non time-varying heterogeneity across companies, the year fixed effects accounted for changes over time that affected all companies in all states, such as interest rates and the federal R&D tax credit, while the state-specific year trends accounted for any state-level trends that affected all companies in the state.\(^{17}\)

As reported in Table 4, column (1), the coefficients of sales revenue and EBITDA were positive and significant, while the coefficient of the market-book ratio was not

\(^{16}\)As mentioned above, absolute measures such as R&D expenditure and sales were specified in logarithms, while relative measures such as the market-book ratio were specified in their original form.

\(^{17}\)R&D intensity, being an industry-level characteristic, does not vary within companies. It is essentially a constant, and so, cannot be identified in a regression with company fixed effects.
significant. The next, baseline, specification included an indicator for the UTSA being in effect (= 1 if the UTSA was in effect in the year in the state where the company was located, and = 0 otherwise) lagged by two years. In all R&D regressions, all company-level control variables were lagged by one year, while all explanatory variables relating to trade secrets law and state policy were lagged by two years. These lags allowed a reasonable time for corporate resources and state policies to affect R&D. For brevity, in the discussion below, I simply refer to the variable itself and omit mention of the lags.

Table 4, column (2), reports the results. The coefficients of the controls were similar to those in the first regression. Importantly, the coefficient of UTSA was negative and precisely estimated, $-0.024 (\pm 0.007) \ (p = 0.001)$. Apparently, the UTSA was associated with a 2.4% ($\pm 0.7\%$) reduction in company-level R&D expenditure. By Proposition 2, this result implies that own and spillover R&D are complements. Intuitively, stronger trade secrets law would have reduced spillovers. For the reduction in spillovers to have resulted in lower R&D, the reduced spillovers must have reduced the return to own R&D, implying that own and spillover R&D are complements.

It is intriguing that the UTSA was associated with a significant (albeit slight) reduction in R&D expenditure. How did the UTSA affect R&D? To address this question, recall that the UTSA possibly affected state law in three ways. One was to codify the common law. A codified law offers less uncertainty as compared with the vagaries of judge-made common law. To the extent of this reduction of legal uncertainty and businesses’ aversion to uncertainty, enactment of the UTSA would have affected the behavior of businesses. The second legal effect of the UTSA was to harmonize the law across the states. This would affect the behavior of businesses that engage in trade and investment across state boundaries. The third legal effect of the UTSA was to strengthen the law by expanding the scope of secrecy to innovations that are not business related and in continuous use. Besides the legal differences, UTSA enactment might also have raised the general level of awareness of protection of trade secrets and the implications for business.

One way to discern the way by which the UTSA affected R&D is to study the experience of states that enacted trade secrets laws after 1979, when the Uniform Law Commissioners published the UTSA, and that differed from the UTSA. These state

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18Below, I report a check for the robustness to the assumption about the company location. I use the NBER Patent Database to identify the companies for which all patents originated from a single state, being the same state as the headquarters location as reported in Compustat.

19The dependent variable in the R&D regressions is the logarithm of R&D expenditure.
trade secrets acts would have codified the law and raised awareness but not harmonized the law. Table 4, columns (3)-(6), report estimates for four such states.

North Carolina enacted a comprehensive trade secrets law and relatively early – effective from 1981. The North Carolina Trade Secrets Act does not require that information have been obtained by “improper means” for it to be judged as being misappropriated (Root and Blynn 1982: 834-835). Accordingly, it provides substantially broader protection than the UTSA. Table 4, column (3), reports a specification including an indicator for the state trade secrets act (TSA). The coefficient of UTSA was the same as in the baseline. However, the coefficient of the state TSA was very small (one-quarter of the coefficient of UTSA in absolute magnitude) and not significant. This suggests that trade secrets law did not affect R&D through codification, the strength of the law, or awareness.

Alabama enacted the UTSA with effect from 1987 but defined trade secrets more narrowly (Samuels and Johnson 1990), so providing less protection than the UTSA. Table 4, column (4), reports a specification including an indicator for the Alabama Trade Secrets Act. The coefficient of UTSA was the same as in the baseline. However, the coefficient of the state TSA was not significant. This estimate provides further evidence that trade secrets law did not affect R&D through codification, the strength of the law, or awareness.

Finally, Wisconsin enacted the UTSA, but with multiple differences, effective from 1986 (Uniform Laws Annotated, page 436), and South Carolina enacted the UTSA, effective from 1992, but then replaced the UTSA with its own Trade Secrets Act to broaden the protection of trade secrets, effective from 1997 (Pooley 1997: 2-30.5). As reported in Table 4, columns (5)-(6), the inclusion of the state TSAs did not affect the estimated coefficient of UTSA, which was essentially the same as in the baseline. Among the state TSAs, only the coefficient of the South Carolina TSA, \(-0.042 (\pm 0.016)\), was significant. Apparently, South Carolina’s trade secrets act was associated with lower R&D, to an even larger extent than the UTSA.

Overall, with the exception of South Carolina, the picture appears to be that the state trade secrets acts that did not conform with or deviated substantially from the UTSA did not have a statistically significant effect. These suggest that the UTSA affected R&D through harmonization of the law rather than codification or substantive changes in the law, or raising awareness.

Having explored how the UTSA influenced R&D, it is also useful to understand whether the impact of the UTSA differed among industries and companies. Cohen et
al. (2000: Table 8) classified industries by whether key product or process technologies are discrete (commercialization relies on one or a few patentable elements) or complex (commercialization relies on a combination of multiple patentable elements).  

Table 4, column (7), reports a specification including the UTSA indicator as well as the UTSA indicator for a complex industry, UTSA x complex. Owing to the limited coverage of Cohen et al.'s (2000) categorization, the sample size was substantially smaller (by about 40%). The coefficient of the UTSA indicator, which represents the effect of the UTSA on discrete industries, was negative, and about a third larger than the baseline estimate, and precisely estimated. The coefficient of UTSA x complex was positive and precisely estimated, which implies that the UTSA had systematically different impact on discrete vis-a-vis complex industries. The sum of the coefficients of the UTSA indicator and UTSA x complex, $-0.031 + 0.058 = 0.027$ (Pr($F(1, 700) > 1.00) = 0.317$), represents the effect of the UTSA on complex product industries. Subject to the imprecision of the estimates, they suggest that the UTSA was associated with a reduction in R&D of 3.1% in discrete industries and an increase of 2.7% in complex industries.

Next, I distinguished the effect of the UTSA on high-technology industries, using the classification published by the U.S. Department of Commerce (1983) as refined by Brown et al. (2009). Table 4, column (8), reports a specification including the UTSA indicator as well as the UTSA indicator for a high-tech industry, UTSA x high-tech. The coefficient of the UTSA indicator, which represents the effect of the UTSA on low-tech industries, was negative, and double the baseline estimate, and precisely estimated. This implies that the UTSA was associated with a relatively large, 4.8% ($\pm 1.2\%$) reduction in R&D among low-tech industries. The coefficient of UTSA x high-tech was positive and precisely estimated. Hence, the impact of the UTSA clearly differed between high-tech and other industries. The sum of the coefficients of the UTSA indicator and UTSA x high-tech, $-0.048 + 0.049 = 0.000$ (Pr($F(1, 1411) > 0.00) = 0.946$), represents effect of the UTSA on R&D in high-tech industries. Apparently, the UTSA was associated with a significant reduction in R&D among low-tech industries, but no significant change in R&D among high-tech industries.

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20 As described in the Data Appendix, I concorded the ISIC (the International Standard Industrial Classification) to SIC, and classified ISIC 2320: Petroleum, ISIC 2423: Drugs, and ISIC 2710: Steel as complex as more than 50% of respondents from these three industries reported using patents in negotiations (Cohen et al. 2000: Table 8).

21 I included aerospace (SIC 372 and 3760), which Brown et al. (2009) excluded as they focused on financing of R&D. I excluded software computer and data processing services (SIC 737) as this is not a manufacturing industry.
Finally, to further investigate the relative impact of the UTSA on industries by R&D intensity and companies by size, I estimated a specification including the UTSA indicator as well as interactions between UTSA and industry-level R&D intensity (UTSA x R&D intensity) and company-level sales revenue (UTSA x revenue). Each interaction was constructed as the product of UTSA with the difference of the interacting term from its mean. I used the Compustat data to compute the industry-level R&D intensity, for each 4-digit SIC, as the ratio of R&D expenditure to sales over all of the companies over the entire sample period.

As reported in Table 4, column (9), the coefficients of the control variables were similar to those in the baseline estimate. By construction of the interaction variables as the product of the UTSA and the difference from means, these terms would vanish at the mean R&D intensity and company sales revenue. Accordingly, the impact of the UTSA at the mean R&D intensity and mean company sales revenue would be just the main effect, \(-0.020 (\pm 0.010)\), or about 20% less than the baseline estimate.

Consistent with the findings from the high-tech specification, the coefficient of UTSA x R&D intensity, 0.728 (±0.181), was positive and significant. Further, the coefficient of UTSA x revenue, 0.0004 (±0.0002), was positive and significant. Hence, for any particular company, the impact of the UTSA on the logarithm of R&D expenditure would be \(-0.020 + 0.728 \times \) the difference between the industry R&D intensity and the mean R&D intensity plus 0.0004 times the difference between the company sales revenue and the mean sales revenue. Accordingly, the UTSA had a relatively more positive impact in more R&D-intensive industries and larger companies.

For a better feel of the impact of the UTSA on companies of varying R&D intensity and size, Table 5 uses the estimates from Table 4, column (9), to present counterfactual estimates for two pairs of industries, which are close in terms of industry classification but differ in R&D intensity and average company size. In medicinal chemicals and botanicals as compared with pharmaceuticals, industry R&D intensity is lower and companies are smaller. The UTSA was associated with a 4.2\% (±0.1\%) reduction in R&D among manufacturers of medicinal chemicals and botanicals, but no significant increase among pharmaceutical manufacturers.

In computer terminals as compared with computer communications equipment, industry R&D intensity is lower and companies are smaller. The UTSA was associated with a 4.7\% (±0.1\%) reduction in R&D among manufacturers of computer terminals, and an increase of 3.3\% (±1.9\%) among manufacturers of computer communications equipment.
Overall, my estimates suggest that, on average, the UTSA led businesses to reduce R&D. By Proposition 2, stronger trade secrets law would lead to less R&D only if own and spillover R&D are complements. Accordingly, my results imply that, on average, own and spillover R&D are complements – a reduction in spillovers reduces the return to own R&D, and so, leads to less R&D.

In a more detailed specification, the UTSA was associated with a negative main effect moderated by positive effects increasing with industry R&D intensity and company size. The moderating effect of industry R&D intensity suggests that, among more R&D intensive industries, own and spillover R&D are relatively more substitutable.

One possible explanation of the moderating effect of company size is that larger companies have larger R&D budgets and focus relatively more on original innovation, while smaller companies (with smaller R&D budgets) focus relatively more on reverse engineering. Since trade secrets law has a larger impact on reverse engineering than original innovation, it would then have a larger impact on manufacturers that focus on reverse engineering.

Below, I confirm my findings with multiple checks for robustness. In addition, I further confirmed the findings through various validation and falsification exercises, which tested the impact of the UTSA on other categories of company-level expenditure and the impact of other uniform laws on R&D. As reported in the Appendix, the findings accorded with theory and intuition.

**Robustness**

To confirm the robustness of my findings, as reported in Table 6, I conducted checks for omission of possibly relevant variables, specification of control vis-a-vis treatment, geographic samples, and definitions of location. For easy reference, Table 6, column (1), reproduces the baseline estimate from Table 5, column (2).

In the first robustness check, I addressed the sensitivity of the results to omission of state policies influencing R&D. As reviewed in Section 4 above, the only state policy directed at R&D is the state R&D tax credit. Table 6, column (2), reports a specification including the indicator for the state R&D tax credit. The coefficient of UTSA is somewhat smaller than the baseline, but still precisely estimated. However, the coefficient of the indicator of the state R&D tax credit is negative and significant. While puzzling, this result is not inconsistent with research on the state R&D tax credit which shows
that the credit served mainly to divert R&D from one state to another rather than raise R&D within the state (Wilson 2009). A specification with company fixed effects, such as estimated here, amounts to testing the impact of the UTSA on differences relative to company averages and would not detect diversion of R&D.

Further, the appropriate measure of the state R&D tax credit would be the effective rate of the credit. As these were available only for the year 2006 (Wilson 2007: Table 1), I used an indicator of the credit. Over time, the states might have adjusted the rate of credit so as to induce a spurious negative correlation between R&D and the presence of a credit. To check this possibility, I estimated a specification including the effective rate of the state R&D tax credit with the sample limited to the years 2000-06, over which period the 2006 rates would more accurately represent the rates actually in effect. In the estimate (unreported for brevity), the coefficient of the effective rate of the tax was close to zero and not significant. This result supports the the argument that the inclusion of the indicator of the state R&D tax credit in estimates over the entire period 1976-2006 might have induced spurious correlation.

The second robustness check addressed the sensitivity of the results to omission of state educational policies, which also possibly influence R&D. Table 6, column (3), reports a specification including the numbers of graduates with master and doctoral degrees in science and engineering. The coefficient of masters graduates was positive but not significant, while the coefficient of doctoral graduates was positive and marginally significant. The coefficient of UTSA, $-0.011 \pm 0.006$, was reduced to slightly less than half the baseline estimate, but still close to significant ($p = 0.064$).

Although the number of doctoral graduates was related to R&D (albeit at a marginal level of significance), the interpretation of causation is problematic. Corporate R&D would affect the number of doctoral graduates directly through corporate funding of doctoral programs and students. Corporate R&D would also affect the number of doctoral graduates indirectly through employment opportunities. The more researchers that companies recruit, the more people would be attracted to doctoral study. Accordingly, to avoid this reverse causality, I prefer to include the numbers of master and doctoral graduates only in a robustness check.

The third robustness check aimed to reduce unobserved heterogeneity and confounds. It limited the sample to states that did enact the UTSA, so excluding states that never enacted a trade secrets act, or enacted one that did not conform to or substantially differed from the UTSA. Since the states enacted the UTSA at different times, the staggered timing can be the source of identifying variation. In this context, the control
group is the states which had not yet enacted the UTSA (but which eventually enact the UTSA).

Limiting the sample to states that did enact the UTSA reduces potential bias in two ways (Biderman et al. 2010). One, it reduces the unobserved heterogeneity between the control and treatment groups – given that all of the sample states enacted the UTSA, either earlier or later, they must be relatively more similar than states which did enact or never enacted the UTSA. Further, limiting the sample would reduce the risk of confounds from unobserved policies. The states that enact the UTSA later might adopt unobserved policies later, or the states that enact the UTSA earlier might adopt unobserved policies earlier, and so, confounding the empirical tests. However, the unobserved policies must be timed to coincide with the UTSA enactment, which makes the confound less likely.

As reported in Table 6, column (4), the estimates on the sample limited to states that did enact the UTSA were very close to the baseline estimate. In particular, the coefficient of UTSA was negative, precisely estimated, and very close to the baseline estimate. Accordingly, I infer that my findings were robust to how the control vis-a-vis treatment states were specified.22

The fourth robustness check also aimed to address unobserved heterogeneity and confounds. It limited the sample to Metropolitan Statistical Areas (MSAs) that span more than one state. To the extent that an MSA is a reasonable definition of a market, there should be fewer unobserved differences between the parts of the MSA on the various sides of state borders. In particular, if businesses lobbied for the UTSA, they should have done so in all states encompassed by the MSA, so, any differences between the states in UTSA enactment are less likely due to business lobbying. As reported in Table 6, column (5), the estimates on the sample limited to multi-state MSAs were close to the baseline estimate. In particular, the coefficient of UTSA was identical to the baseline estimate and precisely estimated.

The last set of robustness checks addressed the location of the companies. In constructing the sample, I stipulated each company to be located in the state of its headquarters as reported in Compustat. This might be misspecified to the extent that companies moved their head office between states and that they conducted R&D away from their head office state. (Regarding the former issue, just 5% of Compustat companies shifted their headquarters between 1992-2004 (Garmaise 2011).) To check sensitivity to the

22Further, in an unreported estimate, I limited the sample to states that enacted some trade secrets act, whether conforming to the UTSA or not, after 1979, when the Uniform Law Commissioners published the UTSA. Again, the results were very close to the baseline estimate.
assumption about location, I used the NBER Patent Database together with Compustat to identify the companies for which all patents throughout the period 1976-2006 originated from the same state as the headquarters. The sample was reduced by more than three-quarters to 720.

As Table 6, column (6), reports, by contrast with the baseline estimate, the market-book ratio was significant. More pertinent to the subject of this study, the coefficient of UTSA was positive but not precisely estimated, suggesting that the UTSA was associated with more, rather than less, R&D. The reason for the difference between this result and the baseline estimate explanation is that the sample with all patents originating from the same state as the headquarters was more R&D intensive than the full sample. The average industry R&D intensity was 0.0867 (±0.0657) as compared with 0.0606 (±0.0657) in the full sample. Since the impact of the UTSA was positively associated with R&D intensity, it would be more positive in a more R&D intensive sample.

To further check, I estimated the specification allowing for heterogeneous effects on this sample. Re-assuringly, as Table 6, column (7), reports, the coefficient of UTSA x R&D intensity was quite close to the coefficient with the full sample, as reported in Table 5, column (9). This estimate helps to support my conclusion that the positive estimated coefficient of UTSA in the preceding specification was due to the sample being relatively R&D intensive.

In summary, my finding that the UTSA affected business R&D was robust to multiple checks for omission of possibly relevant variables, specification of control vis-a-vis treatment, geographic samples, and definitions of location.23

7 Results – Patents

Much of the existing analytical and empirical literature on trade secrets has focused on the choice between patents and trade secrecy as substitute ways to protect innovation (Anton and Yao 2004; Kultti et al. 2007; Ottoz and Kugno 2008; Moser 2005; Moser 2010). By contrast, practitioners (Jorda 2008) have emphasized that patents and trade

23To address any concern that UTSA might be endogenous, I conducted multiple tests of endogeneity using factors that I identified in Section 4 as influencing UTSA enactment – the legislative workload, sitting days, and political composition. With all three instruments, the null hypothesis that UTSA was exogenous could not be rejected. Indeed, the test statistics were close to zero. Specifically, using the workload as an instrument, $\chi^2(1) = 0.088$ ($p = 0.766$), and using sitting days as an instrument, $\chi^2(1) = 0.298$ ($p = 0.585$), while using political composition as instruments, $\chi^2(1) = 0.009$ ($p = 0.925$)
secrecy are complementary in appropriating the returns from innovation. Taking account of both the substitution and complementarity, Proposition 1 predicts that, controlling for R&D, stronger trade secrets law would lead to less patenting under condition (4).

So, empirically, how did the UTSA affect patenting? A preliminary issue was the estimation method. The distribution of patent applications was over-dispersed (mean = 11.75, over-dispersion = 7.315), which contradicts the assumption of the Poisson model that the mean and variance are equal. However, with Poisson estimation, the coefficients are consistent if the mean specification is correct and the robust standard errors are consistent although the distribution is misspecified (Wooldridge 2002: 646-649). Accordingly, following Hall and Ziedonis (2001), I used the Poisson model with robust standard errors, clustered by state and industry.

I first estimated a background specification, regressing patent applications on sales revenue and R&D expenditure (both lagged by one year), and including company and year fixed effects and state-specific year trends. As reported in Table 7, column (1), the coefficient of sales revenue was positive and significant, which is consistent with economies of scale in patenting. The coefficient of R&D expenditure was positive, albeit marginally significant (it was more precisely estimated in the other specifications). This result does help to validate the model underlying Proposition 1, which implies that patenting increases with R&D and is consistent with previous empirical studies of patenting (for instance, Hall and Ziedonis (2001)).

Next, I estimated the baseline specification – including the indicator for the UTSA. (In the patent regressions, as in the R&D regressions, all UTSA-related variables were lagged by two years. For brevity, in the discussion below, I simply refer to the variable itself and do not explicitly mention the lag.) As Table 7, column (2), reports, the coefficients of the controls were similar to those in the background estimate. The coefficient of UTSA was positive but not significant.

In Cohen et al.’s (2000) survey, technology managers reported whether patents were effective in ensuring the appropriability of product and process innovations. The impact of the UTSA on patenting should increase with the effectiveness of patents. Further, to the extent that trade secrecy is relatively more effective in protecting process as compared with product innovations (Arundel and Kabla 1998; Cohen et al. 2000; Arundel 2001; Jorda 2008), the UTSA should have a relatively larger impact on the patenting of

\footnote{I focused on patent applications rather than patent grants, since the issue is how businesses seek to appropriate the returns from their innovations. In practice, most patent applications are eventually granted, so applications and grants are highly correlated (Jaffe and Lerner 2004).}
process innovations.

Table 7, column (3), reports the estimate of a specification including the UTSA indicator and its interaction with the percentage of managers reporting that patents were effective in ensuring the appropriability of product innovations.\textsuperscript{25} Cohen et al.’s (2000) survey covered a limited number of manufacturing industries, and so, the inclusion of this interaction reduced the sample by about two-thirds. The coefficient of UTSA was negative, but not significant. The coefficient of the interaction of UTSA with the effectiveness of patents for product innovation was negative, but only marginally significant.

Continuing this line of investigation, Table 7, column (4), reports the estimate of a specification including the UTSA indicator and its interaction with the percentage of managers reporting that patents were effective in ensuring the appropriability of process innovations. The coefficient of UTSA was negative, but not significant. Interestingly, the coefficient of the interaction of UTSA with the effectiveness of patents for process innovation, $-0.053 \ (\pm 0.018)$, was negative, and precisely estimated. The coefficient implied that a one standard deviation increase in the effectiveness of patents for process innovation, 0.074, would be associated with a change in the expected number of patents by $\exp(0.074 \times -0.053)$ or 0.4%.

To check the robustness of the results with respect to the effectiveness of patents, I replicated the estimates using the negative binomial model. As reported in Table 7, column (5), the coefficient of the interaction of UTSA with the effectiveness of patents for product innovations was negative but not significant. Further, as Table 7, column (6) reports, the coefficient of the interaction of UTSA with the effectiveness of patents for process innovations was negative and precisely estimated. The results for the interaction variables were qualitatively similar to those with the Poisson model. However, I do prefer the Poisson model as revenue was not significant in the negative binomial model, which might suggest specification error.

I interpret the findings reported in Table 7, columns (2)-(6), as showing that, overall, the UTSA had no significant effect on patenting, while the UTSA did have a small but significant negative impact where patenting was effective, and particularly, on patents for processes. These results are quite reasonable as trade secrecy can only substitute for patents where patents are effective. Moreover, the larger impact on patents for processes is consistent with the prior academic and practitioner literature which suggests that trade secrecy is relatively more useful in protecting processes as compared with products for products.

\textsuperscript{25}To facilitate interpretation, as with all interactions of UTSA with continuous covariates, the continuous covariate was measured relative to its sample mean.
The absence of a significant overall impact on patenting could be interpreted in two ways. Referring to Proposition 1, one is that trade secrets law affects the exclusivity of the complementary know-how relatively less than the exclusivity of the innovation itself. The other possible explanation is that innovators are patenting for strategic objectives not directly related to appropriability. These include blocking competitors, as a defensive measure, for use in negotiations, and to attract venture capital investments (Cohen et al. 2000; Hall and Ziedonis 2001). Changes in trade secrets law might have little effect on patenting for such reasons. Trade secrecy cannot be used to block a competitor and trade secrets might not help to attract venture capitalists.

8 Concluding Remarks

Through various empirical tests, I have robustly shown that the UTSA had a nuanced effect on company-level innovation. At the investment stage, on average, it was associated with lower R&D. I interpret the results as showing that own and spillover R&D are complements. By reducing spillovers, the UTSA reduced the expected return from R&D, and so, led to less R&D. More specifically, the UTSA was associated with a negative main effect moderated by a positive effect increasing with complexity, and technology and R&D intensity of the industry, and company size.

At the patenting stage, on average, the UTSA had no significant effect on patenting, while the UTSA was associated with a small but significant reduction in patenting in industries where patents are relatively effective in protecting process innovation. These results suggest that, outside of industries where patents are effective for processes, either the UTSA affected the exclusivity of complementary know-how relatively less than the exclusivity of the innovation itself, or strategic objectives for patenting were more important than directly protecting appropriability.

My results imply that trade secrets law matters for investment in R&D generally, and, for particular industries, also might matter for the decision whether to patent technical innovations. These findings are significant for public policy and managerial practice.

In the realm of public policy, my results suggest that policy-makers concerned about technical innovation should look beyond patents, and give more attention to trade secrets. The UTSA served to codify the pre-existing common law and to harmonize the law across states. My results for the UTSA compared with the individualized state trade
secrets laws suggest that the UTSA affected innovation through harmonization rather than codification or substantive changes of the law.

My results also provide guidance for management practice. I show that the effect of trade secrets law on R&D differs between discrete vis-a-vis complex, low vis-a-vis high-technology, and more and less R&D-intensive industries, and according to company size. Further, I show that the effect of trade secrets law on patenting is relatively stronger where patents are effective protecting processes, but less so where patents are effective in protecting products.

For academic purposes, my findings suggest that the theoretical literature on trade secrecy should be re-oriented from focusing on trade secrecy as an alternative to patents as a way to protect the appropriability of innovation. Patents and secrecy might possibly fulfill distinct objectives, with the role of secrecy being mainly to regulate spillovers of knowledge at the investment stage of innovation.

A limitation of my analysis is that it treated all state enactments of the UTSA as identical. In fact, the states were prone to enact the UTSA with variations (Samuels and Johnson 1990; Pooley 1997). One direction for deeper legal research would be to catalogue the differences in the states’ versions of the UTSA and then to study the impact of the state laws on innovation. The challenge to such a study is that there is no ready legal analysis of the differences among the states’ versions of the UTSA, unlike that available for non-competition agreements.\(^{26}\)

Most importantly, my study points to a new research agenda – the impact of trade secrets law on (i) entrepreneurship and venture capital, (ii) collaboration, (iii) business and marketing innovation, and (iv) international trade and investment.

Gilson (1999) famously argued that California is more entrepreneurial than Massachusetts because it does not enforce non-competition agreements. However, the laws of the two states differ not only with respect to enforceability of non-competition agreements. California enacted the UTSA with effect from 1985, while Massachusetts relies on a very simple statute, published in 1967, and common law. Indeed, Hewlett-Packard’s suit mentioned trade secrets but not any non-competition agreement. So, does entrepreneurship thrive in California in spite of a tougher trade secrets regime? This would imply that the effect of non-competition law is even stronger – strong enough to

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\(^{26}\)While the Bureau of National Affairs has published a state-level survey of trade secrets law (Pedowitz et al. 1997), the results of the survey cannot be so readily codified as their corresponding survey for for non-competition agreements (Malsberger et al. 2008).
outweigh the trade secrets law. This is a question that is obviously deserving of further investigation.

It is worth emphasizing that stronger trade secrets law would not necessarily affect entrepreneurship in a negative way. Stronger trade secrets law might reduce spillovers of knowledge, and so reduce entrepreneurship. On the other hand, stronger trade secrets law would increase security of property rights, and so facilitate agreements for collaboration and spin-off businesses.

Related to the above, the second important direction for future research is the impact of trade secrets law on collaboration between businesses. A major risk in any business or technical collaboration is that one party might steal the ideas of the other. By providing security of property rights over work in progress, trade secrecy may foster collaboration and sharing of information. Secrecy is the only available protection for innovation which has not reached the stage to qualify (if at all) for patent or trademark protection. To the extent that the UTSA strengthens trade secrecy whether in law or simply in the minds of businesses, it might foster collaboration.

A third useful direction for future research is the impact of trade secrets law on business and marketing innovation. One of the most common subjects of trade secrets litigation is customer lists (Almeling et al. 2010). The challenge to this research would be to procure the relevant data on investment in business and marketing innovation. One possible proxy is advertising expenditure, which is reported by Compustat. However, it is imperfect to the extent that the advertising copy and media placement are public, hence only the planning and resource allocation are secret.

Finally, trade secrets law possibly affects international trade and investment. The multilateral Agreement on TRIPS (Trade-Related Aspects of Intellectual Property Rights) came into effect on January 1, 1995. TRIPS, in Article 39.2, specifically provides for protection of trade secrets. However, just as trade secrets law varies within the United States, it varies across countries. Even the European Union, which has energetically sought to harmonize patent, copyright, and trademark laws, has not done so with trade secrets. Given the international variation of trade secrets law (and enforcement), it would be very useful to study their impact on international trade and investment.
References


Hewlett-Packard Company v Mark V. Hurd, Superior Court, County of Santa Clara, September 7, 2010.


Hutter, Michael, Email, November 1, 2010.


Pooley, James, Personal conversation with author, November 30, 2010.


The Book of the States, Lexington, KY: Council of State Governments.


Table 1. State trade secrets acts

<table>
<thead>
<tr>
<th>State</th>
<th>Year</th>
<th>State</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arkansas</td>
<td>1981</td>
<td>District of Columbia</td>
<td>1989</td>
</tr>
<tr>
<td>Idaho</td>
<td>1981</td>
<td>Hawaii</td>
<td>1989</td>
</tr>
<tr>
<td>Kansas</td>
<td>1981</td>
<td>Maryland</td>
<td>1989</td>
</tr>
<tr>
<td>Louisiana</td>
<td>1981</td>
<td>New Mexico</td>
<td>1989</td>
</tr>
<tr>
<td>Minnesota</td>
<td>1981</td>
<td>Utah</td>
<td>1989</td>
</tr>
<tr>
<td>Delaware</td>
<td>1982</td>
<td>Arizona</td>
<td>1990</td>
</tr>
<tr>
<td>Indiana</td>
<td>1982</td>
<td>Georgia</td>
<td>1990</td>
</tr>
<tr>
<td>Washington</td>
<td>1982</td>
<td>Iowa</td>
<td>1990</td>
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<tr>
<td>Connecticut</td>
<td>1983</td>
<td>Kentucky</td>
<td>1990</td>
</tr>
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<td>North Dakota</td>
<td>1983</td>
<td>Mississippi</td>
<td>1990</td>
</tr>
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<td>California</td>
<td>1985</td>
<td>New Hampshire</td>
<td>1990</td>
</tr>
<tr>
<td>Montana</td>
<td>1985</td>
<td>South Carolina</td>
<td>1992-97</td>
</tr>
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<td>1986</td>
<td>Ohio</td>
<td>1994</td>
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<td>Oklahoma</td>
<td>1986</td>
<td>Missouri</td>
<td>1995</td>
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<td>Rhode Island</td>
<td>1986</td>
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<td>1996</td>
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<td>1998</td>
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<td>West Virginia</td>
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<td>Nebraska</td>
<td>1998</td>
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<td>Tennessee</td>
<td>2000</td>
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<td>1987</td>
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<td>Nevada</td>
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<td></td>
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<td></td>
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<td>Illinois</td>
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<td>Oregon</td>
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<td>Texas</td>
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</tr>
<tr>
<td>South Dakota</td>
<td>1988</td>
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</table>

Notes: Wisconsin and Alabama enacted trade secrets acts that differed substantially from the UTSA. Massachusetts and North Carolina enacted trade secrets acts that do not comply with the UTSA. South Carolina enacted the UTSA with effect from 1992, and then replaced it with its own trade secrets act with effect from 1997.
Table 2. State enactment of UTSA

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Macro-economic</th>
<th>(2) Tax credit</th>
<th>(3) Education</th>
<th>(4) Legislative agenda</th>
<th>(5) Session length</th>
<th>(6) Politics</th>
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</thead>
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<tr>
<td>GSP (ln)</td>
<td>-1.244</td>
<td>-1.295</td>
<td>-1.034</td>
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<td></td>
<td>(2.046)</td>
<td>(2.113)</td>
<td>(1.912)</td>
<td>(3.172)</td>
<td>(4.175)</td>
<td>(2.252)</td>
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<tr>
<td>R&amp;D (ln)</td>
<td>0.209</td>
<td>0.200</td>
<td>-0.126</td>
<td>0.163</td>
<td>-8.494*</td>
<td>0.237</td>
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<td></td>
<td>(0.229)</td>
<td>(0.235)</td>
<td>(0.410)</td>
<td>(0.487)</td>
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<td>(0.302)</td>
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<td>Population (ln)</td>
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<td>0.572</td>
<td>0.931</td>
<td>0.648</td>
<td>3.768</td>
<td>0.995</td>
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<td></td>
<td>(2.417)</td>
<td>(2.494)</td>
<td>(2.218)</td>
<td>(3.714)</td>
<td>(3.619)</td>
<td>(2.712)</td>
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<td>GSP growth</td>
<td>24.587**</td>
<td>24.500**</td>
<td>32.064</td>
<td>20.186*</td>
<td>151.391***</td>
<td>28.190**</td>
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<td>R&amp;D growth</td>
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<td>0.551</td>
<td>0.826</td>
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<td>-3.709</td>
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<td></td>
<td>(0.631)</td>
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<td>(3.362)</td>
<td>(1.399)</td>
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<td>(29.339)</td>
<td>(30.289)</td>
<td>(49.520)</td>
<td>(31.590)</td>
<td>(68.097)</td>
<td>(46.802)</td>
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<td>R&amp;D tax credit</td>
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<td>2.058*</td>
<td>1.624</td>
<td>9.262</td>
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<tr>
<td></td>
<td>(0.907)</td>
<td>(1.111)</td>
<td>(1.088)</td>
<td>(6.791)</td>
<td>(1.005)</td>
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<td>Master graduates (ln)</td>
<td>0.015</td>
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<td></td>
<td>(0.012)</td>
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<td>Doctoral graduates (ln)</td>
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<td></td>
<td>(0.025)</td>
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<td>Legislative workload</td>
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<td>Session days (ln)</td>
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<td>Lower house Republican</td>
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<td>(4.429)</td>
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<td>Observations</td>
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<td>224</td>
<td>157</td>
<td>177</td>
<td>92</td>
<td>216</td>
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</tbody>
</table>

Notes: Estimation by Cox proportional hazard regression of UTSA in effect. Focal variables: Column (2): Indicator of state-level tax credit for R&D; Column (3): Numbers of graduates with master and doctoral degrees; Column (4): Two-year moving average of number of bills tabled relative to number of legislators; Column (5): Two-year moving average of number of calendar days legislature in session (in logarithm); Column (6): Percent of Republicans in lower house and upper houses of legislature (excluding Nebraska which has a unicameral legislature and whose members may not be affiliated to any party); All estimates exclude South Carolina. Robust standard errors clustered by state in parentheses (*** p<0.01, ** p<0.05, * p<0.1).
Table 3. Summary statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D</td>
<td>$ million</td>
<td>42266</td>
<td>0.552</td>
<td>3.323</td>
<td>0.000</td>
<td>132.157</td>
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<tr>
<td>Sales revenue</td>
<td>$ million</td>
<td>42266</td>
<td>17.898</td>
<td>96.481</td>
<td>0.000</td>
<td>3323.137</td>
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<tr>
<td>Market/book value</td>
<td>million</td>
<td>36385</td>
<td>2.54E-06</td>
<td>0.0003</td>
<td>-0.052</td>
<td>0.023</td>
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<tr>
<td>EBITDA</td>
<td>$ million</td>
<td>42185</td>
<td>2.581</td>
<td>15.119</td>
<td>-12.688</td>
<td>669.681</td>
</tr>
<tr>
<td>Patents</td>
<td></td>
<td>42266</td>
<td>11.747</td>
<td>59.131</td>
<td>0</td>
<td>2355.000</td>
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<td>R&amp;D intensity (industry)</td>
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<td>42266</td>
<td>0.061</td>
<td>0.066</td>
<td>0</td>
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<td>Complex industry</td>
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<td>Effectiveness of patents</td>
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<td>26252</td>
<td>36.447</td>
<td>11.816</td>
<td>12.080</td>
<td>54.700</td>
</tr>
</tbody>
</table>

Table 4 (please see next page)

Table 5. R&D expenditure: UTSA impact

<table>
<thead>
<tr>
<th>SIC</th>
<th>Industry</th>
<th>R&amp;D intensity</th>
<th>Average company sales revenue ($ mill)</th>
<th>UTSA impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>2833</td>
<td>Medicinal chemicals and botanical products</td>
<td>0.0396</td>
<td>1.226</td>
<td>-0.042***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td>(0.010)</td>
</tr>
<tr>
<td>2834</td>
<td>Pharmaceutical preparations</td>
<td>0.106</td>
<td>15.99</td>
<td>0.007</td>
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<td></td>
<td></td>
<td></td>
<td>(0.014)</td>
</tr>
<tr>
<td>3575</td>
<td>Computer terminals</td>
<td>0.0332</td>
<td>1.766</td>
<td>-0.047***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.010)</td>
</tr>
<tr>
<td>3576</td>
<td>Computer communications equipment</td>
<td>0.143</td>
<td>3.917</td>
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</tr>
<tr>
<td></td>
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<td>(0.019)</td>
</tr>
</tbody>
</table>

Notes: UTSA impact calculated as the sum of: (i) coefficient of UTSA; (ii) product of coefficient of UTSA x R&D intensity with the difference between the respective industry R&D intensity and the average for all industries; and (iii) product of the coefficient of UTSA x revenue with the difference between the average company sales revenue for the industry and the average sales revenue for all companies. Coefficients and robust standard errors clustered by state and industry from Table 4, column (9) (** p<0.01, * p<0.05, * p<0.1).
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Company</th>
<th>(2) UTSA (baseline)</th>
<th>(3) North Carolina</th>
<th>(4) Alabama</th>
<th>(5) Wisconsin</th>
<th>(6) South Carolina</th>
<th>(7) Discrete/complex</th>
<th>(8) High tech</th>
<th>(9) Heterogeneity</th>
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</thead>
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<td>Revenue (ln)</td>
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<td>0.237***</td>
<td>0.238***</td>
<td>0.237***</td>
<td>0.237***</td>
<td>0.237***</td>
<td>0.237***</td>
<td>0.251***</td>
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<td>(0.022)</td>
<td>(0.022)</td>
<td>(0.022)</td>
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<td>(0.031)</td>
<td>(0.022)</td>
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<td>Market/ book value (mill)</td>
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<td>0.924</td>
<td>0.924</td>
<td>0.924</td>
<td>0.924</td>
<td>0.924</td>
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<td>(0.899)</td>
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<td>(0.899)</td>
<td>(0.899)</td>
<td>(0.827)</td>
<td>(0.888)</td>
</tr>
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<td>EBITDA (ln)</td>
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<td>0.167***</td>
<td>0.167***</td>
<td>0.167***</td>
<td>0.167***</td>
<td>0.167***</td>
<td>0.167***</td>
<td>0.179***</td>
<td>0.168***</td>
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<td>0.508</td>
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Notes: Estimation by ordinary least squares with company and year fixed effects and state-specific year trends. Dependent variable is log R&D expenditure, all control variables are lagged by one year, and all trade secrets law-related explanatory variables are lagged by two years. Columns (3)-(6): State TSA refers to the Trade Secrets Act of the state; Column (7): Discrete and complex industries as classified by Cohen et al. (2000) (ISIC 2320: Petroleum, ISIC 2423: Drugs, and ISIC 2710: Steel classified as complex) and concorded from ISIC to SIC by the author; Column (8): High-tech industries as classified by U.S. Department of Commerce (1983) but excluding software computer and data processing services (SIC 737); Column (9): UTSA x R&D intensity and UTSA x revenue are constructed as UTSA x difference of R&D intensity and revenue from respective sample mean. Robust standard errors clustered by state and industry in parentheses (** p<0.05, * p<0.1).
Table 6. R&D – Robustness

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) UTSA baseline</th>
<th>(2) R&amp;D tax credit</th>
<th>(3) Education UTSA states</th>
<th>(4) Multi-state MSAs</th>
<th>(5) Patent location</th>
<th>(6) Patent location</th>
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<td>Revenue (ln)</td>
<td>0.237***</td>
<td>0.238***</td>
<td>0.267***</td>
<td>0.253***</td>
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<td>(0.024)</td>
<td>(0.025)</td>
<td>(0.034)</td>
<td>(0.029)</td>
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<td>(3.071)</td>
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<td>0.167***</td>
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<td>0.135***</td>
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<td>-0.019**</td>
<td>-0.011*</td>
<td>-0.023***</td>
<td>-0.024**</td>
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<td>(0.006)</td>
<td>(0.007)</td>
<td>(0.011)</td>
<td>(0.014)</td>
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<td>(0.033)</td>
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Notes: Estimation by ordinary least squares with company and year fixed effects and state-specific year trends. Dependent variable is log R&D expenditure, all control variables are lagged by one year, and all trade secrets law-related explanatory variables are lagged by two years. Column (2): Included indicator state R&D tax credit in effect; Column (3): Included number of master and doctoral graduates; Column (4): Excludes states which have not enacted UTSA (AL, MA, NC, NJ, NY, SC, TX, WI); Column (5): Limited to companies in multi-state MSAs; Column (6): Limited to companies for which all patents in period 1976-2006 were filed in headquarters state; Column (7): Limited to companies for which all patents in period 1976-2006 were filed in headquarters state, UTSA x R&D intensity and UTSA x revenue are constructed as UTSA x difference of R&D intensity and revenue from respective sample mean. Robust standard errors clustered by state and industry in parentheses (*** p<0.01, ** p<0.05, * p<0.1).
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<td>0.676***</td>
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<td>(0.075)</td>
<td>(0.132)</td>
<td>(0.117)</td>
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<td>0.200**</td>
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<td>(0.100)</td>
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<td>(0.124)</td>
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Notes: Dependent variable is number of patent applications by company and year; company-level control variables – sales revenue and R&D expenditure – lagged by one year; UTSA-related variables lagged by two years. All estimates included company and year fixed effects and state-specific year trends. Columns (3)-(4): Focal variable constructed as UTSA x difference of effectiveness of patent for product/process from respective mean. Robust standard errors clustered by state and industry in parentheses (** p<0.01, * p<0.05, * p<0.1). Columns (5)-(6): Focal variable constructed as UTSA x difference of effectiveness of patent for product/process from respective mean. Estimation by negative binomial regression. Standard errors in parentheses (** p<0.01, * p<0.05, * p<0.1).
Figure 1. Decision on R&D and patenting

**Investment stage**

1. R
   - fail
     - prob $1 - \alpha$  
     - $-R$
   - succeed
     - prob $\alpha(R,S(L))$

2. Patent
   - do not patent
     - prob $1 - \rho(L)$  
     - $-R$
   - leak
     - prob $\rho(L)$  
     - $-R$

- no leak
  - prob $1 - \zeta(L)$  
  - $M - R - f$

**Exploitation stage**

Notes: States with UTSA in effect shaded in blue.

Figure 2. UTSA enactment, 1990
Figure 3. UTSA enactment lag

Notes: Lag between UTSA enactment and the year in which the UTSA was first tabled (vertical axis) against state-level growth of R&D (horizontal axis).

Figure 4. UTSA enactment and company-level R&D

Notes: Solid line shows coefficients of indicators of years before and after UTSA enactment in regression of company-level ln R&D expenditure on ln sales, market-book ratio, EBITDA, fixed effects for companies and calendar years, state-specific year trends, and indicators of years before and after UTSA in effect. Broken lines show 95% confidence intervals of coefficients.