THE EFFECT OF COORDINATION REQUIREMENTS ON SOURCING DECISIONS: EVIDENCE FROM PATENT PROSECUTION SERVICES

ABSTRACT

Research summary: Although the link between coordination requirements and vertical integration is theoretically well established, empirical tests of this relationship are hard to implement due to the simultaneous determination of both variables. In this study, we take advantage of regulatory changes in patent prosecution in the US to provide plausibly causal evidence linking increases in coordination requirements with insourcing. Moreover, we examine the role of plural sourcing, i.e. simultaneously making and buying, when responding to changes in coordination requirements. We find that the move towards insourcing is more pronounced for plural sourcing firms as compared to firms relying on outsourcing. These results are consistent with the view that plural sourcing provides firms with flexibility to switch between sourcing modes when facing changing coordination requirements.

Managerial summary: We study the sourcing of patent prosecution services in large innovative companies and show that inhouse production is more beneficial when coordination requirements between inventors and attorneys increase. Importantly, we find that plural sourcing firms, i.e. firms that work with both internal attorneys and external law firms, are more likely to respond to these increases and move towards insourcing as compared to firms relying only on outsourcing. This suggests that plural sourcing can be regarded as a strategic investment in sourcing flexibility, allowing firms to respond to changing coordination requirements. This is an adaptive capability which is especially useful in knowledge-intensive sectors.

Keywords: vertical integration; coordination; plural sourcing; AIPA; patent prosecution

1. INTRODUCTION

The governance of vertical relationships lies at the heart of organizations, so it is crucial to understand what drives firm boundary decisions. The existing literature highlights the important role that task interdependence plays. Specifically, vertical integration is preferred when coordination requirements increase (Gibbons, 2005; Gulati, Lawrence, & Puranam, 2005). Transaction cost economics (TCE) has long argued that firms choose “make” rather than “buy” to facilitate adaptive, sequential decision-making and relational adaptation (Williamson, 1985). Similarly, theories of firm knowledge and organizational adaptation suggest that firms are better than markets at devising mechanisms to share knowledge and enable effective coordination (Grant, 1996; Lawrence & Lorsch, 1967; Thompson, 1967).

For such a theoretically well-established idea, there is surprisingly limited empirical work documenting the effect of coordination requirements on firm boundary decisions. This dearth can be attributed to the simultaneous determination of both variables, given that the degree of task interdependence is hardly exogenous to the choice of governance structure (Bidwell, 2012; Brahm & Tarziján, 2016; Gulati *et al.*, 2005). A number of studies provide important evidence on the link between coordination and vertical integration (Baker & Hubbard, 2003; Januszewski Forbes & Lederman, 2009; Nickerson & Silverman, 2003; Novak & Eppinger, 2001). But direct tests of how changes in coordination requirements impact firms with heterogeneous sourcing strategies are lacking.

In this study, we bring novel evidence of the link between coordination requirements and firm boundary decisions by studying changes in the sourcing of patent prosecution services resulting from the American Inventor's Protection Act of 1999 (AIPA). AIPA was a major reform in the United States and brought two significant changes in the patent application process. First, whereas patent applications used to remain secret until the grant date, these are published 18 months after their filing date following AIPA. This precipitated the disclosure of firms' technological developments and increased the importance of the information revealed to competitors in patent applications (Baruffaldi & Simeth, 2020; Hegde & Luo, 2018; Lück, Balsmeier, Seliger, & Fleming, 2020; Saidi & Zaldokas, 2020). Second, AIPA made patent term adjustments contingent upon the exercise of "reasonable efforts to conclude patent prosecution". Both changes increased the need for knowledge exchange and closer coordination between attorneys undertaking patent prosecution and R&D staff.

We use two complementary identification strategies that rely on variation in patent pendency across technological classes and on the presence of foreign equivalent applications to test the impact of AIPA (Hegde & Luo, 2018; Saidi & Zaldokas, 2020). We show that firms increased their reliance on inhouse attorneys when filing patents that were disproportionately affected by AIPA, as expected by TCE and theories of organizational adaptation. We then explore firms' heterogeneous responses to AIPA based on their pre-

AIPA sourcing strategy. We find that the shift towards insourcing was more pronounced for plural sourcing firms, i.e. those firms that used both internal and external attorneys to prosecute patents prior to AIPA, as compared to firms that relied solely on outsourcing. Our preferred explanation for this result is that plural sourcing provides firms with flexibility to switch between sourcing modes when facing changing coordination requirements.

Our study contributes to the literature by providing plausible causal evidence on the relationship between coordination requirements and vertical integration. To date, an empirical investigation of this well-established theory has been hampered by endogeneity concerns (Bidwell, 2012; Gulati *et al.*, 2005). Inasmuch as AIPA imposed an exogenous change in coordination needs, our paper is one of the few to document a causal link between coordination and insourcing, and the first to do so within the context of knowledge-intensive services. This study also highlights the flexibility benefits of plural sourcing (Krzeminska, Hoetker, & Mellewigt, 2013; Parmigiani, 2007). Our results suggest that maintaining inhouse and outsourced production provides firms with the option to better adjust their procurement mode for transactions facing changing coordination requirements. This is likely to be particularly relevant for task environments where different types of interdependencies emerge and evolve over time (Adler, 1995; Bigley & Roberts, 2001). In such cases, the benefits of increased flexibility could outweigh the costs of employing two distinct sourcing modes and render plural sourcing an efficient response to the canonical make or buy decision.

2. BACKGROUND

2.1 Coordination requirements and sourcing decisions

The division of labor across organizations is key to understand firm governance and the vertical structure of production. TCE has been central in addressing this question. Firms set their boundaries in order to minimize *ex ante* transaction costs arising from asset specificity, and costly *ex post* contract renegotiation (Williamson, 1985). In the presence of uncertainty, firms need to adapt and adjust, which is easier to achieve inhouse (Klein & Murphy, 1997; Williamson, 1985). Hence, a key prediction from TCE is that increases in the need to coordinate across vertically related activities favor vertical integration.

Theories of organizational adaptation and firm knowledge similarly argue that firms are better than markets at devising mechanisms to share knowledge and facilitate effective coordination (Grant, 1996; Lawrence & Lorsch, 1967; Thompson, 1967). Coordination may take the form of rules and directives; sequencing of tasks; mutual adjustment under reciprocal interdependence; and group problem-solving (Gibbons, 2005). Such remedies work less well across market interfaces, so coordination needs encourage insourcing. Building on these ideas, Nickerson and Zenger (2004) frame sourcing decisions as problem solving. Problems that can be easily decomposed into separable modules tend to be outsourced while problems of low decomposability, which necessitate coordination among specialists, tend to be carried out within the firm. Thus, task interdependence puts a premium on coordination, and "making" rather than "buying" provides better adaptive capacity (Gulati *et al.*, 2005).

Notwithstanding the widespread theoretical consensus, the causal relationship between coordination requirements and insourcing has been harder to establish empirically. This can be primarily attributed to the simultaneous determination of the two variables (Gulati *et al.*, 2005). As Bidwell (2012: 1637) notes, firm boundary decisions can be understood as an endogenous outcome of the system of incentives, information, and authority that organizational structure creates. A limited number of studies try to address this challenge (Nickerson & Silverman, 2003; Novak & Eppinger, 2001). For example, Januszewski et al. (2009) link climate conditions, which affect coordination needs in air transportation, with airlines' boundary decisions. Baker and Hubbard (2003) examine changes in truck ownership resulting from the adoption of on-board computers that facilitate coordination in the trucking industry. These studies have helped establish the effect of coordination requirements on vertical integration in transportation industries. Additional evidence examining the causal impact of coordination needs in knowledge-intensive services, an increasingly important part of modern economies, would complement existing findings.

Besides that, prior work has not examined how heterogeneous sourcing strategies shape firm responses to changes in coordination requirements. This is an interesting question to explore, as theories of vertical scope have long emphasized the need to adopt a holistic view of the different activities undertaken by firms when setting their boundaries (Argyres & Liebskind, 1999; Langlois, 1992; Leiblein & Miller, 2003). Moreover, firms take long-term, strategic considerations into account in boundary decisions (Helfat & Campo-Rembado, 2016; Kapoor, 2013; Parmigiani & Mitchell, 2009). Thus, there are important interdependencies in firms' boundary choices, and the impact of changes in coordination requirements is likely to vary according to the sourcing strategies firms have put in place.

2.2 The role of plural sourcing in a context of changing coordination requirements

In order to explore the role of different sourcing strategies, we focus on firms that use a single governance mode, i.e. make *or* buy, as compared to firms that use plural sourcing. Plural-sourcing is a distinct sourcing mode where firms simultaneously make *and* buy the same input (Bradach & Eccles, 1989; Harrigan, 1986). There are various reasons for the emergence of plural sourcing. These can be grouped into two, non-mutually exclusive sets of explanations, one based on complementarity and the other on flexibility. First, plural sourcing can arise due to complementarity in incentives or knowledge (Puranam, Gulati, & Bhattacharya, 2013). For example, firms with internal production are better able to monitor external suppliers and can also benefit from sharing expertise (Dutta, Bergen, Heide, & John, 1995; Heide, 2003; Kapoor, 2013; Parmigiani & Mitchell, 2009). Alternatively, strategic flexibility can motivate the use of plural sourcing. Making and buying can help firms deal with demand uncertainty or adapt to technological change (Adelman, 1949; Krzeminska *et* *al.*, 2013; Parmigiani, 2007).

These two views provide different answers to the question of how plural sourcing firms respond to changes in coordination requirements. To see why, let us consider a firm that is facing increasing coordination requirements between its production processes and an outsourced activity, and an otherwise comparable firm that is facing increasing coordination requirements with a plurally sourced activity. Both firms are inclined to rely more on insourcing. But according to the flexibility view, the plural sourcing firm is better able to adjust its sourcing strategy. The outsourcing firm faces substantial search costs, delays and time compression diseconomies while it configures its internal production (Dierickx & Cool, 1989; Makadok, 2001). Moreover, inhouse production may be complicated by resource scarcity and irreversible commitments (Caves & Porter, 1977; Peteraf, 1993). By contrast, the plural sourcing firms benefits from the presence of an internal unit, even of small size, as this entails some expertise and access to channels for the acquisition of resources (e.g. technology or personnel). These facilitate the expansion of insourcing or the reallocation of inputs to the inhouse department. Thus, the adoption of a plural sourcing strategy can be viewed as an investment in sourcing flexibility, providing firms with the ability to switch between internal and external suppliers when coordination needs across activities change.

The complementarity view of plural sourcing offers contrasting predictions. According to this, the main benefits of plural sourcing lie in knowledge sharing between internal and external suppliers or stronger incentives (e.g. via better monitoring). Plural-sourcing firms are therefore less likely to move towards insourcing when coordination requirements increase, as doing so would undermine the added value obtained through such complementarity. In other words, the coordination benefits of moving production inhouse would be offset by the loss of (complementary) value that is created through the joint use of internal and external suppliers.

In what follows, we test these predictions within the context of patent prosecution services in the US and changing regulation at the US Patent and Trademark Office (USPTO).

3. RESEARCH CONTEXT: PATENT PROSECUTION AND REGULATION

Patent prosecution is a key activity for many technology firms.[1] This consists of the process of drafting and filing patents at the USPTO and provides an ideal setting to explore plural sourcing and its role when coordination requirements change. First, plural sourcing is common for these services, with many large technology corporations relying on both inhouse and external patent attorneys (Moeen, Somaya, & Mahoney, 2013; Sako, Chondrakis, & Vaaler, 2016). Second, this is a setting where production is project-based,[2] typically allocated to a single inhouse or external attorney, so we are able to explore heterogeneity in effective coordination needs that are disaggregated at the invention level. Finally, patent prosecution is substantially affected by the relevant legal framework. We can therefore exploit plausibly exogenous variation in cross-functional coordination needs introduced by changes in the regulatory environment. In particular, we study the American Inventor's Protection Act of 1999, a major patent reform that affected the patent application process.

3.1 Coordination between patent attorneys and R&D personnel

Patent prosecution is carried out by authorized patent attorneys or agents, who may be employed by the applicant (inhouse) or may work for an independent law firm (external). Patent attorneys play a key role in the process of securing property rights for inventions by combining their technical knowledge with patent law expertise (Mayer, Somaya, & Williamson, 2012; Somaya, Williamson, & Xiaomeng, 2007). As noted by the IP counsel of a large, global pharmaceutical company:

"Good patent attorneys need to understand the invention and how it works. They must

[1] Patenting is a key mechanism of appropriability for many technology sectors. Mistakes or omissions during patent filing can challenge patent validity and lead to expensive litigation so firms take great care to secure their IP rights during the application stage (Bessen & Meurer, 2005; Burgujian, Lim, & Wang, 2009).

[2] To improve our understanding of the context, we conducted 10 unstructured interviews with general counsels, patent attorneys (inhouse and external) and R&D staff from large, technology-intensive firms. Our interviews confirm other accounts in the literature (e.g. Mawdsley & Somaya, 2018; Moeen *et al.*, 2013) describing patent prosecution as project-based work, undertaken by a single attorney in the vast majority of cases.

be able to write a convincing patent application, discuss the prior art and have a story behind it – why it is useful and novel. The best patent applications are written by attorneys who are familiar with invention and are good writers. They tell good stories."

Patent attorneys collaborate closely with inventors and R&D managers to successfully prosecute patents. As a first step, the patentability of the invention has to be assessed, and the contribution of each member of the research team has to be established in order to determine legal authorship (Rydzewski, 2010). Both tasks naturally involve intense interaction between attorneys and inventors. Patent attorneys are also in charge of drafting the patent in collaboration with inventors. Inventors often provide descriptions of the inventions, while attorneys focus on the legally substantial parts: claims and prior art disclosure. Coordination between the two parties allows for a coherent patent document with good chances of being granted and later enforced. According to a patent attorney working for a US law firm:

"Of course we talk to inventors because they know the technology and can help us narrow down the claims. I always start with a phone call and have them describe the invention but I often talk to them more times. This facilitates the whole process and can speed things up."

Effective collaboration between patent attorneys and R&D managers is also crucial in order to determine the scope of the application – how much to claim – and the amount of knowledge disclosed. Moreover, patent attorneys are in charge of interacting with the USPTO during the examination process once the application has been filed. This implies addressing the USPTO's requests as well as writing and submitting the necessary amendments. These tasks involve non-trivial changes and decisions that need to be agreed with R&D managers and inventors. The ongoing collaboration between attorneys and inventors was highlighted by the chief scientist of a major oil and gas company in the US:

"We help patent attorneys especially to draft the claims. But they will come back to us and say do this or do that to help improve the document. In some cases, they will ask us to run some additional experiments to help the patent move forward."

3.2 The American Inventor's Protection Act (AIPA) of 1999

A peculiarity of the US patent system was that patent applications were confidential until the grant date. Firms were able to keep their inventions secret until property rights on them were secured. This was in contrast to the practice of other major patent offices where patent applications were published 18 months after the filing date. The official passage of AIPA aligned the US law with that of the rest of the world by establishing a similar 18-month disclosure rule for patents filed on or after November 29, 2000. AIPA was devised with the purpose of increasing transparency and reducing the incidence of involuntary infringement. However, it also substantially accelerated the disclosure of technological developments through the publication of patent applications (Baruffaldi & Simeth, 2020; Hegde & Luo, 2018; Lück *et al.*, 2020; Saidi & Zaldokas, 2020). Applicants can opt-out of pre-grant publication if they agree to relinquish international protection, but this option is rarely used[3] (Graham & Hegde, 2015). An intense debate about the potentially harmful effects of this disclosure requirement followed, indicating that AIPA increased the importance of patent applications as a source of information for competitors and imposed some level of involuntary disclosure to inventors (Ergenzinger, 2006; Graham & Hegde, 2015).

AIPA also altered the calculation of patent term adjustments for patents filed on or after May 29, 2000. These provisions are intended to compensate inventors for delays in the prosecution process. Before AIPA, patent term extensions were granted when delays were caused by administrative processes such as secrecy orders or interferences. AIPA added extensions due to delays in the examination process at the USPTO, in particular when failing to issue a patent in less than three years from the application date. Such extensions could be reduced due to delays caused by the applicant both before and after AIPA. But AIPA pressured applicants to respond faster. Under AIPA's provisions, patent term extensions are reduced for the period of time in which the "applicant failed to engage in reasonable efforts to

[3] The vast majority of applicants choose not to restrict the publication of applications for patents without foreign equivalents. But this does not imply that patent disclosure is irrelevant. Publishing patent applications can confer private benefits to inventors, such as provisional patent rights, signaling, or licensing opportunities (Graham & Hegde, 2015; Hegde & Luo, 2018), that can compensate for the costs of early disclosure.

conclude prosecution” which is defined as including taking longer than three months “to respond to a notice from the USPTO making any rejection, objection, argument or other request” (Tyson, 2000:800). This requirement is much stricter compared to the previous regime where applicants were required to act with “due diligence”. In fact, under AIPA, applicant delays can be used to reduce patent terms extensions even when the applicant’s delay did not lead to delays by the USPTO (Tyson, 2000:801). Overall, there is widespread agreement that adherence to the deadlines imposed by AIPA is challenging (Slate, 2000).

Both changes, namely the 18-month disclosure rule and the higher cost of applicant delays, increased the coordination requirements between patent attorneys, inventors and R&D managers. Before AIPA, applications were not in the public domain and inventors could choose secrecy any time prior to the grant date if they were not satisfied with the scope of the claims allowed by the USPTO. The eighteen-month publication rule introduced by AIPA makes information available to competitors much sooner. It also imposes in most cases an interim period in which property rights are not consolidated and secrecy has been lost. In fact, all of the dialogue between inventor and examiner is made public after eighteen months, making patent prosecution completely transparent to competitors (Barich, 2001:420).

Admittedly, there is some skepticism over the disclosure function of patents. This is based on studies arguing that patents do not disclose valuable technical information and that firms avoid reading competitors’ patents in order to avoid willful infringement (Lemley & Tangri, 2003; Roin, 2005). Notwithstanding these arguments, there is compelling evidence that patents are an important information channel. For example, Ouellette (2011) reports that 70% of nanotechnology researchers have used patents as a source of technical information while Cockburn and Henderson (2003) found in a survey of senior IP practitioners that almost 90% of companies routinely monitor competitors’ IP activity for competitive awareness. Hence, AIPA led to more subtle trade-offs in deciding what information to include in the application, and more sophisticated drafting strategies that required the coordination of inventors, attorneys and R&D managers. Rydzewski (2010: 130) describes how firms go to great lengths to camouflage the key components of their inventions during the application stage:

> *"If it's a patent, you're more than likely going to have the compound specifically claimed…If it's a patent application, people tend to try to hide it, because those applications publish. In time, you can amend your claims for the particular compound you are most interested in. Some companies don't like to do that, but they'll still try to hide it in a claim, say, covering a dozen or so compounds. In fact a lot of companies will try to camouflage what the real compound is and they'll have several claims to compounds that they're not that interested in."*

The disclosure of patent applications then substantially increased the coordination requirements between inventors and R&D managers on the one hand and patent attorneys on the other. Similarly, the "reasonable effort" obligation to conclude patent prosecution introduced by AIPA required a faster turnaround of patents. Given the three-month limit, any USPTO requests need to be answered quickly if applicants want to maximize patent terms. As all correspondence with patent examiners becomes public sooner, applicants need to balance speed of response with vigilance to avoid the disclosure of information that would better remain confidential.[4] Overall, AIPA led to increased pressures for patent attorneys to coordinate with inventors and R&D managers, with the objective of speeding up patent approval and carefully selecting the claims and information publicly revealed in applications.

3.3 Heterogeneity in the increase of coordination requirements

While AIPA led to an overall increase in the need to coordinate R&D and patent prosecution, such increases were not homogenous. This is due to differences in patent pendency, i.e. the time it takes from application to publication, across technological areas (Saidi & Zaldokas, 2020). These are relatively stable over time and reflect differences in the complexity, submission requirements, or prior art that influence the examination process (Popp, Juhl, &

[4] Patent-term extensions are eventually irrelevant for the majority of patents as these are not renewed to their full term by assignees. However, at the time of the application the invention value is typically not known and inventors have therefore strong incentives to acquire the strongest protection possible. The importance of patent term is also evident in the different extension strategies employed by firms to increase the lifespan of patents.

Johnson, 2004). Figure 1 presents the distribution of average grant lag across all patent classes for patents filed three years prior to AIPA's implementation, i.e. 1997 to 1999. The mean is 26.75 months while the median is 25.59 months. Classes like 112 ("Sewing") or 144 ("Woodworking") have a much lower average grant lag though, about 19 months. In others, for example in class 370 ("Multiplex communications") or 718 ("Electrical computers and digital processing systems"), patents require, on average, more than 44 months to get granted.

- Insert Figure 1 about here -

Accordingly, cross-class heterogeneity can be used to identify the effect of increased coordination requirements caused by AIPA. For applications in technology areas with short grant lags AIPA had little effect. Patents were already granted, and thus published, relatively quickly. Moreover, the pressure to adhere to the more stringent response requirements of the USPTO is lower as these patents are less likely to receive patent term adjustments resulting from USPTO delays.[5] In contrast, coordination requirements increased more sharply for classes with long grant lags. In those areas, publication takes place much sooner than it did before AIPA and, therefore, the coordination effort to decide what to disclose increases. Besides, applicants in areas with a long grant lag are more likely to be awarded patent term adjustments due to the USPTO's failure to issue a patent in less than three years. Increased coordination effort aimed at ensuring a fast response to examiner requests is more beneficial in these areas, as it protects applicants from potential reductions in patent term extensions.

As we discuss later, this identification strategy could be influenced by events contemporaneous to AIPA's implementation with asymmetric effects across different sectors. We therefore employ a complementary approach that relies on AIPA's heterogeneous effects across patents with (or without) foreign equivalent applications (Hegde & Luo, 2018).

[5] Based on our own calculations, the correlation between average pre-AIPA patent grant lag and post-AIPA average patent term adjustments across all USPTO patent classes is 0.77.

4. METHODS & DATA

We collect information on the patenting activities of firms, as well as of their subsidiaries, in the 2002 *Fortune* 500 list. We focus on granted applications filed during the 1995-2005 period to allow sufficient time to examine sourcing decisions before and after AIPA's implementation. AIPA's changes took effect in different points in time during the year 2000 but we choose the earliest date of May 29, 2000 as the cutoff point after which applications are subject to the increased coordination requirements. We restrict our sample to firms with data in Compustat and to firms with at least one patent application filed in each year between 1995 and 1999. This ensures that the firms included in our analysis file patents on a regular basis and thus face the tradeoffs associated with developing alternative sourcing strategies. This leaves us with 101 firms that applied for a total of 217,480 patents in 413 distinct patent classes. Table 1 presents descriptions of all variables used.

- Insert Table 1 about here -

4.1 Dependent variable

We use *Insourced*, a dummy variable taking the value of one when a patent was filed using an inhouse attorney as opposed to an external law firm, as the dependent variable. To construct this variable we rely on the NBER and PatentsView databases together with the patent application data from the USPTO (Hall, Jaffe, & Trajtenberg, 2001). In particular, we look into the 'Attorney/Agent' field in the application documents where the lawyer responsible for filing the patent is listed. When information was missing in the application, we relied on the granted patent. Roughly 1% of patents did not list attorney information in both application and grant documents and were thus excluded from our sample. This process is complicated by inconsistent reporting and misspellings. Using a semi-manual approach, we were able to identify cases where internal attorneys or external law firms were employed.[6]

4.2 Independent variables

Our key independent variable is *Patent class grant lag*, calculated as the average time (in months) it takes from application to publication for all patents filed at the USPTO in the technology class of the patent during the 1997-1999 period. This variable reflects how quickly patents in a specific class are expected to be granted so it allows us to capture the extent of increase in coordination requirements between attorneys, inventors and R&D managers brought about by AIPA. We also include *Post-AIPA*, a dummy taking the value of one when a patent is filed on or after May 29, 2000. Lastly, we create *Plural sourcing firm*, a dummy variable taking the value of one when the filing firm used both in-house and external attorneys to prosecute patents during the 1997-1999 period. In our sample, 89 firms engaged in plural sourcing while 12 relied exclusively on outsourcing patent prosecution work.

4.3 Control variables

We control for a number of additional factors that could affect the decision to insource. First, we calculate the number of inventors listed in the patent as multiple inventors likely increase the coordination effort required. Second, we use the Herfindahl index of concentration of outsourced patents to external law firms to consider whether firms develop strong relationships with their suppliers (Moeen *et al.*, 2013; Sako *et al.*, 2016). A higher concentration reflects stronger ties as the focal firm relies on fewer law firms for patent prosecution. We adjust this measure in order to account for the stability in supplier relationships. Hence, instead of looking only at year *t*, we calculate the average share of outsourced patents to a specific law firm for years *t* to *t*-3. This measure captures the intensity

[6] We identified law firm names based on name structure, e.g. name ending in "LLP" or "Associates" etc and coded these as outsourced. A concern arose when an individual was listed. In these cases the patent attorney is usually, but not always, an in-house lawyer. To account for this, we compared the address of the attorney listed with corporate addresses. All unique assignments were manually checked to ensure that our classification is correct. Moeen et al. (2013) provide detailed instructions on disambiguating law firm and attorney names.

of interactions between the focal firm and law firms over time, and proxies the presence of shared relationship-specific assets that can be used to facilitate coordination.

We also add a number of control variables to account for differences in the characteristics of firm patenting output. We include the (log) count of patent applications filed in a given year by the focal firm to control for scale effects. Then, we include the non-biased Herfindahl index of technological concentration across patent classes (Hall, 2002) to account for the diversity of patenting output, and a measure of technological proximity between current and past patenting output using Jaffe's (1986) measure of similarity. This measure considers all patent classes listed in patent documents, thus reducing potential bias (Benner & Waldfogel, 2008), and allows us to account for changes in firms' technological trajectory. To these we add the standardized difference between patent applications in years *t* and *t-1* to control for variation in the amount of patent prosecution work over time.

Subsequently, we add various patent-specific characteristics. These include the (log) number of citations received adjusted for truncation to account for the quality of the patented invention (Hall *et al.*, 2001) as well as the (log) number of claims listed in the patent to control for its scope. Moreover, we add measures of generality and originality – see Trajtenberg, Henderson and Jaffe (1997) – and the (log) number of citations made to other patents. These measures help us capture differences in the effort required to file a patent application. Following other papers on patent prosecution insourcing (Mayer *et al.*, 2012; Moeen *et al.*, 2013), we also control for litigation potential, using a dummy variable taking the value of one when the patent cites a previously litigated patent based on the LitAlert database; past outsourcing, that is the (log) count of outsourced patents in the same patent class during years *t-1* to *t-3*; and degree of patent firm-specific knowledge, by calculating the percentage of self-citations made out of total citations made. Finally, we include information on R&D intensity, (log) sales, profitability, and (log) employee count for the focal firm.

Table 2 presents descriptive statistics and correlations between the variables used.

- Insert Table 2 about here -

4.4 Econometric specifications

We employ a difference-in-differences (DiD) analysis to estimate the effect of AIPA on the probability that a given patent application is assigned to an in-house attorney, as opposed to an external law firm. In particular, we estimate the following model:

$$P(Insourced)_{icjt} = \beta_0 + \beta_1 \times PostAIPA_t + \beta_2(L_c \times PostAIPA_t) + \gamma' X_{ijct} + \rho_c + \mu_j + \eta_t + \varepsilon_{icjt}$$

where the left-hand side of the equation captures the probability that the patent application associated to invention *i*, corresponding to USPTO patent class *c*, filed by firm *j* in year *t* is prosecuted by an in-house attorney. L_c captures the average grant lag for patent class *c*, and $PostAIPA_t$ is a dummy indicating the period in our sample where AIPA takes effect, i.e. mid-2000 to 2005. Our key estimate of interest therefore is β_2, which captures the AIPA treatment. Importantly, the main effect of filing in a specific patent class is captured by a set of dummy variables, ρ_c, while time effects are absorbed by the set of year dummies η_t. μ_j are firm fixed effects that capture time-invariant, firm-specific differences that influence insourcing propensity and X_{ijct} includes our vector of control variables. To explore AIPA's heterogeneous effects across firms that employ plural sourcing versus pure outsourcing, we add to the model we described the three-way interaction term of *Patent class grant lag*, *Post-AIPA*, and *Plural sourcing firm* along with the corresponding two-way interaction terms.

Our identifying assumption is that AIPA is exogenous to firms' sourcing decisions. Like other major patent reforms, AIPA was subject to ongoing debates in different Congress committees as early as 1995. While it is unlikely that specific firms had much influence on the final legislation[7], it is reasonable to assume that some knowledge of the provisions was

[7] The main purpose of AIPA was to align the USPTO with practice in other international patent offices (Barich, 2001; Ergenzinger, 2006).

disclosed prior to AIPA becoming a law. It is possible then that firms in our sample increased their reliance on insourcing before AIPA's implementation, assuming that they were willing to use insourcing for patents not yet subject to the increased coordination requirements. Figure 2 does not provide support to this conjecture as there is little indication of a move towards insourcing in the run up to AIPA. We look more into this point in our analysis below, but we should note that our results could be underestimating the move towards insourcing if firms increased their reliance on insourcing in anticipation of AIPA.

- Insert Figure 2 about here -

Lastly, we discuss the model we use. Although the dependent variable is a dummy, a Logit model is less appropriate in our case, given the difficulty of estimating interaction effects (Hoetker, 2007). We therefore use a linear probability model as our preferred specification. This provides consistent estimates of average partial effects and works well when probabilities are not extreme, i.e. close either to zero or one, like in our case. We also provide results with a Logit model in robustness tests. A final point relates to the calculation of standard errors. Bertrand, Duflo & Mullainathan (2004) explain that the DiD estimator could be biased due to serial correlation. We adopt the solution they put forward and estimate standard errors clustered at the patent class level (which is our treatment level), thus allowing for an arbitrary covariance structure over time within each patent class.[8]

5. RESULTS

We start our analysis by looking into patterns of insourcing for firms in our sample. Plural sourcing is quite common amongst Fortune 500 tech companies. From the 101 firms in our sample, 12 outsourced all patent applications during the pre-AIPA period. None insources all patent applications but there are individual years when firms in our sample insource all applications. Moreover, there is a clear downwards trend in insourcing (see Figure 2). This

[8] Note that these clustered standard errors are also robust to the presence of heteroskedasticity in the data.

could be attributed to the fast increases in patenting during these years – inhouse departments might struggle to expand quickly – or to the rising incidence and costs of patent litigation – patent prosecution in contested areas could benefit from external attorneys (Mayer *et al.*, 2012). Interestingly, the decline in insourcing appears to decelerate around the time when AIPA was implemented. Of course, this evidence is only suggestive and an in-depth look is required in order to test the extent to which AIPA and associated increases in coordination requirements prompted firms to move work inhouse.

5.1 Coordination requirements and insourcing

Table 3 reports results from the regression analysis. Results in Model (1) provide support to the link between coordination requirements and vertical integration as the DiD estimator is positive with a *p*-value of 0.05. This suggests that firms filing applications in technology classes with relatively high patent pendency disproportionally increased insourcing (as compared to firms filing applications in technology classes with low patent pendency) after AIPA took effect. Increases in insourcing are moderate as the probability to insource patent prosecution after AIPA increases by 2.5 percentage points when comparing patents filed in a patent class with grant lag one standard deviation above the mean versus patents filed in a class with grant lag one standard deviation below the mean.

- Insert Table 3 and Figure 3 about here -

The 'parallel trends' assumption is key for the interpretation of our findings. In practice, we need to examine whether these results are driven by pre-existing trends in the insourcing behavior of firms. We provide evidence to suggest that violations of this assumption are not evident. We compare changes in average insourcing ratios during the pre-AIPA period across two groups of firms, those that are (a) above or equal to and (b) below the median in the average grant lag they face for patents filed during the 1995-1999 period. A *t*-test produces no statistically significant difference between the two (*p*-value=0.70), suggesting that the two groups exhibited similar insourcing behavior before AIPA took effect.

Alternatively, a good way to assess the parallel trends assumption is through the visual inspection of pre- and post-AIPA insourcing ratios. Figure 3(a) plots average insourcing ratios for the two groups of firms (above or below the median in grant lag) throughout the study period. Before AIPA, firms that patented in high- and low-patent pendency classes exhibited a similar downwards trend in insourcing. However, there is a clear break in the trend for firms filing applications in long-lag classes after AIPA. This is not the case for short-lag firms that are less affected by AIPA. We also estimate the coefficients of individual year dummies interacted with our treatment, *Patent class grant lag*. In Figure 3(b) we can see that before AIPA the interaction coefficients are indistinguishable from zero (with the exception of year 1995, which is marginally positive). But after AIPA the interaction coefficients turn positive as expected. This evidence provides us with increased confidence in the interpretation of the DiD analysis.

A second concern for the interpretation of our results is that the legal changes brought about by AIPA might have led to changes in the patents filed by the most affected firms and these, in turn, might have influenced the choice of the sourcing mode. We address this issue by adding to our specification the interaction of different firm/patent characteristics[9] with the *PostAIPA* dummy to account for potential changes after AIPA took effect (see Table A1(a) in the Appendix). The DiD estimates remain unchanged, with low *p*-values across all models, suggesting that changes in patent characteristics post-AIPA are not driving our results.

Lastly, we consider whether the results we report translate into an increase in insourcing at the firm level. Given our setting, analysis at the patent level is advantageous as it allows us to model coordination needs at a very disaggregated level corresponding to the decision firms

[9] These are *Inventors, Relational suppliers, Patents applied, Tech concentration, Jaffe tech proximity, Dif in patents applied, Citations received, Claims, Generality, Originality, Citations made, Litigation, Past outsourcing*, and *Self-cites*.

face when allocating individual patents to attorneys. It also allows us to directly control for different patent characteristics that could explain the decision to insource an application. Given the heterogeneity in size and patenting activity across companies in our sample, however, the results we have presented so far do not necessarily imply an increase in insourcing at the firm level. To test for this, we aggregate all variables at the firm-patent class-year level and at the firm-year level and present results in Models (2) and (3) of Table 3 respectively. In both cases, we find the DiD estimator to be positive with low *p*-values.

5.2 Additional analysis & robustness tests

An idiosyncratic challenge for our identification strategy is the burst of the so-called "dot-com bubble", which coincides with AIPA's implementation. In particular, one concern could be that Internet and ICT firms, which were primarily affected by the burst of the bubble and tend to file patents in technology areas with longer pendency, increase insourcing in order to reduce costs. To account for this, we undertake two tests. First, we exclude firms from industries that were directly affected by the dot-com bust[10] and repeat our analysis. We find support for our hypotheses with this subsample (see Table A2 in the Appendix).

Second, we use an alternative identification strategy that relies on the presence of foreign equivalent applications (Hegde & Luo, 2018). As mentioned before, a key change resulting from AIPA was the publication of applications. However, this change had a disproportionate effect on applications that were only filed in the US. Most international patent offices were already publishing applications eighteen months after their filing date so US applications with foreign equivalents were already subject to pre-grant disclosure. Naturally, disclosure in foreign patent offices is likely to be less effective than in the USPTO. Moreover, the decision to file in different patent offices could be affected by changes brought by AIPA. But this

[10] We exclude 12 firms with the following primary 3-digit SIC codes: 360 (Electr, Oth Elec Eq, Ex Cmp), 361 (Elec Transmission and Distr Eq), 364 (Electric Lighting, Wiring Eq), 366 (Communication Equipment), 367 (Electronic Comp, Accessories), 737 (Cmp Programming, Data Process).

source of variation is not affected by contemporaneous events that affect specific sectors so it complements our analysis. Reassuringly, we are able to replicate our results in Model (4) of Table 3 when using *No foreign equivalent* as a measure of exposure to AIPA.

Next, we check whether additional contextual factors in our analysis (in particular, the number of co-inventors in the patent, the type of supplier relationships, and the technology patent renewal rate) provide evidence consistent with our suggestion that AIPA increased coordination requirements and led to more insourcing. An important element in this respect is the number of inventors that produced the patented invention. Coordination is costlier in terms of both time and effort when multiple individuals are involved (Srikanth & Puranam, 2011). So, patents with more inventors should be disproportionately affected by AIPA and the shift towards insourcing should be more pronounced. Model (5) in Table 3 provides support to this proposition as the triple interaction term between *Patent class grant lag*, *Post-AIPA*, and *Inventors* is positive with a *p*-value of 0.07.[11]

We also find evidence consistent with our coordination mechanism in the analysis of contracting strategies with external suppliers presented in Model (6) of Table 3. Firms that work with a few, long-term suppliers develop relationship-specific assets in the form of transactional interfaces, knowledge-sharing routines and governance mechanisms that facilitate coordination (Dyer, 1997; Sako *et al.*, 2016). Hence, the relative advantage of insourcing in terms of coordination should be smaller when the firm works with suppliers on a relational basis. Our results are consistent with this conjecture as the triple interaction term between *Patent class grant lag*, *Post-AIPA*, and *Relational suppliers* is negative with a *p*-value of 0.03. These findings provide us with additional confidence that coordination needs

[11] It is worth to note that, in this setting, the fixed-effects estimator uses both within-group and between-group variation to estimate the triple interaction effect – see Shaver (2019) for an extended discussion. We thus present additional results in Table A3 in the Appendix using a "double-demeaning" method suggested by Giesselmann & Schmidt-Catran (2019) that relies solely on within-group variations. This also applies to the case of the triple interaction effect with *Relational suppliers* discussed below. Results were qualitatively similar in both cases.

between attorneys and R&D staff is the key driving force behind our main results.

In addition to considering heterogeneity in grant lag, we also identify technology areas where AIPA is likely to have a disproportionate effect by looking at their obsolescence rate. We argued above that AIPA encouraged insourcing as it prompted firms to respond faster to the USPTO in order to qualify for potential patent term extensions through patent term adjustments. In practice, patent-holders often let their patents expire before the end of their full term if they become obsolete. Hence, we expect AIPA's effects to be stronger in areas where patents tend to be renewed to their full term and less relevant when patents typically expire sooner. To explore this, we create the variable *Renewal rate*, which captures the average renewal rate (to full term) for patents filed in each patent class during the three years prior to AIPA's implementation. Results provide support for the mechanism we put forward as the triple interaction term between *Patent class grant lag*, *Post-AIPA*, and *Renewal rate* is positive with a *p*-value lower than 0.01 in Table 3, Model (7).

Next, we check the robustness of our results to a number of different analytical choices. In Model (8) we use a Logit model with standard errors clustered at the technology class level and obtain similar results. We also estimate our baseline model without firm fixed effects and get consistent results (see Table A4 in the Appendix). Moreover, we use two or four years before AIPA to calculate *Patent class grant lag* or the median (instead of the average) grant lag and our results remain unchanged (see Table A5 in the Appendix). Our results are also robust to excluding patent applications for the year 2000, when only excluding patents filed during the May 29, 2000 – November 29, 2000 time period, or when excluding continuation applications (see Table A6 in the Appendix).

Lastly, we explore if changes in patent propensity are driving our results. It is plausible that the disclosure requirements imposed by AIPA discouraged firms from filing patent applications, especially in technology areas with long grant lags. Firms could foreseeably opt for secrecy instead of having their inventions in the public domain for long without consolidated rights. If that were the case, increases in insourcing could reflect the fact that firms file fewer applications using their existing inhouse capacity, not shifts due to increased coordination requirements. While we control for the overall number of applications filed by firms, we probed this mechanism further. We run a DiD analysis at the firm level with the number of patent applications as the dependent variable. Results do not suggest a change in patent propensity post-AIPA (see Table A7 in the Appendix). Hegde, Herkenhoff and Zhu (2019) similarly find no evidence of changes in patent propensity as a result of AIPA.

5.3 Coordination requirements, insourcing and plural sourcing

We now move to explore AIPA's heterogeneous effects depending on firms' prior choice of sourcing strategy. Table 4 presents results for firms relying on plural sourcing as compared to firms relying only on outsourcing.[12] In Model (1) we estimate the coefficient of the triple interaction term between *Patent class grant lag*, *Post-AIPA*, and *Plural sourcing firm*.[13] This is positive with a *p*-value lower than 0.01, suggesting that increases in insourcing following AIPA are sharper for firms that use both insourcing and outsourcing for patent prosecution. To interpret this finding, we consider the change in the probability to insource patent prosecution after AIPA when comparing patents filed in a patent class with grant lag one standard deviation above the mean versus patents filed in a class with grant lag one standard deviation below the mean. The increase in the probability to insource is 4.1 percentage points larger when firms already undertake plural sourcing as compared to firms that outsource all patent prosecution. In Model (2) we use the alternative identification strategy relying on US only patent applications, that is without foreign equivalents, and find similar results.

[12] The full set of estimated coefficients from the models of Table 4 are available in Table A8 of the Appendix.
[13] While multicollinearity increases dramatically as a result of including the additional interaction terms (e.g. the VIF of the triple interaction terms is 420), this is not a problematic issue given that a simple re-scaling of interacted variables dramatically reduces the VIF without affecting the size and p-value of interaction terms (Allison, 2012). In any case, our sample size is large enough to provide statistical power for the analysis.

- Insert Table 4 and Figure 4 about here -

We also run separate regressions for outsourcing and plural-sourcing firms. In Model (3) we find no evidence of an increase in insourcing for firms that relied only on outsourced patent prosecution before AIPA. In contrast, in Model (4) we find that plural-sourcing firms moved towards insourcing for patent applications disproportionately affected by AIPA (the Wald test of the equality of the DiD coefficients across the two groups is rejected with a *p*-value lower than 0.01). These results are also robust to using a Logit model and to using a more granular measure of plural sourcing at the firm-patent class level (see Table A9 in the Appendix). Our estimates suggest that the probability to insource patent prosecution after AIPA increases, for plural sourcing firms, by 2.3 percentage points when comparing patents filed in a patent class with grant lag one standard deviation above the mean versus patents filed in a class with grant lag one standard deviation below the mean. Figure 4(a) shows average insourcing ratios for the two types of firms. We can see that plural-sourcing firms decelerate the move towards outsourcing after AIPA. In Figure 4(b) we look more specifically into treated patents and plot the coefficients of individual year dummies interacted with *Patent class grant lag* and *Plural sourcing firm*. The interaction coefficients are indistinguishable from zero before the year 2000 but turn positive after AIPA as expected.

Our finding that plural sourcing firms disproportionately increased their reliance on insourcing following AIPA is at odds with the view of plural sourcing as a strategy to exploit complementarities between sourcing modes. Rather, this result is consistent with the view of plural sourcing as an investment in sourcing flexibility, allowing firms to better respond to changes in coordination requirements. There are, however, two alternative mechanisms that could explain this result and are worth exploring. First, it is possible that firms became eager to switch from pure outsourcing to plural sourcing in the run-up to AIPA in anticipation of future insourcing needs. Second, the sharper increase in insourcing among plural sourcing firms could simply reflect the fact that plural sourcing firms are more sensitive to changes in coordination requirements than outsourcers.

While it is difficult to pinpoint the merits of each of these mechanisms, we provide some evidence that the flexibility view is the most plausible explanation for our findings. First, as we noted before, we see no evidence of a pre-AIPA move towards insourcing. Importantly, no firm in our sample switched from outsourcing to plural sourcing during the 1995-1999 time period, as expected by the anticipation explanation. Hence, our results are unlikely to be driven by firms switching to plural sourcing as they prepare for AIPA's implementation.

Next, we explore whether the moderating role of relying on insourcing operates differently at the extensive margin of insourcing (i.e. the choice to rely on plural sourcing versus outsourcing) than at the intensive margin (i.e. the intensity of insourcing among plural-sourcing firms). The flexibility explanation is based on the idea of having a legal department with capacity ready to operate, and suggests only (or primarily) an effect at the extensive margin. On the other hand, differences in sensitivity to coordination requirements that may exist between plural-sourcing firms and outsourcing firms should also exist within the group of plural-sourcing firms across different levels of insourcing. In other words, while the flexibility explanation predicts primarily differences (in the effects of increased coordination requirements) at the extensive margin of plural sourcing, the sensitivity to coordination requirements extends this prediction to the intensive margin of insourcing.[14]

In Model (5) of Table 4 we use *Insourcing ratio*, that is the average percentage of patent applications filed using an inhouse attorney by plural-sourcing firms during the 1997-1999 time period, and estimate the coefficient of the interaction term between *Patent class grant lag*, *Post-AIPA*, and *Insourcing ratio*. This is negative with a *p*-value at 0.83, suggesting that differences at the intensive margin have less explanatory power as compared to differences at

[14] See Parmigiani (2007) for a similar approach and analysis.

the extensive margin. This result favors the flexibility explanation we described above.[15]

Lastly, we look into the performance implications of insourcing. If plural sourcing is an investment in sourcing flexibility, then firms choosing this strategy should benefit when facing changes in coordination requirements. Insourcing should generate some tangible advantages in a context of increasing coordination requirements. To explore this, we analyze the delays in patent prosecution caused by applicants. This information is recorded by the USPTO for all patents filed after AIPA, and is available in its Patent Application Information Retrieval (PAIR) database. Applicant delays reduce the effective life of patents and impede the consolidation of patent rights, thereby limiting firms' ability to profit from them.[16]

The average applicant delay for the patents in our sample submitted after May 2000 is 55.7 days, with 65% of patents having at least one day of applicant delay. In Models (6) and (7) of Table 4 we use *Applicant delay* as a dependent variable and present its relationship with *Insourced* during the post-AIPA period.[17] This is negative with a low *p*-value in both models, suggesting that patents filed by inhouse attorneys have shorter applicant delays. The effect is noteworthy, with insourcing being associated with a 10.6% reduction in delays based on Model (6). Of course, we should be cautious in the interpretation of this finding as the decision to insource is likely endogenous. But these results suggest that the ability to move quickly towards insourcing is beneficial in terms of avoiding delays at the USPTO. This

[15] We looked more into this result and run a separate regression for firms below the median in *Insourcing ratio*. Firms above the median might have little room to increase insourcing as they already undertake the majority of patent prosecution work in-house. But firms below the median in *Insourcing ratio* have the space to increase patent prosecution insourcing as a response to increases in coordination requirements. Results do not support the sensitivity to coordination requirements explanation as differences at the intensive margin have little explanatory power for this subsample. Alternatively, we created dummy variables for firms in the different quartiles of *Insourcing ratio* and interacted these with *Patent class grant lag* and *Post-AIPA*. Again, we do not find support for the sensitivity to coordination requirements explanation. These results are available in Table A10 in the Appendix. Note also that if plural-sourcing firms were more sensitive to coordination requirements, they would likely differ from outsourcing firms in some underlying characteristics. Hence, accounting for these characteristics should attenuate our findings. The results we present in Table A1(b) do not support this view.

[16] Firms could strategically prolong the time during which patents are under examination in some cases. However, this strategy was more prominent before 1995 and was primarily employed by smaller firms that were trying to profit from infringement suits (Graham & Mowrey, 2004).

[17] Given that data related to applicant delays are only available post-AIPA, we are unable to run a comparison across the two time periods.

provides additional evidence consistent with the flexibility explanation we put forward.

Overall, there are several plausible explanations for our result that plural-sourcing firms disproportionally drove the increase in insourcing following AIPA. We acknowledge that we cannot provide a direct test to unequivocally identify the predominant one. Taken together though, the analyses presented in this section provide support to the view that plural sourcing plays a role as an investment in sourcing flexibility, allowing firms to switch more easily between sourcing modes when facing changes in coordination requirements.

6. DISCUSSION AND CONCLUSION

This study provides new and important evidence concerning the impact of coordination requirements on vertical integration. While this link has been well established theoretically, its empirical investigation has been hampered by the simultaneous determination of both variables. In our empirical setting of patent prosecution services, we exploit a plausibly exogenous change in patent regulation that increased the coordination requirements between patent attorneys and firm R&D staff. We show that firms respond to this change by increasing their reliance on inhouse patent attorneys, as expected by TCE and theories of organizational adaptation and knowledge.

Importantly, we find that the shift towards insourcing was primarily driven by plural-sourcing firms. This evidence is consistent with the view that plural sourcing offers firms flexibility to respond to changes in coordination requirements and points towards additional benefits associated with plural sourcing. In contrast to explanations emphasizing learning or incentive complementarities, our analysis suggests that plural sourcing may be, at least partly, an investment in sourcing flexibility. A long line of organizational scholarship has highlighted the merits of hierarchical governance when task interdependence necessitates effective coordination (Grant, 1996; Gulati *et al.*, 2005; Lawrence & Lorsch, 1967; Thompson, 1967). However, coordination requirements are neither static nor homogenous, especially in the case of knowledge-intensive tasks (Adler, 1995; Bigley & Roberts, 2001). Thus, firms may develop a plural sourcing strategy in order to better respond to changes in task interdependence and resulting coordination needs. The adoption of plural sourcing affords firms quick access to both inhouse production and market contracting and thus provides them with flexibility to adapt governance mode with task characteristics.

6.1 Implications for theory

This work contributes to theories of organizational design and firm boundaries. These have emphasized the importance of task coordination and sequential decision-making for firm boundary decisions (Gibbons, 2005; Williamson, 1985). The knowledge-based view of the firm builds on these insights by conceptualizing the firm as an institution that possesses superior coordination mechanisms and tools for sharing knowledge (Grant, 1996). Hence, production is organized based on a discriminating alignment between task characteristics and governance form (Nickerson & Zenger, 2004). Nevertheless, empirical tests of the adaptation - integration link are notoriously hard to implement. The degree of task interdependence is hardly exogenous to the choice of governance structure as both choices are the result of a joint determination process (Bidwell, 2012; Brahm & Tarziján, 2016; Gulati *et al.*, 2005). To the extent that our work exploits a plausibly exogenous change in coordination needs, we are able to address this empirical challenge. Our study then is one of the few to empirically identify the advantages of insourcing over market contracting when dealing with task interdependencies, and the only one to do so within the context of knowledge-intensive services, an increasingly important part of modern economies.

This paper also contributes to scholarly work in the area of plural sourcing. Extant theories have attributed the emergence of plural sourcing to complementarity in incentives and knowledge (e.g. when performance ambiguity is high) or to flexibility benefits when dealing with technological change and volume uncertainty (Bradach & Eccles, 1989; Dutta *et al.*, 1995; Harrigan, 1986; Parmigiani, 2007). In such cases, inhouse production and market contracting complement each other and the benefits of making and buying may outweigh the potential inefficiencies of maintaining two distinct sourcing modes. Our framework provides some evidence that shifts in cross-functional coordination requirements between vertically adjacent activities can be an alternative motivation for making and buying. If the different modes of procurement have set-up costs, then plural sourcing can be an efficient response to task environments characterized by heterogeneous coordination requirements and uncertainty regarding their evolution. The relative flexibility afforded by plural sourcing suggests that firms may sustain making and buying precisely as an adaptive capability to accommodate changes in task interdependence across the value chain.

6.2 Implications for practice

The results we present here have relevant implications for managers. Specifically, we provide a framework to think around the emergence and design of make and buy strategies. This can help firms plan investments in inhouse capacity with a view to evolving coordination requirements between the focal input and other firm functions. This framework is particularly salient for knowledge-intensive tasks, which are harder to standardize and require substantial coordination across the different steps of production or service delivery.

Our results are also relevant to policy makers, in particular those concerned with the design of patent institutions. AIPA precipitated a lively debate over the merits of disclosure. On the one hand, those opposing the publication of applications argued that AIPA would penalize small firms given their limited ability to protect their intellectual property (Barich, 2001; Graham & Hegde, 2015). On the other hand, there is evidence that AIPA facilitated transacting in markets for technology and improved access to financing (Chondrakis, Serrano, & Ziedonis, 2021; Hegde & Luo, 2018; Mohammadi & Khashabi, 2020; Saidi & Zaldokas, 2020), both of which are crucial for smaller firms. Our results contribute to this debate by suggesting that smaller firms might have been disproportionately harmed by the increased coordination requirements following AIPA. Given that it is uneconomical to employ a patent attorney for a few patent applications, small firms are less likely to do plural sourcing, and might have been unable to reduce coordination costs by shifting work inhouse.

6.3 Limitations and future research

Our study is subject to some limitations. While we provide solid evidence concerning the effect of coordination requirements on vertical integration, our finding that plural-sourcing firms primarily drive this effect is subject to interpretation. In light of the complementary evidence presented in this article, our preferred explanation is that plural sourcing firms enjoy increased sourcing flexibility. Nevertheless, unobservable (to us) characteristics that make plural sourcing firms particularly sensitive to coordination needs could also account for this result. Future work could study this issue and identify settings where the idea that plural sourcing is an investment in sourcing flexibility can be explicitly tested.

Relatedly, we do not examine the conditions under which the adoption of plural sourcing is an optimal response to settings characterized by evolving coordination requirements. It is plausible that the flexibility value of plural sourcing becomes more relevant when uncertainty regarding coordination requirements increases. It would be interesting to explore this question, albeit different data and analyses would be required for that purpose.

Lastly, we leave for further research the investigation of the relevance of each of the specific mechanisms that make inhouse production a more appropriate alternative in the presence of increased coordination requirements. According to the literature, vertical integration is advantageous when task interdependence is high due to centralized decision-making, the existence of common programming and hierarchical authority, enhanced feedback, common language, and co-location. While all these mechanisms may play a role, we do not attempt to isolate them. Future work could look into them in more detail.

In conclusion, this paper provides robust empirical support for the link between coordination and vertical integration. In addition, we make important strides in explaining the emergence and design of plural-sourcing strategies. We hope this study encourages scholars to continue working towards a unified theory of firm boundary and structure.

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Figure 1. Patent class grant lag distribution, 1997-1999
This graph presents the average grant lag (in months) across all patent classes for patents filed at the USPTO during the 1997-1999 time period.

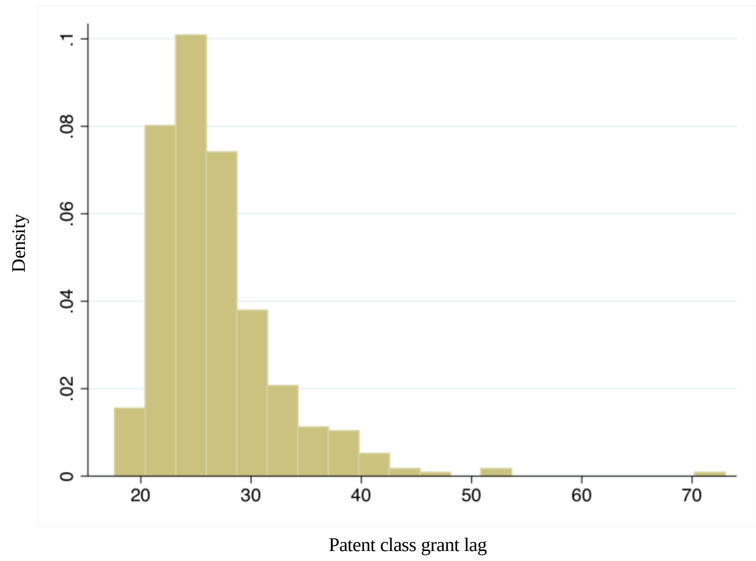


Figure 2. Patent application insourcing, 1995-2005
This graph presents the average insourcing ratio over our study period

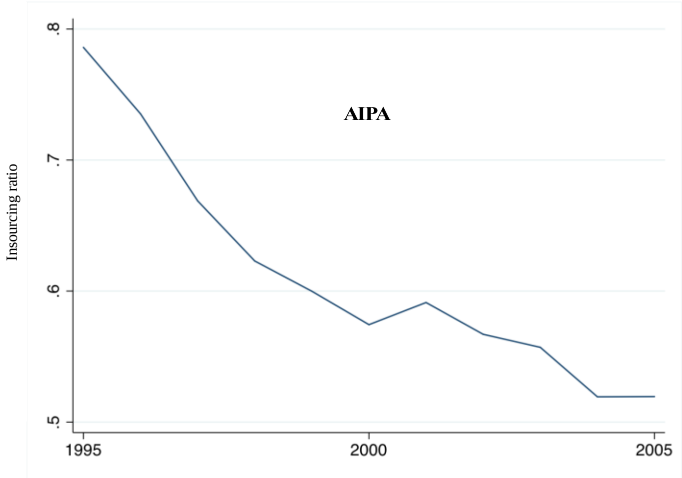
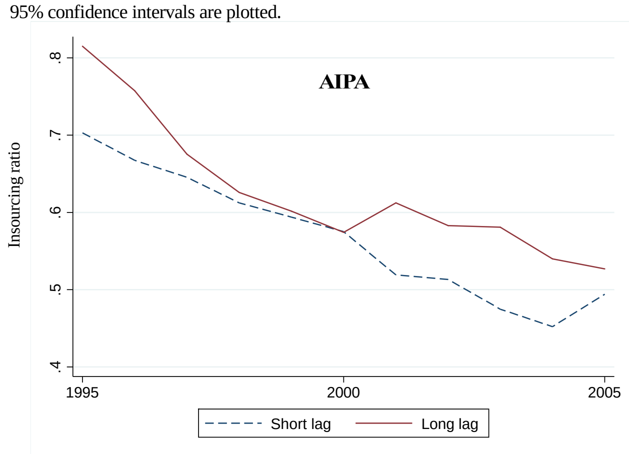
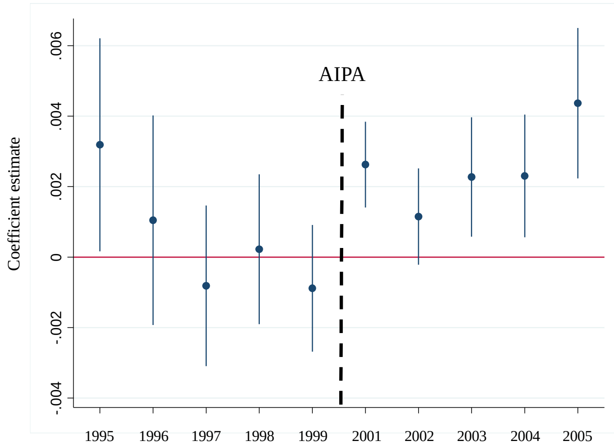


Figure 3. Pre-AIPA trends in insourcing
Panel (a) presents the average insourcing ratio across two groups of firms that (a) are above or equal to the median in the average grant lag they face for patents filed during the 1995-1999 period or (b) are below the median in the average grant lag they face for patents filed during the 1995-1999 period. Panel (b) presents the coefficient estimates of individual year dummies interacted with *Patent class grant lag*. The year 2000 is the base year and thus excluded. Standard errors are clustered at the patent class level and 95% confidence intervals are plotted.

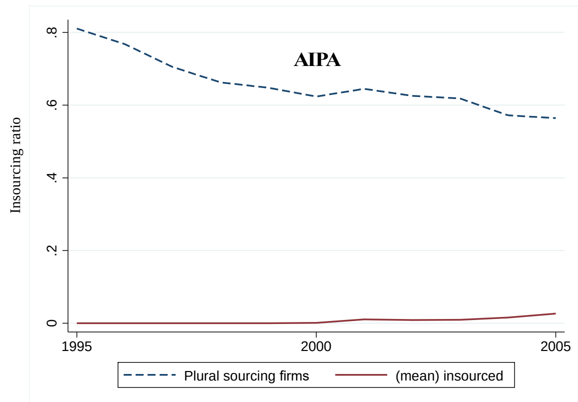


Panel (a)

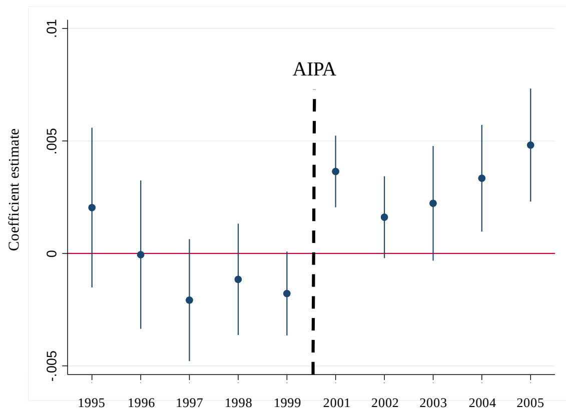


Panel (b)

Figure 4. Pre-AIPA trends in insourcing
Panel (a) presents the average insourcing ratio across two groups of firms that (a) used plural sourcing during the 1995-1999 period or (b) used outsourcing during the 1995-1999 period. Panel (b) presents the coefficient estimates of individual year dummies interacted with *Patent class grant lag* and the *Plural sourcing firm* dummy. The year 2000 is the base year and thus excluded. Standard errors are clustered at the patent class level and 95% confidence intervals are plotted.



Panel (a)



Panel (b)

Table 1. Variable names, descriptions and sources

Variable name	Variable description
Insourced	A dummy variable taking the value of one when firm *i* uses an in-house attorney to prosecute a patent
Post-AIPA	A dummy variable taking the value of one when the patent is filed on or after May 29th, 2000
Patent class grant lag	The average publication lag (i.e. the time it takes from application to publication) in months for patents filed during the 1997-1999 period in the technology class of the patent
Plural sourcing firm	A dummy variable taking the value of one when the focal firm used both in-house attorneys and external law firms to prosecute patents during the 1997-1999 period
Inventors	The natural logarithm of the number of inventors listed in the patent application
Relational suppliers	For each firm *i* we calculate the Herfindhal index of concentration based on the distribution of outsourced patent applications to the different law firms they use in year *t*. To account for the stability of the relationship, we take the average of the share of patents outsourced to each specific law firm also for the past 3 years, i.e. also for *t*-1 to *t*-3
Patents applied	Natural log of the number of patent applications filed by firm *i* in year *t*
Tech concentration	Non-biased measure of Herfindahl index of concentration across patent classes for patents applied by firm *i* in year *t*
Jaffe tech proximity	Jaffe's measure of technological proximity (considering all patent classes listed in the patent document) between patents applied by firm *i* in year *t* and the firm's existing patent stock (*t-1* to *t-3)*
Dif in patents applied	Standardized difference in the number of patent applications by firm *i* in year *t* from year *t-1*
Citations received	Natural log of the number of (forward) citations received by the patent
Claims	Natural log of the number of claims listed in the patent
Generality	Trajtenberg *et al.* (1997)'s measure of generality for the patent
Originality	Trajtenberg *et al.* (1997)'s measure of originality for the patent
Citations made	Natural log of the number of backwards citations for the patent
Litigation	A dummy variable taking the value of one when the patent is citing a previously litigated patent
Past outsourcing	Natural log of the number of outsourced patent applications in the technology class of the patent during the past three years
Self cites	The percentage of self citations out of total citations in the patent
R&D intensity	R&D expenses of firm *i* divided by sales
Sales	Natural log of firm *i* sales
Profitability	Operating income (EBITDA) of firm *i* divided by sales
Employees	Natural log of firm *i's* number of employees

Source: USPTO, Compustat, Capital IQ, LitAlert

Table 2. Descriptive statistics and pairwise correlations

Variable	Mean	St.Dv.	Pair-wise correlations																					
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
(1) Insourcing ratio	0.60	0.49	1.00																					
(2) Post-AIPA	0.48	0.50	-0.10	1.00																				
(3) Patent class grant lag	30.45	6.29	-0.10	0.07	1.00																			
(4) Plural sourcing firm	0.93	0.26	0.35	-0.06	-0.08	1.00																		
(5) Inventors	0.82	0.61	0.03	0.08	0.00	0.05	1.00																	
(6) Relational suppliers	0.18	0.16	-0.20	-0.09	-0.07	-0.41	0.01	1.00																
(7) Patents applied	6.25	1.08	0.00	0.14	0.30	-0.17	-0.01	-0.20	1.00															
(8) Tech concentration	0.08	0.07	-0.13	-0.07	0.03	0.10	0.05	0.15	-0.42	1.00														
(9) Jaffe tech proximity	0.85	0.22	0.42	-0.02	0.04	0.65	0.07	-0.40	0.28	-0.04	1.00													
(10) Dif in patents applied	0.04	0.26	-0.04	-0.12	0.08	-0.04	-0.03	0.05	0.16	0.02	-0.01	1.00												
(11) Citations received	2.65	1.10	-0.04	-0.18	0.14	0.01	0.06	0.00	-0.01	0.09	0.04	0.07	1.00											
(12) Claims	2.85	0.64	-0.13	0.13	0.11	-0.05	0.07	0.00	0.06	0.03	-0.04	0.02	0.15	1.00										
(13) Generality	0.46	0.29	0.05	-0.16	-0.02	0.07	0.02	-0.02	-0.10	-0.04	0.02	0.01	0.45	0.05	1.00									
(14) Originality	0.49	0.27	0.04	0.03	-0.08	0.07	0.02	-0.02	-0.15	-0.04	-0.01	-0.03	0.01	0.03	0.33	1.00								
(15) Citations made	2.43	0.90	-0.05	0.09	-0.04	0.05	0.10	0.01	-0.14	0.06	-0.02	0.01	0.16	0.12	0.09	0.43	1.00							
(16) Litigation	0.02	0.14	0.00	-0.01	0.06	0.00	0.00	0.00	0.01	0.03	0.01	0.01	0.04	0.01	0.00	-0.02	0.02	1.00						
(17) Past outsourcing	2.26	1.80	-0.41	0.22	0.34	-0.27	0.05	0.07	0.32	0.16	-0.14	0.00	0.07	0.13	-0.15	-0.18	0.00	0.02	1.00					
(18) Self cites	0.17	0.23	0.11	-0.03	-0.10	0.07	0.08	0.02	0.04	0.01	0.13	-0.04	-0.03	-0.02	-0.02	-0.07	-0.04	0.02	0.05	1.00				
(19) R&D intensity	0.08	0.06	-0.22	0.08	0.26	-0.14	0.03	-0.08	0.33	0.19	0.04	0.06	0.08	0.05	-0.11	-0.20	-0.11	0.03	0.39	-0.07	1.00			
(20) Sales	9.84	0.99	0.09	0.16	0.08	-0.08	0.02	-0.17	0.48	-0.41	0.13	0.01	-0.04	0.04	0.02	0.03	-0.03	-0.01	0.06	0.01	-0.21	1.00		
(21) Profitability	0.22	0.13	-0.15	-0.02	0.21	-0.38	0.06	0.11	0.24	0.08	-0.11	0.16	0.11	0.05	-0.04	-0.10	0.01	0.03	0.30	0.00	0.26	0.12	1.00	
(22) Employees	4.17	0.84	0.12	0.04	-0.04	-0.03	-0.01	-0.19	0.33	-0.44	0.11	-0.03	-0.03	-0.02	0.08	0.07	-0.03	-0.03	-0.06	0.02	-0.32	0.90	-0.05	1.00

N= 217,480

Table 3. Regression analysis of patent applications insourcing, 1995-2005

In all models analysis is at the individual patent level, with the exception of models (2) and (3) where analysis is at the firm-patent class-year level and firm-year level respectively. Models (1), (4), (5), (6), and (7) employ a linear probability model and use a dummy variable equal to one when a patent is filed using an in-house attorney as a dependent variable and standard errors are clustered at the technology class level. In model (2) all variables are averaged at the firm-patent class-year level and Post-AIPA is defined as equal to one after the year 1999. In model (3) all variables are averaged at the firm-year level and Post-AIPA is defined as equal to one after the year 1999. Both models (2) and (3) use OLS with standard errors clustered at the technology class and firm level respectively. Model (4) uses the same dependent variable with a linear probability model but we use No foreign equivalent as a measure of treatment intensity and robust standard errors. Contextual factors refer to Number of Inventors in Model (5), Relational Suppliers in Model (6), and Renewal Rate in Model (7). Model (8) uses the same dependent variable but a logit estimator and standard errors are clustered at the technology class level. *p*-values are reported in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post-AIPA	-0.063			-0.011	-0.025	-0.103	0.391	-0.485
	(0.02)			(0.04)	(0.35)	(0.00)	(0.00)	(0.01)
Post-AIPA x Treatment	0.002	0.008	0.007	0.006	0.001	0.004	-0.018	0.014
	(0.05)	(0.00)	(0.01)	(0.08)	(0.34)	(0.00)	(0.00)	(0.02)
Post-AIPA x Contextual factors					-0.044	0.225	-0.708	
					(0.01)	(0.07)	(0.00)	
Treatment x Contextual factors					-0.001	0.009		
					(0.02)	(0.00)		
Post-AIPA x Treatment x Contextual factors					0.001	-0.010	0.031	
					(0.07)	(0.03)	(0.00)	
No foreign equivalent				0.010				
				(0.00)				
Inventors	0.010	0.002	0.027	0.010	0.045	0.010	0.010	0.063
	(0.00)	(0.63)	(0.50)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Relational suppliers	-0.200	-0.176	-0.118	-0.206	-0.198	-0.446	-0.188	-1.502
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Patents applied	0.029	0.009	0.048	0.030	0.028	0.029	0.026	0.252
	(0.00)	(0.25)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Tech concentration	-0.085	-0.140	0.032	-0.090	-0.092	-0.117	-0.126	-1.046
	(0.42)	(0.01)	(0.62)	(0.00)	(0.38)	(0.28)	(0.19)	(0.13)
Jaffe tech proximity	0.162	0.199	0.309	0.160	0.163	0.159	0.165	2.061
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Dif in patents applied	-0.028	-0.017	-0.024	-0.029	-0.028	-0.028	-0.026	-0.254
	(0.00)	(0.02)	(0.04)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
Citations received	-0.004	-0.005	0.022	-0.005	-0.004	-0.004	-0.004	-0.029
	(0.02)	(0.12)	(0.33)	(0.00)	(0.02)	(0.02)	(0.04)	(0.02)
Claims	-0.030	-0.049	-0.003	-0.031	-0.031	-0.030	-0.030	-0.229
	(0.00)	(0.00)	(0.94)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Generality	0.003	0.022	-0.064	0.004	0.004	0.003	0.001	0.039
	(0.55)	(0.06)	(0.47)	(0.32)	(0.53)	(0.55)	(0.81)	(0.36)
Originality	-0.016	0.025	-0.093	-0.016	-0.016	-0.016	-0.016	-0.126
	(0.04)	(0.09)	(0.41)	(0.00)	(0.03)	(0.04)	(0.04)	(0.03)
Citations made	-0.013	-0.024	-0.050	-0.012	-0.013	-0.013	-0.013	-0.085
	(0.00)	(0.00)	(0.06)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Litigation	0.003	0.008	0.143	0.002	0.003	0.003	0.003	0.020
	(0.68)	(0.70)	(0.46)	(0.67)	(0.69)	(0.69)	(0.64)	(0.68)
Past outsourcing	-0.045	-0.022	-0.120	-0.045	-0.045	-0.045	-0.046	-0.317
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Self cites	0.071	0.057	0.233	0.071	0.071	0.072	0.072	0.560
	(0.00)	(0.00)	(0.06)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R&D intensity	-0.205	-0.158	-0.197	-0.198	-0.202	-0.202	-0.209	-1.967
	(0.02)	(0.06)	(0.05)	(0.00)	(0.02)	(0.02)	(0.01)	(0.01)
Sales	-0.001	-0.021	-0.010	-0.001	-0.000	-0.008	0.000	0.151
	(0.94)	(0.18)	(0.76)	(0.87)	(0.98)	(0.63)	(1.00)	(0.22)
Profitability	0.012	0.020	-0.108	0.008	0.013	0.011	0.020	-0.233

	(0.77)	(0.60)	(0.21)	(0.66)	(0.74)	(0.78)	(0.61)	(0.47)
Employees	0.030	0.044	0.014	0.029	0.030	0.038	0.030	-0.070
	(0.08)	(0.00)	(0.73)	(0.00)	(0.08)	(0.03)	(0.08)	(0.57)
Constant	0.549	0.733	0.491	0.544	0.535	0.596	0.538	-1.312
	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.13)
Technology area FE	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE*Tech area FE	No	Yes	No	No	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	217480	37568	1055	217480	217480	217480	217480	202057
No of firms	101	101	101	101	101	101	101	101
R^2 (Pseudo R^2)	0.454	0.249	0.410	0.454	0.454	0.454	0.455	(0.342)

Table 4. Heterogeneous effects across plural sourcing vs. outsourcing firms

Models (1)-(5) employ a linear probability model and use a dummy variable equal to one when a patent is filed using an in-house attorney as a dependent variable with standard errors clustered at the technology class level. Models (6) uses OLS and the days applicants delayed their response to the USPTO as a dependent variable while Model (7) uses the same dependent variable with a Poisson estimator.

	DV: Insourced					**DV: Applicant delays**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post-AIPA	0.058	-0.001	0.009	-0.071	-0.102		
	(0.09)	(0.84)	(0.24)	(0.01)	(0.06)		
Post-AIPA x Treatment	-0.002	-0.001	-0.000	0.002	0.002		
	(0.09)	(0.72)	(0.21)	(0.03)	(0.14)		
Post-AIPA x Plural sourcing firm	-0.126	-0.010					
	(0.00)	(0.03)					
Treatment x Plural sourcing firm	-0.006	0.005					
	(0.00)	(0.20)					
Post-AIPA x Treatment x Plural sourcing firm	0.004	0.007					
	(0.00)	(0.10)					
Post-AIPA x Insourcing ratio					0.041		
					(0.57)		
Treatment x Insourcing ratio					-0.001		
					(0.61)		
Post-AIPA x Treatment x Insourcing ratio					-0.000		
					(0.83)		
No foreign equivalent		0.006					
		(0.02)					
Insourced						-3.443	-0.053
						(0.03)	(0.03)
Constant	0.676	0.537	-0.016	0.463	0.473	120.665	4.145
	(0.00)	(0.00)	(0.94)	(0.00)	(0.00)	(0.00)	(0.00)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Technology area FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	217480	217480	16167	201313	201313	119294	119294
No of firms	101	101	12	89	89	101	101
R^2 (Pseudo R^2)	0.454	0.454	0.279	0.382	0.382	0.072	(0.104)