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Abstract

This paper studies the relationship between two decisions shaping the organizational configuration of a firm: whether to make the upstream resources more general and deployable to more markets (vs. keeping them tailored to a few markets), and whether to trade with downstream firms as an upstream supplier of intermediate products and services (vs. directly entering downstream markets). While the literature has looked at these two decisions separately, we argue that they depend on each other. This has the important implication that they can generate organizational complementarities, inducing firms to implement them simultaneously. We are motivated in particular by the observation that an increasing number of firms invest in general upstream resources and exploit them as upstream suppliers of intermediate services or products—an organizational configuration resulting from a strategy that we refer to as specialization in generality. Interestingly, the literature following the seminal work by Penrose (1959) and Nelson (1959) has mainly highlighted the use of general upstream resources to enter new downstream markets. We identify the supply and demand conditions under which specialization in generality is instead more likely to emerge: lack of prior downstream assets, on the supply side, and a roughly equal distribution of buyers across intermediate markets (a "broad" demand), on the demand side. We test our predictions using a sample of firms in the U.S. laser industry between 1993 and 2001. A regulatory shock that increases the value of trading relative to downstream entry provides the setting for a quasi-natural experiment, which corroborates our theoretical predictions.

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Introduction

Upstream resources such as technological knowledge are the essence of a firm's opportunity set. These resources are typically scale-free and as such generate "excess" capacity that can be used at zero or low cost in multiple businesses (Levinthal and Wu 2010), extending "the productive possibilities that" the firm's managers "see and take advantage of" (Penrose 1959, p. 28). However, not all upstream resources are equally deployable across diverse settings. Some are specific to certain applications, and others are more easily reconfigured for alternative uses, such that they produce higher excess capacity potentially deployable in multiple businesses (Helfat and Eisenhardt 2004). This characteristic is referred to as the generality, general-purpose nature (Bresnahan and Trajtenberg 1995), or fungibility (e.g., Kim and Bettis 2014) of an upstream resource.

A leading argument in the resource-based view theory of entry and diversification is that entry into new *downstream* markets is the dominant option for taking advantage of a general upstream resource stock (Montgomery and Wernerfelt 1988, Penrose 1959, Teece 1980). However, an emergent literature in economics and organizational theory emphasizes the increasing importance of vertical disintegration and the emergence of *intermediate* markets, whereby upstream suppliers provide intermediate products and services to downstream firms (e.g., Arora et al. 2001, Baldwin and Clark 2000, Dushnitsky and Klueter 2017, Jacobides and Winter 2005, Kapoor and Adner 2012, Moeen and Agarwal 2017). The existence of intermediate markets naturally expands the options to use a general upstream resource stock, in that general resources could be exploited not only via direct entry into new downstream markets but also via trading in the corresponding intermediate markets. It also changes the incentives to invest in the generality of the upstream resource stock. Absent intermediate markets, only the few firms that control the costly assets for entering and operating downstream will find investing in the generality of upstream resources attractive (Nelson 1959). When trading in intermediate markets is a viable option, on the other hand, investment in a general upstream resource stock might appeal to a larger pool of firms, including those interested in operating as upstream suppliers only (Bresnahan and Gambardella 1998).

Based on these considerations, we maintain that two decisions are *endogenous* to each other and taken *simultaneously* by firms: whether (a) to invest (vs. not invest) in a more general upstream resource stock, and whether (b) to trade in intermediate markets (vs. directly entering downstream). In doing so we depart from extant literature that takes as exogenous either the level of upstream resource generality (e.g., Penrose 1959) or the exploitation mode of upstream resources, whether via entry (e.g., Nelson 1959) or trading (Bresnahan and Gambardella 1998). We build on the intuition that firms invest in more general upstream resources and trade as upstream suppliers of intermediate products or services—an organizational configuration of activities resulting from a strategy that we refer to as *specialization in generality*—whenever they face conditions that generate complementarity between the activities of investing in more general upstream resources and trading in intermediate markets (Milgrom and Roberts 1990).[1]

We argue that this complementarity depends on both supply and demand conditions that firms face.

On the supply side, one factor that affects the complementarity between investing in general resources (vs. not investing) and trading these resources in intermediate markets (vs. entering in new downstream markets) is whether firms own or not downstream assets and expertise that can be reused when entering new downstream markets (Teece, 1986). On the demand side, a factor that affects the complementarity between investing in general resources and trading is the extent to which potential downstream buyers are equally distributed across markets—a condition that, following previous literature (Bresnahan and Gambardella 1998), we define as "broad" demand—versus being concentrated in just a few of those markets—a condition of "deep" demand.

To test our theoretical predictions, we empirically assess how firms that do not yet have downstream assets and capabilities (vs. firms that own them) and firms facing a broad (vs. deep) demand respond to a shock that increases the value of trading in intermediate markets relative to entry in downstream markets: we claim evidence for complementarity if the expected increase in trading is accompanied by a joint increase in upstream resource generality.

We offer a first empirical test of our theoretical framework based on a sample of firms in the U.S. laser industry between 1993 and 2001, which is an ideal empirical setting because it satisfies some necessary conditions for our theory to be valid. First, the crucial upstream resource in this industry is the technological know-how for producing the laser technology itself. This know-how can be more or less general as connected to laser technologies having a higher or lower number of applications (each one linked to a specific downstream market). Second, in the laser industry, specialized and integrated firms coexist, with some firms vertically specializing upstream in the production of lasers (standalone intermediate technologies), some firms specializing downstream in the production of laser systems ("ready to use" downstream products), and some firms doing both. This implies that, in this context, intermediate markets exist and work smoothly. Such industry conditions are obviously necessary but not sufficient for observing firms' specialization in generality, which is a strategy that individual firms choose on the basis of firm-specific contingencies. In the current study we identify two of these contingencies, namely lack versus presence of prior downstream assets and the demand characteristics (breadth vs. depth) the firm is facing.

[1] We use the label *specialization in generality* as a tribute to George Stigler's (1951) account of the importance of "general specialties," i.e., activities "(like shipping, railroads, banking, etc.) which are not closely attached to any one industry" (p. 192) but which were crucial for economic growth in 19th century England. The term *specialization* in our context refers to the firm choice of vertically specializing in intermediate markets, that is, to reach some markets only as upstream supplier of intermediate products or services.

Finally, during our sample period, an exogenous regulatory shock affecting U.S. firms increased the relative value of trading in intermediate markets versus entering downstream markets (by increasing the cost of the latter activity relative to the former activity). We use this shock to test our hypotheses on the complementarity between investing in the know-how for producing more general lasers (vs. not investing) and trading these lasers in intermediate markets (vs. entering downstream markets). Our difference-in-difference analysis tests whether firms located in states enacting a regulation—our treatment group—that increases production costs in downstream markets are more likely to specialize in generality (i.e., to invest in the knowledge necessary to produce more general lasers and trade these lasers) than firms in the other states—our control group. We employ both bivariate probit and linear probability models for the four combinations of activities defined by the choice of investing / not investing in more general upstream resources, on one hand, and trading in intermediate markets / entering in downstream markets, on the other hand. We find results consistent with our predictions.

Overall, our work offers a theoretical as well as an empirical contribution. From a theoretical point of view, this paper contributes to the organizational research on vertical integration and disintegration (e.g., Baldwin and Clark 2000, Kapoor 2013, Kapoor and Adner 2012), showing how the decision about a firm's vertical scope (i.e., whether to operate as an upstream supplier or to enter downstream) cannot be isolated from the decision about investment in different types of upstream resources and capabilities. Furthermore, showing that there might be complementarity between these two decisions is important for organizational research scholars who are interested in understanding the contingencies under which different organizational configurations emerge and persist (e.g., Galbraith 1973, Milgrom and Roberts 1990, Thompson 1967). In this respect, this paper emphasizes two conditions determining whether investment in general resources is exploited via vertical integration or via upstream specialization, corresponding to completely different strategies, which have not been systematically studied by prior research. Finally, from an empirical point of view, the realization that two activities are simultaneously chosen by firms (and so depend on each other) suggests the importance of overcoming the natural estimation bias that arises by considering either the former or the latter activity as exogenous. For instance, studies analyzing firm entry in a new market as a function of the generality of the firm resource stock should adopt an appropriate identification strategy (e.g., instrumental variables) to obtain reliable estimates.

Specialization in Generality as a Distinct Firm Strategy

It is well established that general upstream resources (such as technological knowledge applicable to several different downstream markets) generate an impetus toward the division of innovative labor and vertical disintegration in the economy (Bresnahan and Gambardella 1998). Indeed, the "extent of the market" tends to be larger for the services or products provided by more general upstream resources, which therefore are more likely to economically sustain vertical specialization (Bresnahan and Gambardella 1998). This is confirmed by the emergence, in parallel with the development of intermediate markets, of a class of companies investing in general upstream resources (in particular technological knowledge) and trading the services and products derived from such resources to downstream firms (Gambardella and McGahan 2010). We define this strategy as specialization in generality. However, specialization in generality has not been explicitly recognized as a strategy by extant research, which has treated either the generality of the firm upstream resource stock (e.g., Penrose 1959) or the exploitation modes of these resources (e.g., Bresnahan and Gambardella 1998) as exogenous and therefore as outside the control of managers when they delineate their strategy.

But whether to invest or not in upstream resource generality and whether to trade the services or products deriving from these resources in intermediate markets (vs. use them for entering downstream) are endogenous and interrelated choices. Several firms have chosen to simultaneously invest in upstream resource generality and trade in intermediate markets the services and products deriving from their upstream resources. For instance, the most valuable resource that IDEO—a leading design company known for pioneering a new business model—has invested in is the overall procedural knowledge for designing new ideas. This knowledge was developed to be extremely general, such that it could lead to developing products in multiple downstream market domains including, for instance, electronics, robotics, and apparel. However, IDEO has not entered these downstream markets. Doing so required downstream assets and capabilities that are costly and time-consuming to develop, generating considerable diseconomies of scope for IDEO, which began as a small company with no downstream assets or capabilities. By taking advantage of corporate downsizing in the 1990s and the creation of "markets for designing," IDEO traded in intermediate markets the services coming from its procedural and general knowledge, offering design services to several companies operating in several downstream markets (such as Apple, AT&T, Samsung, Philips, Amtrak, Steelcase, Baxter International, and NEC Corporation).

Similarly, Echelon, an industrial automation company, developed technological knowledge about a universal automated control system (LonWorks) with applications in sectors as diverse as elevators, manufacturing processes, cars, and utilities (Thoma 2009). Because of the high costs of entering and operating in these downstream markets, the company chose not to enter any of them, focusing instead on increasing the generality of its controller and expanding its span of applications to trade its product in intermediate markets (Gambardella and McGahan 2010).

Even the transformation of IBM from a mainframe-computer producer to a service-based firm, offering its general knowledge to other companies operating in multiple businesses, might be seen as an example of our specialization-in-generality strategy. IBM operated in downstream markets in the early 1990s. However, the rise of both UNIX (the open system environment developed by Sun and HP) and the personal computer challenged IBM's downstream position in mainframes (Christensen 1997, Gans 2016), rendering the company's downstream assets and capabilities obsolete. IBM responded to this shock by simultaneously investing in more general upstream resources capabilities (reinforcing its upstream IT-based capability to solve complex business problems in different contexts) and selling the services deriving from this general capability in intermediate markets to firms operating in different downstream sectors (Rothaermel et al. 2016). As Louis Gerstner (2002, p. 123), the CEO who engineered this transformation between 1993 and 2002, puts it: "We decided to stake the company's future on a totally different view of the industry." This "totally different view" could be considered an instance of specialization in generality.

Whereas the above companies operate in highly innovative industries, the choice about whether to "specialize in generality" (i.e., to invest in general resources and trade them in intermediate markets) is also faced by companies in more traditional sectors. Consider the steel industry. There are about three thousands different grades of steel, encompassing unique physical, chemical, and environmental properties, which present different degrees of generality. For example, some grades of stainless steel are quite general in that they can be used in household hardware, surgical instruments, automotive, aerospace and construction; some grades of maraging steels are much less general, as they are mainly used in aerospace. In this context, some steel producers decide to invest in the knowledge and assets needed to produce and trade the former (more general) versus the latter steel types, i.e. they specialize in generality.

However, in several industries, including steel, not all companies choose to invest in generality for trading. Rather, some companies see generality mainly as an opportunity to enter multiple downstream markets, consistent with the classical view of general resources as an option for downstream entry and diversification (e.g., Penrose, 1959). For example, steel firms such as ArcelorMittal or Nucor have utilized their knowledge in general steel grades to invest in downstream operations such as building and construction (ArcelorMittal 2009). Similarly, in a quite different setting, 3M has used its general technological knowledge about adhesive technologies to vertically integrate into some industries where those adhesive technologies were applicable, such as the home care and cleaning, home improvement, home office and school supplies, and personal health care sectors.

Thus, the goal of our paper is precisely to understand the conditions under which companies invest in general upstream resources and exploit such generality not to enter new downstream markets but rather to trade the resulting services or products in intermediate markets. In other words, we aim to identify the conditions that are conducive to complementarity between investment in the generality of upstream resources and vertical specialization via trading in intermediate markets (rather than between investment in upstream resource generality and entry into new downstream markets). This approach underscores that our paper claims not that specialization in generality is a dominant strategy but rather that, under certain conditions, investing in general upstream resources and trading in intermediate markets are complementary choices. Under these conditions, firms will then specialize in generality.

Theoretical Development

Consider a firm that faces an opportunity to tap into new markets and is considering how to exploit this opportunity. The most obvious decision such a firm should make is whether to exploit these new markets by entering downstream or by trading in the corresponding intermediate markets. However, to tap into a larger number of new markets, such a firm might also decide to expand the generality of its upstream resource stock by investing in a scale-free general resource, whose application in one specific new market would not preclude in any way its simultaneous application in the other new markets. This characteristic could make investing in a unique scale-free general resource – applicable to several markets – convenient compared with investing in multiple market-specific resources (Levinthal and Wu 2010).

Potential applicability of a general upstream resource to several markets does not imply *actual* monetization in those markets, though. Actual monetization requires commercially exploiting these resources (by trading in intermediate markets or entering downstream markets). This makes the decision whether to invest or not in more general upstream resources interdependent with the decision on how to commercially exploit these resources. Hence, the two activities on which this firm must make *simultaneous* decisions—possibly generating complementarities—are (i) whether to invest (vs. not invest) to increase the generality of its upstream resource stock,[2] and (ii) whether to sell the intermediate products or services deriving from these upstream resources to downstream firms (vs. using such resources to enter into downstream markets themselves). This framework generates a typology of four possible firm strategies, each resulting from a specific combination of the two decisions (Table 1).

******* Insert Table 1 about here *******

Two considerations are important in developing this typology and understanding the payoffs to firms from the four strategies. First, it is plausible to assume that when intermediate markets exist, the natural alternative to downstream entry into a new market is to trade as a supplier in the corresponding intermediate market—rather than pure no entry.[3] This consideration is motivated by the fact that when

[2] We assume that generality ranges on a continuum such that even firms that start with a general resource stock might still enhance the level of generality.

[3] The choice of entering new downstream markets does not exclude, in principle, some trading in the corresponding intermediate markets. Yet, the returns from trading are likely to be limited for firms that operate downstream, for instance because of a "rent dissipation" effect: selling resources to firms in the same market (likely competitors)

intermediate markets work smoothly, trading in these markets is generally valuable because it does not require substantial investments in complementary assets and capabilities (Arora et al. 2001). In this sense, the zero-return option of not entering is dominated by trading, and it can safely be ruled out in our theoretical development.

Second, firms face a trade-off when deciding to invest in more general upstream resources because these resources tend to be applicable to a higher number of markets, but the value they can generate in each specific market is lower than that for a more specialized resource (e.g., Montgomery and Wernerfelt 1988). Indeed, while a more general upstream resource is adaptable to a larger number of markets, it is also less perfectly tuned to each individual market (e.g., Bresnahan and Gambardella 1998). Therefore, firms take into account that the returns from either trading in intermediate markets or entering downstream markets change according to the degree of upstream resource generality, as shown in Table 1.

In particular, consider how the returns of trading vary according to the generality of the upstream resource stock. A "simple trading" strategy (investment in generality = 0; trading = 1) consists of keeping (or even decreasing) the current generality of the upstream resource stock, which implies that the firm can only trade in a limited number of intermediate markets: the returns of this strategy are the profits obtained by serving a relatively low number of intermediate markets, but with an upstream resource stock tailored to each market ($\Pi(0,1) = \Pi^T$). The returns from a specialization-in-generality strategy (investment in generality = 1; trading = 1) correspond, instead, to the returns from trading the services or products deriving from a more general resource stock in a higher number of intermediate markets, but at a lower average profitability ($\Pi(1,1) = \Pi^{TG}$). The lower average profitability can be thought of either as the cost of market-specific adjustments required to tailor a more general upstream resource stock to each specific market—which will make the buyer indifferent between buying the services or products provided by a more general versus a more dedicated resource stock—or as the lower price that the seller of the services or products of a more general upstream resource stock should accept—again, to make the buyer indifferent between the services or products provided by a more general versus a more dedicated resource stock.

Similar to the returns from trading, the returns from entry vary with the generality of the upstream resource stock. A "simple downstream entry" strategy (investment in generality = 0; trading = 0) is pursued when firms enter downstream markets keeping unaltered (or even decreasing) the generality of their current resource stock. This strategy's payoff corresponds to the benefit of entering a limited number

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reinforces the competitor's position (Arora et al. 2001). Moreover, buyers may not be inclined to buy intermediate products from a competitor. Therefore, in the rest of the article, we focus on trading in intermediate markets and entering downstream markets as two mutually exclusive choices.

of markets with a less general upstream resource stock, which however raises profitability in each market in which the firm enters ($\Pi(0,0)= \Pi^E$). A “synergistic downstream entry” strategy is, instead, the strategy that emerges from the joint decision to invest in upstream resource generality and to enter downstream. The payoff of this strategy ($\Pi(1,0)= \Pi^{EG}$) is equal to the benefit from entering a high number of markets with lower returns in each due to the higher generality of the upstream resource stock.

Overall, our framework suggests that there will be complementarity between investing in generality and trading in intermediate markets—that is, we will observe firms adopting a specialization-in-generality strategy—in the circumstances in which the value of investing in greater generality of the upstream resource stock is higher when the firm is trading in intermediate markets than when it is entering downstream markets. We derive this consideration building on the basic definition of complementarity by Milgrom and Roberts (1990, p. 514): “the defining characteristic [. . .] of complements is that if the levels of any subset of activities are increased, then the marginal return to increases in any or all of the remaining activities raises.” That is, when there are two activities *A1* and *A2*, the function $\Pi(A1,A2)$, which defines the incremental profitability generated by adopting the two activities, is supermodular, and *A1* and *A2* are complements if and only if $\Pi(1,1) - \Pi(0,1) \geq \Pi(1,0) - \Pi(0,0)$.

In our context, activity *A1* is investing (vs. not investing) in upstream resource generality and activity *A2* is trading in intermediate markets (vs. entering downstream markets), such that the condition of complementarity between these two activities can be written as $(\Pi^{TG} - \Pi^T) \geq (\Pi^{EG} - (\Pi^E)$. Hence, there will be complementarity between investment in generality and trading when ($\Pi^{TG} - \Pi^T$), or the incremental return from investing in greater generality for trading in intermediate markets, at the cost of being less profitable in each market, is greater than ($\Pi^{EG} - \Pi^E$), or the incremental return from investing in greater generality for entering more downstream markets but with a lower fit in each market.

Whether this condition is satisfied depends on supply and demand factors, which determine the complementarity between investment in generality and trading by affecting the inequality ($\Pi^{TG} - \Pi^T$) $\geq$ ($\Pi^{EG} - \Pi^E$). Specialization in generality is in fact a firm strategy that companies adopt only when provided with the capabilities to so do (on the supply side) or when confronted with favorable demand configurations (on the demand-side).

In particular, on the supply side, one factor that affects this inequality is whether firms already possess or not downstream assets and expertise that can be reused when entering new downstream markets (Teece, 1986). This will have an effect on ($\Pi^{EG} - \Pi^E$), the incremental return of entering downstream by investing versus not investing in higher generality. To generate value downstream, firm upstream resources (e.g., technological knowledge) need to be combined with downstream assets and capabilities (e.g., production, marketing, and distribution) that cannot be acquired overnight (Moeen and Agarwal 2017). When firms enter downstream markets for the first time, their lack of downstream assets and expertise makes them less able to handle the complexity associated with entry in multiple markets. They are especially likely to experience diseconomies of scope when entering multiple markets at once (Qian, Agarwal, and Hoetker 2012). Thus, for firms with no prior downstream assets, the difference between Π^{EG} and Π^{E} (the incremental return from investing in greater generality to enter more downstream markets) is likely to be low or even negative. Firms that already have some level of downstream assets and expertise, on the other hand—because they are already active in some downstream markets—are more likely to enjoy downstream economies of scope when entering additional markets. Like the established corporation described by Penrose (1959) and Nelson (1959), these firms can reuse their extant downstream assets and capabilities in new downstream markets. By virtue of these downstream economies of scope, these firms are likely to fully exploit the advantages of upstream resource generality, as they can enter and profitably operate in many downstream markets that can be reached by a more general upstream resource stock. Therefore, for these firms, the difference ($\Pi^{EG} - \Pi^{E}$) is likely to be positive and high.

However, the extent to which the focal firm faces downstream economies of scope when entering new downstream markets will likely have no effect on ($\Pi^{TG} - \Pi^{T}$). Indeed, the presence or lack of *downstream* assets is unlikely to affect firms' profitability in trading technologies in *intermediate* markets. If anything, ($\Pi^{TG} - \Pi^{T}$) might be higher for firms that so far have been exclusively dedicated to trading technologies (and that have not acquired any downstream assets and expertise) than for firms already active in downstream markets. The former companies, compared with the latter, are possibly better able to identify what buyers in different intermediate markets want and to consequently adapt a general resource to such diverse needs. Firms that have been already operating downstream might instead have so far diverted resources from exploring the needs of buyers in intermediate markets—especially when such buyers operate in different downstream markets and have quite diverse needs—because of their prior focus on final customers.

To sum up, our arguments suggest that for firms without prior downstream assets, ($\Pi^{EG} - \Pi^{E}$) is likely to be lower than for firms with prior downstream expertise—while ($\Pi^{TG} - \Pi^{T}$) is likely to be the same and, if anything, higher. Since the condition for complementarity between investing in generality and trading is for ($\Pi^{TG} - \Pi^{T}$) to be higher than ($\Pi^{EG} - \Pi^{E}$), our first hypothesis is as follows:

Hypothesis 1. *Firms with no prior downstream assets are more likely to exhibit complementarity between investing (vs. not investing) in general upstream resources and trading in intermediate markets (vs. entering downstream markets). Therefore, these firms are more likely to specialize in generality.*

From the demand side, the choice to specialize in generality depends on the extent to which firms currently operating in downstream markets are equally spread across these markets rather than being concentrated in a few heavily populated markets. Such downstream firms constitute potential rivals for a firm considering entering downstream but constitute potential buyers for a firm considering trading in intermediate markets. Hence, using the terminology of Bresnahan and Gambardella (1998), the distribution of firms in downstream markets determines the extent to which the demand for the intermediate products or services is "broad"—spread across several relevant markets—versus "deep"—concentrated in a few large markets.

The breadth versus depth of demand influences the profitability of trading in intermediate markets via a more general upstream resource stock (Π^{TG}) versus the profitability of trading in fewer but on average more profitable intermediate markets with a less general resource stock (Π^{T}). That is, the breadth versus depth of demand affects ($\Pi^{TG} - \Pi^{T}$). This is because for a firm employing a trading strategy, the distribution of firms across different markets has a direct impact on profitability of trading with a more versus less general upstream resource stock. Consider the case in which demand is deep: the potential buyers of the intermediate products (i.e., firms in downstream markets) are all concentrated in a few intermediate markets rather than spread equally across all intermediate markets. The more concentrated the buyers in a few markets (such that there are only a few markets highly populated), the less valuable the strategy of investing in upstream resource generality to reach more intermediate markets. Under this scenario, expanding in intermediated markets beyond the most populated ones does not add substantially to the pool of total buyers. Investing in greater generality might overall even harm firm profitability, since more general upstream resources are less valuable in those few "deep" intermediate markets heavily populated by buyers because a more general resource is less fit for each individual market. All this implies that firms facing a deep demand will probably find a specialization-in-generality strategy less profitable than a simple trading strategy. In other words, firms that face a deep demand (i.e., all or most potential buyers concentrated in a few intermediate markets) may exhibit a negative ($\Pi^{TG} - \Pi^{T}$). Conversely, firms that face a broad demand (i.e., potential buyers equally spread across all intermediate markets) will likely adopt a specialization-in-generality strategy versus a simple trading strategy, as the former is the most appropriate for exploiting the diverse needs of multiple downstream markets, roughly equally populated. Thus, firms that face a broad demand may exhibit a positive ($\Pi^{TG} - \Pi^{T}$).

At the same time, the distribution of firms across downstream markets has no clear effect on ($\Pi^{EG} - \Pi^{E}$). As we said, for a potential entrant, the distribution of firms across downstream markets determines whether possible rivals are concentrated in a few heavily populated markets or spread across a higher number of less populated markets. In equilibrium the number of rivals in each downstream market is unrelated to profitability since all downstream markets are equally attractive for the marginal entrant—if this were not the case, firms would move from the least profitable to the most profitable markets, which would equalize profits across markets. It follows that the distribution of firms across downstream markets—which reflects the number of firms present in each market—is unrelated to the profit that a possible entrant is expected to gain. Hence, there is no reason to conclude that either (Π^{EG}), the profitability from entry in multiple markets through a more general resource, or (Π^{E}), the profitability from entry in fewer markets through a more dedicated resource stock, changes with the distribution of downstream firms across markets.

Complementarity between trading and investing in generality depends on whether ($\Pi^{TF} - \Pi^{T}$) is greater than ($\Pi^{EG} - \Pi^{E}$). We have established that when firms are concentrated in a few markets (i.e., demand is deep, from the perspective of a trading firm), ($\Pi^{TG} - \Pi^{T}$) is likely to be small or even negative; when downstream firms are equally spread across markets (i.e., demand is broad, from the perspective of a trading firm), however, ($\Pi^{TG} - \Pi^{T}$) is likely to be positive and large. In contrast, the distribution of firms across markets is unlikely to influence ($\Pi^{EG} - \Pi^{E}$). This implies that ($\Pi^{TF} - \Pi^{T}$) is more likely to be larger than ($\Pi^{EG} - \Pi^{E}$) when downstream firms are equally spread across markets, which leads us to hypothesize the following:

Hypothesis 2. *Firms facing a broad (vs. deep) demand in intermediate markets, are more likely to exhibit complementarity between investing (vs. not investing) in general upstream resources and specializing in trading in intermediate markets (vs. entering downstream markets). Therefore, these firms are more likely to specialize in generality.*

Data and Empirics

Empirical Setting

Our theory is potentially applicable to industries in which the following key conditions hold: (a) there are scale-free upstream resources (e.g., technological knowledge) that firms can invest in, possibly to increase the generality of their upstream resource stock; (b) there is the possibility of exploiting new markets; (c) such new markets can be exploited either by direct entry or by trading with firms already active in those downstream markets, since the corresponding intermediate markets operate efficiently. These industry conditions are necessary but not sufficient for a firm adopting a specialization-in-generality strategy, in that such a choice is firm-specific and—as we explained in the theoretical part—likely depends on firm-specific contingencies, including the level of economies of scope and demand structure a firm faces. Hence, to offer a first test of our theory—and to verify whether the firm-specific conditions we have identified actually lead firms to specialize in generality—we have considered an industry in which the aforementioned conditions hold: the laser industry.

We build a novel longitudinal data set containing information about a sample of U.S. firms active in the laser manufacturing industry over a nine-year period (1993–2001) that we complement with interviews of managers and industry experts. The term "laser"—"light amplification by stimulated emission of radiation"—refers to devices that emit light through a process of optical amplification based on the stimulated emission of electromagnetic radiation. Based on theoretical work by Charles Hard Townes and Arthur Leonard Schawlow, the first laser was built in 1960 by Theodore H. Maiman at Hughes Laboratories (Hecht 2011).

All laser technologies comprise a set of standard components that include a lasing material (i.e., the gain medium), a pump source, and a laser cavity. The atoms of a material such as crystal, glass, liquid, dye, or gas are excited by the pump source to a semi-stable state so that lasing can be achieved. Usually, the pump source is another light source (e.g., a laser diode or flash lamp) or an electric discharge. The light emitted by an atom interacts with the excited atoms nearby as it drops back to the ground state. Identical pairs of photons are released in a process called stimulated emission. The process is further duplicated while the photons bounce back and forth in the cavity from mirrors or other reflective cavity structures. In this way, the light emission is further amplified and beams of light at specific frequencies are produced (Hecht 2011).

Lasers differ in power and in the wavelength of light they emit, which has implications for their applications (and, thus, markets in which they can be applied). These include biomedical/medical (e.g., medical imaging, dermatology) information processing (e.g., scanning, optical disk reading), telecommunications (e.g., data transmission, pulse generation), military (e.g., target designation), and industrial (e.g., cutting, welding, marking) applications.

As noted, the laser industry is an ideal setting to test our theory, for several reasons. First, the industry has a clear vertical structure: upstream technological knowledge can be used to produce either lasers (intermediate components) or ready-to-use laser systems (downstream products). In fact, the laser industry has been characterized, since its inception, by a significant division of labor between firms specializing in producing laser technologies and firms producing laser systems, that is, embedding the laser technologies into final products. This specialization was enhanced by the inherent general-purpose nature of the laser technology, which can be applied to several industries. This is consistent with Klepper (1997), who considers laser industry patterns using data from the annual Buyers' Guide of Laser Focus for the period 1966–1994—where year 1966 roughly corresponds to the origins of the laser industry, since the first laser was built in 1960 (Hecht, 2011). Despite the specialization being marked, it is not complete: specialized and integrated firms coexist, with some firms vertically specializing upstream in the production of lasers, some firms specializing downstream in the production of laser systems, and some firms doing both. This industry is therefore an ideal empirical setting for studying the conditions that lead firms to use general resources just for trading versus entering downstream.

Second, technological knowledge is a scale-free resource—which once acquired can be applied in multiple contexts at the same time—and firms vary in the generality of their upstream technological knowledge such that some firms have more general upstream technological knowledge (and are thus able to produce lasers for use in a large number of laser systems for different markets) and some have less general upstream technological knowledge (and produce lasers targeted to specific downstream applications and related downstream markets).

Third, in the period studied, the applications of lasers expanded considerably in new downstream markets, such that firms in the laser industry faced precisely the choice of whether to enter these new markets by direct entry or by trading in the corresponding intermediate markets. Interestingly for our analysis, the directory we use for data collection is meant to be an outlet for firms to advertise their lasers and/or laser systems. Hence, by construction, if a firm is reported in the directory, it is exploiting new markets either by trading as an upstream supplier of intermediate products (lasers) or by operating downstream (as a seller of laser system)—consistent with our theoretical framework.

Finally, as we explain in the next section, in the period considered, we can exploit an exogenous regulatory shock affecting the relative value of trading in intermediate markets versus entering downstream markets. In so doing, we follow Brynjolfsson and Milgrom's (2012, p. 58) suggestion that "legal and institutional changes are often ideal candidates to . . . [estimate complementarities in organizations] . . . because a change in a law or government policy can provide a precise date and specific geographic area or jurisdiction for the change to occur."

To define the laser industry and its boundaries, we rely on the Photonics directory by Laurin Publishing, which lists all companies active in the laser context. We select all U.S. companies listed in the directory as active in the laser industry between 1993 and 2001. The sample includes both private and public firms; thus, it is generally representative of the different categories of firms active in high-technology contexts. It also includes firms that enter or exit the industry during the period, limiting any survival bias. We extract information on their characteristics (e.g., independence status, size, age, location) for each year. We use the same directory to collect information on the laser types that each firm is able to produce as well as on firm entry and trading. We pick our time window for empirical reasons: first, during the period 1993–2001 many U.S. states enacted laser safety regulations that increased the costs of operating in downstream markets—and we use those enactments as exogenous shocks. Second, during this period, the number of possible laser applications increased considerably due to the dramatic diffusion of the Internet.

We also match the data from the directory with firms' patent data. To obtain patent data, we use firms' names and locations and match them to patent assignees' names in the National Bureau of Economic Research (NBER) patents database. The NBER data set provides patent data consolidated at the parent-portfolio level for public firms. For private firms, we use the D&B *Who Owns Whom* database to build a list of their worldwide subsidiaries for each year of the study. We match this list with the NBER data set to obtain the list of patents filed by each of the firm's subsidiaries and consolidate the list of patents at the parent-firm level. This procedure yields a sample of 204 firms corresponding to 783 firm-year observations.[4]

Methodology

Testing our theory is not straightforward. The first and most obvious problem to address is that we cannot just take the correlation between investment in more general upstream resources and trading. It is well known that positive correlation is a necessary but not sufficient condition for complementarity (e.g., Bresnahan et al. 2002). To address this problem we need a (plausibly exogenous) shock that affects either the value of investing in generality versus not investing or the relative value of trading in intermediate markets versus entering downstream markets, and we ought to observe how this shock affects the other choice. Indeed, when a set of activities complement each other, if the marginal returns associated with some activities increase (decrease) it will be optimal to increase (decrease) the level of all the activities (Milgrom and Roberts 1990, p. 514). In the particular case of two discrete and complementary activities, we will naturally observe that a shock that makes one of the two activities more versus less convenient will lead firms to find the other activity more or less attractive also.

In our empirical analysis, we employ a shock that raises the costs of operating downstream and which, therefore, increases the value of trading in intermediate markets relative to the value of entering downstream markets. This implies that, as a direct response to this shock, firms will increase their trading in intermediate markets as opposed to entering downstream markets. Moreover, we expect that those firms for which trading in intermediate markets is complementary to investment in upstream resource generality (i.e., firms with no downstream assets and firms facing an equally spread distribution of potential buyers in intermediate markets) will also increase their investment in upstream resource generality compared with the counterfactual situation where the downstream costs stay constant.

We identify an exogenous increase in downstream production costs by taking advantage of the fact that in the period under investigation, some U.S. states enacted laser safety regulations that increased the

[4] The laser industry exhibits low concentration; in particular, it is populated by many small and very small firms. Other studies have noted the low concentration of the laser industries, e.g., Sutton (1998) and Klepper and Sleeper (2005).

costs of downstream operations by establishing new rules that laser system manufacturers (i.e., firms operating downstream) must follow to reduce the risk of accidents. The laser industry is heavily regulated because laser technologies present potential hazards for individual users. In the United States, safety requirements are the product of federal regulatory agencies and some voluntary standards: the Laser Product Performance Standard of the Center for Devices and Radiological Health, the American National Standards Institute, the Occupational Safety and Health Administration, and the Federal Aviation Administration. In addition to the federal and industry regulations, in the 1990s some U.S. states enacted local regulations to further increase laser safety controls (Rockwell and Parkinson 1999).

The introduction of these state regulations increases the costs of producing downstream products (but less so the costs of producing laser technologies not immediately usable without being embedded in a product), for two reasons. First, it adds costly activities that *only* downstream firms producing laser systems (i.e., products directly usable by final customers and so potentially more dangerous) in the state must comply with. In addition to being subject to federal regulations and standards, laser system manufacturers are subject to state regulations that affect the manufacturing of laser systems. For example, Arkansas Act 460 (Electronic Product Radiation Control Act) imposes specific requirements on all companies that "make, sell, lease, transfer, lend, assemble or install radiation machines."[5] The laser system manufacturers included in our sample would qualify within this description. Similar requirements targeted at products embedding laser technologies are contained in other regulations, also in line with the information that we received from the compliance specialist whom we interviewed. They clearly imply a cost for companies producing and selling laser systems[6].

Second, the introduction of a state regulation increased, *mainly* for downstream companies producing laser systems directly usable by final customers, the chances of being sued in the case of an accident and thus being involved in a costly lawsuit. In this respect, the new regulations stipulated the prompt reporting of all accidents occurring during the use of a laser system. For example, section 40 of the Illinois Laser System Act establishes that "the operator of a laser system shall promptly report to the Agency an accidental injury to an individual in the course of use, handling, operation, manufacture, or discharge of a laser system."

In general, an expert in laser compliance whom we interviewed confirmed: "The State requirements [. . .] can be problematic and they can produce added costs and reduction of commerce and things [. . . ;]

[5] The regulations we have examined do not contain any specific reference to the generality or the specificity of the technology, in line with the idea that the enactment of the regulation per se does not have a direct effect on firms' incentives to invest in generality.

[6] Following the enactment of the regulation, demand of laser technologies from the regulated states would decrease, given the higher costs of laser system production. However, this would affect similarly all upstream producers of laser technologies, regardless of their location, since in the United States the market for lasers is not restricted by state boundaries.

they come at it from a safety of use standpoint. [. . .] The State monitors very carefully, for the safety of the patients, that the equipment is compliant, they know where it is, they come and test it now and then, etc."

Importantly, whereas the firms operating in this industry sell lasers or laser systems throughout the country, or even internationally, they are mostly small to medium-sized firms: hence, they would hardly move their manufacturing from their own area or town because of an unfavorable regulation enactment—which is confirmed by robustness checks (see Table 13, column 1). In the period we considered (1993-2001) the new regulations were introduced by the states of New York (1994), Arizona (1996), Florida (1996), Massachusetts (1997), Illinois (1997), and Texas (1999). Because those regulations are introduced in different years, in our panel the shock is not a mere chronological threshold. Moreover, accounts of the regulations' enactment suggest that they were exogenous to the economic and political conditions of each state (Rockwell and Parkinson 1999). We also corroborate the exogeneity of our shock in our robustness checks.

We assess the effect of our shock by comparing firms in states that enacted such regulations—our treatment group—with firms in states that did not—our control group. In particular, our treatment is the variable *Downstream production cost*, a dummy equal to 1 for firms operating in a state that introduced the regulation after its enactment, and 0 otherwise. Since we control for year fixed effects and we introduce state dummies—besides clustering the error at the state level as suggested by Bertrand and Mullainathan (2003)—our approach is a classical diff-in-diff regression, where the coefficient of *Downstream production cost* produces an estimate of the impact of an increase in downstream production costs on the outcome of interest.[7]

In particular, our dependent variable *Specialization in generality* is the joint occurrence of two events: (1) the focal firm invests in more general upstream resources, and (2) it trades in intermediate markets (rather than entering downstream markets). Considering again Table 1, our main dependent variable is the strategy that the focal firm pursued in each period of the four possible strategies identified. These strategies are defined by all possible combinations of undertaking (or not) each of the two activities (i.e., investment in upstream resource generality and trading in intermediate markets). The most appropriate way to estimate a joint likelihood of undertaking or not two activities is through a bivariate probit; however, as a robustness check, we also use a linear probability model.

To measure whether a firm exploits its resources by trading in intermediate markets rather than entering downstream, we use *Trading in intermediate markets,* a dummy equal to 1 if in year *t* the firm

[7] A reliable estimate is obtained even when using, as we do here, a nonlinear estimation model (Puhani 2012): in this case the coefficient estimating the treatment effect is still a valid indicator of the actual treatment effect. At any rate, we also use linear models as robustness checks.

exploits any new market where laser technology could in principle be applied in the focal period (e.g., communication, information processing, industrial, medical, military, and miscellaneous) by trading rather than entering. Specifically, the industry directory that we used indicates whether, in each year, each of the firms produces and sells lasers to downstream firms (i.e., trades the upstream resource in intermediate markets) versus (also) producing and selling laser systems (i.e., the downstream product). Hence, for each of the years in our sample, we gave the variable *Trading in intermediate markets* the value of 1 if the directory indicated that the focal firm was selling lasers to downstream firms and 0 if the directory indicated instead that the focal firm entered downstream and also began producing and selling a laser system in a new market[8].

To measure *Investment in general upstream resources,* we take advantage of the fact that laser technology has several possible market applications depending on the laser medium.[9] Based on the medium, lasers can be classified in the following categories: Alexandrite; ArF; Argon-Ion; CO_2; CO_2 TEA; Metal Vapor; Diode; Dye; Er:Glass; Er:YAG; Excimer; HeNe; Krypton-Ion; Nd:YAG; Ruby; Thulium; HeCd; KrF; Lead Salt; Nd: Glass; Ti:Sapphire; Color-Center; HF/DF; and Holmium YAG. Each category can be used in a broader versus narrower range of applications. For instance, a KrF laser can be applied to industrial drilling but not to applications in dermatology. An Er:Glass laser technology, however, is appropriate for use in dermatology but not in laser drilling. A third alternative, the Alexandrite laser, can be used for applications in both dermatology and industrial drilling. Therefore, the Alexandrite laser is a more general technology than the KrF or the Er:Glass lasers. To measure the generality of the firm technology, we first measure the individual laser's degree of generality by calculating the ratio of the number of uses/markets to which that specific laser type can be applied to the total number of applications/markets across all laser types. We then compute the degree of the firm's technology generality in each year by considering the average degree of generality of the lasers in the firm's portfolio. Finally, we measure *Investment in general upstream resources* as a dummy equal to 1 if the firm increases its average laser generality from year t–1 to year t, and 0 otherwise.

[8] It is worth noting that "entry", might not only mean vertical integration for firms that have so far been only upstream players but also entry in a new market and so diversification for firms that are already vertically integrated.

[9] We computed generality using all 96 specific applications of a laser across the six main markets, to fully capture the real generality of a laser. For instance, a laser that can be used in the industrial market, as it can drill and cut, is more general than a laser that can only cut: in other words, a firm's possibility of entering the industrial submarket (or of trading the laser in the corresponding intermediate market) is higher when provided the former than the latter laser. However, our results are robust to adopting an alternative measure of generality obtained considering whether a laser has at least one application per submarket, without counting the exact number of applications. Furthermore, as the application table was just available after 1997, for the period 1993–1997 we considered as valid the laser applications in 1998.

To test hypothesis 1, we estimate (through both bivariate probit and linear probability models) the effect, on the joint likelihood of investing in general upstream resources and trading in intermediate markets, of the interaction between *Downstream production cost* and *Lack of downstream assets.*

The variable *Lack of downstream assets* distinguishes between firms that, when the decision to trade versus enter a new downstream market is made, do not already own downstream assets and capabilities and firms that do. Therefore, this variable is a dummy variable equal to 1 if a firm, before a certain year *t*, was not producing and selling laser systems (the downstream product). Since this firm was not active in downstream markets prior to year *t*, it had no downstream assets or expertise. To alleviate any potential endogeneity between the regulatory change and the decision to vertically integrate, we measured this variable by looking at the "status" of the firm in the year immediately before the regulatory change for firms based in states where the regulation is issued and year of entry into the database for firms based in states in which such regulation was never issued.

To test hypothesis 2, we estimate the effect, on the joint likelihood of investing in general upstream resources and trading in intermediate markets, of the interaction between *Downstream production cost* and *Breadth of demand.* The latter variable is calculated by looking at how firms operating in downstream markets are distributed across them, for each firm-year. In more detail, for each focal firm in the sample that supplies lasers, we consider the markets in which its lasers are potentially applicable and we calculate the variable *Breadth of demand* as 1 minus the Herfindhal index of concentration of downstream buyers across these markets. Note that downstream firms constitute potential buyers for the focal firms' lasers. The value of *Breadth of demand* is low when potential downstream buyers of the focal firms are mostly concentrated in a few markets; it is high when potential downstream buyers are instead equally spread across markets.

Moreover, in all specifications we include as an additional control variable the *Number of lasers,* which controls for the number of different types of lasers produced by the firm. We also control for the *Number of patents* applied for and granted to the firm in the five years prior to the focal year, *Firm size* (number of employees), and *Firm age.*

Results

Main Results

Table 2 shows some descriptive statistics for the population of firms in the laser industry between 1993 and 2001. During this period about 44% of firms do not have downstream assets (as they are only laser suppliers) and 56% do, also producing and selling final laser systems for downstream markets. On average, each laser supplier sells two types of lasers and employs about 300 people—even though the distribution of employees is skewed. As noted, six states enacted new regulations that increase the costs of operating downstream; in our sample, this enactment affects about 20% of our firm-year observations. Moreover, about 7% of the suppliers enter new downstream markets, and almost 16% invest in more general upstream resources during our time window.

******* Insert Table 2 about here *******

We first want to show that our shock is relevant, in that it constitutes a relevant increase in downstream production costs, pushing fewer laser firms to enter downstream markets and so reducing the overall number of downstream manufacturers. That is, we want to show that our shock makes entering downstream less convenient than trading in intermediate markets. Therefore, we compute the probabilities that in year *t* a firm operates in intermediate markets selling lasers (measured by the dummy "being in intermediate market") and in downstream markets selling laser systems (measured by the dummy "being in downstream market") as a function of whether the firm used to operate in intermediate markets or downstream markets in year *t*–1, the compliance shock, and the interaction between these variables. In doing so, we cover all possible firm types because in a particular year a firm can be operating only in upstream intermediate markets (being in intermediate market = 1; being in downstream market = 0), operating only in downstream markets (being in intermediate market = 0; being in downstream market = 1), operating in both (being in intermediate market = 1; being in downstream market = 1), or out of the industry (being in intermediate market = 0; being in downstream market = 0).

Our bivariate probit in Table 3 and the corresponding marginal effects in Table 4 show that the shock prevents the firms so far operating only in upstream intermediate markets from entering downstream: the probability that an upstream firm integrates downstream decreases by about 5%. To some extent, the change also stops the downstream entry of brand-new companies (firms that were outside the industry earlier)—even if the effects are not statistically significant at the conventional levels. All in all, this suggests that the regulatory change determines an increase in production costs that acts mainly as a barrier to entry. Even though it does not induce the exit of firms already operating downstream, the shock lowers the number of downstream producers.

Consistent with the previous results, Table 5 presents the findings of a Poisson regression in which the dependent variable is the number of companies selling laser systems in any state, market, and year. After the new regulation, the number of downstream firms in the state affected by the regulation diminishes considerably, by about 16%.

******* Insert Tables 3, 4, & 5 about here *******

Having assessed the relevance of our shock as an increase in the costs of operating downstream, we can now assess the validity of our theory. According to the results of both the linear probability (seeming unrelated regression estimation) model in Table 6 and the bivariate probit in Table 7, the increase in downstream production costs encourages trading versus entry (Table 6 and Table 7, column 2) and induces firms to invest in more general upstream resources (Table 6 and Table 7, column 1) but the latter effect is not significant at the conventional level. Furthermore, the impact of the increase in downstream production costs on both the probability of investing in more general upstream resources and the probability of trading is positive for firms lacking downstream assets (Table 6 and Table 7, columns 3–4). It is also positive when buyers are more equally distributed across markets (Table 6 and Table 7, columns 5–6).

However, Table 7 provides only the estimates of the effect of our shock on the separate probability of investing in generality, on one side, and trading, on the other. Hypotheses 1 and 2 refer instead to the effect of the shock on the *joint* probability of investing in general upstream resources while trading—which precisely defines the likelihood of adopting a specialization-in-generality strategy. The marginal effects of an increase in downstream production costs on the likelihood of pursuing a specialization-in-generality strategy—as well as on the likelihood of adopting the other strategies defined in Table 1—are shown in Table 8. The increase in downstream production costs raises the probability of specializing in generality by a technology supplier by about 3%. However, the effect is not very pronounced either economically or statistically ($p = 0.35$; confidence interval [CI]: 0.036–0.1). This is because, as noted in the theoretical section, the complementarity between investing in general upstream resource stock and trading in intermediate markets depends on the supply and demand conditions that a company faces.

In line with hypothesis 1, the effect of the shock on the probability of specializing in generality (trading in intermediated markets and increasing upstream resource generality) is much larger for firms with no downstream assets than for firms that do already have some downstream assets. For firms with no downstream assets, this probability increases by more than 10 percentage points—passing from 0.14, which is the baseline probability of adopting a specialization-in-generality strategy, to 0.25—and is measured more precisely ($p = 0.059$; CI: −0.004 to 0.21), whereas the probability for firms that do have downstream assets does not change. Our results also imply that more than half the firms lacking downstream assets would enter the market without the increase in downstream production costs: the probability of adopting a simple entry or a synergistic entry strategy decreases respectively by about 4% and 1%.

Similarly, as suggested by hypothesis 2, the likelihood of specializing in generality increases when buyers' distribution across markets is more balanced. In particular, when the variable *Breadth of demand* is at the 75th percentile (approximately equal to 0.735, corresponding to a more homogenous distribution of buyers across markets), the probability that a firm, after the increase in downstream costs, pursues a specialization-in-generality strategy (which means investment in generality = 1 and trading = 1) increases by about 13 percentage points ($p = 0.001$; CI: 0.056–0.20)—passing from 0.14 to about 0.27. Instead, when the variable *Breadth of demand* is at the 25th percentile (approximately equal to 0.711, corresponding to a more skewed market distribution in our setting), the probability decreases by about 8.5 percentage points (p = 0.003; CI: −0.14 to −0.029).

******* Insert Tables 6, 7, & 8 about here *******

To better understand these results—and to investigate possible interactions between market and supply conditions—we report graphically the effect of an increase in downstream production costs on the probability of specializing in generality (Figure 1), for different levels of demand breadth, and for firms with and without downstream assets. Figure 1 shows that not only firms without downstream assets but also firms with downstream assets seem to choose a strategy of "generality and trading" as the breadth of demand across markets increases. This suggests that if the opportunity to profitably sell resources to many markets is available, a specialization-in-generality strategy becomes attractive even for firms with downstream assets.

******* Insert Figure 1 about here *******

Further on this point, in additional analyses (available upon request) we investigate which firms, of those having downstream assets, are more likely to specialize in generality in the presence of high costs of downstream production. Interestingly, the results indicate that firm age and size matter. We find that younger and smaller firms, even those with downstream assets, are more likely to choose a specialization-in-generality strategy. These additional results suggest the intriguing possibility—which could be investigated by future research—that an increase in downstream production costs (or any other shock making trading relatively more convenient than entry) might induce flexible, vertically integrated firms, which can still experiment with their strategies, to specialize in generality: that is, to increasingly move toward a business model focused on serving multiple markets as an upstream supplier of intermediate products and services. In this regard, our findings suggest that corporate experimentation may involve not only the choice of which downstream market to operate (e.g., Kerr et al. 2014) but also the decision on the most appropriate business model for serving these markets.

Robustness Checks

Comparison between treatment and control groups. An important assumption of any experimental and quasi-experimental methodology is that the treatment is exogenous and therefore not systematically correlated with firm characteristics. We verify this assumption empirically by analyzing whether firms in the treatment and control groups differ along all variables included in our analysis. Specifically, we compare the means of the groups in the first year of our sample, before the regulatory changes are enacted. Table 9 shows that, overall, the two groups are similar, which corroborates our identification assumption. The main difference (in magnitude but not in statistical significance) is in the number of patents. However, about two-thirds of the companies in both the treatment and control groups have zero patents, and the difference is produced by a few outliers.

******* Insert Table 9 about here *******

Political economy of laser regulation enactment. Based on Table 9, we can conclude that the average firm size—which might also proxy for the resources that state firms can spend on lobbying and/or campaign contributions—does not differ significantly across firms operating in treated versus control states. This finding should alleviate the concern that the change in regulation is driven by some lobbying efforts. However, we perform further controls to check whether the change in regulation is associated with any other economic and political characteristics of the states that could affect the business environment in general, and the probability of entering into a downstream market and/or investing in general upstream resources. To do so, we run a simple linear probability model predicting the likelihood of a state enacting a laser regulation as a function of state GDP per capita, the overall taxation level, the state political orientation (as proxied by having a "Red" [Republican] governor or having voted for a Red U.S. president in the last presidential election), the lobbying activity in the state (as measured by the number of establishments classified by the County Business Patterns as "political organizations" [SIC code 8651]; Sobel and Garrett 2002), the laser industry agglomeration (as measured by the number of firms producing lasers in the state), the presence of a dominant firm (as measured by a dummy equal to 1 if in the state there is a company in the top 10% of the laser-firm size distribution), and the number of major laser accidents per capita. To measure the latter variable we used Factiva to collect the number of news articles containing the word "laser" together with the word "accident" published in each state and each year in our sample. We randomly selected a sample of the articles that emerged from this search to verify that the search process employed was appropriate for the purpose. We used the number of news articles in each state and year as a proxy for the occurrence as well as the salience of the laser accidents. No predictor shows any significant correlation with the probability of enacting the new regulation, which reinforces our identification strategy (see Table 10).

******* Insert Table 10 about here *******

Relaxing the parallel-paths assumption. A specific assumption of the quasi-experimental diff-in-diff approach is the so-called parallel-paths assumption. This assumption implies that, for the diff-in-diff estimation to indicate the real impact of the treatment, the outcome variable should exhibit a similar trend for individuals in the treatment and control groups. As indicated by Angrist and Pischke (2009), a simple way of relaxing this assumption is to introduce an interaction term in the diff-in-diff regression, that is, the interaction between a dummy for treated units and a time trend. This interaction captures any differential trend between treated and control units before the treatment. We adopt this approach to check whether our results are robust to the inclusion of a different time trend for each state. Unfortunately, including this variable in the bivariate probit makes the estimation impossible. Hence, we use a linear probability model, where the dependent variables are the four possible strategies resulting from the combinations of investing in more general upstream resources (or not) and trading exclusively in intermediate markets (vs. entering downstream). The results are again largely consistent with our theory. The likelihood that a firm invests in more general upstream resources and trades in intermediate markets (which represents the specialization-in-generality strategy and is reported in columns 10–12 of Table 11) increases for firms without downstream assets and for firms whose potential buyers are equally distributed across markets (such that the demand is broad).

******* Insert Table 11 about here *******

Inclusion of firm fixed effects. An additional concern of the main analyses is the presence of some firm-unobserved characteristics, which we do not control for in the bivariate probit model. Overall, we believe this is not a major concern, as we show that our shock is arguably exogenous—and thus uncorrelated with both time-variant and time-invariant firm characteristics. Moreover, a fixed-effect model would rely only on within-firm variation in the likelihood of entering a downstream market and/or investing in general upstream resources, whereas most variation is across firms. However, we also check whether our results change when we introduce firm fixed effects in the previous linear probability model. Table 12 shows that the main results are robust to the inclusion of firm-specific dummies (columns 10–12).

******* Insert Table 12 about here *******

Stable unit treated value assumption (SUTVA). One possible concern is that our shock, by inducing some firms to move across states, might change the composition of the treated and control groups—which would violate the SUTVA and therefore bias our estimates. However, this is not the case. In Table 13 (column 1) we find that the costs associated with stricter regulation are not high enough to convince the firms in our sample to change states—which would represent a quite dramatic change. The enactment of a regulation increasing the cost of producing downstream is not significantly associated with any firm move. Furthermore, our results hold even when we exclude from our sample the few firms that, for some reason, moved to different states over time (Table 13, columns 2–4).

******* Insert Table 13 about here *******

Conclusions

The thrust of our analysis is that, under some supply and demand conditions, the organizational decision of a firm to trade in intermediate markets complements the decision to increase the generality of its resources to reach different markets. This complementarity reflects the firm's willingness to grow in intermediate markets to overcome the limitations of growth in downstream markets. The market development manager of a large international laser company summarizes our approach: "Our lasers can be applied to any type of industry. What I tell our customers is 'I do not care what you need to make with it: I have the laser for you!' [. . .] We have developed this skill through the years. We do not need to move into systems. Some companies do but it is not our business concept."

Our study treats investment in upstream resource generality and resource exploitation modes (which could occur by entering new downstream markets vs. trading in intermediate markets) as distinct but interrelated and endogenous choices. In so doing, it offers both theoretical and empirical contributions.

From a theoretical point of view, our paper contributes to organizational research. The complementarity between these two crucial firm decisions contributes to the stream of research focused on the contingencies under which different organizational configurations emerge and persist precisely as a result of complementarity among organizational activities (e.g., Galbraith 1973, Milgrom and Roberts 1990, Thompson 1967). Furthermore, this paper contributes to the organizational research on vertical integration and disintegration (e.g., Baldwin and Clark 2000, Kapoor 2013), showing how the decision about a firm's vertical scope (whether to enter downstream or to operate as an upstream supplier of intermediate products or services) cannot be isolated from the decision about investment in different types of upstream resources and capabilities.

This paper also contributes to strategy research, in particular to the stream of literature on general upstream resources (e.g., Bresnahan and Trajtenberg 1995, Helfat and Eisenhardt 2004, Kim and Bettis 2014). Prior research in this domain has emphasized that a more general upstream resource stock poses a relevant trade-off, between a broader set of reachable markets and a lower fit with each individual market. However, much of this research has overlooked the strategic challenge associated with this choice, taking the generality of firm resources as given rather than as something that firms might purposefully change. This paper, instead, explores the trade-off that firms face when deciding whether to invest in generality, suggesting that the optimal choice is not only intertwined with the decision about resource exploitation mode (via trading in intermediate markets vs. entering downstream markets) but also with supply and demand conditions.

Our results also generate some consideration of the interdependence between the development of markets for technology and the prevalence of general-purpose technologies (Bresnahan and Trajtenberg 1995, Gambardella and McGahan 2010). On one hand, the incentive to invest in general-purpose technologies depends on the existence of well-functioning markets for technologies, because trading general technologies in intermediate markets for technologies is crucial to monetizing investment in these technologies (Gambardella and McGahan, 2010). On the other hand, the development of general technologies naturally affects the division of inventive labor between companies specializing in producing technologies and those embedding these technologies into final products. As Rosenberg (1982, p. 71) emphasized, general technologies lead to "wholly new patterns of specialization," with "the emergence of specialized firms and industries that produce no final product at all—only capital goods."

In addition, this paper offers insights on firms' strategic responses to disruptions in downstream markets. While we focus on an increase in downstream production costs as the trigger for specializing in generality, any other trigger that makes trading relatively more valuable than downstream entry could produce a similar response, such as more efficient vertical markets (Arora et al. 2001) or new disruptive downstream products that compete with the firm's focal products and which the firm is unable to counter (Christensen 1997, Gans 2016). In this respect, our answer is that, apart from standard responses within the current business model, an alternative strategy is to refocus upstream and exploit general capability.

Finally, from an empirical point of view, recognizing that the choices about investment in general upstream resources and resource exploitation modes are simultaneous allows us to overcome the natural estimation bias that arises by considering either the former or the latter activity as exogenous. In this regard, future research analyzing firm entry into a new market as a function of the generality of the firm's resource stock should adopt appropriate identification strategies (e.g., instrumental variables) to obtain reliable estimates.

Our paper is also defined by its limitations. First, as in any quasi-experimental setting, we cannot argue that our treatment is completely exogenous and thus uncorrelated with other factors potentially affecting our outcome of interest. However, the several robustness checks that we conducted tend to corroborate the idea that we can consider the treatment to be exogenous.

Second, a single-industry study generates concerns about the generalizability of the results. In particular, some characteristics of the laser industry—for example, the division of labor between upstream firms providing laser technologies and downstream firms embedding those technologies into laser systems—might not extend to other sectors. Several characteristics of the laser industry—including the division of innovative labor—are common across knowledge-intensive industries though; for this reason, other scholars have chosen this industry as an empirical setting for their theoretical predictions (e.g., Klepper and Sleeper 2005). However, it would be useful for future research to explore further our theoretical predictions in different industries.

Third, a longer timeframe may produce more robust results. However, the period we consider allows us to capture sufficient variations in the main independent and dependent variables. Not only does the timeframe covered by our data set allow us to compare states enacting a regulation that increases downstream production costs with states not enacting such a regulation; it also allows us to observe a wide variance among lasers in the number of their potential applications.

Despite these limitations, this paper provides relevant implications for practitioners. In particular, specialization in generality is a natural prescription of our discussion. Translating Stigler's (1951) intuition into the business environment, we argue that, under certain contingencies, managers may find it profitable to develop a general upstream resource to serve different downstream markets as an upstream supplier of intermediate products or services rather than to enter any one of these markets. In this regard, while Penrose (1959), Chandler (1990), or Nelson (1959) saw economies of scope mostly as accruing within—usually large—organizations, in this paper we suggest that the benefits of economies of scope can be achieved (also) through markets and the division of innovative labor (Arora et al. 2001). Studying the extent to which firms can take advantage of internal economies of scope to enter multiple markets, rather than exploiting external economics of scope, by selling in these markets, is an interesting avenue for future research.

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TABLES

Table 1 Typology of Strategies and Payoffs When Intermediate Markets Operate Efficiently

	Trading = 0	Trading = 1
Investment in generality = 0	Simple entry strategy $\Pi(0,0) = \Pi^{E}$	Simple trading strategy $\Pi(0,1) = \Pi^{T}$
Investment in generality = 1	Synergistic entry strategy $\Pi(0,1) = \Pi^{EG}$	Specialization-in-generality strategy $\Pi(1,1) = \Pi^{TG}$

Table 2 Descriptive Statistics and Pairwise Correlations Between Variables

Variable	Observations	Mean	S.D.	Min.	Max.													
Investment in general upstream resources	783	0.157	0.364	0.000	1.000	1.000												
Trading in intermediate markets	783	0.932	0.251	0.000	1.000	−0.037	1.000											
Synergistic entry	783	0.014	0.118	0.000	1.000	0.277	−0.443	1.000										
Specialization in generality	783	0.143	0.350	0.000	1.000	0.946	0.110	−0.049	1.000									
Simple trading	783	0.789	0.408	0.000	1.000	−0.836	0.522	−0.231	−0.791	1.000								
Simple entry	783	0.054	0.225	0.000	1.000	−0.103	−0.884	−0.028	−0.097	−0.461	1.000							
Downstream production cost	783	0.202	0.402	0.000	1.000	0.037	0.072	−0.033	0.049	0.002	−0.063	1.000						
Number of lasers	783	1.927	1.514	1.000	12.000	0.169	−0.110	0.149	0.126	−0.176	0.045	−0.058	1.000					
Number of patents	783	46.147	338.339	0.000	4941.858	0.058	0.030	−0.010	0.064	−0.036	−0.029	−0.066	−0.057	1.000				
Firm size	783	336.648	1379.587	1.000	21760.000	0.164	−0.013	0.062	0.149	−0.136	−0.018	−0.032	0.326	0.264	1.000			
Firm age	783	20.789	18.831	2.000	134.000	0.031	0.006	0.056	0.013	−0.007	−0.036	0.038	0.094	0.195	0.363	1.000		
Breadth of demand	783	0.690	0.120	0.000	0.749	0.126	−0.042	0.038	0.118	−0.127	0.026	0.088	0.148	0.017	0.029	0.095	1.000	
Lack of downstream assets	783	0.439	0.497	0.000	1.000	0.085	0.064	−0.040	0.101	−0.047	−0.051	0.017	−0.138	0.019	−0.034	0.042	−0.002	1.000

Table 3 Impact of Increased Downstream Production Costs on the Probability of Being in Intermediate and/or Downstream Markets: Bivariate Probit Estimation

Variables	(1) Being in intermediate markets (*t*)	(2) Being in downstream markets (*t*)
Downstream production cost (*t−1)*	0.026	−0.072
	(0.132)	(0.102)
Downstream production cost (*t−1)* × Being in downstream markets (*t−1)*	0.072	0.350***
	(0.153)	(0.125)
Downstream production cost (*t−1)* × Being in intermediate markets (*t−1)*	−0.016	−0.194
	(0.176)	(0.146)
Being in downstream markets (*t−1)*	−0.362***	1.770***
	(0.066)	(0.047)
Being in intermediate markets (*t−1)*	2.507***	−0.090
	(0.073)	(0.066)
Year fixed effects	Included	Included
State fixed effects	Included	Included
Constant	−1.984***	−1.356***
	(0.382)	(0.318)
Observations	5,533	5,533

Note. Robust standard errors clustered by state in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4 Impact of Increased Downstream Production Costs on the Probability of Being in Intermediate and/or in Downstream Markets: Marginal Effect Estimation (Based on the Bivariate Probit Estimation in Table 3)

			ON THE PROBABILITY OF BEING, at *t*:			Effect size when downstream production cost = 0	Effect size when downstream production cost = 1	Difference between marginal effects	Prob > chi^2
Outside the industry	U(*t*−1) = 0	D(*t*−1) = 0	Outside the industry	U(*t*) = 0	D(*t*) = 0	0.825***	0.837 ***	0.012	0.607
Outside the industry	U(*t*−1) = 0	D(*t*−1) = 0	In intermediate markets only	U(*t*) = 1	D(*t*) = 0	0.027***	0.03 ***	0.003	0.6669
Outside the industry	U(*t*−1) = 0	D(*t*−1) = 0	In downstream markets only	U(*t*) = 0	D(*t*) = 1	0.115***	0.1 ***	−0.015	0.4053
Outside the industry	U(*t*−1) = 0	D(*t*−1) = 0	In both intermediate and downstream markets	U(*t*) = 1	D(*t*) = 1	0.033***	0.032 ***	−0.001	0.9141
In intermediate markets only	U(*t*−1) = 1	D(*t*−1) = 0	Outside the industry	U(*t*) = 0	D(*t*) = 0	0.202***	0.202 ***	0.000	0.992
In intermediate markets only	U(*t*−1) = 1	D(*t*−1) = 0	In intermediate markets only	U(*t*) = 1	D(*t*) = 0	0.669***	0.716 ***	0.047	0.3158
In intermediate markets only	U(*t*−1) = 1	D(*t*−1) = 0	In downstream markets only	U(*t*) = 0	D(*t*) = 1	0.005***	0.003 ***	−0.002 *	0.0829
In intermediate markets only	U(*t*−1) = 1	D(*t*−1) = 0	In both intermediate and downstream markets	U(*t*) = 1	D(*t*) = 1	0.124***	0.079 ***	−0.045 *	0.057
In downstream markets only	U(*t*−1) = 0	D(*t*−1) = 1	Outside the industry	U(*t*) = 0	D(*t*) = 0	0.242***	0.166 ***	−0.076 ***	0.0093
In downstream markets only	U(*t*−1) = 0	D(*t*−1) = 1	In intermediate markets only	U(*t*) = 1	D(*t*) = 0	0.000***	0.000 **	0.000	0.1489
In downstream markets only	U(*t*−1) = 0	D(*t*−1) = 1	In downstream markets only	U(*t*) = 0	D(*t*) = 1	0.729***	0.799 ***	0.070 **	0.0173
In downstream markets only	U(*t*−1) = 0	D(*t*−1) = 1	In both intermediate and downstream markets	U(*t*) = 1	D(*t*) = 1	0.029***	0.035 ***	0.006	0.5718
In both intermediate and downstream markets	U(*t*−1) = 1	D(*t*−1) = 1	Outside the industry	U(*t*) = 0	D(*t*) = 0	0.162***	0.142 ***	−0.02	0.5573
In both intermediate and downstream markets	U(*t*−1) = 1	D(*t*−1) = 1	In intermediate markets only	U(*t*) = 1	D(*t*) = 0	0.109***	0.103 ***	−0.006	0.7676
In both intermediate and downstream markets	U(*t*−1) = 1	D(*t*−1) = 1	In downstream markets only	U(*t*) = 0	D(*t*) = 1	0.151***	0.146 ***	−0.005	0.8432
In both intermediate and downstream markets	U(*t*−1) = 1	D(*t*−1) = 1	In both intermediate and downstream markets	U(*t*) = 1	D(*t*) = 1	0.577***	0.61 ***	0.033	0.5739

*Note.**** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5 Impact of Increased Downstream Production Costs on the Number of Firms Operating Downstream: Poisson Estimation

Variables	(1) Number of downstream firms
Downstream production cost	−0.154** (0.057)
Market dummies	Included
Year fixed effects	Included
State fixed effects	Included
Constant	0.009 (0.059)
Observations	3,330
R-squared	0.887

Note. Robust standard errors clustered by state in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6 Impact of Increased Downstream Production Costs on the Probability of Investing in More General Upstream Resources and/or Trading in Intermediate Markets: SURE Linear Estimation

Variables	(1) Investment in general upstream resources (vs. No investment)	(2) Trading in intermediate markets (vs. Entering downstream markets)	(3) Investment in general upstream resources (vs. No investment)	(4) Trading in intermediate markets (vs. Entering downstream markets)	(5) Investment in general upstream resources (vs. No investment)	(6) Trading in intermediate markets (vs. Entering downstream markets)
Downstream production cost	0.030	0.037*	−0.012	0.032*	−0.823***	−0.075
	(0.041)	(0.022)	(0.040)	(0.016)	(0.170)	(0.053)
Lack of downstream assets			0.049***	0.029		
			(0.017)	(0.019)		
Downstream production cost × Lack of downstream assets			0.106	0.014		
			(0.081)	(0.028)		
Breadth of demand					0.328***	−0.110***
					(0.054)	(0.042)
Downstream production cost × Breadth of demand					1.219***	0.158*
					(0.224)	(0.082)
Number of lasers	0.047***	0.000	0.049***	0.001	0.042***	0.002
	(0.015)	(0.006)	(0.015)	(0.006)	(0.016)	(0.006)
Number of patents	0.000	0.000***	0.000	0.000***	0.000	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm size	0.000**	−0.000	0.000***	−0.000	0.000**	−0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm age	−0.001*	−0.000	−0.002*	−0.000	−0.002**	−0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Year fixed effects	Included	Included	Included	Included	Included	Included
State fixed effects	Included	Included	Included	Included	Included	Included
Observations	783	783	783	783	783	783

Note. Robust standard errors clustered by state in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7 Impact of Increased Downstream Production Costs on the Probability of Investing in More General Upstream Resources and/or Trading in Intermediate Markets: Bivariate Probit Estimation

Variables	(1) Investment in general upstream resources (vs. No investment)	(2) Trading in intermediate markets (vs. Entering downstream markets)	(3) Investment in general upstream resources (vs. No investment)	(4) Trading in intermediate markets (vs. Entering downstream markets)	(5) Investment in general upstream resources (vs. No investment)	(6) Trading in intermediate markets (vs. Entering downstream markets)
Downstream production cost	0.137	0.419*	−0.047	0.230	−39.252***	0.047
	(0.176)	(0.215)	(0.206)	(0.167)	(8.230)	(0.720)
Lack of downstream assets			0.236*	0.237		
			(0.123)	(0.167)		
Downstream production cost × Lack of downstream assets			0.455	4.892***		
			(0.320)	(0.240)		
Breadth of demand					5.970***	−1.033***
					(2.227)	(0.356)
Downstream production cost × Breadth of demand					54.161***	0.490
					(11.196)	(0.957)
Number of lasers	0.188***	0.019	0.206***	0.022	0.186***	0.025
	(0.052)	(0.029)	(0.055)	(0.030)	(0.067)	(0.031)
Number of patents	0.000***	0.001***	0.000***	0.001***	0.000***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm size	0.000***	−0.000	0.000***	−0.000	0.000**	−0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm age	−0.009*	−0.006	−0.009*	−0.005	−0.009**	−0.005
	(0.005)	(0.010)	(0.005)	(0.010)	(0.004)	(0.010)
Year fixed effects	Included	Included	Included	Included	Included	Included
State fixed effects	Included	Included	Included	Included	Included	Included
Constant	−0.834***	0.265	−1.065***	0.017	−5.152***	0.982**
	(0.289)	(0.298)	(0.265)	(0.324)	(1.747)	(0.466)
Observations	783	783	783	783	783	783

Note. Robust standard errors clustered by state in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8 Impact of Increased Downstream Production Costs on the Probability of Investing in More General Upstream Resources and/or Trading in Intermediate Markets: Bivariate Probit Marginal Effect Estimation

MARGINAL EFFECT OF:	ON THE JOINT PROBABILITIES OF:				
Downstream production cost	Investment in general upstream resources (vs. No investment)	Trading in intermediate markets (vs. Entering in downstream markets)	Corresponding to strategy:	Effect size	*p*-value
	1	0	Synergistic entry	−0.006 *	0.098
	0	0	Simple entry	−0.032 **	0.011
	0	1	Simple trading	0.006	0.839
	1	1	Specialization in generality	0.032	0.354
WHEN: Lack of downstream assets is equal to:					
0 (Firm with downstream assets)	1	0	Synergistic entry	−0.005	0.290
0 (Firm with downstream assets)	0	0	Simple entry	−0.022	0.117
0 (Firm with downstream assets)	0	1	Simple trading	0.029	0.440
0 (Firm with downstream assets)	1	1	Specialization in generality	−0.002	0.935
1 (Firm lacks downstream assets)	1	0	Synergistic entry	−0.014**	0.007
1 (Firm lacks downstream assets)	0	0	Simple entry	−0.043***	0.000
1 (Firm lacks downstream assets)	0	1	Simple trading	−0.048	0.405
1 (Firm lacks downstream assets)	1	1	Specialization in generality	0.105*	0.059
WHEN: Breadth of demand is equal to:					
25% (More concentrated distribution)	1	0	Synergistic entry	−0.011***	0.001
25% (More concentrated distribution)	0	0	Simple entry	−0.026*	0.085
25% (More concentrated distribution)	0	1	Simple trading	0.122***	0.000
25% (More concentrated distribution)	1	1	Specialization in generality	−0.085***	0.003
75% (More equally spread distribution)	1	0	Synergistic entry	−0.003	0.624
75% (More equally spread distribution)	0	0	Simple entry	−0.037***	0.001
75% (More equally spread distribution)	0	1	Simple trading	−0.088**	0.014
75% (More equally spread distribution)	1	1	Specialization in generality	0.128***	0.001

Note. Robust standard errors clustered by state in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 9 Comparison of Treated and Control Groups

	Average control group	Average treated group	Difference	*p*-value
Number of lasers	1.660	1.817	−0.157	0.4161
Number of patents	67.159	1.364	65.795	0.1886
Firm size	305.535	247.511	58.024	0.7282
Firm age	19.271	16.483	2.788	0.3596
Lack of downstream assets	0.424	0.483	−0.060	0.4362
Breadth of demand	0.666	0.691	−0.025	0.2834

Table 10 Impact of State Economic and Political Characteristics on the Probability of Enacting a New Laser Regulation

Variables	(1) New laser regulation	(2) New laser regulation	(3) New laser regulation	(4) New laser regulation	(5) New laser regulation	(6) New laser regulation
Number of firms				0.001		0.001
				(0.001)		(0.001)
Presence of a dominant firm (top 10 per cent in terms of size)				0.024		0.024
				(0.017)		(0.017)
Number of laser accidents per capita					0.022	0.022
					(0.028)	(0.028)
GDP per capita	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Red presidential elections	0.023	0.021	0.021	0.028	0.019	0.027
	(0.018)	(0.017)	(0.017)	(0.019)	(0.017)	(0.018)
Red governor	−0.003	−0.002	−0.003	−0.003	−0.004	−0.005
	(0.009)	(0.009)	(0.009)	(0.008)	(0.009)	(0.009)
Taxation level		−0.001	−0.001	−1.030	−0.987	−1.120
		(0.001)	(0.001)	(0.838)	(0.866)	(0.888)
Number of lobbying establishments			−0.000	−0.000	−0.000	−0.000
			(0.001)	(0.001)	(0.001)	(0.001)
Year fixed effects	Included	Included	Included	Included	Included	Included
State fixed effects	Included	Included	Included	Included	Included	Included
Observations	471	471	471	471	471	471
R-squared	0.038	0.039	0.040	0.047	0.052	0.060

Note. Robust standard errors clustered by state in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 11 Impact of Increased Downstream Production Costs on the Probability of Pursuing Different Strategies: OLS Estimation Including Time Trend

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Synergistic Entry Investment in general upstream resources = 1, Trading in intermediate markets = 0			*Simple Entry* Investment in general upstream resources = 0, Trading in intermediate markets = 0			*Simple Trading* Investment in general upstream resources = 0, Trading in intermediate markets = 1			*Specialization in Generality* Investment in general upstream resources = 1, Trading in intermediate markets = 1		
Downstream production cost	−0.011	−0.014	0.043	−0.070**	−0.067**	−0.012	0.036	0.099	0.947***	0.041	−0.022	−0.955***
	(0.010)	(0.013)	(0.045)	(0.035)	(0.034)	(0.035)	(0.053)	(0.087)	(0.138)	(0.052)	(0.078)	(0.142)
Lack of downstream assets		−0.009			−0.028*			−0.001			0.037*	
		(0.011)			(0.017)			(0.034)			(0.022)	
Downstream production cost × Lack of downstream assets		0.008			−0.009			−0.156			0.155*	
		(0.012)			(0.029)			(0.099)			(0.089)	
Breadth of demand			0.052			0.074***			−0.388***			0.286***
			(0.051)			(0.022)			(0.066)			(0.059)
Downstream production cost × Breadth of demand			−0.074			−0.080			−1.286***			1.404***
			(0.062)			(0.050)			(0.212)			(0.191)
Number of lasers	0.010	0.010	0.009	−0.011***	−0.012***	−0.012***	−0.033**	−0.034**	−0.028*	0.035***	0.037***	0.031***
	(0.008)	(0.008)	(0.008)	(0.003)	(0.004)	(0.003)	(0.015)	(0.016)	(0.016)	(0.011)	(0.012)	(0.012)
Number of patents	−0.000	−0.000	−0.000	−0.000***	−0.000***	−0.000***	−0.000	−0.000	−0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm size	−0.000	−0.000	−0.000	0.000***	0.000*	0.000***	−0.000***	−0.000***	−0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm age	0.001	0.001	0.001	−0.000	−0.000	−0.000	0.001	0.001	0.002	−0.002***	−0.002***	−0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Year fixed effects	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
States fixed effects	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
Time trend × States dummies	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
Constant	−0.075	−0.050	0.060	1.140***	1.242***	0.137***	0.275	7.331***	1.133***	−0.126	−7.507***	−0.271***
	(0.130)	(0.153)	(0.041)	(0.133)	(0.171)	(0.019)	(0.305)	(0.422)	(0.082)	(0.191)	(0.287)	(0.057)
Observations	783	783	783	783	783	783	783	783	783	783	783	783
Number of firms	204	204	204	204	204	204	204	204	204	204	204	204

Note. Robust standard errors clustered by state in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 12 Impact of Increased Downstream Production Costs on the Probability of Pursuing Different Strategies: OLS Estimation Including Time Trend and Firm Fixed Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variables	*Synergistic Entry* Investment in general upstream resources = 1, Trading in intermediate markets = 0			*Simple Entry* Investment in general upstream resources = 0, Trading in intermediate markets = 0			*Simple Trading* Investment in general upstream resources = 0, Trading in intermediate markets = 1			*Specialization in Generality* Investment in general upstream resources = 1, Trading in intermediate markets = 1		
Downstream production cost	−0.009	−0.020	−0.004	−0.039	−0.109	0.206*	0.030	0.316**	1.859**	0.018	−0.187	−2.061**
	(0.010)	(0.015)	(0.078)	(0.045)	(0.066)	(0.114)	(0.061)	(0.140)	(0.896)	(0.051)	(0.128)	(0.857)
Downstream production cost × Lack of downstream assets		0.027			0.168***			−0.690***			0.495***	
		(0.020)			(0.049)			(0.187)			(0.179)	
Breadth of demand			−0.011			−0.188**			−0.318			0.517**
			(0.014)			(0.084)			(0.331)			(0.253)
Downstream production cost × Breadth of demand			−0.006			−0.338**			−2.527*			2.871**
			(0.109)			(0.154)			(1.250)			(1.204)
Number of lasers	0.009	0.009	0.009	−0.036***	−0.036***	−0.035***	0.003	0.004	0.003	0.023	0.023	0.022
	(0.014)	(0.014)	(0.014)	(0.007)	(0.007)	(0.006)	(0.024)	(0.023)	(0.024)	(0.021)	(0.019)	(0.020)
Number of patents	0.000	0.000	0.000	−0.000***	−0.000**	−0.000**	0.000	0.000	0.000	−0.000	−0.000	−0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm size	−0.000***	−0.000**	−0.000***	−0.000	−0.000	−0.000	−0.000***	−0.000***	−0.000***	0.000*	0.000**	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm age	−0.004	−0.004	−0.004	0.008***	0.007***	0.008***	−0.104***	−0.103***	−0.103***	0.100***	0.100***	0.099***
	(0.004)	(0.004)	(0.004)	(0.002)	(0.002)	(0.002)	(0.006)	(0.005)	(0.006)	(0.007)	(0.006)	(0.007)
Firm fixed effects	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
Year fixed effects	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
States fixed effects	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
Time trend × States dummies	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
Constant	1.587	1.482	1.601	42.569***	41.909***	43.102***	−179.520***	−176.814***	−176.394***	136.364***	134.423***	132.690***
	(6.085)	(6.056)	(6.140)	(4.761)	(4.716)	(4.461)	(10.848)	(11.835)	(10.522)	(11.973)	(13.666)	(8.789)
Observations	783	783	783	783	783	783	783	783	783	783	783	783
R-squared	0.073	0.074	0.073	0.064	0.070	0.067	0.120	0.150	0.126	0.169	0.191	0.185
Number of firms	204	204	204	204	204	204	204	204	204	204	204	204

Note. Robust standard errors clustered by state in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 13 Laser Regulation and Firm Mobility

VARIABLES	(1) Move to another state	(2) Specialization in generality (subsample of non-moving firms)	(3) Specialization in generality (subsample of non-moving firms)	(4) Specialization in generality (subsample of non-moving firms)
Downstream production cost	0.019	0.065**	−0.098	−1.637***
	(0.022)	(0.030)	(0.075)	(0.567)
Downstream production cost × Lack of downstream assets			0.501**	
			(0.223)	
Breadth of demand				0.548*
				(0.280)
Downstream production cost × Breadth of demand				2.370***
				(0.746)
Number of lasers	−0.014**	0.024	0.025	0.022
	(0.006)	(0.029)	(0.026)	(0.027)
Number of patents	0.000	−0.000	−0.000	−0.000
	(0.000)	(0.001)	(0.001)	(0.001)
Firm size	−0.000	0.000*	0.000*	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
Firm age	0.001	0.024***	0.024***	0.025***
	(0.003)	(0.008)	(0.008)	(0.008)
Year fixed effects	Included	Included	Included	Included
State fixed effects	Included	Included	Included	Included
Firm fixed effects	Included	Included	Included	Included
Observations	783	719	719	719
R-squared	0.017	0.119	0.139	0.136

Note. Robust standard errors clustered by state in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure 1 **Effect of an Increase in Downstream Production Costs on the Probability of Specializing in Generality for Different Levels of Demand Breadth**