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## Which industries are served by online marketplaces for technology?

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### ABSTRACT

This study investigates a recent phenomenon in the market for technology: online marketplaces for technological inventions, which support the listing, search, and exchange of technological inventions by sellers and buyers. Focusing on three salient theoretical factors that affect markets for technology—search costs, ambiguity about the underlying knowledge and its applications, and expropriation concerns—our research systematically explores which industries are served by online marketplaces. We exploit the fact that the magnitude of these factors varies across industries and identify key features of online marketplaces that may address these factors. Our proprietary dataset covers 12 online marketplaces for technology and spans over 140 industries. The results indicate that online marketplaces are more likely to serve an industry with (a) a higher cost of searching for technologies in that industry, (b) greater ambiguity about the underlying technology's potential applications across industries, and (c) greater ability to protect inventions from expropriation.

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### 1. Introduction

Markets for ideas and technologies have grown dramatically over recent decades and are receiving increasing attention from both scholars and practitioners (Agrawal et al., 2015b; Arora et al., 2001; Rivette and Kline, 2000). The result is a large body of work investigating a broad range of issues important for the market for technology. These issues include factors driving inventors' participation in these markets (e.g., Bercovitz and Feldman, 2007; Ceccagnoli and Jiang, 2013; Conti et al., 2013; Fosfuri, 2006), the way in which the exchange is organized (e.g., Arora et al., 2013; Laursen and Salter, 2006; Leone and Reichstein, 2012), and institutions supporting the market for technology (Lamoreaux and Sokoloff, 2003; Zhang and Li, 2010).

In this paper, we study an institution that has emerged recently in the market for technology: online technology marketplaces. These marketplaces use information technology and the Internet to facilitate the listing, search, and exchange of inventions between inventors and technology owners or sellers on one hand and prospective licensees or technology buyers on the other (Bakos, 1997; Brynjolfsson and Saunders, 2009; Dushnitsky and Klueter, 2011). For over a decade, a number of marketplaces have operated

successfully, connecting tens of thousands of technology sellers and buyers (e.g., Yanagisawa and Guellec, 2009) and being used by prominent organizations such as NASA, Du Pont, and major academic research institutions (Lakhani et al., 2012; Leone and Reichstein, 2012). Anecdotal evidence suggests that online marketplaces have the potential to expand the reach of markets for technology between sellers and buyers, similar to online marketplaces for consumer goods (e.g., Amazon or eBay), physical products, or real estate (e.g., Craigslist or Zillow) (Brynjolfsson et al., 2011; Brynjolfsson and Saunders, 2009; Dushnitsky and Klueter, 2011; Palomeras, 2007). However, while a growing number of firms participate in such online marketplaces (Agrawal et al., 2015b), we still know little about which industries are actually served by online technology markets in the first place.

The purpose of this paper is to address this gap by investigating which industries are served by online technology marketplaces. That is, we ask: In what industries do online marketplaces exist? Do they extend to technologies from the biotechnology and semiconductor industries as well as the transportation and construction industries? By analogy to online real estate marketplaces (like Zillow.com), we explore whether the marketplaces cater to properties in Boston and San Diego as well as other metropolitan areas like Pittsburgh and Philadelphia. This question is important, as studies in the market for technology typically focus on only a few industries (e.g., pharmaceuticals, chemicals) in which markets for technology are most prevalent (e.g., Fosfuri, 2006; Nishimura and Okada, 2014).

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Yet, we know little about the presence of a market for technology in dozens of other industries (e.g., transportation, construction).

The focal point of the paper is to explain which industries are served by online markets to begin with rather than to focus on consummated transactions between sellers and buyers within a marketplace (implicitly conditioned on the existence of a marketplace). Returning to the real estate analogy, consider the popular marketplace, Zillow.com. We focus on the metropolitan areas covered by Zillow, independent of which properties are ultimately sold. This initial search and identification of sellers and buyers – a stage which precedes the actual bilateral negotiations or deal-making between a pair of participants – has been shown as one of the most crucial but challenging stages in the market for technology, (Agrawal et al., 2015b).

In particular, we examine industry characteristics that impede prospective sellers and buyers from identifying each other, and study the potential of online markets for technology to alleviate these frictions. Our theoretical arguments pivot on three salient factors that affect markets for technology: search costs, ambiguity with respect to the underlying technology and its potential applications, and concerns regarding appropriation (Akerlof, 1970; Coase, 1960; Klevorick et al., 1995; Stigler, 1961; Teece, 1986). The frictions associated with these factors may prevent sellers and buyers from identifying each other and, in the extreme case, may altogether preclude participation in the market for technology (Arora et al., 2001; Teece, 1986). We exploit the fact that the magnitude of these frictions varies across industries and identify key features of online marketplaces that may address these frictions. This approach allows us to conjecture as to which industries can benefit from being served by online marketplaces and to empirically demonstrate what industries online marketplaces do – or do not – serve. Table 1 summarizes our key arguments.

We posit that industries characterized by high geographic dispersion and firm fragmentation impose high search costs on industry participants. In those industries, an institution such as an Internet-based online marketplace can likely offer valuable services to facilitate interaction and identification among prospective sellers and buyers of technology (Forman et al., 2009; Lamoreaux and Sokoloff, 2003). Similarly, in industries with high ambiguity about the underlying technological knowledge and its potential applications, sellers and buyers may face challenges in sharing, communicating, and evaluating technological inventions. Online marketplaces mitigate ambiguity and direct buyers' and sellers' attention by offering a codified representation of all the listed technologies in a highly standardized manner. Online technology marketplaces therefore enable the assessment of a focal invention's applicability, and facilitate its valuation by benchmarking it to the many other listed inventions. However, not all industries with high search costs and knowledge ambiguity will see the emergence of online marketplaces. Rather, the advent of such an institution is shaped by its ability to protect inventors' intellectual property (Teece, 1986). Because inventions that are disclosed, codified, and aggregated online can be at risk of imitation, we expect online markets to serve industries in which inventions cannot be easily expropriated, namely, industries that are characterized by strong appropriation regimes.

We test our predictions using a hand-collected sample of 12 online technology marketplaces that connected inventors and technology sellers with technology buyers in 2008. These marketplaces address specific industries and facilitate the listing, search, and exchange (i.e., licensing, sale, etc.) of innovative technologies between globally distributed parties. In the aggregate, the online technology marketplaces in our sample serve over 100 different industries in agriculture, manufacturing, and information technology. Importantly, the cross-section of industries in our data allows us to observe notable variation in search costs, knowledge

ambiguity, and appropriation concerns across industries. We can therefore investigate the impact of these industry characteristics on the presence of online markets for technology for a given industry. Our findings suggest that online-based marketplaces are not ubiquitous as one might expect. We observe systematic variation in the number of online marketplaces across industries, and that the variation is explained by the predicted critical factors (i.e., search costs, knowledge ambiguity, and appropriation). These findings illuminate the unique role of information technology in the market for technology and suggest the potential for the expansion of the market for technology through online markets.

Finally, qualitative data and interviews with managers using online technology marketplaces further substantiate the implication of our investigation. The interviews reveal that transactions in the market for technology often originate online, where the parties initially identified each other, and proceed in interaction and negotiations that are consummated offline (Arora, 1996; Hagi and Yoffie, 2013). This finding suggests that online marketplaces have considerable potential to address frictions between sellers and buyers and serve as an important starting point for industry participants to identify each other. This aspect is not much different from the real estate context, where online listings facilitate the identification of opportunities and offline interaction remains important for subsequent actions such as inspection, due diligence, and potential haggling before a property ultimately changes hands.

Our study is among the first to systematically examine multiple online markets for technologies that mold the interactions among sellers and buyers prior to consummation of a deal. Importantly, it expands the perspective on markets for technology to dozens of industries that have received little attention. Studying online markets for technology provides new insights into which industry characteristics lead to coverage of such markets by online technology marketplaces. In doing so, it sheds light on the initial stage of the market for technology, where prospective sellers and buyers initially search for, identify, and interact with each other. More broadly, the study explains the unique characteristics of online marketplaces and the role of information technology in shaping the market for technology in the face of search costs, knowledge ambiguity, and appropriation concerns between sellers and buyers. We elaborate on the implications of these findings in the discussion section.

## 2. Theory and hypotheses

### 2.1. The market for technology

Prior work indicates that inventions can be codified and “disembodied” from the original inventor so that development and commercialization are not limited to the inventing person or company (Conti et al., 2013). Accordingly, a market for technology may emerge in which participants with new technologies interact with participants who can commercialize the technologies and exchange inventions for a price (Arora et al., 2001).

Although the market for technology is growing rapidly (Arora and Gambardella, 2010), we know little about either the extent to which it supports gainful innovation or the specific pattern of its emergence across industries. Prior work has investigated a host of factors that influence the way prospective sellers and buyers identify each other and interact in the market for technology (Agrawal et al., 2015b; Arora et al., 2001; Gans and Stern, 2003). This study focuses on three of the most salient frictions this literature identifies, which relate to (a) the cost of searching for quality inventions across different geographies and companies, (b) the challenge of communicating and assessing technologies when ambiguity exists about the underlying knowledge and its potential applications, and

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