Determinants, causal connections and outcomes of corporate technology licensing: A systematic review and research agenda[1]

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Abstract

Exchanges in markets for technology (MfT) have grown rapidly in recent years. MfT involve transactions for the use, diffusion and creation of technology. In this article we conduct a systematic review of the emerging market for technology literature and examine one of its most important aspects, corporate technology licensing. Using thematic analysis, we systematically review 78 papers published in 29 journals over 30 years covering the academic disciplines of technology/knowledge management, strategic management, entrepreneurship, innovation management and industrial economics. Based on this analysis, we present an organizing framework for the most prominent determinants, causal connections and outcomes of technology licensing research to date, and identify a research agenda highlighting important avenues for future research in this domain.

Keywords: Technology commercialization; markets for technology; systematic review; technology licensing.

1. Introduction

Exchanges in markets for technology (MfT) have grown rapidly in recent years (Gambardella, 2010). MfT involve transactions in technological alliances, licensing agreements, R&D contracts, acquisitions and joint ventures (Arora, 2001), all of which have been attracting increasing attention from practitioners and academics (Lamoreaux and Sokoloff, 1999; Thursby and Kemp, 2002). MfT have contributed to the substantial growth in technology transfer activities of small specialists as well as larger firms. High-tech industries such as chemicals, electronics and software have seen a proliferation of small, specialist technology producers which operate upstream and license their technologies in MfT (Arora, 2001; Di Stefano, 2012; Hall, 2001). Larger firms have also relied significantly on external sources of knowledge in order to gain access to new technologies and enhance their performance (Chesbrough et al., 2006; Cohen and Levinthal, 1990; Conti, 2013; Rivette and Kline, 2000; Rønde, 2013; Tripsas, 1997).[1] As a result, a distinct literature focusing specifically on technology licensing in MfT has emerged (Gambardella, 2010). In this paper we use the term '*corporate technology licensing'* to refer to licensing between two partners for the transfer of knowledge in MfT (Arora et al., 2001).

This systematic review was motivated by a quest to map the emerging MfT literature and examine one of its most important aspects, corporate technology licensing, and specifically its determinants and outcomes. Since the seminal work by Arora, Fosfuri, and Gambardella (2001), there has been a rapidly growing body of research on technology licensing. We therefore see a need for a comprehensive review and synthesis of the determinants and outcomes of this important strategic decision. Since the research on corporate technology licensing is

[1] In the open innovation paradigm, firms increasingly use external sources of knowledge in their innovation activities (Chesbrough *et al.* 2006). Apart from acquiring technologies in MfT, large firms also supply their knowledge assets. For example, in 2001, IBM received more than $1 billion in licensing revenues, representing one-ninth of its pre-tax profits for that year (Rivette and Kline, 2000).

heterogeneous in terms of theory, methods, and samples, we provide a systematic literature review with the objective to identify research gaps that offer opportunities for future research (Frank and Hatak, 2014). Given its success in medicine, the systematic review methodology has been adopted in many fields (e.g. education, social policy research and management) (Briner et al., 2009; Cunningham et al., 2016; De Medeiros et al., 2014; Hackett and Dilts, 2004). Our review strategy was designed to provide a systematic and explicit method for reviewing the determinants and outcomes of corporate technology licensing in the MfT. Using thematic analysis (Dixon-Woods et al., 2005a; Thomas and Harden, 2008), we systematically reviewed 78 papers published in 29 journals over 30 years covering the academic disciplines of technology/knowledge management, strategic management, entrepreneurship, innovation management and industrial economics. Based on this analysis, we present an organizing framework for the most prominent determinants, causal connections and outcomes of corporate technology licensing research to date, and identify a research agenda highlighting important avenues for future research in this domain.

The results of the systematic literature review (SLR) point to three important gaps in prior literature which constitute promising areas for future research. First, extant research does not take into account how the *demand* side shapes technology strategies nor the dynamic nature of markets for technology and the long-run configuration of small, specialist firms' strategies in the wider ecosystem. Second, prior literature on licensing has drawn primarily on transaction cost economics (TCE), the resource-based view (RBV) of the firm, and the economics of innovation perspective (EoI). Future research, however, might adopt more recent perspectives to examine licensing such as the resource orchestration, innovation ecosystems and open innovation perspectives thereby contributing to the further convergence of the MfT and strategic

management literature. Third, an important observation drawn from the literature review is the lack of longitudinal studies and the omission of sample selection and endogeneity correction methods. Future studies should address the above methodological issues in order to tackle current challenges in empirical research on licensing and move the field forward.

We begin our literature review by addressing the *scope* of MfT. We then move on to examine the *domain* of MfT. Following a detailed description of our review strategy, we then present a systematic review of the literature that addresses the fundamental question of what factors condition the formation and growth of corporate technology licensing in the MfT, which represents the bulk of the literature on MfT. Using thematic analysis, we systematically synthesize the findings of previous studies that have examined the determinants of corporate technology licensing in MfT. We also identify the causal connections and outcomes reported most frequently in previous work. Finally, we describe our model and summarize our findings, identifying avenues for future research.

2. Definitions

A market for technology can be described as ‘transactions for the use, diffusion and creation of technology’ (Arora et al. 2001a, p.423). Technology in MfT can take the form of "intellectual property" (patents) or intangibles (e.g., a software program, or a design), or it can be embodied in a product (e.g., a prototype, or a chip), or it can take the form of technical services. Thus, technology transactions can take different forms, from pure licensing of well-defined intellectual property, to complicated collaborative agreements which may include the further development of the technology, or its realization from scratch (Arora et al., 2015).

Transactions in MfT have been conceptualized in various ways. Whereas narrow conceptualization describe strictly anonymous arm’s-length transactions involving exchanges of

goods for money (Gambardella, 2010), broader conceptualizations encompass transactions in technological alliances, licensing agreements, R&D contracts[2], acquisitions and joint ventures.

We focus our review specifically on *technology licensing* between two partners for the transfer of knowledge in MfT because this represents the bulk of the MfT literature (Arora et al., 2001). Corporate technology licensing involves both horizontal and vertical market licensing as well as the licensing of existing and future technologies (Arora et al, 2001). We define a licensing contract as a less integrated, more market-based alternative that enables firms to profit from their innovation (Fosfuri, 2006). We specifically *exclude* MfT transactions that are purely focused on alliances or R&D contracts, acquisitions and joint ventures and which explicitly do not involve any licensing. We also exclude licensing relating to university inventions because it differs from company technology licensing with respect to the institutional, organizational, and individual context dimensions (Phan and Siegel, 2006). In sum, our review of the literature on technology licensing includes transactions[3] involving mainly technology licensing but also other arrangements which explicitly include licensing.

3. Review strategy and descriptive data

3.1 Review strategy

Our review strategy was designed to provide a systematic and explicit method for reviewing the determinants and outcomes of corporate technology licensing in MfT. The review followed the protocols outlined by Tranfield et al. (2003) and included published peer-reviewed articles held within the following databases: Web of Science, ProQuest, Business Source Complete, Science

[2] Often, transactions for technology involve quite detailed contracts and may be embedded in technological alliances of some sort. These include arrangements in which the parties agree to conduct activities, jointly or independently, leading to future developments of technologies that will be exchanged (or jointly owned) among them. This is typically the market for contract R&D and the various technological alliances and joint ventures (Arora et al., 2015).
[3] Market transactions in technology may also take the form of intellectual property (patents) or copyrights and trademarks, all of which are included in our definition.

Direct, Emerald and Jstor. Following previous SLRs in entrepreneurship (Macpherson and Holt, 2007), we have chosen to start with a broader database search (rather than narrow journal searches) in order to ensure coverage of all papers on technology licensing. Although this approach may have certain limitations due to the large number of returns using our search terms (Henry et al., 2015), it meant that our review was not limited to specific journals or authors who publish in this area, which is a precondition for a complete, exhaustive summary of the literature (Tranfield et al., 2003). First, the review team identified keywords (search terms) based on their prior experience. These included, among others, *technology licensing*, *licensing decision*, *technology commercialization strategies* and *markets for technology*. The keywords were then constructed into search strings.[4] An initial search of six databases was undertaken using the basic strings 'technology licensing', 'technology commerciali?ation', 'commerciali?ation of technology', 'market for knowledge/technology' and 'technology commerciali?ation strategy'.[5] Each database was interrogated by the search strings listed above. Titles and keywords were searched, with search date and numbers returned recorded. In order to refine the search and following previous SLRs (Macpherson and Holt, 2007), all studies identified from the above search terms were reviewed according to the inclusion and exclusion criteria (Table 1).

INSERT TABLE 1 ABOUT HERE

More specifically, studies (published peer-reviewed articles) that were initially retrieved from the database search were exported to Endnote, where they were further reviewed against the inclusion and exclusion criteria using keyword searches and title analysis. Duplicate studies were

[4] Tables are available from the authors on request.

[5] We include these broader search terms in order to ensure that we do not miss papers examining licensing activities but which do not explicitly include licensing in their title or keywords. E.g. In Arora et al.'s (2001) seminal paper 1) the title does not include "licensing" and 2) nor do the keywords. While the first search terms are directly related to licensing, we believe the second, broader set of search terms was necessary to be able to provide a more complete review of the literature.

deleted, which reduced the relevant articles to 358. We then conducted a thorough review of the abstracts, which led us to classify the articles into four categories: primary, secondary, peripheral and not relevant.[6] In order to reduce further the number of articles, an abstract screening and thorough review of the papers was undertaken and this process identified the final 78 studies included in the systematic review (Pittaway et al., 2004).[7]

Thematic analysis was used to identify the most recurrent themes in the studies included in our literature review and to summarize the findings of previous studies under *thematic* headings (Dixon-Woods et al., 2005a). Thematic analysis was chosen for two reasons: first, because it allows reviewers to deal with both qualitative and quantitative evidence (Barnett-Page and Thomas, 2009); and second, because it provides potential for theory building (Dixon-Woods *et al.*, 2005b; Lucas *et al.*, 2007). Our central focus was to delineate the determinants and outcomes of corporate technology licensing by systematically reviewing empirical and theoretical evidence fitting pre-specified eligibility criteria (Higgins and Green, 2008). These determinants and outcomes were revealed from the thematic coding process and analysis of the literature. Next, we also coded the theoretical perspectives used to establish the link between the determinants and outcomes in the articles reviewed. Following Keupp and Gassman (2009), we labelled this category "causal connection", representing the theoretical foundation of the relationship between licensing determinants and outcomes. By doing so, our thematic analysis strategy not only provides a *descriptive* account of the literature, but also allows for an

[6] Studies relating directly to technology licensing with implications for policy and practice that had a high level of coherence and contribution were categorized as primary articles. We classified as secondary articles those with information on only theory or findings or which made limited contributions to policy and practice. Finally, peripheral articles were those with theories that were not evidently relevant to *technology licensing* and/or with findings that were unrelated to policy and practice. For example, articles whose relevance to technology licensing was ambiguous such as papers focused purely on alliances where classified as peripheral.

[7] The full protocol followed in the review process is available from the authors upon request.

understanding of the most prominent theoretical perspectives connecting determinants and outcomes (see section 4 for thematic analysis results).

3.2 Descriptive data

The results show that corporate technology licensing has been studied in a number of fields, as it stretches across a broad range of journals and disciplines, including industrial economics, strategic management, technology management, entrepreneurship, and innovation management. The key journals contributing to the review in terms of their coverage of this topic are *Research Policy (21)*[8], *Strategic Management Journal (10), R&D Management (7), Industrial and Corporate Change (6), Management Science (5), Organization Scienc*e *(3), The RAND Journal of Economics (3) and The Academy of Management Journal (2).* In addition to these, the review sourced articles from another 21 journals. When the year of publication is taken into account, it becomes clear that there was an upward trend in articles on technology licensing between 1986 and 2015 (see Figure 1).

The reviewed papers were also analyzed according to the countries studied (Table 2) and industrial focus (Table 3). The locus of the studies has been primarily in North America, Germany and the rest of Europe (led by the United Kingdom) and Asia (led by Japan). About half (50 per cent) of the studies have focused on the US, demonstrating not only that technology licensing has been particularly pertinent to US institutions, but also that the findings are generalizable to this particular setting. Factors causing the popularity of research on MfT in the US include policy and institutional factors, such as the Bayh-Dole Act (Lamoreaux and Sokoloff, 1999; Mowery and Ziedonis, 2002).

INSERT FIGURE 1 AND TABLES 2 AND 3 ABOUT HERE

[8] The number of articles published in each journal.

In terms of sector, a large proportion have been mixed sector studies. The sample of papers reviewed is biased toward high-technology (72 per cent) and manufacturing (18 per cent) industries. Industries such as services are under-represented, which underlines the specific settings in which MfT can grow. The reasons why biological and engineering sciences are more important to licensing activity than other sectors such as the physical sciences have been reported in previous studies (Cohen et al., 2000; Levin, 1987; Thursby and Kemp, 2002). Thursby and Kemp (2002) attribute this to the more applied nature of engineering and the better market opportunities and orientation toward markets of biological sciences. While several recent studies have reported increases in licensing activities and revenues, this increase is apparently pertinent to only a small number of firms operating in specific industries and countries. In other words, although technology markets are growing, they are limited in extent and in their industrial and geographic scope (Gambardella, 2010).

Nearly 64 per cent of the studies used quantitative methodologies and the remaining 36 per cent were either conceptual papers or used qualitative methods. It is evident that only a small number of studies have included a time component (Figure 2). Panel data methods and hazard rates have rarely been employed in the MfT literature, thus neglecting important dynamic interactions between technology and product markets.

INSERT FIGURE 2 ABOUT HERE

4. Review findings

Our analysis converged on an analytical framework comprising three overarching categories that we label ‘determinants’, ‘causal connections’ and ‘outcomes’ of corporate technology licensing. Our organizing framework (see Figure 3) exhibits the most frequently occurring topics in the wider MfT and licensing literature. The counts in each block show the

occurrence of a variable in the papers reviewed. This highlights the most prominent variables used in the literature and those that have received less attention (Keupp and Gassmann, 2009). The determinants, causal connections and outcomes of corporate technology licensing that emerged from the systematic review are analyzed next.

INSERT FIGURE 3 ABOUT HERE

4.1. Individual-level determinants

The systematic review identified the prior licensing experience of owners and managers as well as their risk-taking propensity as an important determinant of corporate technology licensing (Atuahene-Gima, 1992). Managers with prior licensing experience have less difficulty in searching for, selecting and absorbing external technology through licensing. Risk-averse managers prefer licensing technology over internal R&D due to the higher costs and uncertainty associated with performing technology development in-house. In addition, the level of management stockholdings in a firm also influences the perceived threats associated with licensing, and ultimately determines the choice of licensing over acquisition (Steensma and Corley, 2001). When management stock options are high, threats of opportunism and commercial risk are less relevant in decisions regarding firm boundaries. The systematic review identified management's perception as an important determinant of licensing (Atuahene-Gima and Patterson, 1992). Perceptions of the relative costs and benefits of licensing as well as managers' perceptions of the external environment are likely to influence the licensing decision of the firm. Apart from the managers perceived costs of licensing which may impede licensing, the perceived loss of decision-making autonomy is another major impediment to licensing.

4.2. Firm-level determinants

Most studies have discussed firm-level determinants of corporate technology licensing (90%). Complementary assets, technology characteristics, IPRs, external funding, firm size, and R&D

intensity are among the most cited factors that condition firm licensing. A key factor affecting returns from licensing that has been prominent in the MfT literature is the concept of complementary assets (Arora, 2006; Chesbrough et al., 2006; Jacobides and Billinger, 2006; Teece, 1986). Complementary assets are important because they can help innovators to appropriate value from their technology by investing downstream. Other studies have identified the 'mobility' of complementary assets as a determinant of profiting from technologies (Jacobides, 2006; Williamson, 1981), which suggests that firms' strategic choices are dynamic and complex and that they can advantageously shape their strategies towards complementary assets in order to profit from innovation.

A large proportion of studies has focused on the nature of the technology traded and its effects on technology licensing. Generally, the supply of technology in these markets is greater when there is greater protection, more codified or general knowledge, non-core technologies and less firm-specific knowledge (low asset specificity), and when the patent is of greater economic value (Bresnahan, 1995; Fosfuri, 2006; Gambardella, 2007; Nerkar and Shane, 2007). Most studies that we examined investigated the effects of technology characteristics on the decision to license, without considering the intermediate effects of acquisition and accumulation of the technology, or the subsequent capability development affecting technology licensing and performance.

The appropriability regime has been consistently examined in the wider MfT literature. Appropriability studies have shown that weak IPR innovators move downstream, whereas strong IPR innovators favor licensing (Gans, 2002). Formal IPRs facilitate gains from technological trade (Gans, 2008), whereas appropriability problems may seriously retard inter-firm technology transactions (Teece, 1986). Various explanations have been offered for the way in which firms in

different industries protect and extract value from their innovations (Cohen et al., 2000; Leiponen, 2009; Levin, 1987). Research has shown that patents are still not the major mechanism for appropriating returns from innovation in most industries, and that secrecy, lead times and complementary marketing and manufacturing capabilities may protect firms' profits from invention (Cohen et al., 2000; Levin, 1987). More recent work has suggested that appropriability regimes may be endogenous to the firm: firms may influence their appropriability regime, given their complementary assets position (Pisano, 2007), and realize strategic gains by setting industry standards or guaranteeing freedom to operate. In general, appropriability may also be fostered by weakening or loosening the appropriability regime as part of the firm's strategy to profit from innovation. Merck's Gene Index and open source software are examples of making findings publicly available, enabling firms to shape their appropriability regimes strategically in order to stimulate momentum for their technology and protect future areas for research (Pisano, 2007).

From our thematic analysis, it is evident that firms engaged in ties with reputable VCs see substantial boosts in co-operative activity through licensing (Hsu, 2006). The role of financing in new ventures' licensing strategies has attracted increased interest in the licensing literature. Also, internal R&D is an important determinant of licensing. Inputs into innovation have been extensively studied in the innovation management and strategic entrepreneurship literatures. The evidence shows that the presence of relatively poor internal R&D productivity tends to increase a firm's propensity to acquire technology in technology markets (Ceccagnoli, 2010). In addition, firms that are engaged in only a single innovation activity (either internal R&D activities or external sourcing of knowledge) are found to introduce fewer new or substantially improved products than firms that combine internal and external sourcing (Cassiman, 2006). Preliminary

research suggests a complementary relationship between internal and external R&D (Cassiman, 2006); however, more research is needed to examine the dynamic interrelationship between product and technology markets. As technology buyers may also have internal R&D, we need to investigate more closely whether external innovation sources are more valued in industries with high levels of R&D, or in low-level R&D industries where firms lack internal capability and thus are more dependent on external sources (Chesbrough, 2002). Small, specialist firms who license and thus diffuse their technology may be unable to survive in the future merely as suppliers of technology (Gambardella, 2010). Finally, our systematic review identified firm size as an important determinant of the actual occurrence of patent licensing (Gambardella, 2007; Lieberman, 1987).

4.3. Industry-level determinants

Industry structure has been examined extensively in the literature (Arora, 1997; Fosfuri, 2006; Gambardella and Giarratana, 2008). At the industry level, MfT may lower barriers to entry, increase competition and reduce product lifecycles, all of which need to be managed with relevant strategic configurations (Arora, 2001). Strategies vis-à-vis internalizing and externalizing knowledge assets should not neglect factors such as entry barriers, product differentiation, competition, market share of industry players, industry homogeneity, uncertainty and industry stage. Specifically, firms are less likely to license when there are many competitors in a product market, as licensing revenues will be too low (Fosfuri, 2006). In addition, product differentiation reduces the rate of licensing, because licensing technologies to competitors in the same product niche means that more profits will be destroyed than if both firms operate in more homogeneous markets (Arora, 2003; Fosfuri, 2006; Gambardella and Giarratana, 2008; Lieberman, 1987). The results of thematic analysis of the determinants of corporate technology

licensing corroborate the importance of industry structure considerations when developing decisions regarding the commercialization of knowledge assets.

A key determinant that has received increased scholarly attention is the legal and regulatory environment of firms and research institutions (Klein, 2005). Differences in regulatory structures and in interpretations of contractual clauses may greatly influence licensing strategies, thus exposing the crucial role of innovation policy in fostering economic growth and technological progress. Finally, in terms of location in the context of technology markets, licensing is more likely to be chosen in a distant market in which the market share of the licensor is small and the downstream market is highly competitive (Arora, 2001; Gambardella and Giarratana, 2008).

4.4. Outcomes

The most prominent outcome in our literature review is firms' out-licensing activity (55%). This shows that a significant amount of licensing research has focused on the antecedents of the firm's decision to license-out technology to other companies. These studies seek to identify factors that induce a firm to license-out technology. It is striking how in-licensing (15 counts), reflecting the *demand* side of licensing, has received considerably less attention than out-licensing (43 counts). Research on corporate technology licensing seems to have focused narrowly on the *supply* side of technology, with very little focus on the demand for external technology (Ceccagnoli and Jiang, 2013; Ceccagnoli, 2010; Gambardella, 2010). Most MfT literature has been driven by determinants influencing the supply of technology, largely ignoring the demand perspective (Gambardella and Giarratana, 2008).

Our literature review also reveals that a considerable number of studies (24%) use licensing as an independent variable linking it to firm performance such as profit and market share (Zahra and Bogner, 2000) and innovative performance such as new patents and products

(e.g. Nicholls-Nixon and Woo, 2003). The majority of these studies examine how licensing-in technology influences firm performance and innovative performance (10 counts). By licensing-in external technologies, firms can gain several benefits such as speeding up product development and avoiding the costs of internal development (Granstrand et al., 1992). In addition, accessing external technology also contributes to the firm's technological knowledge and strengthens its technological capability (Chatterji, 1996). However, strong internal R&D capabilities are necessary in order to enjoy the benefits arising from licensing-in external technologies. Indeed internal R&D and external technology-sourcing function as complements rather than substitutes (Cassiman and Veugelers, 2006; Tsai and Wang, 2007). Some studies link licensing-out to firm performance and innovative performance (8 counts). Licensing-out drives firm performance (Giarratana, 2004) but the extent to which firms can profit from their innovation is conditioned by their dependence on complementary assets held by incumbents (McGahan and Silverman, 2006). Kline (2003) goes beyond financial performance indicators and argues that licensing-out technologies may give rise to the establishment of new industry standards.

4.5. Causal connections

Our systematic literature review reveals that there are three dominant theoretical perspectives in the licensing literature: TCE (17 counts), RBV/Capabilities/Learning (17 counts), and EoI (28 counts). Studies employing TCE typically link asset specificity and the level of uncertainty to the decision to license-in external technology. Under conditions of high transaction costs due to high levels of asset specificity and/or uncertainty, firms are more likely to acquire technologies externally or develop technologies in-house, rather than license-in technologies from third parties (Schilling and Steensma, 2003; Ceccagnoli et al, 2010). Next to TCE, a significant number of studies on firm licensing use the RBV, capabilities and learning perspective. Most studies using RBV focus on the role of resources and capabilities in the formation, governance and

performance of collaborative relationships. For instance, Arora and Ceccagnoli (2006) use the resource-based theory of the firm to argue that firms lacking specialized complementary assets have higher payoffs from licensing compared to firms endowed with high levels of specialized complementary assets. Another stream of the literature focuses on the process of learning from collaborative relationships. For instance, Anand and Khanna (2002) use learning theory to examine whether firms exhibit learning effects across a portfolio of alliances. Nicholls and Woo (2003) argue that greater use of R&D contracts and licenses is associated with stronger reputation for possessing expertise in biotechnology and that both internal and external R&D are needed to build the firm's absorptive capacity. Fewer studies focus on the knowledge integration capabilities of firms. Ceccagnoli and Jiang (2013) argue that the buyer's cost of integrating a licensed technology can be affected by suppliers' knowledge transfer capabilities. The most prominent theoretical perspective used in the studies included in our review is the EoI. This perspective draws primarily on the seminal work by Teece (1986) where he elaborated on the role of complementary assets and the appropriability regime in determining the compete versus collaborate decision. In essence, licensing relies on the firm's dependence on complementary assets and/or the strength of the appropriability regime (Gans, 2002). Our review also shows that only a small number of studies adopt a multi-theoretic approach (11 studies). The overwhelming majority of these studies integrate the TCE perspective with RBV (3) or EoI (4). Importantly, a large proportion of the studies specify no clear theoretical framework (27%), despite our systematic effort to select studies with somewhat more reliable evidence.

4.6. Trends in determinants, outcomes, and causal connections

The following figures show the trends in the licensing literature with respect to determinants, outcomes and causal connections. Figure 4 clearly demonstrates that the literature has primarily

focused on firm level determinants of licensing, followed by industry level determinants, whereas only a minority of studies have focused on individual level determinants. Studies increasingly examine firm and industry level determinants of licensing over individual level ones.

INSERT FIGURES 4, 5, 6 ABOUT HERE

Figure 5 shows the trends over time in the theories used in the licensing literature. EoI is the most prominent perspective, closely followed by RBV and TCE. A large number of studies did not specify a clear theoretical framework. Finally, figure 6 demonstrates that studies in MfT increasingly examine out-licensing as an outcome variable. More recently, scholars have started investigating other outcomes in the MfT such as firm performance, innovative performance and licensing-in. However, these outcomes are disproportionately underrepresented in the literature compared to licensing-out.

5. Future directions for MfT research

The purpose of this study was to systematically map the MfT literature and identify the determinants of corporate technology licensing. Using thematic analysis, we reviewed 78 papers covering the wider MfT literature published in 29 journals over 30 years. In the next section we relate the findings from the systematic review to what we believe are the major knowledge gaps that define the need for future research in this area, and elaborate suggestions for future research directions.

5.1. Need for new design methodologies: longitudinal studies and endogeneity problems

First, an important observation drawn from this systematic review is that very few studies have used a time component (see Figure 2). In addition, panel data methods have rarely been

employed in MfT research (only 3 studies out 78). Thus, we have a static view of technology markets and we lack insight into the long-run configurations of small, specialist firms' strategies. Second, this lack of focus on the dynamics of MfT is also revealed in the single unit of analysis adopted by the majority of the articles reviewed (76%) (see Figure 4). The unit of analysis has been primarily at the firm level, and subsequently at the industry (33%) and individual level (4%). There is a need for further research on the role of managers in the licensing decision. The individual level only received limited attention in the literature to date (see Figure 4). Future research could examine the decision-making process regarding the corporate licensing choice by drawing on the strategic decision-making perspective (Eisenhardt and Zbaracki, 1992). Few papers (4%) examine the macro level and how policy issues affect technology licensing. We call for future research to examine in greater detail how policy influences corporate technology licensing by performing cross country studies. Such studies could draw on the emerging literature on public-sector entrepreneurship[9] (Leyden, 2016), which refers to "innovative public-policy initiatives that generate greater economic prosperity by transforming a *status quo* economic environment into one that is more conducive to individuals in either the public sector or the private sector engaging in greater innovative activities in the face of uncertainty" (Leyden, 2016: 557-558). Future empirical studies could examine how differences between countries in direct (e.g. institutional structures) and indirect (e.g. extrinsic incentives) public-sector entrepreneurship influence the rate of corporate technology licensing. Multiple levels of analysis are better able to address the complex exchanges in MfT, as well as the effects of corporate technology licensing on the whole value chain (Jacobides et al., 2006). The inadequacy of the existing literature to address the above dynamic considerations may be a significant

[9] We thank an anonymous reviewer for this point.

impediment to the development of the field. Future research on licensing might benefit from more longitudinal research designs that go beyond the focus on a single level of analysis.

A third observation from the systematic review is that econometric methods for the correction of sample selection and endogeneity have been lacking (see Figure 2). Of the 52 quantitative papers, only five were concerned with potential biases due to the endogenous choice between alternative strategies, and five of these employed correction techniques. This is surprising, as basic empirical techniques accounting for omitted variables and endogenous self-selection have been available for decades (Hamilton and Nickerson, 2003). Studying the choice of strategies and their causal effect on new ventures' performance is inherently endogenous; appropriate techniques must therefore be employed to correct for endogeneity (Gans, 2002). In addition, firms that choose to license-in or license-out are not a random set. Selection biases are common in studies of innovation, as simply observing these start-ups does not take into account that these firms (innovative start-ups) are not a random sample. Therefore, another empirical challenge for the study of corporate technology licensing is to overcome sample selection issues which may distort results. Future research on MfT should address common empirical challenges such as selection and endogeneity issues.

5.2. Need for new topics: demand side and market dynamics

Our review shows that research on the demand side of external technology in the MfT literature is strikingly limited. Indeed, the focus of trade in technology has generally been on the supply side ignoring the role of potential buyers in MfT. The most studied outcomes of corporate technology licensing have been the rate, pattern and value of out-licensing (55%). Remarkably, in-licensing (*demand* for external technology) has received considerably less attention than out-licensing (only 19% of the studies included in our review) (see Figure 6). As a result, current studies do not account for the complexities of the joint occurrence of in-licensing (Jason and

Wang, 2015). For instance, the relationship between making and buying technology has not been systematically investigated (Gambardella, 2010). Future research might examine the determinants that influence the demand for external knowledge. Other questions might include: how demand interacts with supply in technology markets; how 'not invented here' (NIH) syndrome affects the demand for external technology; the role of absorptive capacity in evaluating and integrating external knowledge from trade; whether there is a substitution relationship between internal and external knowledge; and how interactions between demand and supply may offer a better understanding of the complexities involved in the technology trade (Gambardella and Giarratana, 2008). By analyzing more explicitly the demand side of technology licensing, future research should be able to provide a better understanding of what limits and facilitates licensing between firms (Ceccagnoli and Jiang, 2013).

Inputs into innovation have been extensively studied in the innovation management and strategic entrepreneurship literatures; however, how R&D markets work and how they influence firms' innovative activities are areas offering many opportunities for additional conceptual and empirical work. For instance, the role of a firm's absorptive capacity in its ability to evaluate and utilize external knowledge effectively is unclear (Ceccagnoli and Jiang, 2013; Conti, 2013). In the context of corporate technology licensing, it would be interesting to examine how a firm's internal organization shapes its acquisition and integration of externally sourced knowledge. Thus, integrating the notion of *absorptive capacity* (Cohen and Levinthal, 1990) and *transaction cost theory* (Williamson, 1981) with the literature on corporate technology licensing could enhance our understanding of the relationship between in-house R&D and external know-how. The ability to combine internal and external knowledge sourcing is a critical source of competitive advantage (Cassiman, 2006).

Most studies that we examined have investigated the effects of technology characteristics on the decision to license-out without considering the intermediate effects of acquisition and accumulation of the technology, or the subsequent capability development that affects technology licensing and performance. Technology buyers, who have been given less attention in the literature, may also have internal R&D. Are technology buyers attracted by the same technological characteristics that drive the supply of technology? In addition, can firms strategically use MfT strategies to connect with other actors in an entrepreneurial ecosystem? How do technology characteristics influence the role of firms in the wider ecosystem? Research is needed to delineate the characteristics that make a technology tradable for both the internalization and externalization of knowledge. Introducing the *open innovation* paradigm and integrating it with current perspectives on technology licensing could improve our understanding of both outside-in and inside-out movements of technologies and ideas (Chesbrough et al., 2006; van de Vrande et al., 2009).

A second important observation is the limited understanding of the dynamics of technology markets (Gambardella, 2010). Small, specialist firms inevitably diffuse their technology, and are therefore unable to fully appropriate the gains from their innovation. In their appropriation efforts, they may try to form alliances in MfT and access downstream assets for the development of their technology. They may also provide complementary services associated with their technology (Arora et al., 2001). If such firms fail to develop the necessary capabilities to create a second innovation, then their sustainability in the long run is severely threatened. The long-term configurations of small, specialist firms' strategies are inadequately reflected in the literature, and we lack a systematic understanding of how these firms create value for their customers in the long run (Clarysse et al., 2011). We also have limited information on ways in

which small, specialist firms create wealth for their stakeholders, as acquisitions are typically excluded from studies of MfT. Because moving downstream can be very difficult for small, specialist firms, being able to survive and grow presents a big challenge to them. Future research might investigate the resources acquired through an MfT or MfP strategy and examine how these are managed to create competitive advantage for firms. We expect that integrating corporate technology licensing and the *resource orchestration* (Sirmon et al., 2010) and *innovation ecosystem* (Nambisan and Baron, 2013) perspectives might provide insights into the dynamics of MfT and shed light on the strategic resource allocation decisions of MfT and MfP firms. We elaborate on this in the next section.

5.3. Need for new perspectives: resource orchestration and innovation ecosystem

Our review reveals that there are three dominant theoretical perspectives in the corporate technology licensing literature (see Figure 5): TCE (17 counts), RBV/Capabilities/Learning (17 counts), and EoI (28 counts). However, more than 25% of the studies included in our literature review do not have a clearly specified theoretical framework to examine their research question. In addition, very few studies have integrated different theoretical perspectives to address their research question (only 14% of the studies in our review). This narrow focus represents a significant obstacle to the development of the field, as this approach is unable to address the complexities of MfT and their implications for both upstream and downstream actors in the wider ecosystem. Internal and external technology sourcing need to be consistent with both the firm's overall strategy and its position in the entire ecosystem; yet, so far, these two topics have been treated in isolation from the firm's decisions and environment. Therefore, introducing new theoretical perspectives and integrating them with the existing, dominant perspectives in technology licensing research should enhance our understanding of the relationship between

determinants and outcomes of corporate technology licensing. We present two perspectives that could contribute to the further convergence of the MfT and strategic management literature next.

Recent work on dynamic managerial capabilities (Helfat et al., 2007; Teece et al., 1997) and resource management (Sirmon et al., 2007) has highlighted the critical role of managers in assembling and *orchestrating* resources for value creation (Helfat et al., 2007). The resource management (Sirmon et al., 2007) and orchestration frameworks (Helfat et al., 2007) may be particularly useful in examining the effect of different resource configurations on the choice between MfT versus MfP strategies and the resulting leveraging capabilities to create competitive advantage. We propose that integrating the MfT and resource orchestration frameworks might reveal important theoretical and empirical insights into the complementarity of resources (bundles), the particular resources acquired and accumulated through an MfT versus an MfP strategy, and how these are orchestrated to fit a particular strategy. Other questions include: whether small specialist firms start out by offering upstream technologies and then move downstream later on and, if so, at what stage of their lifecycle they move downstream; what resources are needed to support their strategies at each stage of their lifecycle (founding, growth and maturity stage); and how these resources differ under various environmental conditions. A dynamic component in the analysis might help identify the leveraging strategies of firms and their sustainability in the long run.

A second potential perspective is to study corporate technology licensing through an innovation ecosystem lens (Nambisan and Baron, 2013; Thomas et al., 2014). A neglected implication of the proliferation of MfT is that firms are now confronted with ever-increasing choices of technologies to license-in and license-out, which may crucially impact on their innovation strategy. The innovation ecosystem perspective recognizes that innovations are rarely

standalone, and that firms are embedded within an ecosystem of interdependent innovations (Adner and Kapoor, 2010). Innovation often necessitates changes in the firm's external environment; for instance, innovation on the part of other actors may be required for successful technology commercialization. Future research might examine the roles of different ecosystem players (both downstream and upstream) and investigate their respective strategies for value co-creation in MfT.

The literature on value creation has identified a number of conditions under which firms may create and capture value. First-mover advantages may benefit firms who gain early entry into new markets (Lieberman and Montgomery, 1988). Complementary assets in combination with appropriability regimes (well-protected IP rights) also help innovators capture the fruits of their innovative efforts (Teece, 1986). Although influential, Teece's discussion of appropriability applies at the level of dyads, whereas recent work has shown that mutual dependencies are not just bilateral, but extend to the wider ecosystem (Adner and Kapoor, 2010; Jacobides, 2006; Pisano, 2007). Thus, interesting questions to explore include how dependence on other actors in the ecosystem influences small, specialist start-ups' innovation strategies; how co-innovation and value co-creation in an ecosystem occurs between upstream and downstream players in MfT; whether openness to external actors produces benefits for all firms; and what kinds of MfT strategy ecosystem players use to attract the interest of other actors and increase the adoption of the innovation in the ecosystem. Research on corporate technology licensing and on ecosystems has been surprisingly disconnected so far. We believe that future research exploring the link between these two literatures might offer a fruitful research direction. Apart from shedding light on the value-creating strategies used by different actors, future research might explore the business models used by firms in MfT (Gambardella and McGahan, 2009; Zott et al., 2011);

specifically, what kinds of business model new ventures use to interact successfully with entrepreneurial ecosystems, and how MfT firms configure and orchestrate the entire innovation ecosystem. While research has begun to address some of the aspects involved in designing strategies for value co-creation, this remains an exciting area for future research.

6. Limitations

This study has some limitations. The research is fragmented, as it stretches across a large number of authors, journals and disciplines in the social sciences. Furthermore, the overwhelming number of articles resulting from the literature search, combined with ambiguity in titles, abstracts and/or keywords in articles, made our judgments and interpretations of the articles critical. Despite these limitations, the use of thematic analysis helped us to deal with diverse evidence and promote theory building (Dixon-Woods et al., 2005b). The systematic review has provided a replicable and transparent method for mapping the MfT literature. It has also provided rigorous evidence on corporate technology licensing, based on an exhaustive literature search of published, peer-reviewed studies.

7. Conclusion

This systematic literature review has demonstrated that the extant literature has focused mainly on firm-level factors that condition the supply of technology in MfT. In addition, most MfT papers have provided limited understanding of the dynamics of technology markets. Hence, we have identified a research agenda in the area of corporate technology licensing. proposing the need to investigate the *demand* for external technology along with supply in MfT, and to address the lack of insight into the value-creating strategies of small, specialist firms. In order to do this, we propose that future research in corporate technology licensing should employ new perspectives such as the resource orchestration framework and innovation ecosystem lens. We expect that such integration between technology licensing and the resource orchestration and

innovation ecosystem perspectives might provide insights into the dynamics of MfT and shed light on the strategic resource allocation decisions of MfT firms. Finally, future research might explore the link between technology licensing and innovation ecosystems. We have attempted an initial exploration of the link between these two literatures, which have so far been disconnected, and have offered several avenues for further research. Although a natural consequence of MfT is that more technologies are available for adoption, the implications of these for the wider ecosystem have generally been overlooked. We hope that the insights of our systematic review and suggested research agenda might inspire future research in the domain of MfT.

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Appendix

Table 1 – Inclusion and exclusion criteria

Inclusion citeria		
N	**Criteria**	**Reason for inclusion**
1	Theoretical papers – internal/ external validity	Provide the working assumptions to be used in the report
2	All sectors	Examine how choice of commercialization of a technology changes between sectors
3	All countries	Ensure cross country comparisons
4	Quantitative and qualitative empirical studies	Capture all empirical evidence

5	Additional papers	Additional articles may be added where it is recommended
Exclusion criteria		
N	**Criteria**	**Reason for exclusion**
1	Pre-1970 articles	The majority of databases do not contain earlier papers. Moreover, with a few significant exceptions contributions to markets for technology were published after 1970
2	Library Licensing	This does not refer directly to technology licensing and markets for technology
3	Information/Data Management	This does not refer directly to technology licensing and markets for technology
4	Internationalization modes	This does not refer directly to technology commercialization and markets for technology
5	University commercialization	Public sector licensing is very different to private sector knowledge commercialization.
6	Working papers	Inclusion of published peer-reviewed articles only

Table 2 - Country analysis of the papers reviewed

Country	No. of Primary Papers	% of Sample
United Kingdom	3	4.41%
Wales	-	
Scotland	-	
North America	34	50.0%
US	32	
Canada	2	
Europe	19	27.9%
Austria	1	
Belgium	2	
Denmark	-	
Finland	-	
France	1	
Germany	3	
Italy	-	
The Netherlands	1	
Spain	2	
Sweden	1	
Switzerland	1	
Other	7	
Asia	12	17.6%
Japan	6	
Korea	1	
Taiwan	3	
Other	2	

Note: Counts are not mutually exclusive.

Table 3 - Industry analysis of the papers reviewed

Industry	No. of Primary Papers	% of Sample
Manufacturing Industries	20	18.3%

Automobile Component Industry	2	
Basic and fabricated metals	3	
Mechanical Engineering Industry	3	
Medical Equipment Industry	2	
Clothing Industry	2	
Industrial equipment and machinery	7	
Other	10	
Service Industries	3	2.75%
Food Industry	2	
Financial Services Industry	1	
High Technology Industries	78	71.6%
Chemicals Industry	18	
Plastics	2	
Petrochemicals	1	
Enzymes	-	
Other	15	
Defense Industries	-	
Electronics (and related)	37	
Software	11	
Semiconductors	3	
Robotics	-	
Prof/nal and scientific instruments	9	
Telecommunications	1	
Other	13	
Pharmaceutical Industries	23	
Biotechnology	9	
Pharma	15	
Other	9	
Multiple Industries	30	27.5 %

Note: Counts are not mutually exclusive.

Figure 1 - Papers reviewed according to year of publication

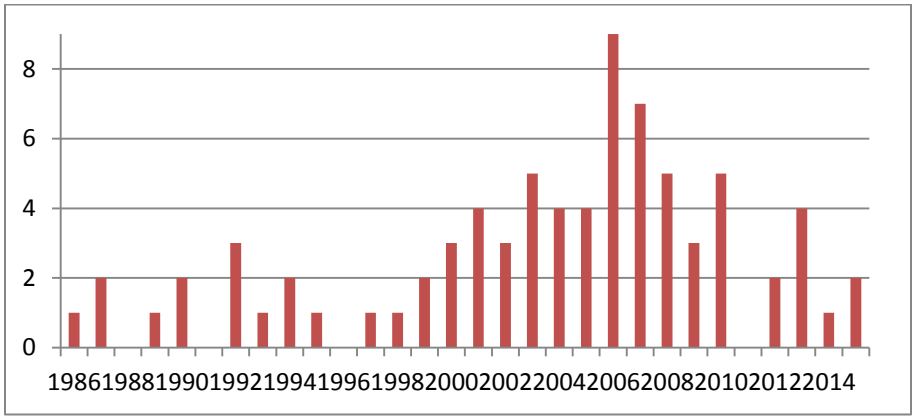
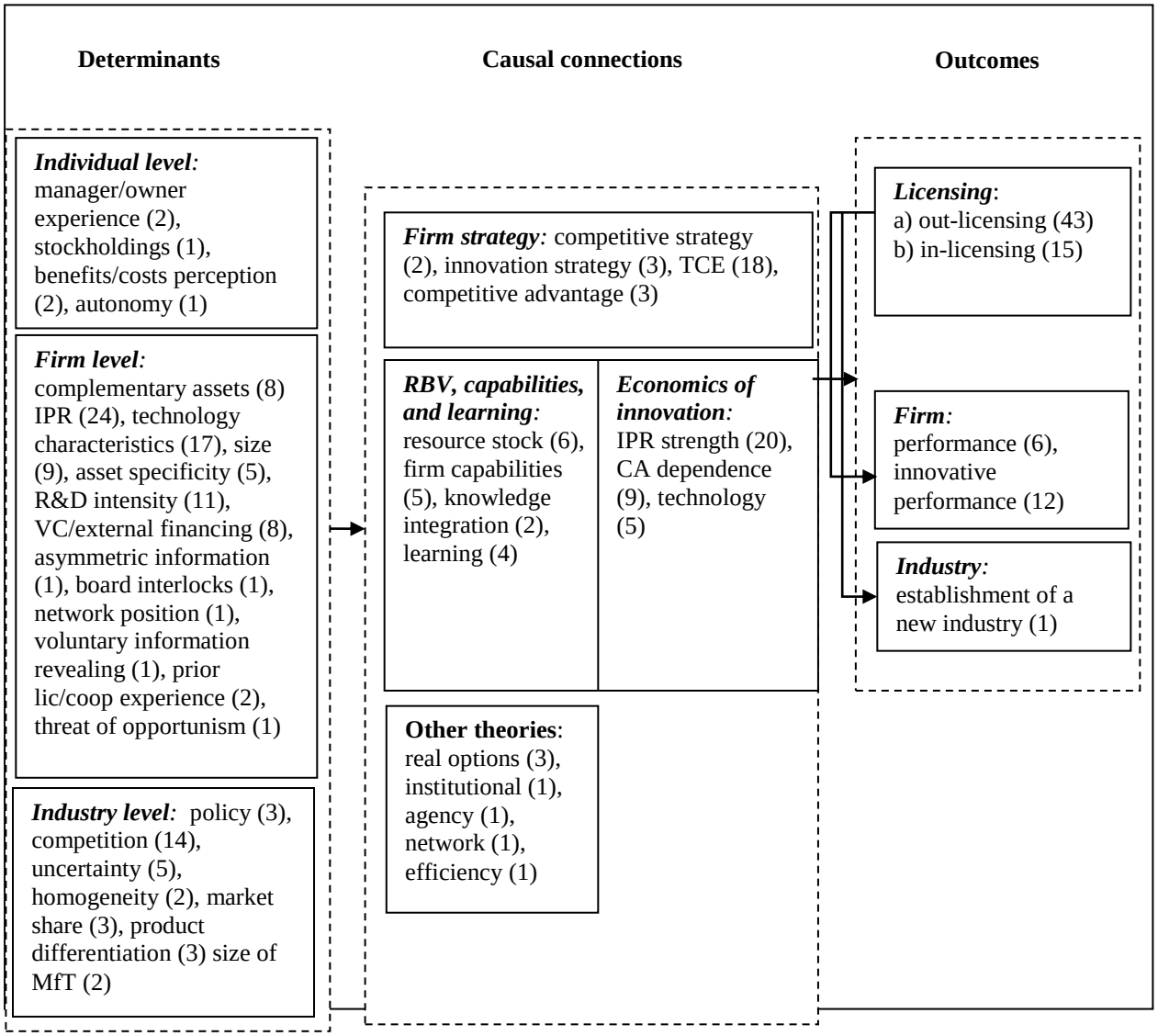


Figure 2 - Methods of analysis used by the 52 empirical articles

Method	Number of times used
Hierarchical/moderated logistic regression (logit and probit models)	19
Hierarchical/moderated ordinary least squares (OLS) regression	10
Other econometric models	9
Multinomial logit or probit models	8
Poisson and negative binomial models	7
Descriptive analysis only	7
Tobit regression	6
Mixed methods (qualitative and quantitative)	5
ANOVA and MANOVA	5
Cluster and factor analysis	5
Hazard rate analysis (including Cox proportional hazard models)	4
Selection correction	3
Endogeneity correction	3
Panel data models (random and fixed effects)	3
Qualitative	1

Note: Of the 78 articles, 26 are conceptual and contain no empirical data. The empirical methodologies of the remaining 52 articles are analyzed in the table. Counts are not mutually exclusive as some articles use multiple methodologies.

Figure 3 - Organizing framework of corporate technology licensing derived from thematic analysis and counts of the topics



Note: Counts are not mutually exclusive.

Figure 4 - Determinants of corporate technology licensing

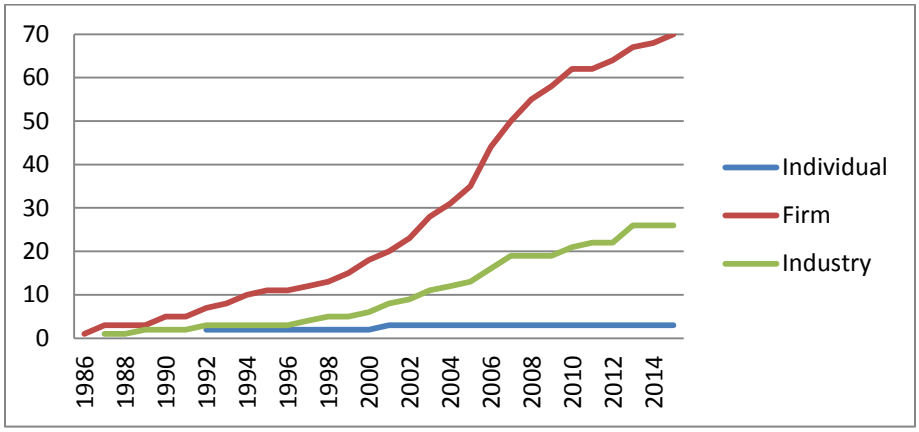


Figure 5 - Theories of corporate technology licensing

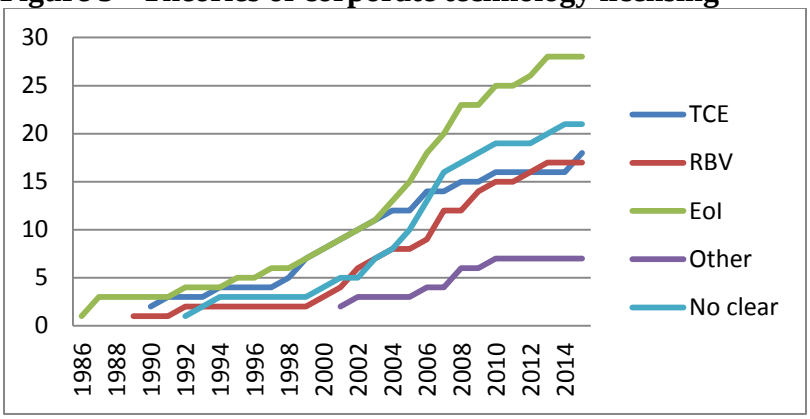


Figure 6 - Outcomes of corporate technology licensing