Received: 11 May 2021 | Revised: 28 February 2022 | Accepted: 4 March 2022
DOI: 10.1111/caim.12488

RESEARCH ARTICLE

WILEY

Outbound knowledge transfer in high-tech small firms: The role of process innovation and development cost

Jeroen P.J. de Jong[1] | **Andreu Turro**[2]

[1]School of Economics, Utrecht University, Utrecht, The Netherlands
[2]Department of Business, Autonomous University of Barcelona, Bellaterra, Spain

Correspondence
Jeroen P.J. de Jong, School of Economics, Utrecht University, Kriekenpitplein 21-22, Utrecht 3584 EC, The Netherlands.
Email: j.p.j.dejong@uu.nl

Innovation-related knowledge can be voluntarily transferred to other organizations for direct or indirect benefits, but firms can also suffer from involuntary transfer when their knowledge leaks and gets stolen. Despite its relevance to managers, outbound knowledge transfer has been understudied. Previous theoretical perspectives suggest that the primary reason why firms innovate—to conquer markets with product innovation or to improve internal processes with process innovation—matters for how outbound knowledge transfer takes shape. Also, higher stakes represented by innovation development cost can be expected to moderate the relationship between innovation type and outbound transfer. We analyse survey data of 176 high-tech small firms to find that, indeed, process innovations are much more likely shared voluntarily, although product innovations leak away without the firm's consent. Development cost moderates voluntary transfer: Low-cost process innovations are barely shared, reflecting a lack of adopter interest, whereas high-cost process innovations are more likely to leak away to similar levels as product innovations. Overall, high-tech small firms are more inclined to voluntary transfer their process innovations.

KEYWORDS
high-tech small firms, open innovation, outbound knowledge transfer, process innovation, product innovation

1 | INTRODUCTION

Innovative firms can be confronted with other businesses copying or adopting their innovation-related knowledge. The classical view in innovation management is that outbound knowledge transfer should be avoided. Value is captured by the commercialization of innovations as new products, although outbound knowledge transfer is considered hostile and at the expense of the firm's profits (Arrow, 1962; Teece, 1986). More recently, however, open innovation scholars have brought to awareness that firms may voluntarily transfer knowledge to reap innovation benefits beyond their organizational boundaries (West & Bogers, 2014). For example, firms can sell knowledge to businesses that may use it for their own product development (Felin & Zenger, 2014; Fosfuri, 2006). Firms may also reveal knowledge to obtain indirect benefits such as reciprocity, evoking new collaborations, expected follow-up innovations or influence standard-setting processes (Alexy et al., 2013; von Hippel, 2005).

From the perspective of the innovating firm, outbound knowledge transfer can be involuntary or voluntary. In line with the previous literature on innovation appropriation (Ritala et al., 2015; Teece, 1986), we define involuntary transfer as the situation in which a firm observes that its knowledge is copied or adopted by other organizations without the firm's consent. Hence, outbound transfer is considered a hostile event where knowledge is leaked or stolen without compensation and at the expense of firm performance (Easterby-Smith et al., 2008). In contrast, when outbound transfer is voluntary, we refer to the open innovation literature (Chesbrough, 2003; West & Bogers, 2014), which points out that firms can voluntarily share knowledge with other organizations. Outbound transfer is then accomplished with the innovating firm's consent—for example, by selling, licensing or sharing knowledge for anticipated benefits.

Although outbound knowledge transfer provides firms with additional opportunities, the open innovation literature has been relatively silent on what makes managers engage in voluntary transfer or try to avoid leakage and appropriate innovation benefits internally (West & Bogers, 2014). Involuntary and voluntary transfer determinants have been studied in isolation (e.g., Cassiman & Veugelers, 2002; Henkel et al., 2014) but not together—a recommended next step (Triguero & Fernández, 2018; West & Bogers, 2014).

The open innovation literature offers various theoretical explanations of what makes managers engage in outbound transfer. Scholars initially considered multinational and large enterprises developing technologies for new product development (e.g., Chesbrough, 2003; Dahlander & Gann, 2010; West & Bogers, 2017). In this setting, it is understood that innovation benefits may be reaped outside organizational boundaries, but if not, appropriation is still accomplished inside. In contrast, other scholars primarily considered innovations developed for internal use (e.g., Baldwin & von Hippel, 2011; von Hippel, 2005). Their focus is on process innovations to enable new functions potentially valuable for other organizations (de Jong & Flowers, 2018; von Hippel, 2005). These innovations also include processes that firms collectively develop for safety (e.g., Nuvolari, 2004) and open-source projects with a strategic interest in the business (Henkel et al., 2014). This part of the literature advocates voluntary outbound transfer as an undeniable choice, and that in general, organizations will be more willing to share knowledge related to process innovations (e.g., de Jong & Flowers, 2018; Duarte & Sarkar, 2011;Penin, 2008; von Hippel, 2005). Some even claimed the existence of different types of ‘openness’, in which the initial open innovation literature (Chesbrough, 2003) is an intermediary form, although collectively developed process innovations are the most open type (Penin, 2008; von Hippel, 2005). In summary, differences in the previous theorizing suggest that the type of innovation, that is, product versus process innovation, matters for how outbound transfer takes shape.

This paper takes the first step to explore (the uncharted area of) determinants of outbound transfer (West & Bogers, 2017) by examining if innovation type (product vs. process) is related to voluntary and involuntary outbound transfer. Product innovation refers to the creation of new goods and services for a market (Guisado-González et al., 2017), changing what a firm offers to the outside world (Schilling, 2010). Process innovation refers to changes in how a company produces and delivers its offerings (Hullova et al., 2019; Schilling, 2010). Hence, process innovation is primarily internally oriented and usually embodied in new/improved machinery, equipment, tools or devices (Wong et al., 2008). As we will explain later, we hypothesize that process innovation are more likely to be subject to voluntary outbound transfer, although product innovation are more likely to be transferred without consent.

Although the distinction between product and process innovation seems essential, it is unlikely to explain firms' engagement with outbound transfer fully. Different perspectives found in the open innovation literature suggest that innovation development costs matter for the eligibility of process innovations to be leaked/stolen, or shared. Specifically, early studies observed that completely waiving intellectual property rights (IPRs) by free revealing is a common practice in open-source software (von Hippel & von Krogh, 2003) and end-user communities (Franke & Shah, 2003). However, the last decade showed that these insights do not directly apply to businesses. ‘Naïve’ free revealing is fragile (Gächter et al., 2010), and firms appear to be calculative about outbound transfer. For example, they want a payment (Fosfuri, 2006), strategic advantage (Henkel et al., 2014) or indirect favours (de Jong & Flowers, 2018) in return. Looking at what distinguishes free revealing (without compensation) from voluntary transfer (for direct or indirect compensation), what seems to matter most is ‘how much is at stake’, that is, the investment done, which a firm has to recoup. In open-source projects and end-user communities, innovators are not in it for money; they appreciate personally using innovations and connecting with like-minded others (Franke & Shah, 2003; Raasch & von Hippel, 2013). However, in business, innovation comes at a cost that is not compensated by process benefits. Accordingly, we investigate whether innovation development cost (as a proxy of value at stake) is a moderator of the relationship between innovation type and outbound transfer.

Innovation development cost is defined as the wages of R&D and innovation workers and out-of-pocket costs such as the lab facilities, materials or supplies related to innovation development (OECD/Eurostat, 2018). Despite their fundamental relevance for any innovation (Schilling, 2010), previous research has rarely focused on its potential moderating role in how outbound transfer occurs. Research did show that the costs of developing new products and processes play a role in how innovations are diffused and marketed (Bunduchi et al., 2011; DiMasi et al., 2016) but have not been related to outbound knowledge transfer in particular.

In overview, our contribution is twofold. First, we investigate whether the type of innovation, that is, product versus process innovation, matters for outbound knowledge transfer. As we will explain in our theory section, we hypothesize that process innovations are more likely shared, although product innovations are more likely to leak away or get stolen. Second, we take an initial step to analyse contingency factors. We hypothesize that outbound transfer of process innovations is moderated by innovation development costs. We reason that high development costs indicate high stakes so that outbound transfer of process innovations—either voluntary or involuntary—will be more likely. Our contributions are inspired by different views and observations offered by open innovation scholars about the viability of different kinds of openness and potentially helpful to clarify why these different observations have occurred.

The empirical context of our research is high-technology small firms: active R&D performers, with a business revolving around product development based on new technology (Grinstein & Goldman, 2006). In this study, we define a small firm as one with a maximum of 100 employees. Outbound knowledge transfer is highly relevant in this context, as high-tech small firms not only make their living from developing and commercializing knowledge but also develop process innovations frequently. Moreover, from a macroeconomic perspective, high-tech small firms are essential for economic development, as they contribute to general economic and employment growth (Simonen et al., 2015).

We analyse data on 447 innovations developed by 176 high-tech small firms. We find substantial differences between product and process innovations; voluntary transfer is a lot more likely for process innovations. In contrast, outbound transfer of product innovations is much more often without the firm's consent. We also find that innovation development costs matter: Involuntary transfer increases at high costs, so the distinction between process and product innovations disappears. Likewise, low-cost process innovations are no longer transferred voluntarily, which probably reflects a lack of adopter interest. Overall, we find that the type of innovation and innovation development costs highly matter for voluntary transfer and firms' engagement in outbound open innovation.

2 | THEORY AND HYPOTHESES

We first elaborate our hypotheses on the relationship between innovation type and outbound knowledge transfer. Next, we explain the moderating role of innovation development costs.

2.1 | Involuntary transfer

As we mentioned in our introduction, the classical view on innovation appropriation is that innovations are potentially interesting for other organizations to copy, and the challenge is to avoid this from happening (Teece, 1986). Innovation results in new products with advanced technological knowledge, but process innovations are usually ignored in this discussion. A second stream of the open innovation literature recognizes that process innovations, despite being initially developed for internal use, can be valuable to other organizations. Many breakthrough innovations in specific product fields were originally developed by companies who initially needed the innovation themselves, that is, for in-house use (von Hippel, 2005). Only later these process innovations were recognized as generally valuable and transferred to other organizations to supply to a broader market (e.g., de Jong & von Hippel, 2009).

Compared with product innovations, we expect that process innovations are less likely to be involuntarily transferred (or reversely, product innovations are more likely to be leaked or stolen) for three reasons: Process innovations have *on average* less general use value, firms have more options to hide process innovations, and firms put less priority to securing process innovation benefits.

First, new products are developed because of their expected high general use value. Product innovations see the daylight to meet the needs of homogeneous markets so that the innovator can recoup its investment (Schilling, 2010; von Hippel, 2005). Assuming that the innovating firm has done proper market research, it will have spotted a market segment with an unfulfilled need. This can attract other businesses trying to take advantage (Teece, 1986). In contrast, although some process innovations have potential broad use value (von Hippel, 2005), this does not apply to all. Fewer other organizations may benefit, or only to the innovating firm. In general, process innovation benefits are more implicit as they often take place in the form of reduced manufacturing costs or increased efficiency (Schilling, 2010; Wan et al., 2019). Process innovations emerge from firms' heterogeneous needs, and their needs for specific processes may be so unique that other organizations, including competitors and commercial suppliers of similar machinery, equipment, tools or devices, may not be interested in adopting them (von Hippel, 2005). As an implication, process innovations, on average, are less attractive candidates to be leaked or stolen.

Second, a general pattern observed for any type of firm is that, compared with product innovation, process innovations are easier to keep secret behind factory walls (Siachou et al., 2021) and harder to patent (Arundel & Kabla, 1998), although secrecy is a more attractive strategy to protect the firm's interests. In contrast, product innovations are self-revealing as they have to be communicated to the outside world in order to be marketed. Other firms then have an easier job at adopting or copying the innovation without the innovating firm's consent.

Third, high-tech small firms likely put different priorities to avoid leaking knowledge related to products and processes. By definition, their business models revolve around product development based on new technology (Grinstein & Goldman, 2006). Because new products are essential to their business, avoiding involuntary transfer is critical for high-tech small firms to recoup their innovation investment. In contrast, high-tech small firms may consider leaking knowledge of process innovations less problematic (de Jong & von Hippel, 2009). Although seemingly contradicting our second argument, the overall point is that firms have better options to keep process innovations secret or do not care as much to avoid that process innovation knowledge becomes available to others. High-tech small firms often operate in early-stage industries where technology is evolving and having unique processes does not yet provide companies with a competitive advantage (Simonen et al., 2015). On the basis of these arguments, we hypothesize the following:

> **H1.** Compared with product innovations, in high-tech small firms, process innovations are less likely to be involuntarily transferred to other firms.

2.2 | Voluntary transfer

Voluntary outbound transfer is, we argue, is more likely for process innovations. Our hypothesis is based on three arguments: Firms lack complementary assets to appropriate process innovation benefits, process innovations are more obvious candidates to obtain indirect benefits, and firms are less fearful of disclosing process innovation knowledge.

First, voluntary transfer is a better match with process innovation because high-tech small firms probably lack complementary assets to appropriate their value within organizational boundaries. Process innovations are typically concerned with machines, equipment, tools and devices for which the firms lack competencies to commercialize and diffuse (Dziallas & Blind, 2019). Commercializing knowledge requires access to a customer base, distribution and sales channels, and a back office tailored to the process at hand. These assets likely differ from the firm's existing product base. Then, voluntary knowledge sharing may be a preferred strategy (de Jong & Flowers, 2018; von Hippel, 2005). If high-tech small firms lack production and commercialization competencies, outbound transfer by selling or licensing knowledge will be more attractive to obtain any additional benefits on top of what comes from internally applying the process innovation.

Second, in the absence of other firms willing to pay for knowledge, process innovations are more obvious candidates to reveal for indirect benefits. Research has shown that firms are calculative in selectively disclosing process innovations for anticipated reciprocity (de Jong & von Hippel, 2009), to evoke new collaborations (Alexy et al., 2013), to obtain feedback or support from adopters (Henkel, 2006) or to obtain a better version of the innovation if the adopting firm is making additional development efforts (Harhoff et al., 2003). In contrast, revealing product innovations would directly be at the expense of high-tech small firms—recall that their business model revolves around commercializing new products. Sharing product innovations without compensation may be viable only if the firm seeks others to follow their technological path and influence an emerging dominant design (Brem & Nylund, 2021), or alternatively, when the firm seeks to diminish competitive pressure (Pacheco-de-Almeida & Zemsky, 2012). Such considerations, however, mainly apply in times of revolutionary technological change (Schilling, 2010), which is not an everyday situation to most businesses.

Third, high-tech small firms are probably more relaxed about sharing knowledge related to process innovations. The disclosure paradox implies that when an innovator is keen to share knowledge for direct or future benefits, it should reveal information to the potential adopter who may subsequently take it (Arrow, 1962; Gambardella et al., 2007). Indeed, if companies engage intensively in knowledge sharing, they face the risk of involuntary transfer (Ritala et al., 2015), and the perceived risk of knowledge leakage is a key factor depriving firms of voluntary transfer attempts (Ritala & Hurmelinna-Laukkanen, 2009). Yet, the patterns observed in studies of high-tech firms (de Jong & von Hippel, 2009) and small firms (de Jong & Flowers, 2018) suggest that this risk is considered less for process innovations, as the innovation was primarily developed for internal use and already served its primary purpose when being developed. Hence, any additional benefits come as an extra to the high-tech small firm and are more likely for process innovations that are not as essential to the firm's existence as new products. These arguments lead to the following hypothesis:

> **H2.** Compared with product innovations, in high-tech small firms process, innovations are more likely to be voluntarily transferred to other firms.

2.3 | Moderating role of development cost

Innovation development cost is directly related to investment done (Schilling, 2010), and as such, high cost is a proxy for value at stake. Here, our concern is not with the direct effect of development cost but its potential moderating role in how process innovation relates to voluntary and involuntary outbound transfer. As we explain next, both types of transfer become more likely when the stakes are higher.

First, we anticipate that process innovations are more attractive to potential adopter firms at higher development costs. In general, developmental costs grow with anticipated general use value, which is the perceived utility of an innovation by others in a social system, and which makes firms more cautious in trying to protect their knowledge (Cohen et al., 2000). Innovations with higher general use value are more likely to address problems that other organizations face, with the potential to address sizeable markets (Garcia & Calantone, 2002). We argue that at higher costs, particularly process innovations represent more general use value. When high costs are made to solve a process-related problem, the problem at hand is probably more severe (Hullova et al., 2019). High development cost also indicates that the problem has unlikely been solved before as the threshold for other firms to fix the problem is higher (Anand et al., 2020). Thus, high-cost process innovations imply more anticipated broader market potential, whereas low-cost process innovations are more likely 'local' problem solvers, which are only interesting to the innovating firm and not to others (Haneda & Ito, 2018). In contrast, for product innovations, even at lower development costs, the product is supposed to meet the needs of a potential market of sufficient size and commercial interest (Garcia & Calantone, 2002; von Hippel, 2005). Thus, compared with high-cost product innovations, high-cost process innovations will be relatively attractive to other organizations, which we can then expect to be eager to obtain innovation-related knowledge.

Looking at how the transfer of high-cost process innovations takes shape, we anticipate that both stealing/leaking and sharing will be more likely. Referring to the three arguments we offered at H1, for involuntary transfer, high costs signal higher adopter interest. Being developed at a higher cost, the scale of these process innovations is bigger (Hullova et al., 2019), making secrecy less viable. Also, high-tech small firms will likely be primarily concerned with protecting knowledge from product innovations and less with process innovations (de Jong & von Hippel, 2009). Voluntary transfer is also more likely, as there is more value to be generated to other organizations, for which the innovating firm still lacks complementary assets to accomplish additional benefits within organizational boundaries. We hypothesize:

> **H3.** Compared with product innovations, in high-tech small firms, process innovations are more likely

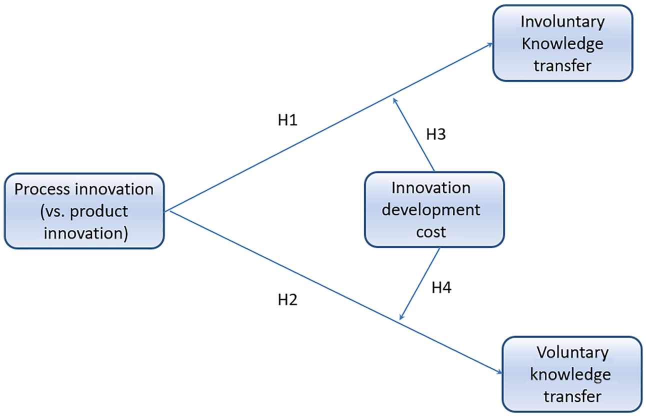

FIGURE 1 Hypotheses [Colour figure can be viewed at wileyonlinelibrary.com]

involuntarily transferred to other firms when development costs are higher.

H4. Compared with product innovations, in high-tech small firms, process innovations are more likely voluntarily transferred to other firms when development costs are higher.

Overall, our hypotheses are summarized in Figure 1.

3 | DATA

3.1 | Sample and data collection

We sent out a survey to 269 high-tech small firms in the Netherlands. All participants had formerly participated in a series of surveys done by a Dutch research institute to investigate the effectiveness of public innovation and entrepreneurship policies. They were sui\ for our research as high-tech small firms likely develop product and process innovations—so that we can compare both types. High-tech small firms are defined as active R&D performers with a business revolving around product development based on new technology (Grinstein & Goldman, 2006) and with a maximum of 100 employees. Thus, our definition of high tech is at the firm level, not the industry level. Participants were active in a broad range of industries. Also, firms in our sample represent a subset of all small- and medium-sized enterprises. As defined by the European Commission, this broader group also includes firms with 101–250 employees, amongst other criteria.

We collected our data utilizing a computer-assisted telephone survey. Answers were given by general managers and business owners who bear responsibility for innovation and any outbound transfer strategies. In advance, we assured full confidentiality. The survey script was first tested by conducting 10 surveys (not used in the analysis of data). We then contacted the 269 respondents. Five contact attempts were made. We completed 180 surveys in 6 weeks (67%). The questionnaire is available on request from the corresponding author.

Firms in our sample can be described in terms of industry and firm size. Respondents were active in manufacturing (e.g., manufacturers of chemicals; machinery and equipment; food and beverages; metals, textiles and wood products) and services (e.g., technical wholesale traders involved in product development; IT and telecom services firms; commercial engineering firms). Forty-three percent was in services. The average firm size was 26.6 employees. Drawing on χ^2 tests and *t* tests, we found no differences between respondents and non-respondents, suggesting that response bias was not problematic.

3.2 | Identifying product and process innovations

We asked questions to identify up to two product innovations within the firm. We followed the definitions and guidelines provided by OECD/Eurostat, 2018). The interviewer first defined product innovation as 'new or improved goods that differ significantly from the firm's previous goods and that have been introduced on the market' (OECD/Eurostat, 2018: p. 21). Then, the interviewer proceeded in asking if the firm in the past 3 years had (1) developed new products and (2) modified or improved existing products. The distinction between new and modified products is not absolute and was only made to trigger recall and maximize our chances of detecting product innovations.

We then asked similar questions to identify up to two process innovations. In the Oslo Manual, process innovation is defined as 'new or improved business processes for one or more business functions that differ significantly from the firm's previous business processes and have been brought into use' (OECD/Eurostat, 2018: p. 21). This definition also includes the adoption of processes developed by other firms, which does not represent value to be appropriated from knowledge generated by the innovating firm. Thus, we followed the method used by previous researchers to identify process innovations with functional novelty (e.g.,de Jong & Flowers, 2018; de Jong & von Hippel, 2009; Kuusisto & Kuusisto, 2013). The interviewer first mentioned a more narrow definition of process innovation: 'new or improved processes which you developed yourself, and primarily for internal needs. Such innovations are typically concerned with the machinery, equipment, software or other devices your company is using to conduct its business (in line with de Jong & von Hippel, 2009). The interviewer then asked two questions: Had the firm in the past 3 years developed (1) new machinery, equipment, software or any other devices and (2) modified or improved existing machinery, equipment, software or any other devices for internal process use? Again, the boundary between creations and modifications is not strict but helpful to trigger respondents' recall.

After each screening question, we asked follow-up questions—again in line with how previous researchers have collected data on specific product and process innovation cases (de Jong & Flowers, 2018; de Jong & von Hippel, 2009; Kuusisto & Kuusisto, 2013). Respondents elaborated on what they had developed and why. If the respondent could report multiple innovations, the interviewer asked them to focus on their most recent case (ensuring a random sample of cases on top of respondents' minds).

Initially, respondents reported 502 innovations (252 product innovations and 250 process innovations). An example of a product innovation created from scratch was "a new kind of cardboard which has the same functionalities as wood. This product broadens our product range". An example of a product innovation based on modification was "Improved our optical sorter; it is now equipped with colour cameras. It works with UV radiation and better sorts products based on their specific weight". An example of a process innovation created from scratch was "We developed a machine to process aloe leaves. We are a supplier to the chemical industry, and so far, most of the extraction process was done manually". An example of a process modification was "A test device for electricity. We had to do a new type of test that was not yet possible, so we expanded our device with new functions".

Two coders rated (with good agreement, Cohen's kappa = 0.77) all descriptions to filter out cases that were not clearly product or process innovations. The first coder was one of the co-authors of this paper; the second one was not at all involved in the research but is an expert with regard to the fundamental concepts of our study. Because we aimed to compare both types of innovation, we wanted to exclude miscellaneous cases. The main criteria for exclusion were (a) innovations in which both elements of product and process innovation were present. For example, an IT services firm reported a process innovation: "software for laser cutting and the production of door frames. To better meet market demand and create new sales opportunities". This example resembled more with a new product. Next, (b) some reported products were tailor-made designs for individual customers and not developed for a general market (e.g., "we assisted one of our customers to build new software to automate their drawing office processes"). The coders discussed any cases on which they disagreed and usually ended up conservatively excluding the case. After this screening, our dataset contained 447 reported innovations (234 product, 213 process innovations) developed by 176 high-tech small firms. The number of firms with one, two, three and four validated innovations was 27, 56, 64 and 29, respectively. Four responding firms had provided no valid examples and were excluded. Our data have a two-level structure (innovations nested within firms), so we estimated both classical and multilevel regression models to test our hypotheses, with similar results (details provided hereafter).

3.3 | Variables

In the survey, we collected data for each reported innovation with a set of identical follow-up questions. Table 1 provides an overview of our variables and descriptive statistics: Some are at the level of reported innovations ($n = 447$), others at the firm level ($n = 176$).

We created a dummy variable if a reported case was a process innovation (= 1, vs. product innovation = 0). Involuntary transfer was measured with a question if any other businesses had adopted or copied the innovation, either in part or as a whole, without the firm's consent. Wherever needed, the interviewer clarified that our focus was on knowledge leaking or stealing, not voluntary sharing. Next, voluntary knowledge transfer was measured with a similar question, but now specifying that the transfer was *with* the firm's consent. Wherever needed the interviewer clarified that our focus now was on knowledge sharing, not leaking or stealing.

Following OECD/Eurostat's (2018) guidelines, we asked the respondent to estimate innovation development costs, including wages and out-of-pocket expenses. The range was 300 Euros to 5.5 million Euros; the estimated average spending had been 286,865 Euros. The development cost was heavily skewed, so we log-transformed it for a mean score of 10.76 and a standard deviation of 1.98 (skewness = 0.11, kurtosis = −0.38).

Control variables at the innovation level included if the firm had contracted or collaborated with other persons or organizations to develop the innovation. This echoes Dahlander and Gann's (2010) distinction of pecuniary and non-pecuniary inbound innovation practices. We included these control variables because the presence of external contributors increases the odds of outbound knowledge transfer (Felin & Zenger, 2014). We also added a dummy variable if the innovation was a modification (= 1, vs. entirely new products/processes = 0). For modifications, there may be less new knowledge to be appropriated, as more knowledge has been obtained from other sources.

We added more control variables at the firm level. Process competition is the extent to which firms in the relevant market distinguish themselves with unique processes. Previous research has shown how competition dynamics influence innovation behaviour in established companies (Tang, 2006), so high process competition may diminish the voluntary transfer of process innovations. We designed two items with sufficient reliability ($\alpha = .73$), based on existing views about the role of competition for product and process innovation (Bonanno & Haworth, 1998). Also, recognizing that ease of imitation is an antecedent of firms' appropriation strategies (Cohen et al., 2000), we anticipated that involuntary transfer would be more likely when imitation is deemed easy. We, therefore, included a two-item measure based on Wu et al. (2019) with sufficient reliability ($\alpha = .70$). Finally, we controlled for industry type (services industry dummy) and firm size (number of employees).

4 | FINDINGS

We first explored with simple percentages and χ^2 tests whether process innovations differed from product innovations when it comes to outbound transfer (Table 2). We found substantial differences. Involuntary transfer was reported much more often for product innovations: 14% versus 2% for new processes. Voluntary transfer was much more common for process innovations: 22%, while only 3% for new products.

As a side issue, we observed interesting differences with respect to inbound innovation practices: innovation contracting and

TABLE 1 Variables

Variable	Description	Statistics
Innovation level ($n = 447$):	Reported innovation was …	
Process innovation	… a process innovation (versus product innovation)	$M = 0.48$; $SD = 0.50$
Involuntary transfer	… adopted or copied by any other company, either in part or as a whole, without the firm's consent	$M = 0.08$; $SD = 0.28$
Voluntary transfer	… adopted or copied by any other company, either in part or as a whole, with the firm's consent	$M = 0.12$; $SD = 0.33$
Development cost	Estimated innovation development cost, including wages and out-of-pocket expenses	$M = 286{,}865$; $SD = 732{,}530$
Modification	… a modification of an existing product or process (versus a new product or process)	$M = 0.47$; $SD = 0.50$
Contracting	… developed with assistance, information or advice contracted from other persons or organizations	$M = 0.44$; $SD = 0.50$
Collaboration	… developed in collaboration with other persons/organizations (no payment)	$M = 0.38$; $SD = 0.49$
Firm level ($n = 176$):		
Process competition	Mean score of two items ($\alpha = .73$) coded 1 (*definitely not*) to 5 (*definitely yes*)	$M = 4.0$; $SD = 1.2$
	… firms in our market try to distinguish themselves with processes, methods and techniques that others do not have.	
	… in our market, being competitive is greatly assisted by having unique processes, methods and techniques.	
Easy imitation	Mean score of two items ($\alpha = .70$) coded 1 (*definitely not*) to 5 (*definitely yes*)	$M = 2.9$; $SD = 1.2$
	… in our industry it is easy to copy others' processes, methods or techniques.	
	… we can easily keep the design of our processes, methods and techniques secret. (reversed item)	
Firm size	Firm size in number of employees	$M = 26.6$; $SD = 25.6$
Services industry	Dummy if the firm operates in a services industry (versus manufacturing)	$M = 0.45$; $SD = 0.50$

Note. *M*, mean; *SD*, standard deviation.

TABLE 2 Differences between product and process innovations

Variable	Product innovations ($n = 234$)	Process innovations ($n = 213$)	Significance
Involuntary transfer	14%	2%	$\chi^2 = 18.5$, $df = 1$, $p = .000$
Voluntary transfer	3%	22%	$\chi^2 = 41.3$, $df = 1$, $p = .000$
Contracting	44%	45%	$\chi^2 = 0.10$, $df = 1$, $p = .753$
Collaboration	54%	21%	$\chi^2 = 52.1$, $df = 1$, $p = .000$

collaboration. Product and process innovation was likely developed with external (paid) contractors. Non-pecuniary collaboration, however, applied more to product innovation (54% vs. 21%). This may reflect differences in the risk perceptions of high-tech small firms, which can be severe for new product development (firms do not know in advance if a new product will be successful) but more minor for process innovations (firms innovating to primarily solve an in-house problem that requires a technical solution). In our discussion section, we briefly come back to this observation.

Next, Table 3 provides correlation coefficients between all variables. Absolute values of the correlation coefficients were mostly <.10, and less than the correlations one can expect in the presence of

TABLE 3 Descriptive statistics ($n = 447$)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) process innovation										
(2) involuntary transfer	−.20**									
(3) voluntary transfer	.31**	−.11*								
(4) modification	−.01	−.04	.06							
(5) contracting	.02	.06	.15**	−.05						
(6) collaboration	−.34**	.03	.00	−.07	.14**					
(7) log development cost	−.19**	.12*	.00	−.30**	.37**	.32**				
(8) process competition	.03	.06	.04	−.01	.05	.09	.19**			
(9) easy imitation	.05	.14**	−.04	−.01	−.06	−.07	−.08	−.13**		
(10) firm size	.01	.01	.02	.04	.08	−.04	.21**	−.23**	.02	
(11) services industry	−.02	.05	.10*	−.01	−.01	.09*	.00	−.01	−.01	−.11*

**$p < .01$. *$p < .05$.

common method bias (Podsakoff et al., 2003). Also, we applied Harman's single-factor test drawing on exploratory principal component analysis. We found that the first factor explained only 15% of the variance, indicating an absence of common method bias.

4.1 | Testing hypotheses

We applied logit regression analysis to test our hypotheses. Variance inflation factors of the independent variables in the models presented hereafter were ≤1.7, so multicollinearity was unlikely a concern. In advance, we mean-centred log development cost to avoid multicollinearity with the interaction term between development cost and process innovation (cf. Aiken & West, 1991). Our main findings are in Table 4, while corresponding marginal effects follow in Table 5.

Model I tests H1. We find that the relationship between process innovation and involuntary transfer is significant ($b = -1.957$, $p < .01$). Compared with product innovations, the odds of process innovations being stolen or leaked away are significantly less. Table 5 shows marginal effects for Model I. For process innovations, the estimated frequency of involuntary transfer is 11.9% less compared with product innovations ($p < .01$). H1 is supported.

Model II provides a test of H2. We find that in high-tech small firms, process innovations are more likely transferred voluntarily ($b = 2.832$, $p < .01$). In Table 5, Model II we, report corresponding marginal effects. For process innovations, the frequency of voluntary transfer is 22% higher compared with product innovations ($dy/dx = .220$, $p < .01$). H2 is supported.

Model III tests H3. The two-way coefficient is significant ($b = .396$, $p < .05$). To further interpret the significant interaction effect, we estimated the marginal effects of process innovation on involuntary transfer at various levels of development cost (cf. Aiken & West, 1991). See Table 5. At low cost, that is, one standard deviation below the mean ($M - 1 \times SD$), the frequency of process innovations being stolen or leaked away was 12% less compared with product innovations. At average (M) and high ($M + 1 \times SD$) costs, we found similar differences. Only at very high development costs ($M + 2 \times SD$) the frequency of involuntary transfer increased in such a way that the negative difference with product innovation vanished ($dy/dx = -.084$, $p > .05$). Thus, we find partial support for H3. At the upper tail of the development cost distribution, process innovations are leaked or stolen more often. Involuntary transfer is then at the same level as product innovation. (In a follow-up analysis, we found that this applies to the top 8% of the development cost distribution; available on request). At the lower end of the distribution, however, no evidence shows that development cost diminishes involuntary transfer of process innovations. We elaborate on this finding in our discussion section.

Model IV reveals results for H4. The interaction coefficient was positive and significant ($b = .724$, $p < .05$). Table 5 shows the marginal effects of process innovation on voluntary transfer at various levels of development cost. At nearly all development cost levels, the difference between process and product innovations remains. Only when development cost is very low ($M - 2 \times SD$) sharing process innovations is as (un)likely as product innovations ($dy/dx = .024$, $p > .05$). In a follow-up analysis, we found that sharing process innovations does not differ from product innovation in the bottom 9% of the development cost distribution; available on request. At higher development costs, no evidence is found that process innovations are more likely transferred with the innovating firm's consent. H4 is partially supported. Again, we elaborate our findings in the discussion section.

4.2 | Robustness checks

We conducted various robustness checks, which are available on request. Our data have a nested structure: most firms reported multiple innovations. To estimate the empirical relationships between higher (firm) level and lower (innovation) level variables on lower level outcomes, we estimated multilevel logit regression models with random intercepts and fixed-effect slopes. Our findings were similar.

TABLE 4 Logit regression models of outbound knowledge transfer ($n = 447$)

Dependent variable	I Involuntary transfer	II Voluntary transfer	III Involuntary transfer	IV Voluntary transfer
Effect parameters:				
Constant	−1.971**	−5.269**	−1.917**	−5.499**
	(.376)	(.676)	(.365)	(.818)
Modification	−.085	.281	−.145	.235
	(.424)	(.325)	(.416)	(.340)
Contracting	.143	.918*	.168	.991*
	(.452)	(.388)	(.455)	(.394)
Collaboration	−.555	.844*	−.517	.882*
	(.435)	(.402)	(.418)	(.391)
Easy imitation	.426**	−.080	.425**	−.070
	(.159)	(.148)	(.158)	(.149)
Firm size	.002	.004	.003	.003
	(.008)	(.006)	(.008)	(.006)
Services industry	.458	.665	.450	.676
	(.373)	(.334)	(.371)	(.342)
Process competition	.200	.120	.188	.094
	(.182)	(.156)	(.185)	(.162)
Log development cost	.173	−.035	.087	−.682*
	(.130)	(.099)	(.139)	(.324)
Process innovation (vs. product innovation)	−1.957**	2.832**	−2.295**	3.032**
	(.564)	(.576)	(.573)	(.722)
Process innovation*log development cost			.396*	.724*
			(.160)	(.328)
Model fit:				
χ^2 (*df*)	31.5 (9)	43.6 (9)	51.8 (10)	41.2 (10)
p value	.000	.000	.000	.000
Pseudo-R^2	.143	.205	.154	.232

Note. Robust standard errors in parentheses.
$^{**}p < .01$. $^{*}p < .05$.

We also recognized that firms' decision to engage in voluntary transfer might be influenced by involuntary transfer and vice versa. Table 3 shows a negative correlation coefficient between voluntary and involuntary transfer ($r = -.11$, $p < .05$). We estimated bivariate probit models in which the determinants of voluntary and involuntary transfer were estimated simultaneously. The Wald test of independence showed that both equations were related, but our findings were maintained.

5 | DISCUSSION

Our study focused on the outbound transfer of innovation-related knowledge, which has been much less investigated than inbound open innovation. Our findings show that high-tech firms maintain diverse strategies to benefit from innovation-related knowledge. Specifically, process innovations are more likely candidates for voluntary outbound transfer, at least in our sample of high-tech small firms. Our interpretation is that process innovations developed for internal use have served their primary purpose after implementation. Voluntary transfer seems a ‘bonus’ from which high-tech small firms may derive additional value.

5.1 | Contribution to theory

The strong differences we observed between product and process innovation (Table 2) shows that process innovations are more likely shared, although product innovations tend to leak away without the firm's consent and are less obvious candidates for voluntary sharing. Thus, firms' initial innovation motive matters for how knowledge transfer occurs. Our study adds to the open innovation literature that voluntary outbound transfer is more likely for those innovations that are not primarily meant to be marketed.

TABLE 5 Marginal effects

	Dy/dx
Model I (voluntary transfer with estimated baseline frequency .086):	
Modification	−.006
Contracting	.010
Collaboration	−.039
Easy imitation	.030**
Firm size	.000
Services industry	.032
Process competition	.014
Development cost	.012
Process innovation	−.119**
Model II (voluntary transfer with estimated baseline frequency .115):	
Modification	.024
Contracting	.080*
Collaboration	.079*
Easy imitation	−.007
Firm size	.000
Services industry	.058
Process competition	.010
Development cost	−.003
Process innovation	.220**
Process innovation in model III:	
At low development cost ($M-SD$)	−.120**
At average development cost (M)	−.128**
At high development cost ($M+SD$)	−.123**
At very high development cost ($M+2*SD$)	−.084
Process innovation in model IV:	
At very low development cost ($M-2*SD$)	.024
At low development cost ($M-SD$)	.167**
At average development cost (M)	.226**
At high development cost ($M+SD$)	.253**

**$p < .01$. *$p < .05$.

Our findings provide evidence for a frequent claim made by open innovation scholars who have been concerned with process innovations (or 'user' innovations) (e.g., von Hippel, 2005). They predicted that compared with classical product innovation projects, firms would see merit in voluntarily transfer when development is done primarily for internal purposes (de Jong & Flowers, 2018; Nuvolari, 2004; von Hippel, 2005). Our findings provide empirical support for this proposition and help to explain why previous open innovation scholars offered different views on the openness of innovation-related knowledge in general. When the focus is on new technology to develop products (e.g., Chesbrough, 2003; West & Bogers, 2017), firms are reasonably more calculative and cautious and less willing to share knowledge. In this context, classical views of appropriation still seem very valid (e.g., Arrow, 1962; Teece, 1986). High-tech small firms try to appropriate value from product innovations in-house, avoid spillovers, and barely engage in voluntary outbound transfer. Instead, they can be faced with knowledge leaking or stealing, which can be caused by various factors including, labour mobility of R&D workers, reverse engineering, etc. In contrast, for process innovations initially developed for internal use (de Jong & von Hippel, 2009; von Hippel, 2005), firms seem more open to go beyond organizational boundaries to reap additional benefits.

We found that the differences between product and process innovation are maintained throughout most of the development cost distribution. Yet, the distinction between product and process innovations disappeared at its extremes. At very low cost (bottom 9%), voluntary transfer of process innovation vanished and no longer differed from new products. We suspect that low-cost process innovations are only relevant to the innovating firm and lack general use value. This echoes an obvious condition for outbound transfer, namely, that there must be general value to be appropriated (DiMasi et al., 2016). We also found that at very high development cost (top 8%), process innovations more often leaked away or were stolen, such that the difference with new products vanished. We conclude that value-at-stake matters, especially in extreme cases, and that the patterns observed in business suggest the calculative use of voluntary sharing to serve the firm's interest. In other words, when stakes are high, firms are increasingly confronted with behaviours described in classical studies of innovation appropriation. This finding sheds new light on claims made by some scholars that firms reveal process innovations for indirect benefits, such as return favours or future price discounts (de Jong & von Hippel, 2009)—this does not seem to happen when stakes are high.

We point out that involuntary transfer as such does not fall under the umbrella of open innovation. Most definitions explicitly stress that open innovation refers to purposively managed knowledge flows (West & Bogers, 2014). However, it could also be argued that when firms engage in open innovation activities, their organizational boundaries also become more permeable for those innovations that are not meant to be transferred intentionally (Lopes & de Carvalho, 2018; Ritala et al., 2015). Our study provides no evidence for this latter proposition, as we did not find significant results for innovation contracting and collaboration in Table 4 (Model I). We interpret our findings as evidence that involuntary transfer is something that high-tech small firms had wanted to avoid. Furthermore, it cannot be considered part of outbound open innovation, even not due to intensified knowledge sourcing (inbound transfer) to develop product innovations. Looking more closely at our findings, we tentatively suggest that product and process innovation are marked by a different kind of openness. Recall that in Table 2, we found that product innovations were more frequently developed in collaboration with others (54% for product innovations vs. 21% for process innovations). When developing products, high-tech small firms seem to spread their risks and engage in external knowledge sourcing more than in the case of process innovation. Overall, it seems that new products are more related to inbound transfer while process innovation is related to voluntary outbound transfer.

Another remark is that, although we detected substantial empirical differences between process and product innovation, it remains to be seen if our findings generalize to other types of firms. High-tech small firms are usually active in emerging industries and at the forefront of technological change (Davey et al., 2011; Simonen et al., 2015). Capturing value from product innovation is essential to them, although process innovation may be less critical. However, process innovation can be more important in other contexts, implying higher stakes, so that possibly voluntary outbound transfer becomes less likely. Examples include firms in scale-intensive industries (Pavitt, 1984) and resource-intensive firms (de Jong & Marsili, 2006). We recommend more research to replicate our findings in samples other than high-tech small firms (see Section 5.2).

In summary, previous open innovation studies have offered different views on the extent to which firms voluntarily transfer knowledge to other organizations or avoid this. Our main theoretical contribution is that these opposing views can be explained by considering the type of innovation at hand. New processes embodied in machines, equipment, tools or devices are more obvious candidates for voluntary outbound transfer and are more likely shared. Product innovations are more likely protected in the spirit of classical appropriation studies—but run a much higher risk of being stolen or to leaking. Only at extremely high or low development costs the differences between product and process innovation disappear. This suggests that at truly substantial investments, firms seem reluctant towards other companies taking advantage of the innovations that they initially developed for in-house purposes. At low costs, their process innovations are most likely less attractive to be adopted.

5.2 | Implications for practitioners

To practitioners, our findings imply that high-tech small firms maintain different strategies to take advantage of the value embodied in various types of innovations. Managers following the classical view of keeping knowledge in-house and striving to avoid knowledge spillovers may become aware of the potential to capture value from innovations that are initially developed for internal purposes—what is valuable in-house may be valuable to others. Managers could consider the interests of similar businesses and/or supplier firms of similar machines, tools, devices or equipment when exploring opportunities for additional value creation. Beyond the direct financial benefits to be obtained from taking knowledge outside organizational boundaries, knowledge sharing can be done for indirect benefits, such as future favours, strengthening network ties or obtaining better versions of the (process) innovation if a commercial supplier adopts, improves and offers the innovation to a broader market.

Likewise, our findings help raise awareness of policymakers and company advisors of where innovation-related knowledge suitable for outbound innovation strategies can be found within companies. The open innovation literature focuses on unexploited technologies and patents that remain on the shelf (e.g., West & Bogers, 2014). Beyond this, our study identifies innovations with regard to the equipment, tools, machinery and devices used within the business as opportunities for outbound innovation.

5.3 | Limitations and future research

Our study had limitations that immediately translate into opportunities for continued research. First, as mentioned before, there is the issue of generalizability. We recommend replicating our study with samples of larger and low-tech enterprises. It is not self-evident that all firms will try to benefit from product innovation in-house and bring process innovations outside.

Second, although we found that process innovations in high-tech small firms are more likely transferred voluntarily, we could not delineate *why* firms engage in this behaviour and if it pays off in terms of performance. Is it done for direct benefits (e.g., money, license fee) or indirect benefits (e.g., strengthening network ties, future discounts)? When investigating these questions, various types of process innovations can be distinguished. We stumbled upon an early paper by Schrader (1991), who observed informal know-how trading between companies with regard to safety-enhancing innovations, simplifications of work processes, cost-reducing innovations and process innovations enabling new products. There can be differences in firms' willingness to share: For example, they keep product-enabling processes behind their factory walls but proactively share safety-enhancing innovations for free, for altruistic reasons.

Third, we analysed when innovations are voluntarily shared or involuntarily leaked away. There is, however, a potential third type of outbound knowledge transfer in which other businesses simply observe a firm's innovation then reversely engineer it. It could be argued that such ‘imitation’ can be considered a different form of involuntary transfer that we did not capture in our survey (in which we asked for leaking and stealing but did not explicitly mention imitation). Although we do not expect that our findings would differ (for the same arguments offered at H1 and H3, we would hypothesize that product innovations are more likely imitated and that high-cost process innovations are more interesting candidates for imitation), our survey did not refer to imitation explicitly. In future research, this is potentially a separate outbound transfer pathway to be explored. We thank an anonymous reviewer for pointing out this possibility.

Finally, our study provides a cross-sectional view of outbound knowledge transfer. In our robustness check, we found that our findings are maintained if voluntary and involuntary transfer is simultaneously analysed, strengthening our conclusion that process innovations are a better match with voluntary transfer. Nevertheless, our methods neglect that in practice, there may be a dynamic interplay: Adopters may only try to copy or imitate innovations if the innovating firm refuses to transfer voluntarily and vice versa. We would recommend starting with individual case studies to explore firms' decision-making process and how the decision to engage in outbound open innovation is influenced by internal (e.g., managerial preferences) and contextual factors (e.g., market growth and industry dynamics).

ACKNOWLEDGEMENT

We thank Daniel Cowen for proof-reading this paper.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Jeroen P.J. de Jong https://orcid.org/0000-0002-2369-5744

REFERENCES

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. SAGE.

Alexy, O., George, G., & Salter, A. J. (2013). Cui Bono? The selective revealing of knowledge and its implications for innovative activity. *Academy of Management Review*, *38*(2), 270–291. https://doi.org/10.5465/amr.2011.0193

Anand, A., Centobelli, P., & Cerchione, R. (2020). Why should I share knowledge with others? A review-based framework on events leading to knowledge hiding. *Journal of Organizational Change Management*, *33*(2), 379–399. https://doi.org/10.1108/JOCM-06-2019-0174

Arrow, K. J. (1962). Economic welfare and the allocation of resources for invention. In R. R. Nelson (Ed.), *The rate and direction of inventive activity: Economic and social factors* (pp. 609–625). Princeton University Press. https://doi.org/10.1515/9781400879762-024

Arundel, A., & Kabla, I. (1998). What percentage of innovations are patented? Empirical estimates for European firms. *Research Policy*, *27*(2), 127–141. https://doi.org/10.1016/S0048-7333(98)00033-X

Baldwin, C., & von Hippel, E. (2011). Modeling a paradigm shift: From producer innovation to user and open collaborative innovation. *Organization Science*, *22*(6), 1399–1417. https://doi.org/10.1287/orsc.1100.0618

Bonanno, G., & Haworth, B. (1998). Intensity of competition and the choice between product and process innovation. *International Journal of Industrial Organization*, *16*(4), 495–510. https://doi.org/10.1016/S0167-7187(97)00003-9

Brem, A., & Nylund, P. A. (2021). Maneuvering the bumps in the New Silk Road: Open innovation, technological complexity, dominant design, and the international impact of Chinese innovation. *R&D Management*, *51*(3), 293–308. https://doi.org/10.1111/radm.12451

Bunduchi, R., Weisshaar, C., & Smart, A. U. (2011). Mapping the benefits and costs associated with process innovation: The case of RFID adoption. *Technovation*, *31*(9), 505–521. https://doi.org/10.1016/j.technovation.2011.04.001

Cassiman, B., & Veugelers, R. (2002). R&D cooperation and spillovers: Some empirical evidence from Belgium. *American Economic Review*, *92*(4), 1169–1184. https://doi.org/10.1257/00028280260344704

Chesbrough, H. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Harvard Business School Press.

Cohen, W. M., Nelson, R. R., Walsh, J. P. (2000), Protecting their intellectual assets: Appropriability conditions and why US manufacturing firms patent (or not), National Bureau of Economic Research, working paper 7552, www.nber.org/papers/w7552

Dahlander, L., & Gann, D. M. (2010). How open is innovation? *Research Policy*, *39*, 699–709. https://doi.org/10.1016/j.respol.2010.01.013

Davey, S. M., Brennan, M., Meenan, B. J., & McAdam, R. (2011). Innovation in the medical device sector: An open business model approach for high-tech small firms. *Technology Analysis & Strategic Management*, *23*(8), 807–824. https://doi.org/10.1080/09537325.2011.604152

de Jong, J. P., & Flowers, S. (2018). Free in, free out? Outbound transfer of user innovations in small UK firms. *Industrial Marketing Management*, *73*, 21–30. https://doi.org/10.1016/j.indmarman.2018.01.008

de Jong, J. P. J., & Marsili, O. (2006). The fruit flies of innovations: A taxonomy of innovative small firms. *Research Policy*, *35*(2), 213–229. https://doi.org/10.1016/j.respol.2005.09.007

de Jong, J. P. J., & von Hippel, E. (2009). Transfers of user-process innovations to producers: A study of Dutch high tech firms. *Research Policy*, *38*(7), 1181–1191. https://doi.org/10.1016/j.respol.2009.04.005

DiMasi, J. A., Grabowski, H. G., & Hansen, R. W. (2016). Innovation in the pharmaceutical industry: New estimates of R&D costs. *Journal of Health Economics*, *47*, 20–33. https://doi.org/10.1016/j.jhealeco.2016.01.012

Duarte, V., & Sarkar, S. (2011). Separating the wheat from the chaff—A taxonomy of open innovation. *European Journal of Innovation Management*, *14*(4), 435–459. https://doi.org/10.1108/14601061111174907

Dziallas, M., & Blind, K. (2019). Innovation indicators throughout the innovation process: An extensive literature analysis. *Technovation*, *80*, 3–29. https://doi.org/10.1016/j.technovation.2018.05.005

Easterby-Smith, M., Lyles, M. A., & Tsang, E. W. (2008). Inter-organizational knowledge transfer: Current themes and future prospects. *Journal of Management Studies*, *45*(4), 677–690. https://doi.org/10.1111/j.1467-6486.2008.00773.x

Felin, T., & Zenger, T. R. (2014). Closed or open innovation? Problem solving and the governance choice. *Research Policy*, *43*(5), 914–925. https://doi.org/10.1016/j.respol.2013.09.006

Fosfuri, A. (2006). The licensing dillema: Understanding the determinants of the rate of technology licensing. *Strategic Management Journal*, *27*(12), 1141–1158. https://doi.org/10.1002/smj.562

Franke, N., & Shah, S. (2003). How communities support innovative activities: An exploration of assistance and sharing among end-users. *Research Policy*, *32*(1), 157–178. https://doi.org/10.1016/S0048-7333(02)00006-9

Gächter, S., von Krogh, G., & Haefliger, S. (2010). Initiating private-collective innovation: The fragility of knowledge sharing. *Research Policy*, *39*(7), 893–906. https://doi.org/10.1016/j.respol.2010.04.010

Gambardella, A., Giuri, P., & Luzzi, A. (2007). The market for patents in Europe. *Research Policy*, *36*(8), 1163–1183. https://doi.org/10.1016/j.respol.2007.07.006

Garcia, R., & Calantone, R. (2002). A critical look at technological innovation typology and innovativeness terminology: A critical review. *Journal of Product Innovation Management*, *19*, 110–132. https://doi.org/10.1111/1540-5885.1920110

Grinstein, A., & Goldman, A. (2006). Characterizing the technology firm: An exploratory study. *Research Policy*, *35*(1), 121–143. https://doi.org/10.1016/j.respol.2005.09.003

Guisado-González, M., Wright, L. T., & Guisado-Tato, M. (2017). Product–process matrix and complementarity approach. *The Journal of Technology Transfer*, *42*(3), 441–459. https://doi.org/10.1007/s10961-015-9435-6

Haneda, S., & Ito, K. (2018). Organizational and human resource management and innovation: Which management practices are linked to product and/or process innovation? *Research Policy*, *47*(1), 194–208. https://doi.org/10.1016/j.respol.2017.10.008

Harhoff, D., Henkel, J., & von Hippel, E. (2003). Profiting from voluntary information spillovers: How users benefit by freely revealing their innovations. *Research Policy*, *32*(10), 1753–1769. https://doi.org/10.1016/S0048-7333(03)00061-1

Henkel, J. (2006). Selective revealing in open innovation processes: The case of embedded Linux. *Research Policy*, *35*(7), 953–969. https://doi.org/10.1016/j.respol.2006.04.010

Henkel, J., Schöberl, S., & Alexy, O. (2014). The emergence of openness: How and why firms adopt selective revealing in open innovation. *Research Policy*, *43*(5), 879–890. https://doi.org/10.1016/j.respol.2013.08.014

Hullova, D., Simms, C. D., Trott, P., & Laczko, P. (2019). Critical capabilities for effective management of complementarity between product and process innovation: Cases from the food and drink industry. *Research Policy*, *48*(1), 339–354. https://doi.org/10.1016/j.respol.2018.09.001

Kuusisto, A., & Kuusisto, J. (2013). Diffusion of user innovations—A firm-level survey. *International Journal of Technology Marketing*, *8*(2), 127–141. https://doi.org/10.1504/IJTMKT.2013.054080

Lopes, A. P. V. B. V., & de Carvalho, M. M. (2018). Evolution of the open innovation paradigm: Towards a contingent conceptual model. *Technological Forecasting and Social Change*, *132*, 284–298. https://doi.org/10.1016/j.techfore.2018.02.014

Nuvolari, A. (2004). Collective invention during the British industrial revolution: The case of the Cornish pumping engine. *Cambridge Journal of Economics*, *28*(3), 347–363. https://doi.org/10.1093/cje/28.3.347

OECD/Eurostat. (2018). *Oslo manual: Guidelines for collecting and interpreting innovation data* (4th ed.).

Pacheco-de-Almeida, G., & Zemsky, P. B. (2012). Some like it free: Innovators' strategic use of disclosure to slow down competition. *Strategic Management Journal*, *33*, 773–793. https://doi.org/10.1002/smj.971

Pavitt, K. (1984). Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy*, *13*(6), 343–373. https://doi.org/10.1016/0048-7333(84)90018-0

Penin, J. (2008), More open than open innovation? Rethinking the concept of openness in innovation studies, Bureau dEconomie Théorique et Appliquée, Working Paper, *18*(33), 1–20.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology*, *88*(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Raasch, C., & von Hippel, E. (2013). Innovation process benefits: The journey as reward. *Sloan Management Review*, *55*(1), 33–39.

Ritala, P., & Hurmelinna-Laukkanen, P. (2009). What's in it for me? Creating and appropriating value in innovation-related coopetition. *Technovation*, *29*(12), 819–828. https://doi.org/10.1016/j.technovation.2009.07.002

Ritala, P., Olander, H., Michailova, S., & Husted, K. (2015). Knowledge sharing, knowledge leaking and relative innovation performance: An empirical study. *Technovation*, *35*, 22–31. https://doi.org/10.1016/j.technovation.2014.07.011

Schilling, M. (2010). *Strategic management of technological innovation*. Singapore.

Schrader, S. (1991). Informal technology transfer between firms: Cooperation through information trading. *Research Policy*, *20*, 153–170. https://doi.org/10.1016/0048-7333(91)90077-4

Siachou, E., Trichina, E., Papasolomou, I., & Sakka, G. (2021). Why do employees hide their knowledge and what are the consequences? A systematic literature review. *Journal of Business Research*, *135*, 195–213. https://doi.org/10.1016/j.jbusres.2021.06.031

Simonen, J., Svento, R., & Juutinen, A. (2015). Specialization and diversity as drivers of economic growth: Evidence from high-tech industries. *Papers in Regional Science*, *94*(2), 229–247. https://doi.org/10.1111/pirs.12062

Tang, J. (2006). Competition and innovation behaviour. *Research Policy*, *35*(1), 68–82. https://doi.org/10.1016/j.respol.2005.08.004

Teece, D. J. (1986). Profiting from technological innovation - implications for integration, collaboration, licensing and public policy. *Research Policy*, *15*(6), 285–305. https://doi.org/10.1016/0048-7333(86)90027-2

Triguero, A., & Fernández, S. (2018). Determining the effects of open innovation: The role of knowledge and geographical spillovers. *Regional Studies*, *52*(5), 632–644. https://doi.org/10.1080/00343404.2017.1395004

von Hippel, E. (2005). *Democratizing innovation*. MIT Press. https://doi.org/10.7551/mitpress/2333.001.0001

von Hippel, E., & von Krogh, G. (2003). Open source software and the "private-collective" innovation model: Issues for organization science. *Organization Science*, *14*(2), 209–223. https://doi.org/10.1287/orsc.14.2.209.14992

Wan, F., Williamson, P., & Yin, E. (2019). Enabling cost innovation by non-traditional organizational processes: The case of Chinese firms. *Technological Forecasting and Social Change*, *139*, 352–361. https://doi.org/10.1016/j.techfore.2018.12.003

West, J., & Bogers, M. (2014). Leveraging external sources of innovation: A review of research on open innovation. *Journal of Product Innovation Management*, *31*(4), 814–831. https://doi.org/10.1111/jpim.12125

West, J., & Bogers, M. (2017). Open innovation: Current status and research opportunities. *Innovation: Organization and Management*, *19*(1), 43–50. https://doi.org/10.1080/14479338.2016.1258995

Wong, P. K., Lee, L., & der Foo, M. (2008). Occupational choice: The influence of product vs. process innovation. *Small Business Economics*, *30*(3), 267–281. https://doi.org/10.1007/s11187-006-9044-8

Wu, J., Harrigan, K. R., Ang, S. H., & Wu, Z. (2019). The impact of imitation strategy and R&D resources on incremental and radical innovation: Evidence from Chinese manufacturing firms. *The Journal of Technology Transfer*, *44*(1), 210–230. https://doi.org/10.1007/s10961-017-9621-9

AUTHOR BIOGRAPHIES

Jeroen P. J. de Jong is a full professor in marketing and business development at Utrecht University School of Economics. His research interests include user and open innovation, household innovation, high-tech small firms, innovation and entrepreneurial behavior, and marketing decisions in innovation management.

Andreu Turro is an assistant professor at University Autonoma de Barcelona (UAB) and member of the Centre for Studies and Research in Entrepreneurship and Social Innovation (CREIS) at UAB. His research is concerned with determinants of entrepreneurship and innovation, applying quantitative methods. His ongoing work is concerned with intra-organizational intrapreneurship and open innovation.

How to cite this article: de Jong, J. P. J., & Turro, A. (2022). Outbound knowledge transfer in high-tech small firms: The role of process innovation and development cost. *Creativity and Innovation Management*, *31*(3), 479–491. https://doi.org/10.1111/caim.12488