

## Article

# How Do Mobility Direction and Human Assets of Mobile Engineers Affect Joint Knowledge Creation after M&As?

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**Abstract:** We focused on mobile engineers, a distinctive employee group that may have unique reactions to mergers and acquisitions (M&As). Mobile engineers, employees that move from one firm to another, were previously recognized as an undesirable loss by most knowledge-intensive organizations. However, in this study, we show that they may return to their former organizations as effective knowledge creators when their previous and new organizations unite through M&As. We specifically investigated how their mobility direction, relational assets, and intellectual assets affect the amount of knowledge that is jointly created through inter-personal collaborations following the M&A. Using the data of 410 mobile engineers in high-technology M&As during 2000–2004 in the United States, we found that the mobility direction from acquiring firms to targets prior to M&A has a positive impact on joint knowledge creation. We also found that such mobility direction positively moderates the relationship between human assets of mobile engineers and their joint knowledge creation.

**Keywords:** joint knowledge creation; M&As; mobile engineer; mobility direction; relational and intellectual assets at the individual level

## 1. Introduction

Mergers and acquisitions (M&As) are well-known vehicles for acquiring human capital, knowledge, and increasing innovation [1–4]. Nonetheless, M&As often face considerable challenge in exploiting synergies for knowledge creation during post-acquisition periods [5,6]. Previous studies have refined the relationship between M&As and knowledge creation by investigating various conditions for knowledge creation, such as the relative characteristics of knowledge bases between targets and acquiring firms, the effect of structural integrations, and the environmental contexts of M&A transactions [7–9]. Most of these studies examined knowledge creation following M&As as typical firm-level phenomena.

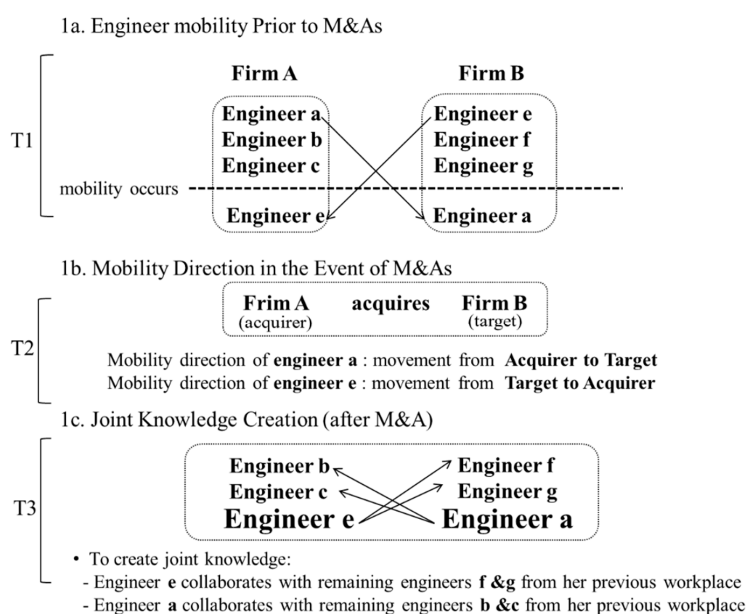
However, knowledge creation post M&As cannot be successful unless individual employees from both targets and acquiring firms voluntarily and actively integrate their sensitive knowledge, which often contains the highest commercial value. Such sensitive knowledge is usually tacit, non-codified, sticky, and embedded in the memory of individual engineers [10,11]. While previous studies examined the effect of key individuals such as star scientists, board members, and top managers on knowledge creation following M&As, they have not actively investigated the effects of average individual engineers.

Human mobility refers to the phenomenon whereby individuals in an organization voluntarily or involuntarily relocate themselves to other organizations with their own personal assets [12–14]. Mobile engineers can act as valuable knowledge workers in technology-intensive firms. By carrying with

them their knowledge and knowhow (intellectual assets) and their formal and informal inter-personal relationships at networks (relational assets) they allow destination firms to learn and create new knowledge in diverse ways at the event of their mobility. Previous studies have captured this by tracking patent citation patterns [15–17]. They showed that the physical relocations of individual engineers can transfer important knowledge across organizations, cities, countries, and even continents. [16,18,19]. Furthermore, studies showed that the amount of personal assets carried by mobile engineers have significant effects on knowledge transfer and creation [20–22]. However, only a few studies examined how the physical relocations of engineers affect knowledge transfer between firms in the context of M&As [23].

By integrating the literatures on M&As and human mobility, we aim to refine the relationship between M&As and subsequent knowledge creation as an individual-level phenomenon. While post-merger integration (PMI) processes are generally perceived to be difficult, we show that engineers with mobility event between acquirers and targets can significantly reduce knowledge-seeking and acquisition costs. We believe that this will be an interesting perspective because first, incorporating the human mobility perspective, the M&A literature can shift the focus of analysis from the firm level to the individual level and track the roles of individual mobile engineers in post-acquisition knowledge creation. Second, the event of M&A creates two contrasting organizational identities, target and acquirer, which form entirely different status in terms of psychological, social, and legal aspects [6,24,25]. Thus, when we investigate the effect of mobile engineers in the context of M&As, special attention should be paid to the mobility direction—whether individual engineers move from targets to acquiring firms or vice versa.

We specifically investigate how mobile engineers, who changed their associations either from targets to acquiring firms or vice versa prior M&As, collaborate with the remaining engineers at their previous organizations for knowledge creation in the post-acquisition period (see Figure 1). At the individual level, we further examine the interaction effects between mobility direction and human assets carried by mobile engineers. To test these questions, we first selected 1744 M&As in the U.S. high-tech sectors from 2000 to 2004. In high-tech sectors, the critical level of knowledge required to run the firm increases with the fast-paced evolution of the industry. This is characterized by frequent M&A and mobility events. To investigate knowledge creation activities of individual mobile engineers in these M&As, we identified a total of 74,591 engineers and collected their patent-filing data from 1973 to 2009.



**Figure 1.** Engineer mobility prior to mergers and acquisitions (M&As), mobility direction in the event of M&As, and joint knowledge creation.

Our study found that mobile engineers can be valuable assets when they are regained through M&A. Specifically, we found that the mobility direction of individual engineers prior to M&As is important for joint knowledge creation during the post-acquisition period. Engineers who moved from acquirers to targets prior to M&As were more active in collaborating with the remaining engineers at their previous organizations than those who moved from targets to acquiring firms. We found that the intellectual assets carried by mobile engineers from acquiring firms to target firms had a larger impact on the dependent variable. We also showed that the interaction term between mobility direction and relational assets had a significant effect on joint knowledge creation.

## 2. Theoretical Background

M&As lead to various reactions from employees of both targets and acquirers, which eventually affect potential knowledge creation post M&As [26–29]. Previous studies showed that a state of shock will spread throughout organizations after M&A announcements [29]. Employees feel that they are unprepared to assume changes in status, new culture, and responsibilities, which can be a source of anxiety [30]. In particular, subsequent employee turnovers may further exacerbate potential anxiety [31] and increase self-survival instincts that drive employees to engage in certain inter-personal collaborations, struggles to retain their status, and battles to sustain their networks [32]. M&As also require employees to deal with challenges of learning new routines, policies, and cultures [33,34]. Studies report that many acquisition failures are caused by an “us vs. them” dynamic, one that is often unavoidable when neither side’s employees can relinquish their former identities [35,36]. Even with good will attempts of the acquirer to integrate and commercialize on the target firm’s technology, acquirers face the challenge of maintaining organizational autonomy [37]. The clash of two different routines can lead to uncertainty, demotivation, and lower commitment, as employees become confused about their sense of identity, experience culture shocks, and occasionally feel emotions of hostility [38].

In comparison to the average employees who have to face various unfamiliarities, there is a small but unique employee group that may have entirely different reactions to the same M&A. This group consists of mobile workers who have work experiences at both targets and acquiring firms prior to the M&A. The group is clearly unique in the sense that its members have moved from targets to acquirers or vice versa. In the context of M&As, their work experience at both sides can provide a strong foundation to deal with upcoming changes, uncertainty, anxiety, cultural differences, and dissimilar routines. Moreover, the familiarity and acquaintance with both organizations, including their interpersonal networks, may allow mobile workers to quickly and easily adapt to and interact with the employees from the new target or acquirer side. In addition, the knowledge base of mobile workers may help them to better search their counterparts for initial inter-personal collaborations allowing them to actively recombine prior knowledge stock of their previous firm with new knowledge. Compared to the employees with no relocation experience, mobile workers with these unique experiences may find it easier and be faster at participating in collaborations from the very early stages of post-merger integration (PMI). Such initial collaborations driven by mobile engineers could actively trigger subsequent inter-personal collaborations by other employees on both sides, which may eventually increase joint knowledge creation throughout the firm as a whole after the M&A. The effect of mobile engineers who have work experiences at both sides is a very interesting phenomenon requiring further investigation.

Previous studies recognized that the personal assets of mobile engineers can be classified as either intellectual or relational assets. Intellectual assets refer to skills, know-how, and knowledge that play a critical role in diffusing knowledge [13,15,16]. Studies showed that human mobility can significantly contribute to the transfer of coded and non-coded knowledge to individuals, entities, or locations at multiple levels in industries such as manufacturing, finance, and service [15,16,18,19,21,22]. For example, Rosenkopf and Almeida [16] looked at 116 semiconductor firms and found that human mobility is a more effective tool than geographical proximity, as mobility may increase trust and common understanding among relevant organizations. Almeida and Kogut [15] found a positive relationship

between the mobility of major patent holders and the localization of technological knowledge due to partial knowledge spillover through institutional and labor networks. They further showed that the degree to which inter-firm mobility of patent holders affects local knowledge transfer can vary significantly across locations.

Previous studies also found that relational assets, such as inter-personal or social networks, can be another source of knowledge transfer and diffusion. While spatial proximity can reduce communication cost and increase the likelihood of face-to-face meetings, social relationships with former colleagues or others at remote locations may be a much more effective channel for the acquisition of knowledge. For example, Agrawal et al. [21] examined how labor mobility affects the diffusion of knowledge among inventors living in different metropolitan areas. They found that knowledge workers who move from New York to Los Angeles are still more likely to rely on New York knowledge bases rather than those in Los Angeles. Corredoira and Rosenkopf [18] showed that human mobility can cause a reverse transfer of knowledge, or a transfer of knowledge from hiring firms to the focal firms who had lost knowledge workers. They argued that focal firms can utilize the former engineers' interpersonal communication channels as tools for knowledge acquisition and monitoring. Oettl and Agrawal [19] found that the cross-border movement of engineers in relation to their social relationships can cause "unintended knowledge flows" between countries. From her arrival, the mobile engineer's new location may gain above and beyond the knowledge flow benefits exploited by the hiring firm.

However, studies have not paid sufficient attention to the effect of individual mobile engineers in the context of M&As. Only a few studies have investigated how M&As affect the productivity of knowledge workers. For example, Kapoor and Lim [39] showed that inventors from acquired firms have lower innovation productivity due to incentive alignment issues including agency problems, moral hazards, and non-verifiability. Paruchuri, Nerkar, and Hambrick [6] also demonstrated that acquisition integration may lead to severe productivity drops, especially for the acquired inventors who have lost their social status and network centrality within the combined organization. Ernst and Vitt [40] suggested that acquisitions may cause key inventors of acquired firms to become less productive or even leave the firm. However, these studies did not focus on mobile engineers, who can differently impact the relationship between M&As and subsequent knowledge creation.

In summary, previous studies showed whether a specific engineer's belong to either a target or an acquiring firm prior M&A has a clear impact on the way she reacts to the M&A. These well-known differences may naturally raise questions on whether the mobility direction of mobile engineers prior M&As, from targets to acquiring firms or vice versa, influences knowledge creation after M&As. In particular, compared to mobile engineers who moved from targets to acquiring firms prior to M&As, mobile engineers who moved from acquiring firms to targets prior to M&As may have starkly different preferences when collaborating with the engineers remaining at their former organizations in terms of subsequent joint knowledge creation. By investigating these questions, we aim to refine the existing literature about knowledge creation, M&As, and human mobility.

### 3. Hypotheses

#### 3.1. Mobility Direction and Joint Knowledge Creation

Previous studies showed that M&As affect individual members react differently depending on whether they belong to targets or acquirers [9]. They showed that, except for a few friendly mergers integrating fairly comparable firms, acquiring firms often have higher productivity, larger knowledge bases, and more financial resources than their potential targets [8,41]. The lead role as acquirer can often translate into a sense of superiority that allows acquiring firms to retain key policies, procedures, systems, organizational routines, and culture after M&As [29]. Such superiority may lead employees of acquiring firms to feel that they have a higher organizational status, stronger political power, and better inter- or intra-organizational relationships [6].

Unlike acquiring firms, targets usually experience more disruption in their task environments, especially if substantive incompatibilities exist [9,42]. Paruchiri et al. [6] noted that the removal of autonomy from target firm employees can bring significant managerial and social disruption. Employees of targets who previously enjoyed high status and powerful influence may lose network centrality and eventually become an average employee with moderate status. Even important R&D employees of the target firm whose status are respected post M&A will face disruption when work practices change and social settings such as key managers or other R&D personnel turnover increases [43,44]. Risberg [45] argued that typical high ambiguity perceived by target employees can cause large departures of key personnel, limiting the absolute number of engineers available at the target firms. The aura of conquest and/or superiority of acquiring firms tend to make employees of targets feel greater stress, insecurity, inferiority, and submission [29,46]. Such imbalance of employee status between the two sides may drive employees of targets to suffer from more serious uncertainty, fear, loss, and even anger [37,47]. These findings indicate that target firm employees are generally more adversely affected by M&As.

However, this same situation affects mobile engineers who have mobility experience between the two organizations in a completely different manner. Mobile engineers, unlike most other employees, may be relatively less affected by all of the above changes in terms of managing interpersonal collaborations for knowledge creation, more specifically for knowledge creation between mobile engineers and the remaining engineers at their previous organizations.

Assuming that a mobile engineer who has moved between acquirer and target prior M&As has to collaborate with the remaining engineers at her previous organization following the M&A, her mobility direction may lead to different conclusions. First, let us consider a case in which the mobile engineer moved from target to acquirer prior to an M&A and works for the acquirer at the time of the M&A announcement. Following the M&A, she must collaborate with the remaining engineers at the target. These counterparts at the target firm need to overcome all of the aforementioned difficulties caused by the M&A, which will take significant time and effort and will delay or inhibit realization of effective knowledge creation. However, if the mobility direction prior M&A is reversed, from the acquirer to the target, her counterparts of collaboration are now remaining engineers at the acquirer. Luckily, unlike the engineers at the target, they can avoid most of the aforementioned distress. Such contrast between the mobile engineer's counterparts of collaboration for the two cases will differently affect the performance of joint knowledge creation after M&As. Thus, assuming the individual assets carried by engineers are equal, we predict the following:

**Hypothesis 1 (H1).** *In terms of joint knowledge creation through interpersonal collaborations between mobile engineers and engineers at their previous workplace, mobile engineers who moved from an acquirer to target prior an M&A will create more joint knowledge than mobile engineers who moved from target to acquirer.*

### 3.2. Mobility Direction and Intellectual and Relational Assets Carried by Mobile Engineers

Previous studies on human mobility suggested that the intellectual assets carried by star engineers can significantly increase the innovation productivity of hiring firms [48], especially where knowledge creation requires a large tacit component [49] or where path-dependent knowledge significantly affects subsequent innovations [50]. Productivity of knowledge creation usually depends on the size and quality of intellectual assets and how they are integrated into the existing knowledge bases. Intellectual assets can play a critical role in future knowledge creation processes, such as codification, abstraction, diffusion, and absorption [51,52]. In particular, previous research has highlighted the role of disproportionately distributed intellectual assets, by investigating star scientists who create and possess much larger knowledge bases than average engineers [53,54]. They can keep up with rapid changes in technological progresses and in many cases, create critical knowledge themselves with better absorptive capacity and better integration capabilities [55]. Engineers with large intellectual assets for collaboration can be a critical foundation for joint knowledge creation.



The interpersonal collaborative experiences of knowledge workers can also affect knowledge creation, since valuable knowledge and expertise often resides in socially complex interactions and relationships among individual engineers [10,56–58]. Joint knowledge creation requires coworkers to undertake intensive problem-solving efforts and spend a large amount of time discussing, reflecting, observing, and interacting [59]. Such relational assets of engineers may include, but are not limited to, interpersonal relationships, co-work experiences, and know-how embedded in such relationships [60,61]. Human mobility literature argues that engineers with collaboration experiences and social relationships will have a positive association with joint knowledge creation [21,22].

If the relationship of hypothesis 1 is sustained, the effect of both intellectual and relational assets of mobile engineers can be moderated by mobility direction. Both assets are not accumulated overnight and take time to accumulate. Thus, following an M&A event where disruption on both assets are likely to occur, when engineers who move from acquirer to target are required to collaborate with engineers at the acquiring firm, the amount of intellectual and relational assets may be a critical determinant of subsequent joint knowledge creation. However, when the direction is reversed, from a target to an acquirer, the impact of those assets may be hindered by the possible costs and delays that the target firm assumes in order to manage the negative influences of M&As. Thus, we predict the following:

**Hypothesis 2A (H2A).** *In terms of joint knowledge creation through interpersonal collaborations between mobile engineers and engineers at their previous workplace, the mobility direction of engineers from an acquirer to target prior an M&A will positively moderate the relationship between intellectual assets of mobile engineers and joint knowledge creation.*

**Hypothesis 2B (H2B).** *In terms of joint knowledge creation through interpersonal collaborations between mobile engineers and engineers at their previous workplace, the mobility direction of engineers from an acquirer to target prior an M&A will positively moderate the relationship between relational assets of mobile engineers and joint knowledge creation.*

## 4. Methods

### 4.1. Sample and Data

Our sample consisted of mobile engineers who moved between targets and acquirers prior M&As and continued to work at one side at the time of M&A announcement, and collaborated with engineers from their previous workplace after the M&A. We selected our sample with the following three criteria. First, there should be at least one engineer who moved from one firm to the other during the ex-ante M&A period (T1, the time window of five years prior to the M&A). Second, there should be an M&A between the two firms after the engineer's mobility (T2,  $T1 < T2$ ). The second criterion is very important, since it is the precondition that allows the mobile engineer to have a mobility direction, between the target and the acquiring firm. Third, the engineer collaborates with remaining engineers at her previous workplace and co-files at least one patent during the ex-post M&A period (T3, the time windows of five years after the M&A,  $T1 < T2 < T3$ ). In keeping with previous studies [6,41], we used the time period or window of five years for measuring knowledge creation activities during both the ex-ante and ex-post M&A periods. To check the robustness of the five-year window, we conducted additional analyses by applying time windows of six and seven years. We found that marginally longer time windows did not change our results.

Patent data give information regarding the inventor, location, time, and owner or assignee of invention [15]. Though the relevance of patent data may vary among industries, for high-tech industries where intellectual assets become an essential source of competitive advantage, it is almost impossible for the same engineer to file a patent application under another firm without actual job relocation [62]. In human mobility literature, patent data have been taken as a reliable source to identify engineer mobility and knowledge creation among mobile engineers [15,21,22]. In keeping

with previous studies [22], we first identified the event of engineer mobility as follows: An engineer's mobility is identified when the engineer is listed in the patent document(s) of applicant firm A at time TX and in the patent document(s) of applicant firm B at time TY, where  $TX < TY$ . If an engineer is listed as an inventor for two different firms at two different times, we assumed that the inventor moved from one firm to the other sometime between time TX and TY. We specifically identified mobile engineers by examining all inventors for all the patents filed by our selected firms and finding solid matches of their full names. We made sure that the inventor name characters had to exactly match both first and last names, and middle initials if included [22].

Using patent data to identify individual engineers and their mobility is not without limitation. First, if an engineer moved between a target and an acquiring firm prior M&A but only filed patents at one or the other, our data structure could not identify such kind mobility. Because there are no comprehensive databases that allow us to track the comprehensive inter-firm mobility of all engineers of our selected firms, we were unable to avoid these types of errors. However, since such errors, if any, may reduce the number of mobility observations (Type I error), we can still design a conservative test for engineer mobility. Second, the method of identifying inventors by using their full names could be subject to another Type I error (i.e., since inventors often use multiple spelling permutations of their names, we may have missed actual moves) and Type II errors (different inventors who have the same name could lead us to erroneously flag a move). Type I errors may reduce the possible sample size and subsequently lead to a more conservative estimate of the overall engineer mobility. For Type II errors, while we did not expect them to significantly change our results, we applied a few more additional backup procedures to minimize potential errors, such as checking the addresses of engineers, the technology classes of patents, and patent application dates. If we found unreasonable matches for these additional criteria, we did not include them in our sample.

We also followed three steps to select M&As for our study. First, we selected 1744 M&As that occurred between 2000–2004, for a total of five years. However, we limited the selection to only those cases where both the acquiring and acquired companies possessed at least one U.S. patent in the five years prior to the effective date of M&As [39,41]. Second, we further limited our sample selection by applying the criteria of minimum deal value of \$1 million [63] and a minimum ownership of 50% after M&As [64,65]. Third, to avoid possible confounding effects of institutional or cultural aspects across countries [44,66], we did not include cross-border M&As. Thus, our final sample included only the M&As between U.S. domestic firms. We collected our M&A data from the Securities Data Corporation (SDC) Platinum's M&A Database. To identify the event date of the M&As, the date when an M&A transaction were completed was used and not when it was announced. Since there is usually a significant time delay of several months or more between M&A announcement and consummation, the announcement dates may increase the probability that any patents applied before M&As would be inadvertently counted as ex post-M&A outputs.

To test our research question, we chose the biotechnology, chemical, computer equipment, software, communications, electronics, and electrical equipment industries for two reasons. First, in these industries, engineers play pivotal roles as knowledge creators. Moreover, these industries have been frequently profiled in various publications and media as sectors for active mobility of engineers and frequent M&As for acquisition of external knowledge [8,15]. Second, these industries are characterized by strong appropriability regimes that encourage active patenting activities. Following all of the above procedures, we identified a total of 74,591 engineers who had filed at least one patent at either target or an acquiring firm during the time window of five years prior M&As. Among the 74,591 engineers, we were able to identify a total of 410 engineers who moved to other organizations in a total of 75 M&As. Those mobile engineers experienced an interesting event whereby an M&A united their previous and current organizations.

## 4.2. Dependent Variable

### Joint Knowledge Creation of Mobile Engineers after M&As

In keeping with previous studies [67–69], our dependent variable was measured by the number of patent applications that a mobile engineer co-filed with other engineers remaining at her previous workplace during the five years after an M&A. We did not include the patent applications filed only by engineers at either target or acquiring firm. Co-filing patent applications is a good proxy for joint knowledge creation. Typically, engineers cannot be listed as co-inventors unless they had meaningful interactions and made significant contributions. Our unit of analysis is the individual mobile engineer and not the firm. Thus, instead of using patent citation data, which are a well-known index for knowledge transfer across firms [13,16], we relied on patent authorship data, which contain information on all related inventors. While knowledge creation can take longer than a year, there is not much of a delay in time between real invention and the actual patent application dates. To protect newly created knowledge assets, most engineers have a strong incentive alignment to file for patents as soon as possible. Thus, following the approach used by previous studies [3], we examined patent applications rather than actual issuances due to inherent time lags between the two.

## 4.3. Independent and Moderating Variables

### 4.3.1. Mobility Direction

The combined contexts of M&As and human mobility allow us to investigate the effect of human mobility direction. As explained above, the engineer mobility from one firm to the other at T1 followed by the M&A at T2 establishes the identity of targets and acquiring firms. For example, tracking instances where an engineer moved from a focal firm A to firm B at T1 and Firm A later acquires Firm B, the engineer's mobility direction is from an acquiring firm to target. Similarly, if the engineer moved from Firm B to Firm A in the same context, then the engineer's mobility direction is from target to acquiring firm. Thus, we coded mobility direction as a binary variable, coded as 1 for the mobility direction where an engineer moves from acquirer to target firm prior to M&As. Our patent data also identified that a few engineers made multiple movements between the same pair of target and acquirer prior to an M&A. We believed that it is not very realistic for an engineer to make multiple movements between the same target and acquirer within the time window of five years. Thus, to design a conservative test on the effect of engineer mobility, we focused on the group with only one mobility event during our study period. In addition, to secure robustness of our mobility direction measure, we conducted the same analyses by including those multiple mobility events and treating such engineer movements in several ways. We coded all of the multiple movements as separate events and their last movement only. We found that these additional tests did not change our results.

### 4.3.2. Intellectual Assets

Intellectual assets are the codified, tangible, or physical descriptions of specific knowledge to which firms can assert legal ownership rights, and are readily tradable in disembodied forms [70]. Following previous studies [18], we measured intellectual assets of mobile engineers by using the cumulative number of patent applications filed before their movement on patent data. While the value of intellectual assets decreases over time, we just counted the total number of patent applications by a mobile engineer from her first application to the last application before her movement. Thus, our measure is a good proxy to indicate the total amount of intellectual assets carried by a mobile engineer with her movement.

### 4.3.3. Relational Assets

Mobile engineers can also carry relational assets with their movements. Their relational assets include both formal and informal inter-personal relationships, such as relationships with friends,



colleagues, subordinates, and supervisors [71]. While various informal relationships are definitely worthwhile for further investigation, it is very difficult to identify all such informal relationships with reliable data. Thus, our study only considered the professional relationship in the context of knowledge creation activities, which we can reliably identify with patent data [72]. We measured a mobile engineer's relational assets as the total number of co-inventors in previous patent applications filed by the engineer prior to her movement. In order to be listed as the co-inventor on a patent application, engineers must not only make significant contributions to specific applications, but must also maintain intensive interactions and knowledge sharing with other co-inventors for a fairly long time [67]. Co-inventor relationships in such knowledge creation communities are often thought to facilitate mutual identification and promote interpersonal trust for future collaborations [73].

#### 4.4. Control Variables

We included several additional variables that may be expected to affect our results but were not critical for our theoretical scope. These control variables are individual, firm, and M&A-related characteristics. Our control variables include the organizational tenure of mobile engineers, organizational identity change, technological dissimilarity, the knowledge base of acquirer and target prior to M&A, M&A experience of acquirer and target, and the geographical proximity between acquirer and target, M&A motivation, and transaction value. As patent applications do not provide information on the mobile engineer's age or seniority, we controlled for the *organizational tenure of mobile engineers*, measured as the log-transformed number of calendar months between effective dates of M&A, and application dates of the first patents filed by engineers prior to their moves [39,74].

Firm-level characteristics can also affect knowledge creation of mobile engineers. To control for organizational identity change after M&A, we examined whether acquiring firms maintained the original company name of the target firm or not. Although company names may not wholly represent corporate identity, previous studies encoded it as central features of organizational identity change [75–77]. The implicit meaning of changing a target company name is the desire of the acquiring firm to actively seek a new organizational identity to facilitate collaborations among knowledge workers of both sides. We coded a change of corporate name as a binary variable, coded as 1 if the target company name was not on the patent application filed after M&A. However, even when company names remained intact, it is possible that no patent application was filed under the target company name. In order to minimize such errors, we double-checked the target company names after M&A by using the COMPUSTAT's profit and loss (P&L) data. Following previous studies [6], we measured technological dissimilarity between acquirer and target by using the Euclidean distance. We used the number of patents in the same three-digit patent class for the five years before M&A.

To measure the knowledge bases of targets and acquirers prior to M&As, we used the total number of patent applications for the five years before the M&A. Knowledge bases can critically influence joint knowledge creations between targets and acquirers, because they constitute a practical foundation for future collaborations and knowledge creation activities. We measured M&A experience by counting prior the total number of M&As conducted by either targets or acquirers during the five years prior to M&A. Geographical proximity may be operationalized in terms of geographic region [16] and physical distance [78]. To control for differences among regional mechanisms that could encourage interpersonal collaborations, we calculated the proximity as the log-transformed number of kilometers between targets and acquirers, taking the corporate addresses from the SDC Platinum database. We also tested geographical regions using a binary variable to indicate whether targets and acquirers were located in the same metropolitan area or state. Both measures yielded fairly consistent results. Lastly, we also controlled for M&A characteristics by including *M&A motivation and transaction value*. To identify M&As for technological acquisitions, we coded M&A motivation as 1 when the acquiring firm's motivation was to obtain technology and research capability of targets. To identify M&A motivations, we examined the full contents of corporate announcements and newspaper articles about M&A announcements. For some cases, acquisitions may have been motivated by multiple factors

where technology may not be a first priority. For those M&As with multiple motivations, we did not include them in our analyses. We also controlled for the log-transformed economic value of individual M&A transactions.

#### 4.5. Analysis Method

We hypothesized that joint knowledge creation is generated by the function  $y = f(x, \beta)$ , where  $y$  is the amount of joint knowledge creation,  $x$  is the vector of explanatory variables identified in our hypotheses and all available control variables, and  $\beta$  is the vector of estimation parameters. Since the dependent variable, the amount of joint knowledge creation, is a count variable and takes on non-negative integer values, conventional linear regression models were inappropriate for our analysis. We needed to apply a nonlinear regression model to avoid heteroskedastic, non-normal residuals [79]. The Poisson model has been widely used to analyze such phenomena measured by count data [80]. A central distributional assumption of the Poisson model is the equivalent of the mean and variance. We tested for over dispersion by the value of Pearson Chi-square dispersion statistic [81]. A Pearson dispersion of 2.41 in excess of 1.0 tends to indicate a Poisson model of over dispersion. If we employ the Poisson regression model, even though the parameters are consistently estimated, the standard errors will typically be underestimated, leading to a spuriously high level of significance. Thus, we used the negative binomial (NB) regression to obtain more efficient estimators [79]. Another econometric concern is the large number of zero observations. The effect of excessive zeroes may be a misspecification of the NB model. That is, a zero-inflated negative binomial (ZINB) model adds an additional mass at the zero value of joint knowledge creation, resulting in a higher proportion of zeroes than is consistent with the underlying NB model. We conducted the Vuong test [82] to choose the optimal model that best reflects the data between the NB and ZINB models. In our case, the Vuong statistic did not favor one model or the other at the 95% confidence level. Therefore, we employed the NB regression model.

### 5. Results

Table 1 provides descriptive statistics and correlations for the variables used in our analyses. Even though the sample involves a total of 75 M&As in the high-tech industry, there was considerable variance on all key variables such as joint knowledge creation, intellectual assets, and relational assets. The data were examined for violations on the assumptions of normality and multi-collinearity. The dependent variable followed a negative binomial distribution, and all other variables approximated normal distributions. On average, 410 mobile engineers in the sample produced about 0.44 joint knowledge creation during the five years after M&A. About 16% of engineers moved from acquirer to target prior to M&A. Compared to target firms, acquiring firms had more M&A experience and a larger knowledge base.

While most pairwise correlations were fairly low, the correlation between intellectual and relational assets (0.71) was inherently high. We analyzed these variables separately to identify the net influence of each variable and then combined them for the full model. Although the low correlations between mobility direction and intellectual and relational assets may suggest that our models may not be subject to multicollinearity problems (the highest variance inflation factor was well below the benchmark level of 5), we implemented additional steps to avoid multicollinearity issues by centering the variables for the interaction effects [83]. The additional tests for the robustness check showed that the results of the hypothesized effects were stable across a number of analyses and unaffected by the high correlations among our control variables.

The results of the negative binomial regression models are reported in Table 2. The variables reflecting the hypothesized effects were entered into the regression individually. Model 1 of Table 2 presents the base model with control variables only. Models 2–4 include mobility direction, intellectual assets and interaction terms, and relational assets and interaction terms, entered successively. Model 5

reports the full model including all variables. The likelihood-ratio tests show how the addition of the independent variables significantly improved the model fit.

Among the control variables in Model 1, we found that some significantly affected joint knowledge creation after M&As. Organizational identity change, which represents the intentional change of the target company name after M&As, had a significant negative impact on the dependent variable. This indicates that an immediate change of target company name could create a meaningful shock and turbulence, hampering interpersonal collaborations of mobile engineers for future knowledge creation. While corporate knowledge assets usually have a positive impact on innovation, we found that the knowledge base of targets and acquirers prior to M&As marginally decreased joint knowledge creation after M&As. This may suggest that firms with large knowledge bases may not exploit significant benefits of joint knowledge creation from their previous engineers who moved to other organizations. However, the M&A experience of targets (as opposed to acquirers) positively affected joint knowledge creation after M&As. This suggests that mobile engineers with more acquisition experience are better prepared to collaborate with engineers at other organizations and especially at their previous organizations. Unlike previous studies, which found a positive association between geographical proximity and inter-personal collaborations among engineers, our study found that geographical distance did not enhance the productivity of joint patent applications of mobile engineers after M&As. In addition, in terms of M&A-related characteristics, the motivation of acquisitions was important. M&As that are primarily motivated by knowledge acquisition increased joint knowledge creation of mobile engineers after M&As.

Hypothesis 1 predicted that the engineers who moved from acquirer to target prior an M&A would be more productive than those who moved from target to acquirer. Model 2 of Table 2 shows that the coefficient for the mobility direction from acquirer to target was positive and statistically significant ( $p$ -value < 0.01). While the positive coefficient of the mobility direction ceased to be significant in the following models with interaction terms, it indicates that engineer mobility, depending on its direction, does have a significantly differential impact on joint knowledge creation after M&As. Thus, Hypothesis 1 is partially supported.

Hypothesis 2A predicted that the impact of intellectual assets would be stronger for the mobile engineers who moved from an acquirer to a target prior to an M&As than otherwise. We expected a positive interaction effect between the intellectual assets of mobile engineers and mobility direction. Model 3 of Table 2 showed that the coefficient for intellectual assets was positive and significant ( $p$ -value < 0.01). This suggests that although engineers may significantly contribute to joint knowledge creation, the number of intellectual assets carried by mobile engineers does matter for joint knowledge creation post M&As. Model 3 further showed that the interaction effect between intellectual assets and mobility direction significantly increased joint knowledge creations, through the positive and significant coefficient for interaction term ( $p$ -value < 0.01). These significant effects were sustained in the full model as well. Hence, Hypothesis 2A was supported.

Hypothesis 2B predicted that the effect of relational assets would be stronger for the mobile engineers who moved from an acquirer to a target prior to an M&A than otherwise. We expected a positive interaction effect between the relational assets of mobile engineers and mobility direction. Model 4 of Table 2 showed that the coefficient for relational assets was positive and significant ( $p$ -value < 0.01), which implies that the amount of relational assets carried by mobile engineers also impacts joint knowledge creation after M&As. Model 4 further showed that the interaction effect between relational assets and mobility direction significantly increased joint knowledge creations, through the positive and significant coefficient for interaction term ( $p$ -value < 0.05). These findings are replicated in the full model. Hence, Hypothesis 2B was supported.

**Table 1.** Descriptive statistics and correlation matrix.

	Mean	Std. Dev.	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Joint Knowledge Creation	0.44	1.43	0.00	14.00	1.00													
2. Mobility Direction	0.16	0.37	0.00	1.00	0.10	1.00												
3. Intellectual Assets	3.21	4.49	1.00	45.00	0.29	−0.09	1.00											
4. Relational Assets	5.13	5.47	0.00	42.00	0.41	−0.04	0.71	1.00										
5. Organizational Tenure	3.80	0.67	0.51	5.88	0.03	−0.24	0.47	0.36	1.00									
6. Organizational Identity Change	0.29	0.45	0.00	1.00	0.00	0.08	−0.19	−0.11	−0.24	1.00								
7. Technological Dissimilarity	0.13	0.22	0.00	1.02	0.02	0.04	−0.18	−0.15	−0.24	0.64	1.00							
8. Geographical Proximity	4.93	3.11	0.00	7.90	0.03	0.06	0.06	0.12	0.17	0.14	0.06	1.00						
9. Acquirer M&As Experience	7.74	8.94	0.00	53.00	−0.04	0.00	−0.09	−0.03	0.05	0.20	0.29	0.40	1.00					
10. Target M&As Experience	1.43	1.62	0.00	8.00	0.08	−0.04	0.12	0.09	0.19	−0.22	−0.25	0.26	0.15	1.00				
11. Acquirer Knowledge Base Prior to M&As	560.07	973.58	2.00	6445.00	−0.05	0.19	0.03	0.01	0.05	−0.13	−0.15	0.18	0.33	−0.06	1.00			
12. Target Knowledge Base Prior to M&As	333.34	485.24	1.00	1221.00	−0.08	−0.09	0.08	0.00	0.31	−0.42	−0.38	0.38	0.22	0.52	0.12	1.00		
13. M&As Motivation	0.84	0.36	0.00	1.00	0.09	−0.05	0.13	0.19	0.03	−0.20	−0.21	0.16	0.04	−0.02	0.15	0.26	1.00	
14. Transaction Value	7.20	2.13	1.84	11.40	0.00	−0.02	0.17	0.18	0.12	−0.50	−0.47	0.10	0.19	0.48	0.25	0.49	0.30	1.00

Source: Author's calculation. Correlations  $\geq 0.08$  are significant at 0.1, correlations  $\geq 0.09$  are significant at 0.05 and correlations  $\geq 0.12$  are significant at 0.01.

**Table 2.** Results of joint knowledge creation test.

	Model 1	Model 2	Model 3	Model 4	Model 5
1. Mobility Direction		1.04 * (0.46)	−0.30 (0.67)	−0.30 (0.61)	−0.48 (0.61)
2. Intellectual Assets			0.30 ** (0.06)		0.07 † (0.05)
3. Intellectual Assets × Mobility Direction			0.50 * (0.22)		0.27 * (0.12)
4. Relational Assets				0.21 ** (0.03)	0.17 ** (0.04)
5. Relational Assets × Mobility Direction				0.14 * (0.07)	0.28 ** (0.09)
6. Organizational Tenure	0.11 (0.18)	0.24 (0.19)	−0.70 ** (0.26)	−0.66 ** (0.21)	−0.89 ** (0.23)
7. Organizational Identity Change	−1.12 * (0.51)	−1.58 ** (0.56)	−1.68 ** (0.55)	−2.28 ** (0.56)	−2.27 ** (0.57)
8. Technological Dissimilarity	0.89 (1.20)	1.44 (1.22)	1.39 (1.07)	2.48 * (1.05)	2.37 * (1.04)
9. Geographical Proximity	0.08 (0.08)	0.03 (0.08)	0.00 (0.07)	−0.04 (0.06)	−0.03 (0.06)
10. Acquirer M&As Experience	0.01 (0.03)	0.02 (0.03)	0.04 † (0.02)	0.02 (0.02)	0.03 (0.02)
11. Target M&As Experience	0.62 ** (0.21)	0.61 ** (0.21)	0.36 * (0.16)	0.31 * (0.13)	0.26 * (0.13)
12. Acquirer Knowledge Base Prior to M&As	−0.00 (0.00)	−0.00 (0.00)	−0.00 (0.00)	−0.00 (0.00)	−0.00 (0.00)
13. Target Knowledge Base Prior to M&As	−0.00 ** (0.00)	−0.00 ** (0.00)	−0.00 † (0.00)	−0.00 (0.00)	−0.00 (0.00)
14. M&As Motivation	1.80 ** (0.59)	1.85 ** (0.58)	1.21 * (0.55)	1.44 * (0.58)	1.19 * (0.57)
15. Transaction Value	−0.10 (0.11)	−0.12 (0.11)	−0.19 † (0.10)	−0.26 ** (0.09)	−0.24 ** (0.09)
16. Constants	−2.84 ** (1.08)	−3.07 ** (1.07)	1.39 (1.32)	1.44 (1.13)	2.26 † (1.18)
LR Chi2	30.70	35.92	71.46	96.59	103.00
N	410.00	410.00	410.00	410.00	410.00

Source: Author's calculation. †  $p < 0.1$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ .

To provide a more intuitive understanding of these results, we graphically displayed the significant results in Figures 2 and 3. Figures 2 and 3 display the interactions between mobility direction and intellectual assets, and mobility direction and relational assets, respectively. In Figure 2, we depict a striking result. If intellectual assets are high, then mobility direction has a strong positive effect. If, however, intellectual assets are low, then mobility direction from acquirer to target is actually harmful for joint knowledge creation. In Figure 3, a similar result is shown for the case of interaction between mobility direction and relational assets.



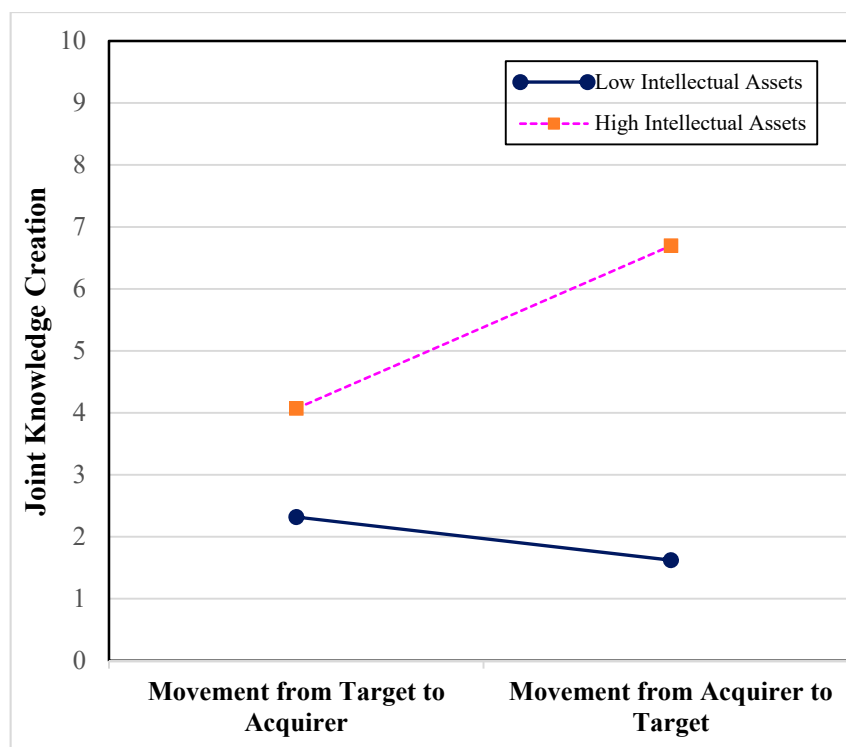


Figure 2. Interaction between mobility direction and intellectual assets.

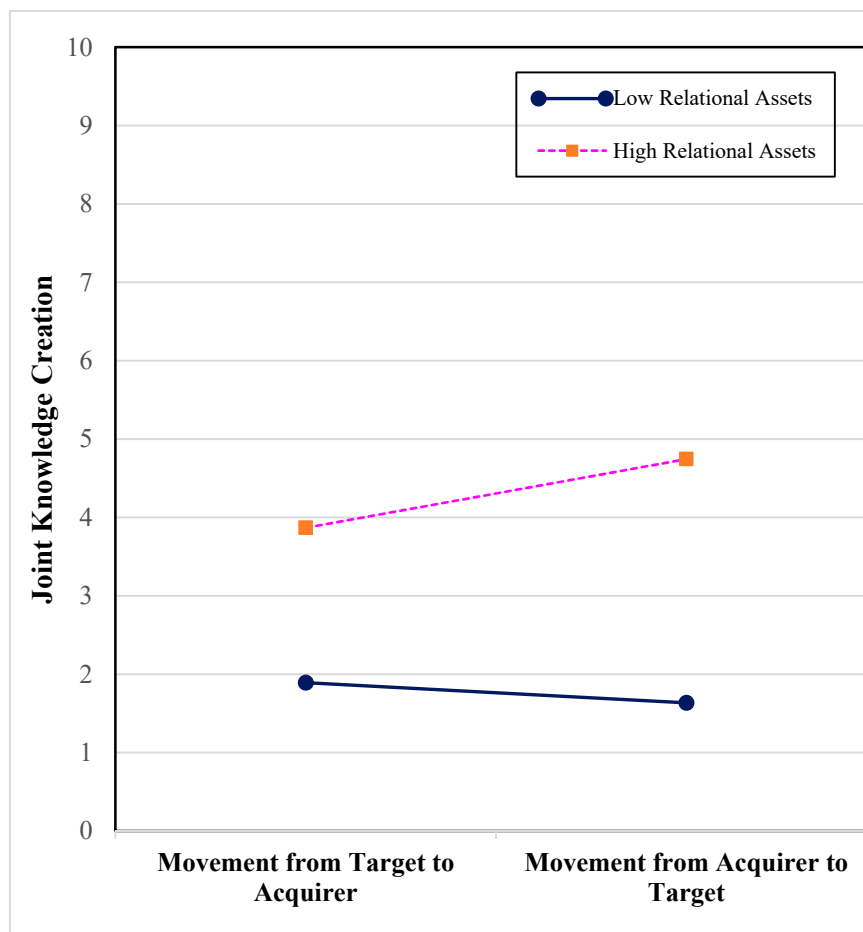


Figure 3. Interaction between mobility direction and relational assets.

### *Robustness Checks*

We conducted additional tests to check the robustness of our findings in terms of basic assumptions, analysis methods, sample selections, and measurement issues. Our first basic assumption was that mobile engineers may be productive immediately following their movement and M&As. However, it is fairly natural for knowledge workers to take a substantial amount of time to adapt to new locations, atmospheres, organizational cultures, and coworkers [84]. To integrate a possible time lag between M&As and subsequent joint knowledge creations, we adjusted the time window of five years by lagging one and two more years, respectively. These additional analyses using the same models did not change the coefficients and standard errors of most variables of interest and confirmed our findings. Relying on the assumption that both individual and organizational knowledge assets may decay quickly over time, we identified and included engineer mobility for the time window of five years prior M&As. While we could not extend the five-year window prior M&As for the entire sample of 74,591 engineers, we did so for a small portion. Our additional tests using a window of six or seven years found no substantial differences.

Our analysis may also be subject to a possible survival bias, since our dependent variable can only identify joint knowledge creation outputs of mobile engineers who continued to patent after M&As. These productive engineers may be systematically different from those who no longer do so after M&As. To address such issue, we ran a Heckman's two-stage model [85], which deals with sample selection issues by including correction factors, and used an inverse Mills ratio, calculated from the logistic regression predicting known survivors (first-stage analysis), as a control variable in the analysis of joint knowledge creation of known survivors (second-stage analysis). The results of these analyses are mostly consistent with our reported results. We also conducted additional analyses to control for the effect of alliances during the pre-merger period while alliances are usually not entire corporate wide events. The addition of alliance related variables for both targets and acquirers before and after M&As did not change our reported results. Lastly, to control for the possible impact from changes in economic conditions during our sample period of 2000~2004, we dummy coded the five years. These dummy variables did not meaningfully change our findings.

## **6. Discussion and Conclusions**

M&As are important events that significantly affect most employees of both targets and acquirers, and may subsequently influence knowledge creation performance during the post-M&A period. However, in terms of employee reactions to M&As, our study found a unique employee group that may show significantly different responses. This employee group includes those who have work experiences at both targets and acquirers prior to M&As. Such work experiences can provide meaningful opportunities for developing acquaintance and familiarity with both firms prior M&As. This allows them to effectively avoid dealing with psychological and emotional challenges from the very early stages of M&As. Thus, we assumed that this kind of employee group may play critical roles in terms of PMI activities between employees of both sides, since joint knowledge creation activities often require engineers of both targets and acquirers to collaborate extensively with their counterparts. In this study, we are interested in determining whether or not the existence of mobile engineers between targets and acquirers affects knowledge creation activities following M&As.

Our integration of M&A and human mobility studies allowed us to expand the scope of our investigation. Rather than looking into what happens in M&A and PMI processes, we examined an ex-ante M&A event: The engineer mobility between two random companies that later became relevant actors as either targets or acquirers. We also focused on the kind of assets those mobile engineers carry with their movement and how they affected subsequent inter-personal collaborations for joint knowledge creation. We further investigated the possible interaction effects between mobility directions and personal assets carried by mobile engineers. In particular, we investigated all of these questions as an individual-level phenomenon rather than typical firm-level events. Our study found that the direction of mobility is important in joint knowledge creation post M&As. Specifically,

when mobile engineers moved from acquirer to a target prior M&As, the direction of mobility has a significant positive effect on joint knowledge creation. When mobile engineers moved with meaningful assets, they cooperated more easily with engineers at their previous workplace. These findings may be attributed to the possibility that, even under the turbulent and uncertain environment of M&As, these engineers may continue to work with the routines, culture, and processes of the acquirer that are already familiar to them. However, task environments may be entirely reversed when mobile engineers move from a target to an acquirer prior to M&As. Even if these engineers retain most of their intellectual and relational assets, they often faced challenges of handling the target workers' resistance, unfamiliarity of routines, processes, culture, and so forth. We further found that human capital of mobile engineers is positively influenced by the mobility direction from acquirers to targets. When mobile engineers moved to a target firm, they could fully exploit the benefits of their personal assets even in the very challenging context of M&As.

Our findings contribute to theoretical developments of M&As, human mobility, and innovation literature. First, previous studies on the relationship between M&As and innovation productivity often emphasize the characteristics of either targets or acquirers such as complementary assets, knowledge bases, cultural fit, R&D intensity, and relative firm size. However, we applied a kind of micro-level investigation to see who is more likely to collaborate in the event of M&As. Another stream of M&A research is about improving the efficiency of PMI [3]. Our findings show that mobility of mobile engineers prior M&As may initiate interpersonal collaborations with those at either targets or acquirers during early PMI period. The relational and intellectual assets of mobile engineers may negate or attenuate potential uncertainty or fears immediately following an M&A. If we combine such micro-level approach to previous M&A studies, we may be able to better explain why certain M&As result in successful knowledge creation and others do not.

Our study contributes to the theoretical development of human mobility literature. While previous research recognized human mobility as an event that creates unidirectional information and knowledge flows from one employer to another, recent studies have suggested that human mobility establishes two-way information flows between firms via the personal ties of mobile inventors [18,61]. Previous studies assumed that mobile engineers may play a passive role such as simply transferring knowledge in various contexts [86]. They relied on the assumption that engineers voluntarily collaborate regardless of which organizations they used to work for. However, our study newly highlighted that not all engineers have the same preference for inter-personal collaborations, and that intentional effort is required to induce productive collaborations among knowledge workers, especially in the undesirable environmental contexts of M&As. Instead of possible downsides such as information leakage, unintended knowledge disclosure, conflicts with potential partners, and limited strategic flexibility [87], our findings showed that mobile engineers may become valuable human resources, especially when they can be regained through M&As.

Our study may refine the literature on governance structures for knowledge acquisition activities. Inter-organizational governances to obtain external knowledge include informal communication, strategic alliances, joint ventures, and M&As. Previous studies have recognized that alliances may be a more efficient mechanism for collaborations in knowledge creation than M&As. Compared to M&As that require complicated transactions of assets, inter-organizational alliances do not need to establish a new legal entity, restructure existing intra-organizational structures, or combine human resources into a conflicting culture [88]. In this perspective, our study suggests that human mobility may be a more efficient alternative to inter-organizational alliances. While both alliances and acquisitions are meaningful events that may affect organizations as a whole, human mobility is a critical issue for only a select few people. A mobile engineer can walk into another organization as a new employee and test the potential synergy of knowledge integration between her previous and new organization. Our findings suggest that mobile engineers with a significant amount of relational assets can reduce the cost and time required to seek out collaboration partners.

Our study is not free from the limitations that may provide new research opportunities. First, our study has an inherent constraint when collecting individual-level data, since we relied mainly on patent filing data to identify and track individual engineer mobility. For example, we calculated the organizational tenure using an engineer's first patent date, even though they may need a certain period for research activity before filing patent applications. However, patent filing data do not provide details such as gender, age, education level, functional specialty area, and so forth. While some research showed that age has no effect on employee mobility [89], future studies may refine our findings by integrating more control variables for individual engineers. In addition, some of our measurement methods have room for improvement. For example, we defined relational assets simply as the total number of co-inventors with whom mobile engineers collaborated to file patents. This measure is geared more toward collecting the than the quality, which may also matter in terms of knowledge creation. Future research needs to develop other measures that can take into account the quality of collaboration experience. For example, the quality of relational assets can be measured by the number of citations or different forms of social capital—structural, relational, and cognitive [71,90]. Future studies may extend our current research questions by focusing on different dimensions of knowledge creation activities. They may examine how mobile engineers affect the timing of knowledge creation, the optimal number of mobile engineers for the best innovation performance after M&As, and whether mobile engineers can create unique synergies between targets and acquirers [91]. They can also examine how other forms of inter-firm collaborations, such as alliances or cross-licensing arrangements, may affect joint knowledge creation of mobile engineers after M&As. We did not control for the effect of possible human capital hazards in M&As, such as departure of key personnel [24]. Future studies can examine how such human capital hazards may affect inter-personal collaborations after M&As.

Our study provides some managerial implications for knowledge management and innovation. According to the Bureau of Labor statistics, in the late 1970s, Americans were estimated to have an average of 7 employers throughout their lifetime, but by 2005, they had an average of 10 employers by the time they reached 40. Mobility is becoming increasingly common, and notions of lifetime employment is no longer the case for many industries. In firms, especially those in the high-tech industry, the motivation behind M&A is valuable knowledge transfer and eventual knowledge creation from and with target firms. Mobile engineers, once seen as an undesirable loss by knowledge-intensive organizations, may return to a former organization as effective knowledge creators when M&As unite their previous and new organizations. Our findings show that mobile engineers may act as important triggers for subsequent interpersonal collaborations among targets and acquiring firms, since they are already familiar with the organizational routines, policies, and cultures of both firms. Thus, mobile engineers between targets and acquiring firms can significantly reduce knowledge-seeking and acquisition costs. We advise firms to reconsider the potential value of employees who have mobility experience. They can be valuable assets especially because of the tacit and sticky component of valuable knowledge. They can act as strong links or initiators of intellectual and relational assets that are important for knowledge creation. They also often have a broader scope of knowledge and outlets to an entirely new knowledge field. For firms seeking external knowledge, employees who possess mobility experience could be a valuable bridge that connects various sources of external knowledge. Hence, firms can support and take advantage of this unique group of employees for example, by intentionally relocating those engineers with mobility experience for a speedy PMI, since mobile engineers with large relational and intellectual assets better understand with whom to collaborate in the event of M&As.

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