

**FROM BORDERS TO BREAKTHROUGHS: HOW IMMIGRATION
LAWS SHAPE TECHNOLOGICAL PROGRESS**

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ABSTRACT

The innovative capacity of firms fundamentally relies on the organization of strategic human capital. Highly skilled and talented employees drive knowledge creation through their expertise and creativity. As such, the organization and redeployment of knowledge workers across global subsidiaries and teams is a pivotal capability underpinning firms' competitive edge. However, firms must operate within and adhere to the macro regulatory environments in the countries where they are located. With increasingly global interconnectedness, there is also a rise in nations' announcing changes to their immigration policies to support national interests. These changes to immigration policies may affect firms' ability to organize human resources in a way that is most conducive for their knowledge creation and innovation objectives. Firms may then respond strategically to meet their innovation objectives while protecting their knowledge from leaking to competitors in foreign or local geographies. This dissertation examines how changes to immigration policies prompt strategic responses from firms in terms of meeting their innovation objectives by reorganizing their human capital and further proposes a three-dimensional framework for an immigration policy that supports economic growth and innovation in the destination country.

The first chapter lays the groundwork for the dissertation and review conceptual foundations of each of the following essays. The second chapter examines the strategic response by multinational enterprises (MNEs) when their ability to deploy knowledge workers across national boundaries is affected by restrictive immigration policies. The third chapter examines individual- and firm-level responses to an increase in employees' bargaining power. Findings reveal that the regulation afforded greater bargaining power

to ethnic inventors, leading to greater interfirm mobility, positional changes in the intrafirm collaboration network, and a change in innovation performance. Finally, the fourth essay then argues that in addition to formal human capital, foreign knowledge workers contribute unique social capital which benefits their MNE employers in terms of innovation outcomes and puts forth a comprehensive three-dimensional immigration policy framework integrating migrants' skillsets with their bridging potential across nations, contingent on inter-state relations. By accounting for security trade-offs and variations in bilateral collaborative intent, this multidimensional perspective allows calibrated screening of talent from allied versus adversarial origins.

Synthesized together, the three studies highlight how regulations pertaining to high-skilled immigration significantly disrupt organizations' access to strategic foreign talent, necessitating trade-offs to reconfigure innovation capabilities. This dissertation contributes to strategic management and international business literature by underlining the global organization of human capital as pivotal to understanding MNE responses to external constraints on foreign talent deployment. Further, it informs immigration policy debates through a multifaceted evaluation of skillsets, bridging ties and bilateral relations that influence productive integration of foreign talent.

DEDICATION

To my wife Prithvi

For her sacrifices, unwavering love, and support

To my Parents

For their many unconditional sacrifices for my success and happiness

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CHAPTER 1

INTRODUCTION

A central notion in economics since Adam Smith's *The Wealth of Nations* (1776) and formally since the introduction of the Cobb-Douglas production function has been that human assets serve as a key input to achieving targeted outcomes. Relatedly, in strategic management literature these targeted outcomes pertain to superlative firm performance driven by its sustained competitive advantage (Penrose, 1959; Peteraf & Barney, 2003; Porter, 1980, 1985). Moreover, it is neither new nor controversial to argue that the human resources possessed by a firm, when oriented and trained towards achieving the firm's objectives, contribute knowledge and skills that endow that firm with sustained competitive advantage (Becker, 1964; Hatch & Dyer, 2004; Kor & Leblebici, 2005; Coff & Raffiee, 2015) leading to its growth. Therefore, it becomes imperative that firms recruit, train (Lepak & Snell, 1999), allocate (Lovallo et al., 2020; Teece, 2020), organize (Chang, 2023), and retain critical human assets (Campbell et al., 2012; Mawdsley & Somaya, 2016) so as to "accrue human capital rents for themselves" (Chadwick, 2017, p.499). These aspects of strategic human capital management become all the more critical for knowledge-based value creation and value capturing activities of the firm and, thereby, the genesis of sustained competitive advantage (Grant, 1996). For instance, studies in strategy (Lahiri, 2010; Argyres et al., 2020) and international business (Patel & Pavitt, 1991; Belderbos et al., 2023) domains have demonstrated firms' preference to organize R&D activities so as to facilitate collaboration between knowledge workers and discover and develop novel ideas serendipitously (a la Building 20 at MIT).

However, despite this progress, there remains tremendous scope to extend our understanding of the interactions between macroeconomic environment surrounding the firm and its influence on deployment of human capital towards the firm's objectives. For instance, changes in the macroeconomic environment often result in heterogeneous responses by firms (Greening & Gray, 1994; Walker et al., 2002, Cuervo-Cazzura et al., 2019) contingent on their resource endowments and origins (Taussig, 2017).

Through this dissertation, I take first steps towards enhancing our understanding of firms' responses to exogenous changes in the regulatory environment that affect its ability to organize and retain its strategic human capital towards its innovation objectives. A variety of regulatory changes can affect firms' ability to organize or retain their employees. For instance, the institution or abolishment of non-compete agreements can promote or hinder interfirm mobility of knowledge workers (Marx et al., 2009; Marx, 2011) with significant implications for the innovation performance of the affected firms. Similarly, the institution of employer-friendly trade secrecy protection hurts innovation of firms located in the affected geography due to lower individual-level incentives to innovate (Contigiani et al., 2018). In essence, an exogenous change in regulation can operate diverse mechanisms that affect innovation outcomes of individuals as well as firms. Thus, in my endeavor to focus on the organization and retention of a firm's strategic human capital in response to exogenous regulatory shocks, I leverage two distinct changes in the U.S. immigration policy. These exogenous shocks were announced as part of the American Competitiveness in the 21st Century Act of 2000 and are related to the H-1B visa program, the most significant immigration channel for firms intending to recruit foreign high-skilled labor for knowledge intensive work. Two

specific provisions of this Act, namely, the temporary increase and rollback in H-1B visa allotments and the increased portability of H-1B visa status allow me to examine firm-level responses in terms of strategic organization and the retention of their R&D workforce, respectively.

In the first essay (Chapter 2), I examine how immigration restrictions affect multinational enterprises (MNEs) R&D organization structure and their contingent innovation performance. The global redeployment of human resources is a crucial pillar of multinational enterprises' (MNEs') competitive advantage. By mobilizing knowledge workers from foreign subsidiary locations to home R&D labs, MNEs strive to maximize the overlaps between their Country-Specific Advantages (CSAs), endowed by the technological environment, past investments, and protection of intellectual property, and Firm-Specific Advantage (FSAs), endowed by the human capital located across its foreign subsidiary network. Migrant inventors serve as sources of human capital as well as bridging ties between their countries of origin and employment. However, nations increasingly impose immigration restrictions, mainly to induce MNEs to hire local citizens instead of foreigners. I study the effect of an exogenous restrictive change in U.S. immigration policy, the 2004 reduction of the H1B visa cap, on the geographic dispersion of R&D workers as well as on innovation outcomes. I use a sample of 371,856 patents assigned to 707 U.S.-based MNEs and find that the global dispersion of the MNEs' R&D workforce increased after the shock. This suggests MNEs chose to conduct R&D with globally dispersed foreign inventors rather than replacing them with locals. The restriction also reduced MNEs' innovation performance due to an increase in coordination costs. Sectors more dependent on codified knowledge experienced greater R&D

workforce dispersion after the shock and experienced less harm in terms of innovation performance. This finding provides insight into the observed positive correlation between the geographic concentration of inventors and communication capabilities. It also places boundary conditions on the effectiveness of work-from-anywhere policies.

In the second essay (Chapter 3), I explore the effects of a regulatory change that affected firms' ability to retain knowledge workers critical to its R&D objectives. The outward mobility of knowledge workers can prove to be detrimental to the origin firm due to its loss of critical human capital as well as knowledge spillovers to its competitors from the moving worker (Almeida & Kogut, 1999; Singh & Agrawal, 2011; Song et al., 2003). Thus retaining knowledge workers is of paramount importance if firms must maintain their competitive advantage. In a labor market characterized by mobility restrictions, firms are "wage makers" while knowledge workers are "wage takers." However, exogenous regulatory changes may invert this equilibrium in favor of knowledge workers, enabling them to capture rents due to their human capital. However, neither are all knowledge workers equally mobile nor do they contribute equally to firm level innovation. For instance, prior research demonstrates the superlative contribution of foreign high skilled workers to firm level innovation (Akcigit et al., 2017; Laursen et al., 2020) by virtue of their diverse and proprietary knowledge (Choudhary & Kim, 2019; Castellani et al., 2022). Moreover, immigration policies may restrict knowledge workers from changing employers by attaching visa approvals to employment sponsorship. I leverage the increased H-1B visa portability provision of the AC21 Act to determine mobility patterns and changes in organizational positions of ethnic immigrant inventors after the passage of the Act. Using a sample comprising 48,793 inventors and their

employment histories between 1998 to 2003 as inferred from their patent assignees, I argue that the 2000 change in H-1B visa portability regulation indeed opened alternative employment avenues in the open labor market for foreign high-skilled labor prompting higher interfirm mobility of ethnic inventors over Anglo-Saxon inventors. The relaxation of mobility constraints experienced by foreign inventors therefore increased the bargaining power of such employees vis-à-vis their employers. The increase in bargaining power of individual knowledge workers implies that firms, with weakened bargaining power, had to agree to terms negotiated by the staying foreign employee. This is clearly demonstrated by ethnic inventors' occupying more central positions in the intrafirm collaboration network as well as by a change in the nature of their inventions towards less firm-specific inventions.

Essay three (Chapter 4), then, proceeds to propose a three-dimensional framework for an immigration policy supportive of technological innovation and economic welfare. Policy discussions on immigration often center around the degree to which migrants either burden or contribute to host countries. The 'human capital' view of migrants is based on a narrow focus on formal skills and education levels. I argue that in addition to human capital, a comprehensive framework needs to account for migrants' social capital and geopolitical considerations. Immigrant knowledge workers whose countries-of-origin possess strong knowledge infrastructure permit them to draw from local as well as foreign knowledge sources, thereby accentuating their own human capital to deliver superlative innovation outcomes. Migrants' bonding social capital enables them to productively integrate into teams and organizations in the host country. Their bridging social capital recognizes that migrants retain connections to origin countries, facilitating

bilateral knowledge flows. However, the degree of friendliness in political and strategic relationships between origin and destination countries shapes whether migrants' bridging ties are an asset or a liability. Antagonistic interstate relations exacerbate security risks and dampen productive bridging of economic and technological exchange as knowledge transfer through immigrants' "bridging" links may increase the risk of reverse knowledge spillovers. Meanwhile, cooperative ties incentivize destination countries to leverage immigration for bilateral gains. I propose a three-dimensional immigration policy lens incorporating human capital, social capital, and origin-destination geopolitical relations. This allows formulating calibrated policies to screen immigrants from adversarial states differently than those from allied nations, accounting for variations in security threats and bridging social capital. A multidimensional perspective is imperative for immigration regulations to serve national interests.

In summary, this dissertation seeks to advance our understanding of firms' strategic responses to exogenous regulatory shocks that affect its ability to create and capture value from its R&D endeavors. I utilize and build on theoretical frameworks from the strategic human capital management, technological innovation, and international business literature and leverage two exogenous changes in the firms' environment related to immigration policies to contribute novel insights on the management of strategic human capital inputs in the innovation process.

CHAPTER 2

RESTRICTIVE IMMIGRATION POLICIES AND MNE INNOVATION

Multinational Enterprises (MNEs) are “internalized bundle of resources which can be allocated...between national markets” (Buckley & Casson, 1998, p.541) that impart firm-specific advantages (FSAs; Rugman, 1981; Rugman & Verbeke, 2003) depending on its resource endowments and configurations. Trade liberalization and the emergence of information and communications technologies have led MNEs to organize as global knowledge producing factories (Buckley, 2011; Buckley & Prasantham, 2016; Cano-Kollmann et al., 2016). Among all resources, a MNE’s human capital is the most critical resource that facilitates efficient orchestration of other resources (Tung, 1984) towards the MNEs growth objectives (Cyert & March, 1963). In this regard, MNEs’ knowledge workers are crucial to its value creation objectives (Munjal & Kundu, 2017) because “individuals are often more mobile than organizations and, thus, may be as (if not more) important as MNEs and other structured institutions as enablers of international knowledge sourcing and recombination” (Castellani et al., 2022: p.14).

Access to specialized talent, especially in science and technology, is key for innovation, but also requires efficient coordination to maximize returns (Teece, 1986; Williamson, 1981). MNEs, despite being efficient mechanisms for knowledge sourcing and integration from dispersed global locations (Kogut & Zander, 1993), demonstrate a ‘home-bias’ in technological innovation and R&D activities of MNEs (Belderbos et al., 2013; Patel & Pavitt, 1991). By co-locating research and development (R&D) activities and skilled inventors, mainly in home countries, MNEs reduce transaction costs associated with transmitting and integrating knowledge across borders (Belderbos et al.,

2013; Patel & Pavitt, 1991) as well as knowledge spillovers arising from operating value creation activities in subsidiary countries with low IPR protection (Bruno et al., 2021). Consequently, mobilizing knowledge workers from foreign subsidiary locations to the MNEs home country to meet innovation objectives is a key facet of MNEs' knowledge sourcing and integration routines (Barnard et al., 2019; Ghemawat, 2003; Hill, 2022).

These

trends are particularly pertinent in developed economies such as the USA, UK, and Australia, where there is an increasing demand for STEM skills in their innovation-driven economies, alongside a decreasing domestic supply of talent, forcing heavy reliance on highly qualified migrants. (Farndale et al., 2021: p.259).

However, policymakers often call for regulatory changes that curb immigration with the objective of forcing companies to recruit locals instead of immigrant workers (Cumming et al., 2019; Mudambi, 2018) despite the strategic importance of foreign high-skilled human capital. Notwithstanding the significant contribution provided by prior studies, little is known about the effect of *immigration restrictions* on the organization of MNEs' R&D and subsequent innovation. I draw from the literature on technology and innovation in MNEs (Cantwell, 1989, 1995; Gupta & Govindarajan, 2000), the knowledge-based view (Grant, 1996; Kogut & Zander, 1993; Phene & Almeida, 2008) and organization of MNEs' innovation activities (Bruno et al., 2021; Belderbos et al., 2013; Belderbos et al., 2023) to complement and extend prior research (e.g.: Glennon, 2023) by addressing the question – *how does a restrictive immigration policy affect the R&D organization in MNEs and what are its contingent impact on MNEs' innovation performance?*

I argue that immigration restrictions disrupt MNEs' global R&D talent sourcing equilibrium. With their strategic human capital becoming location bounded due to immigration restrictions, MNEs are forced to respond strategically to protect their competitive advantage – abruptly forcing more dispersed R&D and inventor networks globally. Thus, while firms conform to the specifics of government policies (Murtha & Lenway, 1994; Shaffer, 1995), competitive reasons often makes it impossible for them to conform to its intent (Bessen, 2014). This structure increases coordination costs for innovation from transacting across international boundaries (Ghemawat, 2003). Specifically, limits on high-skilled immigration increase transaction costs impacting MNEs in three ways. First, dispersed R&D structures require greater investments in routines and processes to coordinate geographically distant innovation activities (Leiblein & Miller, 2003). Second, there are higher costs for cross-border knowledge transfers, especially tacit knowledge important for breakthrough innovations. Prior research shows that restrictions hampering mobility of skilled immigrants negatively impacts knowledge flows and makes knowledge transfer more difficult (Agrawal et al., 2011). Without inventor relocation, MNEs must rely more on codification to share knowledge across sites, which is costly and often insufficient (Kogut & Zander, 1993). Finally, immigration restrictions and dispersed R&D networks increase governance expenses, including monitoring and integration costs to try aligning incentives and objectives across inventors (Teece, 1986). Multi-country projects also have higher team integration expenses to overcome challenges like cultural/language barriers. In sum, limiting high-skilled immigration forces MNEs into second-best R&D structures which abruptly increase transaction costs. Consequently, I argue immigration restrictions on talent critical for

R&D will: (1) increase dispersion of MNE inventor networks and (2) negatively impact innovation performance – especially in industries where tacit knowledge sharing is imperative. These results suggest important boundary conditions on the work-from-anywhere literature (Choudhury et al., 2021) that has burgeoned in the wake of the COVID-19 pandemic.

I test my theory against a sample comprising 707 US public MNEs that actively invested in innovation and intended to recruit foreign skilled labor between 2000 and 2007 from their foreign sites. I leverage an exogenous threefold reduction in the number of H-1B visas in the year 2004 as my identification strategy and employ an estimator that allows comparison of within-firm variation in inventor dispersion, patenting output, and novel recombinations after the shock. My results are in line with my predictions: the reduction in the number of H-1B visas leads to a 4.7% increase in global dispersion in the MNEs' inventor network and 4.15% lower patenting output. These results are robust to different estimation approaches, including a *difference-in-differences* (DD) design and sample composition.

My study contributes to the literature on organization of R&D and innovation in MNEs (Bruno et al., 2021; Belderbos et al., 2013; 2023). I show that, contingent on shortage of a supply of skilled labor relevant for their innovation objectives, MNEs decide to pursue their R&D projects with a globally dispersed workforce and this abrupt change affects innovation negatively. I also uncover heterogeneity in this behavior depending on knowledge codification tendencies in the MNE's industry. MNEs from low knowledge codification industries find pursuing innovation projects with dispersed teams less effective given the higher transaction costs associated with coordination, knowledge

exchange and IPR protection. Therefore, such MNEs tend to “shelve” projects. On the contrary, MNEs in high knowledge codification industries tend to see a smaller drop in their innovation outcomes, pointing to their ability to conduct innovation projects with remote knowledge exchange. Second, I contribute to the literature by shedding light on the intricate interplay between country-specific advantages (CSAs) and firm-specific advantages (FSAs; Rugman, 1981). My findings show how abrupt visa restrictions on high-skilled labor in the home country weaken country specific advantages and, in turn, impacts MNEs’ ability to leverage their internal human capital resources (FSA) optimally. Disruption of routines for R&D projects may prompt MNEs to rely their coordination capabilities (Kogut & Zander, 1993) but, as my results show, this comes at the cost of lower innovation performance. Third, I contribute to the literature on the global mobility of inventors in MNEs and their innovation performance (Choudhury & Kim, 2019; Glennon, 2023; Kerr & Lincoln, 2010; Ghosh et al., 2014; Marino et al., 2020). I show that the effects of a restrictive immigration policy are broad and not limited to human capital originating from specific geographies, thereby extending studies based on ethnic migrant inventors (Breschi et al., 2017; Choudhury & Kim, 2019; Oettl & Agrawal, 2008; Marino et al., 2020). My findings also imply that, for advanced economies such as the US, a steady flow of immigrants is necessary for MNEs to maintain innovation outcomes and, relatedly, their competitive advantage. Finally, my findings may point to a resolution of the puzzle of increasing inventor geographic concentration occurring contemporaneously with rising communication capabilities. Since I find inventor collocation to be most important when the requisite knowledge is

highly tacit, it could be that frontier technologies are those where codifiability is inherently low.

Theory and Hypotheses

MNEs have long resorted to internationalization (Hymer, 1960) with foreign subsidiaries assuming specific roles based on firm-, country-, or subsidiary-specific advantages for products and services (Bartlett & Ghoshal, 2002; Birkinshaw & Hood, 1998; Dunning & Lundan, 1993) as well as for R&D and innovation (Cantwell & Mudambi, 2005). Over time, some foreign subsidiaries may develop technological capabilities on a par with their parent R&D labs and gain competence-creating mandates (Birkinshaw & Hood, 1998; Cantwell, 1995). Such subsidiaries act as suppliers of knowledge to MNEs' home R&D labs (Ambos et al., 2006; Rabbiosi & Santangelo, 2013; Papanastassiou et al., 2020).

This perspective of R&D internationalization and foreign subsidiary competency evolution posits that the flow of technological knowledge between MNEs' home and foreign R&D labs is a crucial basis of competitive advantage (Grant, 1996; Kogut & Zander, 1993; Phene & Almeida, 2008; Gupta & Govindarajan, 2000). However, cross-border knowledge transfers within MNEs are not frictionless and are contingent on knowledge characteristics such as its "Codifiability", "Teachability", "Complexity", "System Dependence", and "Product Observability" (Zander & Kogut, 1995, p.79). The tacit component of knowledge originating from foreign subsidiaries may not be easily transmitted, let alone understood (Tsoukas, 2005; Barnard & Cantwell, 2006). These challenges are heightened in the case of scientific and technological knowledge due to the inherent experimental nature of R&D projects. In sum, MNEs must design elaborate

routines to overcome the impediments to knowledge transfer (Szulanski, 1996; Teece, 1977). While MNEs may implement formal mechanisms (Gupta & Govindarajan, 2000) to facilitate cross-border knowledge flows, the multiple dimensions of distance between the home and foreign R&D sites may still restrict transfer effectiveness (Ambos & Ambos, 2009).

The Optimal Structure for MNEs' R&D Organization

A central pillar of the literature on knowledge flows in MNEs is that firms use these flows to generate competitive advantage by integrating knowledge from foreign subsidiaries with knowledge stocks of local inventors (Awate et al., 2015; Lane & Lubatkin, 1998; Minbaeva et al., 2003; Zahra & George, 2002). A spatially dispersed yet connected knowledge network implies that MNEs can, in theory, conduct their innovation activities globally (Belderbos et al., 2023; Bruno et al., 2021). However, the institutional factors such as IPR and quality of education in host countries impose restrictions on MNEs' R&D location choice (Rosenbusch et al., 2019). Transaction costs associated with distal knowledge exchange and a necessity to set up mechanisms to protect and defend knowledge spillovers imply that MNEs' innovation performance deteriorates "as the difference between home and host IPR regimes increases" (Bruno et al., 2021: p.1945). This is because MNEs decision to "locate their innovation activities in lower IPR protection countries increases the distance between home and host economies in terms of IPR protection, thereby raising the cost of managing the knowledge creation process and lowering innovation performance" (Bruno et al., 2021: p.1950). Thus, we find MNEs displaying a tendency to concentrate their R&D activities in their home countries (Patel & Pavitt, 1991; Belderbos et al., 2013) pointing towards an optimal R&D

organization structure in which their knowledge workers are largely located in the MNEs home country.

In this context, the cross-border intrafirm mobility of inventors achieves two objectives. First, skilled inventors serve as “knowledge carriers” between subsidiaries and headquarters (Song et al., 2003). By relocating, they transfer sticky, tacit knowledge more efficiently through personal interactions and social ties (Mäkelä et al., 2012). Knowledge builds as inventors integrate insights from prior contexts (Oettl & Agrawal, 2008). Immigrant scientists also contribute diverse technological knowledge in the innovation process by injecting alternate cognitive frames, novel recombinations, and “new ways of thinking” into home laboratories. This is possible due to their unique skills drawn from their country-of-origin specific knowledge. Research shows immigrant inventors positively influence creativity in teams and quality of innovations (Ferrucci & Lissoni, 2019; Hunt & Gauthier-Loiselle, 2010), an effect that can be attributed to their colocation with local inventors (Catalini, 2018). Second, inventor mobility can help MNEs overcome costs associated with cross-border knowledge transfer and protective mechanisms for knowledge spillovers (Agrawal et al., 2019; Almeida et al., 2014; Bruno et al., 2021) by facilitating collaboration between local and migrant inventors as the geographic and temporal separation can be reduced to a great extent (Storper & Venables, 2004). Further, by co-locating foreign inventors in home R&D labs, MNEs can significantly reduce the chances of knowledge spillovers in foreign locations. Indeed, inventor mobility can complement or substitute other important approaches used to transfer knowledge within and across MNEs (Wagner & Goossen, 2018; Barnard and

Pendock, 2013). Therefore, intrafirm cross-border mobility of human capital forms a crucial strategy for MNEs to maintain a technological edge relative to their competition.

Immigration Policy, Cross-border Inventor Mobility, and Inventor Dispersion

There is a contentious debate with regard to immigration policies in virtually all advanced countries related to the number of high skilled immigrants admitted to the receiving nation. Policymakers often argue for the reduction of immigration quotas and portray immigration as an influx of human capital that takes away jobs from the local population (Cumming et al., 2019; Mudambi, 2018). Governments typically impose such restrictions to encourage MNEs to recruit local talent and force MNEs to embrace “political goals, such as employment, ahead of efficiency and profit” (Murtha & Lenway, 1994: p.117).

A restrictive immigration policy in its home country renders the MNEs human capital location-bounded leading to significant constraints on the supply of high-skilled foreign human capital. The immediate repercussion of such policies is a disruption in the equilibrium MNEs strive to create in their R&D organization by mobilizing knowledge and knowledge workers to their home R&D labs. Consequently, these MNEs are faced with at least three second-best options. At one extreme, MNEs may altogether shelve projects that cannot be staffed as per plan, an option that has immediate deleterious effects on innovation performance and its competitive advantage. At the other extreme, they may adhere to the policy change (Shaffer, 1995) and recruit local hires for their R&D functions to build social legitimacy and future considerations of political resource dependence (Murtha & Lenway, 1994). However, the downside of recruiting relatively lower-skill and new-to-firm local human capital is their inability to immediately master

the relevant domain knowledge as well as the routines, processes, and informal rules prevalent within the hiring MNE (Dunning & Lundan, 2010). MNEs may also incur higher costs due to aggressive competition to gain access to a relatively smaller and more expensive pool of highly qualified local labor as all MNEs in an industry are affected simultaneously by changes in immigration policy. Despite higher costs in terms of both training and wages, this option may still not provide MNEs with ‘like-for-like’ performance of their migrant employees (Chacar et al., 2010).

The third alternative is a middle path that circumvents the mobility barriers by reconfiguring R&D processes and reallocating projects globally. In this specific case, I propose that MNEs’ could choose to reorganize their R&D projects globally (Mudambi et al., 2007). This means continuing innovation projects with inventors remaining in foreign subsidiary locations and working remotely with inventors based in the home country or locating entire innovation projects in a single foreign subsidiary location. This option allows MNEs to forego the high costs of recruiting a smaller number of domestic R&D workers as well as the investments in training costs while minimizing disruptions to their innovation objectives (Kogut & Zander, 1993). For instance, Glennon (2023) finds that restrictions on high skilled immigration lead to increases in employment at the MNE’s foreign affiliates.

To the extent that this option is implemented by MNEs, I expect that the level of geographic dispersion of R&D workforce, represented as the inverse of concentration of inventors across MNEs’ global locations, will increase because a higher proportion of inventors located in foreign subsidiaries contribute to MNE innovation. In other words, MNEs will pursue a larger proportion of innovation projects across foreign subsidiary

locations going against the optimal structure of concentrating knowledge workers in the home country. Using this strategy MNEs can continue accessing skilled inventors globally (Belderbos et al., 2023), but without relocating them to a host country. Based on these arguments, I predict:

Hypothesis 1a: Other things equal, a restrictive change in immigration policy increases the global dispersion of MNE R&D workforce.

My argument so far pertains to general effects of a restrictive immigration policy on global geographic dispersion of inventors in MNEs. However, whether MNEs can operate innovation projects with a dispersed R&D workforce depends on the transmissibility and interpretability of technological knowledge amongst inventors that are not collocated. In this regard, the increasing use of Information and Communication Technologies (ICT) by geographically dispersed inventors as well as the characteristics of their technological knowledge may influence MNE strategies. Figure 1 shows the exponential adoption of ICT globally which may facilitate remote exchange of technological knowledge and thus, a larger proportion of R&D projects handled by dispersed teams.

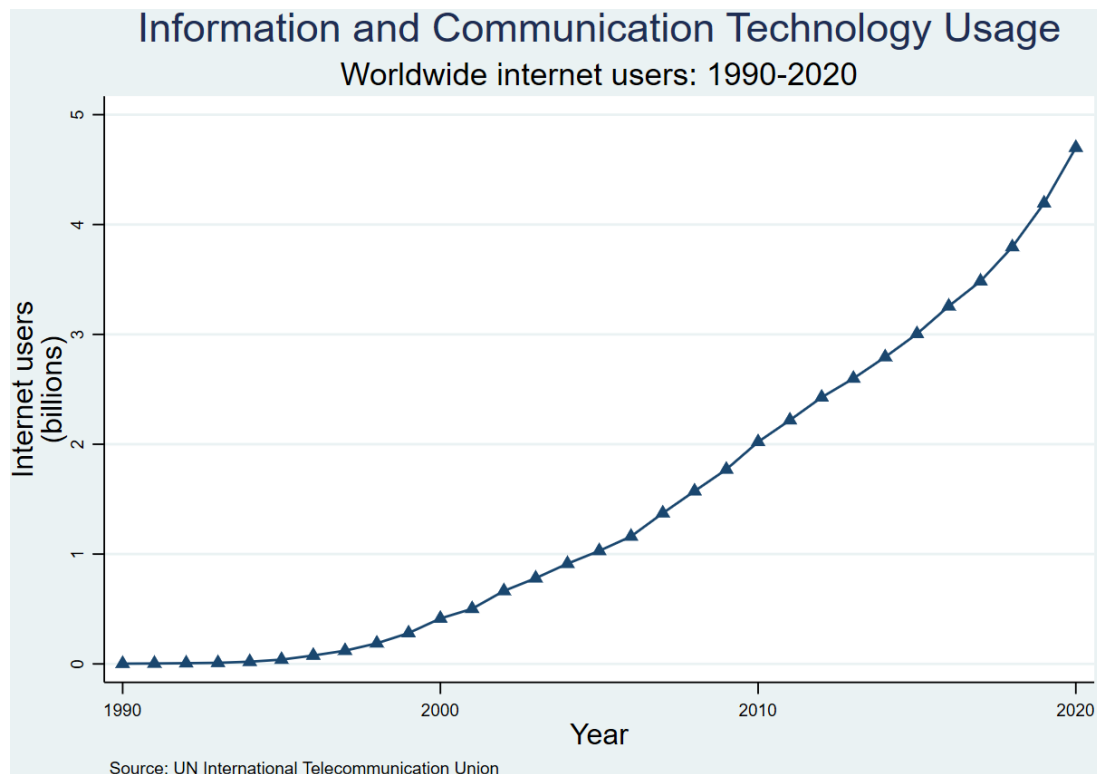
However, technological knowledge characteristics vary considerably across industries in terms of codifiability and, by extension, suitability for transmission using ICT (Balconi, 2002; Cowan et al., 2000). Knowledge codification allows modularization of knowledge (Cohendet & Meyer-Krahmer, 2001) and therefore that innovation activities can be parceled out to geographically dispersed R&D units. Further, the process of knowledge codification encompasses the formation of “epistemic” communities (Cowan et al., 2000) that develop common interpretations, languages, and frameworks.

Thus, MNEs in industry sectors which are more conducive to knowledge codification can transfer knowledge across international locations more easily through ICT channels.

They may thus overcome the challenges in collocating inventors induced by immigration restrictions.

Figure 1

Information and Communication Technology (ICT) Usage: 1990-2020.



In contrast, in industry sectors where technological knowledge does not lend itself to codification and interpretation without articulation (Hakanson, 2007), inventors located in foreign R&D labs may be less useful in working toward the MNE’s innovation objectives. MNEs in such industries may be forced to continue innovation projects with local teams, since they are unable to use their globally distributed R&D workers as effectively. Thus,

Hypothesis 1b: Other things equal, the effect of restrictive immigration policies on the global R&D dispersion of the MNE's workforce will be stronger for MNEs in industries with a higher level of knowledge codification.

Global Geographic Dispersion of Inventors and Innovation Performance

Extending my initial argument, I contend that the unintended global geographic dispersion of inventors induced by a restrictive immigration policy affects the MNEs' innovation performance. Although a large number of prior studies have indicated that one of the most important sources of MNEs' competitive advantage comes from their capacity to manage R&D across different countries (e.g., Ambos et al., 2021; Hurtado-Torres et al., 2018; Nieto & Rodriguez, 2011; Papanastassiou et al., 2020; Pearce, 1999; Zanfei, 2000), this does not refer to geographic dispersion *being imposed* on them due to immigration restrictions. If MNEs are forced to disperse R&D operations, they will likely face challenges in sustaining innovation and knowledge recombination relative to the equilibrium in which they could optimally compose project teams and move inventors across national borders.

I contend that restrictions on the cross-border mobility of R&D workers will affect MNE innovation through multiple mechanisms by introducing an abrupt inability to match FSAs, endowed by MNEs' human capital, to CSAs, endowed by the MNE's home country, impacting MNEs' process geared towards its innovation productivity objectives. First, MNEs cannot reap productivity benefits of R&D agglomeration obtained by adding foreign inventors to their home innovation sites (Rosenthal & Strange, 2004; Andersson et al., 2005; Akcigit et al., 2017). Second, a globally dispersed R&D workforce implies that inventors are geographically and temporally separated. This

increases coordination costs as inventors have to manage interactions with team members located across time zones during overlapping working hours. Limited overlapping hours may lead teams to restrict communication to formal exchanges of codifiable knowledge. Moreover, geographically separated teams lack the face-to-face communication necessary to brainstorm ideas and exchange tacit knowledge and private information informally. As a consequence, inventors located at either end may not be fully aware of knowledge recombination and collaboration opportunities¹ that are necessary for superior innovation performance (Hargadon & Sutton, 1997).

Another issue arising from the global geographic dispersion of inventors relates to MNEs' increasing reliance on innovation teams. MNEs' knowledge production is affected by the incapacity to design optimum teams due to mobility constraints (Wuchty et al., 2007). For example, the diversity of inventor backgrounds in R&D teams is an important factor for superior innovation outcomes and profitability and this is directly affected by the absence country-of-origin specific knowledge contributed by foreign inventors. (Aggarwal et al., 2020). From the company's perspective, the combination of background diversity and geographic proximity is crucial to enable knowledge recombination and innovation. Diverse, yet geographically dispersed teams may face challenges in dealing with exchanging and integrating knowledge (Funk, 2014; Ferruci & Lissoni, 2019). Restrictions on high skill immigration imply that R&D managers are forced to assign certain innovation projects to geographically dispersed inventor teams *or*

¹ Often referred to as the 'metaknowledge' of who knows whom and who knows what in team-based organizational setting (Argote et al., 2003).

co-located teams with suboptimal experience and knowledge diversity. Both of these choices lead to poorer innovation performance as compared to the *ex-ante* situation of freer inventor mobility. The foregoing arguments suggest that MNEs may experience lower output due to the unintended global dispersion of inventors induced by restrictive immigration policy. Therefore, I propose:

Hypothesis 2: Other things equal, a restrictive change in immigration policy reduces an MNE's overall innovation performance in terms of its innovation output.

Knowledge codifiability varies across industry sectors as evidenced by numerous metrics like knowledge governance (e.g., extent of licensing; Arora et al., 2001), knowledge protection (e.g., patenting rates; Cantwell, 1989), and so on. The heterogeneity in codifiability of technological knowledge across industry sectors also influences MNEs' optimal re-organization of their innovation activities in response to immigration restrictions. MNEs in industries with a higher propensity for knowledge codification find it easier to transfer and interpret innovation work performed in geographically distant locations. Hence MNEs in such industries are likely to be able to sustain innovation quantity and quality despite the unintended geographical dispersion of inventors induced by the immigration shock. On the contrary, MNEs belonging to industries in which technological knowledge is not conducive to codification may suspend innovation projects as globally dispersed inventors may not be able to contribute effectively to knowledge creation activities. Moreover, the suspended projects are likely to be innovations of higher quality since they are based on knowledge recombination from diverse locales (Fleming, 2001; March, 1991). Thus,

Hypothesis 3: Other things equal, the negative effect of a restrictive change in immigration policy on MNE innovation performance will be stronger in industries with a lower level of knowledge codification.

Data and Methods

To study the effects of restrictive changes in immigration policy I use data on US public MNEs that (a) mobilize highly skilled employees from their foreign subsidiaries to home locations in the US and (b) actively invest in innovation. This setting is appropriate for my study since the US has long been a leading destination for migrant workers from different parts of the world (International Organization for Migration and the United Nations, 2000). Within US immigration flows, I use data from the H-1B visa program. Among various work-related visa categories in the US, the H-1B visa allows US firms to temporarily transfer and employ highly skilled foreign employees in US worksites in ‘specialty occupations’ requiring the application of mathematics, engineering, technology, and scientific knowledge.

The number of H-1B visas used by companies to transfer foreign employees to the U.S. far exceeds other types of work visas. Further, the U.S. Government’s policy of releasing administrative data on H-1B visas makes it a popular choice among scholars studying immigration and innovation (Choudhury & Kim, 2019; Doran et al., 2022; Glennon, 2023; Kerr & Lincoln, 2010; Ghosh et al., 2014) as a substantial number of beneficiaries of the H-1B visa are employed in STEM-related occupations². Publicly

² A 2013 Brookings Institution report “H-1B Visas and the STEM Shortage” draws from a Department of Labor Survey to conclude that “90 percent—of H-1B applications are for jobs requiring high-level STEM knowledge”. The report can be accessed at <https://www.brookings.edu/articles/h-1b-visas-and-the-stem-shortage/>.

available information on applicant firms in this visa category and their patenting behavior allows me to identify and discern effects on MNEs exposed to immigration policy changes. In this study, I leverage an exogenous variation in the cap on the number of H-1B visas enforced by the United States Citizenship and Immigration Service (USCIS). More specifically, in 2004, the number of H-1B visas offered by USCIS was unexpectedly reduced by more than 65%. This sharp decline forms a critical part of my identification strategy. I combined data from multiple sources for this study. My starting point was financial information on the universe of US public companies active between 2000 to 2007 and headquartered in the U.S. as obtained from the Compustat North America database. Compustat data included MNEs from a wide range of different industries, avoiding potential sample bias arising from specific industries. I ensured that my sample comprises MNEs by confirming that employment affiliations on LinkedIn of a stratified sample of inventors located in foreign countries named on patents in my sample matches the assignee on the relevant patents (Table A). This check confirms my assertion that the firms in my sample not only operated in foreign countries but had employees on their payrolls in these foreign locations and lends further confidence in the mechanisms claimed in my hypotheses. The information I collected is reported in full as Appendix A³.

Next, I obtained data on MNEs that intended to apply for H-1B visas to transfer employees from their foreign locations to US locations. Constructing the dataset used in

³ I also confirmed the international spread of inventors during any 10-year period before the focal year in my sample and by checking the number of foreign subsidiaries operated by a random sample of 2% of parent companies as reported in Exhibit 21 of the 10-K form filed by these companies. Details of these tests are made available in Appendix A.

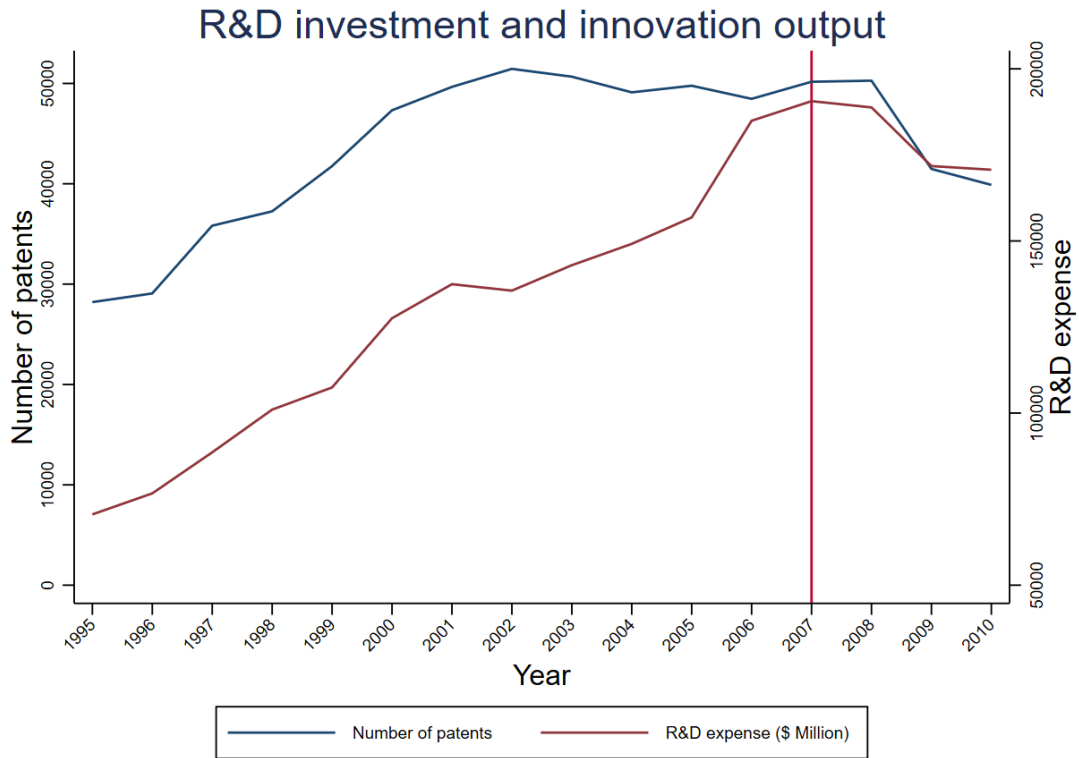
this study was a multi-step process. First, I obtained data on Labor Condition Applications (LCAs) filed by firms at the US Department of Labor between 2000 to 2007⁴. Although LCAs do not necessarily translate one-to-one to H-1B visa applications, these data suffice for my study since I only need to identify MNEs' intentions to transfer high skilled foreign labor to the US⁵. Neither the Department of Labor nor the USCIS associate any unique identifiers to applicant firms. So, I scrutinized and manually matched LCA firm names to Compustat firm names to identify US public companies. My sample starts from 2000 due to the unavailability of LCA data prior to 2000 and terminates in 2007 to avoid confounding effects arising from the 2008 financial downturn when most companies reduced their investments in activities across the board as presented in Figure 2 (Hud & Hussinger, 2015; Filippetti & Archibugi, 2011; Brancati et al., 2022). This provides me with an observation window of four years before and after the shock which is a standard practice in studies that examine the effects of the H-1B visa shock (Ghosh et al., 2014; Chen et al., 2021; Mayda et al., 2018; Xu, 2018; Facchini, et al., 2011).

⁴ 2001 is the earliest year for which LCA data is made available by the US Department of Labor. The data can be obtained through a Freedom of Information Act (FOIA) request made to the Department.

⁵ Before applying for H-1B visas, the US Department of Labor mandates firms to submit Labor Condition Applications with the Office of Foreign Labor Certification (OFLC) to ensure that American workers in the same occupation are not discriminated against and to ensure payment of prevailing wage rates to foreign hires. Firms must submit one LCA for each foreign worker that it intends to transfer under each occupation. The OFLC reviews and approves these LCAs, only following which firms may file a H-1B application with the USCIS. While LCAs do not necessarily translate one-to-one to H-1B visa applications, absent detailed data on the number of actual H-1B visas filed by various firms from the USCIS, the LCA data sufficiently indicate firms' intentions to transfer high skilled foreign labor to the US. This suffices for my study since neither do I hypothesize on the number of H-1B visas applied for nor do I analyze data pertaining to inventors from any specific region.

Figure 2

R&D Investment and Innovation Output During the 2008 Financial Crisis.



Next, I used the DISCERN Patent data (Arora et al., 2021) to match patents to MNEs using GVKEYs. The DISCERN database is an extension of and improvement over the NBER patent dataset (Hall et al., 2001) in that it offers dynamically matched patents to appropriate MNEs based on acquisition and bankruptcy histories. After these steps, my sample comprises 1,010 MNEs that rely on foreign employees and actively invest in innovation. Next, I obtained and mapped inventor, citations, and CPC (Cooperative Patent Classification) technology class data from *patentsview* to the patents in my sample. I used financial information obtained from Compustat to calculate financial control variables relevant to my study. My final estimation sample is an unbalanced panel dataset comprising 371,856 patents assigned to 707 MNEs with 4291

firm-year observations as the unit of analysis for the years 2000 to 2007⁶. These MNEs belong to 18 different industries.

Dependent Variables

Global R&D Dispersion. Testing Hypothesis 1 requires assessing empirically whether MNEs experience a higher international dispersion of inventors following a reduction in the H-1B visa cap. Following prior work (Hannigan et al., 2015; Perri et al., 2017), I construct a measure for inventor dispersion based on the Herfindahl index. Herfindahl index-based measures vary between zero and 1 and capture the concentration of discrete components in their respective contexts. Subtracting this index from 1 inverts the concentration measure and results in a measure of the dispersion of those very components. Thus, I calculate global dispersion in a MNE's inventor network as:

$$Global\ R\&D\ Dispersion_{it} = 1 - \sum_{n=1}^N (Country_{int}/Inventors_{it})^2$$

where $Country_{int}$ is the number of inventors from country n from which MNE i 's inventors applied for patents in year t and $Inventors_{it}$ is the total number of inventors appearing on all patents filed by MNE i 's inventors in year t . $Global\ R\&D\ Dispersion_{it}$ is a continuous variable bounded between 0 and 1.

MNE Innovation performance. The dependent variable for hypothesis 2 and 3, which suggests a reduction in a MNE's innovation performance after the immigration policy shock, is the MNE's annual *number of patents* granted dated by application year

⁶ I lose 27 firms and 362 observations due to missing values in control variables. However, mean comparison tests on the dependent variables reveal that my sample does not suffer from selection bias as p -values from the t-tests remain insignificant at conventionally accepted cutoffs.

(Ahuja & Lampert, 2001)⁷. Annual granted patents reflect the effectiveness of a firm's knowledge production function in generating new knowledge and are a good proxy for innovative activity (Cantwell, 1989; Ferrucci & Lissoni, 2019). I used application year rather than grant year as it is closer to when the innovative activity actually occurred. I opted for patent count because it is one of the most objective measures for innovation output. However, using citation-weighted patent count⁸ as a dependent variable produced the same results as those reported in the paper.

Explanatory Variable

The explanatory variable to test my hypotheses, *Post Shock*, directly captures the effect of the immigration shock. It is an indicator that takes a value of 1 in the post-shock period (2004 – 2007) and a value of 0 otherwise (2000 – 2003). In essence, this variable allows me to compare the average effect on each dependent variable arising from a change in the number of H-1B visas. Prior studies have shown that the change in visa restriction was exogenous⁹ and not anticipated by MNEs (Facchini et al., 2011; Ghosh et

⁷Number of patents measures the quantitative aspect of innovation performance. As robustness, I also test for the effects of restrictive immigration policy on qualitative aspect of innovation performance as measured by the novelty of recombination. Additional details about this variable and results are presented in Appendix C.

⁸The estimations for this alternative dependent variable provide the same results if I weight the patent count with the number of forward citations received within 5, 7, or 10 years since the application year. Please see Appendix H for results.

⁹ Although the AC21 Act increased the number of H-1B visas up to 2003, the subsequent reduction was subject to updates. Publicly available accounts in the media by critics of the H-1B program, academics, and industry personnel indicate that there were ongoing lobbying efforts to keep the H-1B numbers at 195,000 or to increase it further. For instance, Stephen Yale-Loehr, chair of the American Immigration Lawyers Association's Business Committee and adjunct Professor at Cornell University Law School, in his hearing to the Senate Judiciary Committee examining the importance of H-1B visa to the American Economy in September 2003, stated that "... an annual cap of 65,000 is simply too small...Even if there were 65,000 fresh H-1B numbers fiscal year, which there aren't, that's not enough. I believe that a modest H-1B increase of 115,000 for Fiscal Year 2004 would alleviate our immediate labor pressures...". Thus, firms that

al., 2014; Mayda et al., 2018; Xu, 2018; Chen et al., 2021; Glennon, 2023). I also performed a placebo test to confirm that the hypothesized effects on dispersion and innovation outcomes do not exist for a control sample (Appendix I). In other words, null results on the placebo test reveal that the three-fold H-1B visa reduction distinctly leads to the effects I find in my analyses. Thus, concerns about endogeneity of the shock are considerably alleviated.

Codifiability of Knowledge

To examine whether the codifiability of knowledge affects the MNEs' reactions to immigration restrictions in terms of the geographic dispersion of their R&D workforce, I use industry-level data. I drew a subsample corresponding to two-digit SIC industries with the largest number of MNEs, i.e., the top two deciles in my main estimation sample in terms of number of MNEs. This results in a subsample comprising SICs 36, 73, and 28. I then classify these into high and low codification industries based on qualitative and quantitative evidence based on knowledge characteristics prevalent in these industries. As qualitative evidence, prior literature has highlighted the dependence of MNEs in SIC 36 and SIC 73, namely, the 'Electronic and other electrical equipment' and 'Business services' industries, on globally distributed R&D teams (Sosa et al., 2002). These MNEs rely extensively on knowledge codification and the exchange of codified knowledge through ICT channels to operate a '24-hour knowledge factory' model for innovation as well as operational processes (Gupta et al., 2009). Similarly, for MNEs in SIC 28, namely, the 'Chemical and allied products' industry, Davis, Subrahmanian, and

intended to recruit foreign skilled labor could not have anticipated the reversion of H-1B visas to pre-1998 levels.

Westerberg (2005), in their study of Du Pont's R&D laboratories and innovation processes, found that senior scientists "can give good and immediate answers to questions" (Davis et al., 2005, p.109) related to tests that junior scientists are planning to perform and, despite knowledge captured in numerous database, "the effort and difficulty involved in externalizing the tacit dimension of subtle matches ... is non-trivial" (Davis et al., 2005, p.109), pointing to the crucial role of tacit knowledge in this industry. These studies provide me with the qualitative evidence to classify SICs 36 and 73 as high codification and SIC 28 as low codification industries.

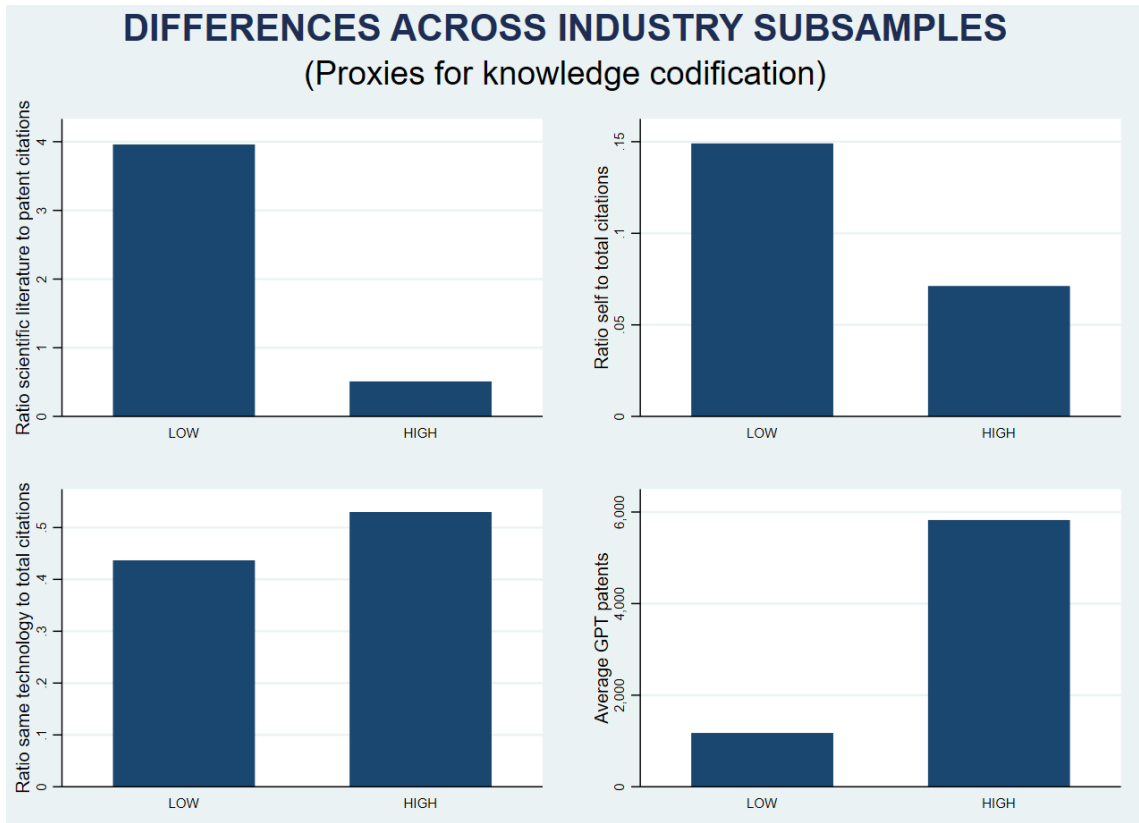
Quantitatively, I compute four variables that allow me to account for differences in knowledge codification tendencies across industries. These proxies for knowledge codification tendencies are citations to science, organizational myopia, technological myopia, and 'General Purpose Technology'ness (GPTness). Following Cassiman, Veuglers & Zuniga (2008) and Perri, Scalera & Mudambi, (2017), I measured the ratio of citations to scientific literature and patents as a proxy for MNEs' tendency to utilize more complex and fundamental knowledge in its R&D. As Tijssen (2001, p.53) notes, non-patent references "are likely to mirror some important features of the complex and interactive nature of knowledge flows" which require interpersonal communication due to lack of extensive codification. Following Agrawal, Cockburn & Rossell (2010), I constructed the ratio of self-citations to total citations as a measure of a MNE's propensity to build upon its own knowledge. This variable measures the "cumulative nature of technology" (Jaffe & Trajtenberg, 2002, p.215) which indicates a close interactive knowledge producing unit that relies heavily on tacit exchange of research scope of the MNE. Agrawal, et al's (2010) measure of ratio of same-technology citations

to total citations is constructed as a measure of a MNE's propensity to build upon the same technological knowledge base. This variable proxies for MNEs' direction of their R&D efforts to a common domain which often requires closer interaction between its inventors indicating tacit knowledge exchange in the MNE. Finally, following Petralia (2020), I count the number of patents that occur at the frontier of '*GPTness*' as a proxy for the ease with which MNEs can build novel inventions using the focal patent, implying ease of interpretation and application of technology contained in the focal patent. A mean comparison test of these four variables for SIC 36 and 73 *vis-à-vis* SIC 28 reveals significant differences as displayed in Figure 3 (t-test results are available on request from the authors) thus validating my qualitative industry classification approach with quantitative tests.

I perform robustness tests by including more industries, i.e., the top three deciles in my main estimation sample in terms of number of MNEs. Increasing the subsample in this manner does not reveal a qualitative change in my results (Appendix F). My study explores industry-specific differences in knowledge codification and their impact on MNE innovation under immigration restrictions. However, I recognize that even MNEs within the same industry can vary dramatically in terms of the extent of their knowledge codification. I undertake preliminary and simple analysis of the intra-industry context and find that my results continue to hold (see Appendix K for details).

Figure 3

Knowledge Codification Differences Across Industry Subsamples.



Control Variables

I controlled for a variety of MNE- and industry-level factors to isolate the effects of a change in the immigration policy on inventor dispersion and patenting outcomes. I controlled for the size of the knowledge production function, *Number of inventors*, measured as the cumulative number of inventors on patents applied for by the MNE each year. Prior studies have shown that the larger the knowledge production function, the higher the tendency to set up foreign R&D labs (Cantwell & Mudambi, 2005; 2011).

I also controlled for the knowledge stock of MNEs by including *Patent stock*, which is the count of granted patents applied for in the three years preceding the focal year (Oettl & Agrawal, 2008; Scalera et al., 2018). I controlled for *Average team size*,

measured as the average number of co-inventors across all patents applied for by the MNE (Wuchty et al., 2007). I controlled for the technological diversity of MNEs (Almeida & Kogut, 1997), *Technological diversity*, measured as the cumulative number of CPC technology subclasses on patents filed in a year. MNEs possessing diverse knowledge could be tapping knowledge from internationally dispersed locations and may be able to generate higher patenting output as well as recombinations (Patel & Vega, 1999). I controlled for MNEs' *R&D intensity*, measured as the ratio of R&D expenditure to revenue, to account for influences on global geographic dispersion as well as on inventive outcomes (Kotabe, 1990). Next, I controlled for MNE size, measured by its *Revenue*, efficiency in deploying its assets to profitable projects, measured by return on assets *RoA* (ratio of net income to total assets); surplus resources which can be used to setup new R&D facilities, *Slack*, measured as the ratio of current assets to current liabilities in a year (Nohria & Gulati, 1996; Malen & Vaaler, 2017).

I also controlled for *Firm growth*, measured as the year-over-year difference in revenue, to account for expansion tendencies of high-growth MNEs. I controlled for MNEs' *Market share*, measured as the ratio of firm revenue to total revenue of all firms, and *Product market competition*, which is a revenue-based HHI measure, to account for relative competitive pressure and the overall competition in their two-digit SIC industry (Blundell et al., 1999). I also control for *International experience* and *International spread* of MNEs. The former accounts for MNEs routines for knowledge transfer and integration from global sources and is constructed as a binary indicator which takes a value of 1 if the MNE has an international applicant on patent filed in three years prior to

the focal year. The latter accounts for the distribution of MNE R&D workforce across the world and is constructed as the number of countries MNEs' inventors are located in.

To account for differences in the nature of knowledge prevalent in MNEs, I control for three variables, namely, the *Ratio of scientific citations*, *Ratio of self-citations*, and *Ratio of technology self-citations* measured at the firm-year level. *Ratio of scientific citations* proxies for a MNEs tendency to conduct more basic, and hence more tacit research (Perri et al., 2017) and is measured as the average of ratio of citations to non-patent literature to total citations a patent receives. *Ratio of self-citations* is a proxy for MNEs tendency to build on their own knowledge, implying greater understanding and tacit information exchange, and is measured as the average of ratio of citations by the MNE to it itself to total citations made on a patent (Agrawal et al., 2010). *Ratio of technology self-citations*, similarly, accounts for MNEs' tendency to build on the same technological domain, implying a focused understanding of a technological area by its employees. This variable is constructed as an average of the ratio of citations to patents with the same technology class to total citations made on a patent (Agrawal et al., 2010).

At the industry level, I also controlled for overall *Industry growth*, measured as the year-over-year difference in total revenue reported by all firms in an industry (Nadkarni & Narayanan, 2007). To account for the difficulty of assimilation of knowledge at the industry level, I control for *Industry average complexity* of patents. This measure is constructed following Fleming and Sorenson (2001) as the ratio of interdependence of technology classes to the total number of classes on a patent. I also account for 'technology stickiness' at the industry level by controlling for *Industry*

average technology self-citations, constructed as the average ratio of technology self-citations to total citations on patents at the industry-year level.

To account for institutional differences across subsidiary locations, I introduce controls for *Subsidiary IPR strength*, *Subsidiary average GDP per capita*, *Average FDI received*, and *Average tax rate*. All of these controls are average values at the subsidiary network level. To calculate *Subsidiary IPR strength*, I used Park's (2008) value of IPR protection due to its coverage of 122 countries and because using more recent index introduced by Papageorgiadis & Sofka (2020) would lead us to drop a substantial portion of subsidiary locations in my data. I calculated this variable as the weighted average of Park's index where the weights are the number of inventors located in a subsidiary country (Berry, 2017; Brandl et al., 2019). Similarly, I measured the weighted *Average GDP per capita*, *Average FDI received*, and *Average Tax rate* using World Bank data at the MNE-year level for all subsidiary countries where inventors are located in to control for institutional differences that may influence MNEs' project location decisions.

Additionally, for Hypotheses 2 and 3, I accounted for the dispersion of inventors by including the dependent variable for hypothesis 1, *Dispersion*, as a control. Finally, I include year dummies in all estimation models to account for time-trends (Wooldridge, 2013).

Estimation Strategy

I am interested in studying the effect of an exogenous reduction in the number of H-1B visas on inventor dispersion and inventive outcomes. To do so, I rely on a *within-firm comparison* of the effects of a reduction in the number of H-1B visas in the pre- and

post-shock periods while controlling for confounding factors described above. My fixed effects estimator for H1a and H1b is of the form,

$$Y_{it} = \beta_0 + \beta_1 Post Shock_i + \gamma X_{it} + \alpha_i + \alpha_t + \varepsilon_{it} \quad (1)$$

where Y_{it} is the dependent variable for each hypothesis being tested, $Post Shock_i$ is the explanatory variable for each panel in my estimation sample, X_{it} is a vector of control variables measured contemporaneous with Y_{it} , α_i and α_t are unobserved firm- and time-effects dummies, and ε_{it} is the error term. All control variables are contemporaneous to the dependent variable in (1) to account for the simultaneity of relationships emerging from firms' decisions.

This empirical setup is similar to an Interrupted Time-series Design (ITD), as I have consistent data before and after the drop in the number of H-1B visas issued by the U.S. Citizenship and Immigration Services (USCIS). This approach offers a crucial advantage in my context (for more details regarding the uses of ITD see Kontopantelis et al., 2015). The restrictive policy on the *number of issued visas* affected all US industries, making it more challenging to use empirical setups like difference-in-differences that require an untreated group of firms¹⁰. Therefore, an ITD approach allows me to assess the impact of introducing visa-restraining policies by comparing the data before and after this measure was implemented.

The estimator for H2a through H3b is of the form,

$$Y_{it} = \beta_0 + \beta_1 Post Shock_i + \gamma X_{it} + \delta Z_{it-1} + \alpha_i + \alpha_t + \varepsilon_{it} \quad (2)$$

¹⁰ To check the robustness of my results I also report difference-in-difference estimations using as a control group firms that did not file LCAs between 2001 to 2007. The results, reported in Appendix D, did not differ from the one used as my main analysis.

where Z_{it-1} is an additional vector of control variables lagged by one year *vis-à-vis* Y_{it} . In addition to contemporaneous controls, I lag relevant control variables to account for the temporal relations between inventive outcomes and factor input decisions made by MNEs. For instance, R&D intensity in the year $t - 1$, which indicates the extent of R&D investments, will result in inventive outcomes starting from the subsequent year, i.e., in year t . The coefficient of interest in (1) and (2) is β_1 which can be interpreted as the change in the dependent variable during 2004 – 2007 in comparison to 2000 – 2003.

In essence, this estimator allows me to obtain aggregate differences in international dispersion of inventors and inventive outcomes, averaged across all MNEs, by comparing the pre-shock behavior to post-shock behavior on the variables of my interest. The dependent variable for hypothesis 1a and 1b is a continuous variable and those for hypothesis 2 and 3 are count variables. Following common econometric conventions, I used a fixed effects linear specification to test hypotheses 1a and 1b and fixed effects Poisson specification to test hypotheses 2 and 3. All models contain MNE and year fixed effects to account for invariant unobservables along these dimensions. As I also report in the Appendix, my results are robust to a variety of robustness tests including a difference-in-difference setup.

Results

Figure 4 represents the overall effect of the visa restriction on the dispersion of inventors working for US MNEs. It illustrates the country-level change in the number of inventors on patents filed between 2000-2003 and 2004-2007 in my sample. This measure is normalized by the total change in the number of inventors in the same period across all countries to facilitate comparison.

The map suggests that, in general, most countries experienced a *relative increase* in the number of inventors applying for patents with the USPTO from their home countries after the reduction in the number of H-1B visas offered by the US (regions shaded yellow, orange, or red). A closer look indicates these countries include China (+26%), India (+29%), Germany (+5%), Australia (+2%), as well as several countries in Europe and South America. All of these countries supply high-skilled human capital to the US. We also see that far *fewer* inventors (-12%) located in the US applied for patents during this period illustrating a shift in productivity and global dispersion of R&D after the H-1B visa shock. These patterns provide suggestive evidence that instead of *contracting their R&D activities* or *replacing foreign immigrant inventors with others already located in the US*, the MNEs reallocated R&D projects to inventors spread across different countries. Next, I report results from more in-depth econometric analyses.

Table 1 presents the descriptive statistics and pairwise correlations between variables used in this study. As expected, the correlations between the key explanatory variable, Post Shock, used to test my hypotheses and control variables raise no econometric concerns. However, some control variables, namely, *Number of inventors*, *Patent stock*, and *Technological diversity* are highly correlated with *Inventive Output*, the dependent variable for H2a and H3a, and *Novel Recombination Patents*, the dependent variable for H2b and H3b in the expected directions.

Figure 4

Change in Global Dispersion After Visa Cap Reduction.

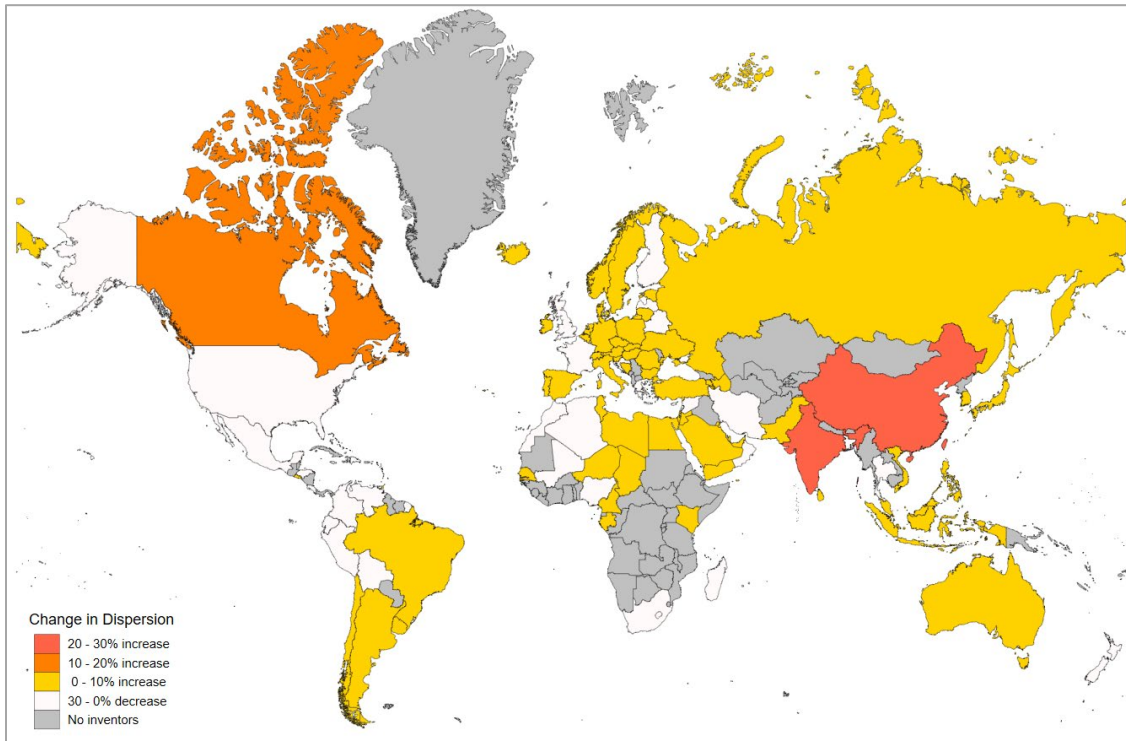


Table 1

Descriptive Statistics and Pairwise Correlations

	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>	<i>11</i>	<i>12</i>
1 Inventor dispersion	1											
2 Inventive Output	0.14	1										
3 Novel recombination patents	0.17	0.70	1									
4 Post shock indicator	0.06	0.00	-0.04	1								
5 Number of inventors	0.16	0.97	0.72	0.01	1							
6 Patent stock	0.15	0.96	0.67	0.02	0.94	1						
7 Average team size	0.04	0.05	0.04	0.04	0.09	0.04	1					
8 Technological diversity	0.23	0.69	0.96	-0.01	0.72	0.69	0.08	1				
9 R&D intensity	-0.11	-0.08	-0.19	-0.04	-0.09	-0.08	0.22	-0.23	1			
10 Revenue	0.27	0.39	0.51	0.09	0.42	0.40	-0.01	0.59	-0.73	1		
11 RoA	0.02	0.04	0.06	0.07	0.05	0.04	-0.04	0.07	-0.24	0.20	1	
12 Slack	0.05	0.13	0.14	0.15	0.14	0.13	-0.06	0.15	-0.56	0.54	0.21	1
13 Firm growth	0.05	0.25	0.28	0.08	0.27	0.23	0.04	0.28	-0.11	0.24	0.04	0.12
14 Market share	0.12	0.41	0.51	0.01	0.45	0.42	0.04	0.54	-0.26	0.46	0.05	0.10
15 International Spread	0.45	0.74	0.73	0.05	0.77	0.73	0.12	0.77	-0.15	0.57	0.07	0.17
16 International experience	0.38	0.15	0.20	0.11	0.15	0.15	0.10	0.26	-0.12	0.35	0.05	0.13
17 Ratio of scientific citations	-0.03	-0.02	-0.06	-0.01	-0.02	-0.03	0.22	-0.06	0.30	-0.17	-0.03	-0.15
18 Ratio self-citations	-0.00	0.14	0.14	0.05	0.14	0.15	0.14	0.18	0.12	0.01	-0.05	-0.07
19 Ratio Technology self-citations	0.05	0.06	0.00	-0.06	0.05	0.06	-0.05	-0.03	-0.05	0.09	-0.02	0.02
20 Inventive quality	0.25	0.48	0.57	-0.16	0.48	0.46	0.16	0.62	-0.16	0.52	0.07	0.20
21 Product market competition	0.02	0.07	0.25	0.04	0.09	0.07	-0.08	0.24	-0.34	0.27	0.06	0.06
22 Industry growth	0.04	-0.01	0.00	0.36	0.01	-0.00	0.13	0.03	0.09	0.00	0.03	0.01
23 Industry avg. complexity	-0.00	0.08	-0.09	-0.02	0.06	0.08	-0.13	-0.14	0.14	-0.14	-0.04	0.07
24 Industry avg. technology self-citations	0.01	0.05	0.00	-0.24	0.02	0.05	-0.22	-0.03	-0.21	0.10	-0.01	0.11
25 Subsidiary IPR strength	-0.54	-0.36	-0.40	-0.06	-0.37	-0.36	-0.11	-0.46	0.14	-0.44	-0.06	-0.14
26 Subsidiary Avg. GDP per capita	-0.32	-0.26	-0.32	0.46	-0.26	-0.24	-0.04	-0.33	0.08	-0.26	-0.00	-0.02
27 Avg. FDI	0.39	0.21	0.25	0.13	0.22	0.20	0.09	0.30	-0.15	0.34	0.08	0.12
28 Avg. tax rate	-0.60	-0.29	-0.37	-0.01	-0.31	-0.29	-0.12	-0.44	0.17	-0.44	-0.07	-0.12
Mean	0.18	86.66	9.52	0.49	136.10	248.42	3.72	20.80	2.63	6.27	6.36	5.38
Standard Deviation	0.19	294.26	19.30	0.50	432.28	830.16	1.73	31.76	1.56	2.29	0.13	0.83

Table 1

(continued)

	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
13 Firm growth	1.00															
14 Market share	0.24	1.00														
15 International Spread	0.28	0.45	1.00													
16 International experience	0.07	0.14	0.31	1.00												
17 Ratio of scientific citations	-0.01	-0.05	-0.02	-0.02	1.00											
18 Ratio self-citations	0.04	0.07	0.16	0.13	0.05	1.00										
19 Ratio Technology self-citations	0.00	0.02	0.08	0.04	-0.11	0.04	1.00									
20 Inventive quality	0.17	0.31	0.63	0.32	-0.06	0.15	0.12	1.00								
21 Product market competition	0.04	0.49	0.12	0.01	-0.15	-0.06	0.00	0.12	1.00							
22 Industry growth	0.12	-0.09	0.03	0.08	0.12	0.12	-0.08	-0.10	-0.16	1.00						
23 Industry avg. complexity	-0.04	-0.26	0.00	-0.06	-0.07	-0.15	0.15	0.04	-0.40	-0.14	1.00					
24 Industry avg. technology self-citations	-0.08	-0.01	0.02	-0.04	-0.21	-0.19	0.27	0.15	0.07	-0.33	0.50	1.00				
25 Subsidiary IPR strength	-0.14	-0.26	-0.64	-0.40	0.03	-0.10	-0.10	-0.54	-0.07	-0.03	-0.02	-0.05	1.00			
26 Subsidiary Avg. GDP per capita	-0.04	-0.18	-0.41	-0.22	0.03	-0.04	-0.12	-0.48	-0.02	0.22	-0.07	-0.19	0.69	1.00		
27 Avg. FDI	0.11	0.18	0.42	0.27	-0.01	0.08	0.00	0.33	0.03	0.13	-0.06	-0.07	-0.41	-0.17	1.00	
28 Avg. tax rate	-0.12	-0.25	-0.58	-0.42	0.04	-0.09	-0.04	-0.47	-0.08	-0.02	0.06	0.01	0.66	0.44	-0.38	1.00
Mean	270.07	0.01	2.67	0.77	1.14	0.10	0.49	5.36	0.04	39638.05	134.88	0.49	4.67	10.46	0.97	44.58
Standard Deviation	1733.83	0.03	4.30	0.42	4.29	0.10	0.18	2.08	0.02	50997.21	60.64	0.05	0.21	0.24	0.76	9.27

Note: N = 707 firms and 4291 observations. †Variables transformed by taking natural logarithm.

The model VIF when including these variables is 3.07 which is well below the cutoff value of 10 (Hair et al., 1995). Moreover, excluding, or entering, any of these controls with high correlation in a step wise manner in my models does not change the results reported in the paper. Alternatively, orthogonalizing these control variables and entering them into the estimations also leads to the same results and interpretation as those reported in my analyses. So, I retain these variables to avoid any bias arising from omission of these variables and refrain from assigning any econometric significance to their coefficients.

Table 2 presents results from fixed-effects OLS regressions of global inventor dispersion on the post-shock indicator variable.

Table 2

H-1B Visa Reduction on Global R&D Dispersion of Inventors.

	Model 1	Model 2	Model 3	Model 4
	H1A		H1B	
	Only controls	Full Sample	SICs 36 & 73	SIC 28
Post shock		0.034 (0.008)	0.053 (0.043)	-0.022 (0.618)
Number of inventors [§]	0.148 (0.499)	0.148 (0.499)	-0.200 (0.227)	2.911 (0.003)
Patent stock [§]	0.046 (0.557)	0.046 (0.557)	-0.113 (0.328)	-0.754 (0.140)
Average team size	-0.001 (0.735)	-0.001 (0.735)	-0.001 (0.802)	0.001 (0.603)
Technological diversity [§]	3.533 (0.299)	3.533 (0.299)	3.552 (0.543)	-2.411 (0.823)
R&D intensity [†]	0.015 (0.051)	0.015 (0.051)	0.010 (0.469)	0.024 (0.054)
Revenue [†]	0.002 (0.805)	0.002 (0.805)	-0.005 (0.751)	0.013 (0.447)
RoA [†]	0.037 (0.005)	0.037 (0.005)	0.017 (0.444)	0.046 (0.000)
Slack [†]	0.015 (0.175)	0.015 (0.175)	0.017 (0.373)	0.016 (0.395)

Table 2

(continued)

	Model 1	Model 2	Model 3	Model 4
	H1A		H1B	
	Only controls	Full Sample	SICs 36 & 73	SIC 28
Firm growth [§]	-0.015 (0.057)	-0.015 (0.057)	-0.024 (0.364)	-0.013 (0.462)
Market share	0.677 (0.117)	0.677 (0.117)	0.246 (0.851)	3.670 (0.189)
International spread	0.006 (0.000)	0.006 (0.000)	0.013 (0.000)	0.002 (0.716)
International experience	-0.022 (0.020)	-0.022 (0.020)	-0.013 (0.359)	-0.020 (0.396)
Ratio of scientific citations [§]	-1.153 (0.736)	-1.153 (0.736)	7.109 (0.663)	-4.975 (0.161)
Ratio self-citations	-0.009 (0.808)	-0.009 (0.808)	-0.077 (0.301)	0.015 (0.763)
Ratio technology self-citations	-0.021 (0.289)	-0.021 (0.289)	-0.006 (0.855)	-0.077 (0.016)
Product market competition	-0.305 (0.497)	-0.305 (0.497)	-0.495 (0.710)	2.848 (0.302)
Industry growth [§]	-0.001 (0.049)	-0.001 (0.049)	-0.001 (0.487)	-0.000 (0.887)
Industry avg. complexity [§]	0.456 (0.864)	0.456 (0.864)	-12.695 (0.052)	79.809 (0.012)
Ind. avg. technology self-citations	-0.190 (0.025)	-0.190 (0.025)	0.040 (0.900)	0.261 (0.661)
Subsidiary IPR strength	-0.023 (0.419)	-0.023 (0.419)	0.023 (0.668)	-0.107 (0.035)
Subsidiary avg. GDP per capita [†]	0.021 (0.408)	0.021 (0.408)	0.050 (0.302)	0.079 (0.078)
Avg. FDI ^{§†}	-15.555 (0.729)	-15.555 (0.729)	-60.276 (0.502)	-2.291 (0.983)
Avg. tax rate [§]	2.907 (0.516)	2.907 (0.516)	3.470 (0.643)	5.234 (0.611)
Constant	-0.234 (0.300)	-0.234 (0.300)	-0.437 (0.284)	-1.636 (0.006)
Year and firm fixed effects	Yes	Yes	Yes	Yes
R-squared	0.031	0.031	0.062	0.048
Observations	4,291	4,291	1,479	892
Number of firms	707	707	255	152

Notes: Fixed effects OLS regressions. Year and firm fixed effects included in all models. *p*-values in parentheses. [†]Variables transformed by taking natural logarithms. [§]variables scaled to facilitate interpretation of coefficients. All variables except Number of inventors lagged by one period.

Models 1 and 2 in Table 2 pertain to the full sample of 707 MNEs. Model 1 pertains to the fixed effects OLS regression of controls on the geographic dispersion of MNE inventors. Model 2 includes the explanatory variable in addition to the controls. The coefficient on the *Post Shock_i* is positive and highly significant ($\beta = 0.034, p < 0.01$) indicating that MNEs experience higher global geographic dispersion of inventors following the immigration policy change which reduced the number of H-1B visas. The coefficients presented above correspond to a 4.7% increase in global dispersion of inventors in MNEs' R&D network following visa restrictions. Thus, this result provides support to hypothesis 1a. Models 3 and 4 present results from the test for hypotheses 1b for the high codification subsample of 255 MNEs in SIC 36 and 73 and low codification subsample of 152 MNEs in SIC 28. The coefficient on the *Post Shock_i* variable is positive and significant for MNEs in SIC codes 36 and 73 ($\beta = 0.053, p < 0.05$) corresponding to a 6.88% increase in global dispersion while MNEs in SIC codes 28 show no such effects ($\beta = -0.022, p = 0.618$). These results suggest that, indeed, MNEs in industries which have a higher propensity for knowledge codification experience higher global dispersion of inventors following the visa shock, thereby supporting H1b.

Models 5 in table 3 presents results of the fixed-effects Poisson regression with number of patents as the dependent variable. Fixed effects Poisson regression effectively ignores observation with no within-group variance and therefore I observe a sample size of 666 MNEs in model 5 despite the fixed effects OLS sample size being 707 MNEs. The coefficient on *Post Shock_i* is negative and highly significant ($\beta = -0.348, p < 0.001$) indicating that MNEs experience a drop in their inventive output after the reduction of H-

1B visas. This coefficient corresponds to a 4.15% drop in the number of patents successfully applied for after the shock. This finding lends support to hypothesis 2.

Table 3

Effects of Immigration Restrictions on Innovation Performance.

	Model 5	Model 6	Model 7
	H2	H3	
	Number of patents	SIC 36 & 73	SIC 28
Post shock	-0.348 (0.000)	-0.186 (0.081)	-0.426 (0.001)
Global dispersion	0.620 (0.001)	0.509 (0.123)	0.708 (0.004)
Number of inventors [§]	3.823 (0.000)	3.449 (0.000)	17.135 (0.000)
Patent stock [§]	-0.397 (0.105)	-0.363 (0.287)	-0.247 (0.792)
Average team size	0.009 (0.715)	-0.076 (0.003)	0.049 (0.252)
Technological diversity [§]	72.000 (0.000)	93.741 (0.001)	42.812 (0.052)
R&D intensity [†]	0.072 (0.257)	-0.074 (0.483)	0.029 (0.713)
Revenue [†]	0.385 (0.000)	0.445 (0.000)	-0.065 (0.638)
RoA [†]	0.129 (0.478)	-0.020 (0.882)	-0.182 (0.244)
Slack [†]	-0.048 (0.572)	-0.180 (0.186)	0.091 (0.466)
Firm growth [§]	0.031 (0.042)	-0.025 (0.451)	-0.075 (0.079)
Market share	-4.931 (0.002)	2.861 (0.580)	5.185 (0.197)
International spread	0.006 (0.312)	-0.013 (0.083)	0.022 (0.028)
International experience	0.165 (0.007)	0.130 (0.167)	0.055 (0.698)
Ratio of scientific citations [§]	-51.016 (0.504)	196.171 (0.366)	-72.946 (0.266)
Ratio self-citations	-0.892 (0.004)	-2.243 (0.000)	-0.346 (0.253)
Ratio technology self-citations	-0.043 (0.807)	-0.095 (0.694)	-0.408 (0.217)

Table 3

(continued)

	Model 5	Model 6	Model 7
	H2	H3	
	Number of patents	SIC 36 & 73	SIC 28
Product market competition	4.101 (0.013)	11.733 (0.224)	-4.773 (0.685)
Industry growth [§]	-0.004 (0.104)	0.000 (0.946)	0.005 (0.561)
Industry avg. complexity [§]	-3.126 (0.847)	25.027 (0.321)	246.076 (0.149)
Ind. avg. technology self-citations	-0.343 (0.327)	-0.325 (0.798)	0.063 (0.961)
Subsidiary IPR strength	-0.214 (0.214)	-0.742 (0.003)	0.103 (0.527)
Subsidiary avg. GDP per capita [†]	-0.157 (0.250)	0.119 (0.497)	0.084 (0.626)
Avg. FDI ^{§†}	292.410 (0.203)	213.739 (0.441)	26.176 (0.951)
Avg. tax rate [§]	-27.340 (0.198)	9.168 (0.818)	-42.923 (0.253)
Year fixed effects	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Log pseudolikelihood	-20847	-7714	-2981
Observations	4,250	1,465	883
Number of firms	666	241	143

Notes: Fixed effects Poisson regressions. *p*-values in parentheses. [†]Variables transformed by taking natural logarithms. [§]variables scaled to facilitate interpretation of coefficients. All variables except Number of inventors lagged by one year in all models.

Models 6 and 7 present results from the test for hypotheses 3 performed on the two-digit SIC industry subsamples defined earlier. Models 6 and 7 demonstrate that MNEs in SIC code 28 ($\beta = -0.426, p < 0.001$) suffered significant innovation output losses whereas MNEs in SIC codes 36 and 73 are affected to a lesser extent ($\beta = -0.186, p = 0.081$). These results suggest that the negative effect of immigration restrictions on innovation output is stronger for MNEs in industries with low knowledge codifiability, thus, supporting H3.

Robustness Checks

I performed a variety of robustness checks to confirm the validity of my findings. Due to space restrictions, I discuss the results from robustness checks only qualitatively and report tabulated results in the Appendix. First, I test my hypotheses using a difference-in-differences setup (Appendix D). To do so, I expanded the sample used in the main analyses with US MNEs that belonged to the same two-digit SIC code as in my estimation sample, had inventors based in foreign countries during the period 2001-07, and did *not* file LCAs during this time frame¹¹. These MNEs have not demonstrated an intent to transfer foreign scientists and inventors to their home location in the US and so are less likely to be affected by the reduction in the number of H-1B visas. I use these MNEs as my control group since they are unaffected by the visa policy change. MNEs from my main estimation sample comprise the treated group. A baseline difference-in-differences estimation revealed a stable pattern of findings aligned with my reported results.

Second, I checked whether my results are robust to the exclusion of the Information Technology (IT) industry (two-digit SIC code 73) from my main estimation sample. The IT industry consumes the highest number of H-1B visas in comparison to other industries. To a large extent, both ACWIA and AC21 Act were passed to address

¹¹ To create the estimation sample for difference-in-differences (DID) setup, I first identified all firms belonging to the same two-digit SIC industry as the firms in my main sample but such that these firms never applied for a LCA during 2001-2007. For these non-H1B filers, I constructed all variables using patents and financial data. My DID sample contained 462 firms in the control group and 608 firms in the control group.

shortages in technical manpower experienced by the IT industry¹². Excluding the IT industry from my analyses lends support to the general effects of H-1B visa reduction on a wide variety of industries reliant on science and technology. I largely find support for my hypotheses in the alternate sample composition excluding IT firms (Appendix E). Finally, my results are robust to an alternate measure of innovation performance, namely, citation-weighted patent count, which represents the impact of innovation generated by the MNE (Appendix A8).

Discussion and Conclusion

In recent years, MNEs in many advanced economies are experiencing a paradoxical situation with respect to value creation in the knowledge economy. On the one hand, competitive pressures prompt MNEs to mobilize highly skilled knowledge workers from foreign subsidiary locations to their home R&D labs. On the other, there is a wave of populism that erects barriers to bringing in immigrant R&D workers from MNEs' foreign operations. In this paper, I examined the impact of restrictive immigration policies on the geographic organization of MNEs' R&D and innovation. My theoretical predictions are tested using a sample of 371,856 *patents* assigned to 707 US MNEs that intended to mobilize high-skilled human capital between 2000 and 2007 from their foreign subsidiary locations. My empirical setup exploits an exogenous threefold reduction in the number of H-1B visas in the year 2004. My estimations provide two main results: after the imposition of restrictive immigration policies, 1) MNEs chose to

¹² IT companies such as IBM, Hewlett-Packard, Cisco, Intel, Oracle, and Microsoft and industry bodies such as Information Technology Association of America played a key role in convincing the U.S. Congress to increase the number of H-1B visas citing a shortage of technical manpower in the US.

pursue R&D projects with a globally as reflected in the significantly increased global dispersion of their R&D workforce; 2) their innovation performance was negatively affected.

My study advances the literature on innovation in MNEs by several accounts. Prior literature suggests that MNEs have clear preferences in composing and organizing R&D teams (Patel & Pavitt, 1991; Belderbos et al., 2013). MNEs strive for an equilibrium in which a major portion of their R&D efforts are concentrated in their home R&D labs staffed by local and foreign knowledge workers transferred from their global subsidiary networks, thus leveraging FSAs and CSAs to achieve their innovation objectives. Co-locating inventors from local and foreign origins has important benefits (Bruno et al., 2021) and “... MNEs contribute to the cross-border mobility of inventors via the allocation of personnel across the firm’s internal network of units ... that correlates with the international exchanges of knowledge.” (Castellani et al., 2022, p.15). This allows R&D managers to maintain the requisite diversity of knowledge and experience in their innovation projects (Laursen et al., 2020). MNEs are, thus, effective mechanisms at global sourcing and integration of knowledge (Kogut & Zander, 1993). However, when this mechanism is disrupted through visa restrictions, competitive pressures prompt MNEs to pursue innovation projects across their global subsidiary network increasing the global dispersion of MNEs’ R&D workforce.

I also advance the literature on MNE efficacy in integrating global knowledge for innovation (Castellani et al., 2022; Belderbos et al., 2023). Prior literature highlights MNE strategies in choosing from global locations for innovation projects (see Papanastassiou et al. (2020) and Mudmabi et al. (2018) for comprehensive reviews) by

optimizing transaction costs. I exploit a setting in which MNEs are forced to abruptly decide to locate innovation projects or forego their competitive advantage. Visa restrictions render MNEs' strategic human capital location bounded (Verbeke & Asmussen, 2016) forcing MNEs to "ship" projects abroad when they cannot "ship" human capital to home location. Post hoc analyses revealed that MNEs indeed pursue R&D projects at high-IPR subsidiary locations (Appendix J) to avoid knowledge spillovers (Bruno et al., 2021). Abrupt changes to the MNEs' routines, increased geographical distance between inventors, and selective pursuit of innovation projects to mindfully optimize transaction costs undermine MNE capability to integrate knowledge effectively to its value creation objectives, thus highlighting a boundary condition in MNEs' global knowledge integration.

Third, I complement the literature on MNEs' strategies to deal with government policies (Murtha & Lenway, 1994; Shaffer, 1995). I show that MNEs are likely to deviate from the intended objective of government policies when they determine the policy to be more of a detriment than an advantage. More precisely, if restrictions to the mobility of immigrants are compounded with an inelastic supply of domestic highly skilled workers, then MNEs reorganize their R&D workforce in the global geography to circumvent constraints on their capacity to move inventors. Thus, MNEs are less likely to embrace policymakers' regulatory changes that compromise efficiency and profit. Relatedly, my findings suggest that geographically reorganizing their R&D workforces helps MNEs respond to a continually changing global innovation landscape. Immigration policies that allow MNEs to mobilize strategic human capital across international borders lead to the development of routines and processes for employee transfer, team formation, and

knowledge transfer. A sudden reduction restriction on immigration implies that the actors enacting these routines cannot be optimally located, with a deleterious effect on innovation outcomes.

Moreover, my study extends prior work on immigration and firm-level innovation by exposing mechanisms that affect innovation performance of MNEs. For instance, Glennon (2023) estimates “the impact of constrained skilled immigration supply on the foreign affiliate employment intensive margin (i.e., did foreign affiliate employment at existing foreign affiliates change)” (Glennon, 2023, p.8). In contrast, I look at the dispersion of MNEs’ R&D activities rather than offshoring and point to a mechanism whereby MNEs ‘ship’ R&D projects to globally dispersed teams when they cannot ‘ship’ R&D employees from foreign locations to home R&D labs. Further, Glennon measures “R&D foreign affiliate employment ... as an imperfect proxy for skilled foreign affiliate employment.” (Glennon, 2023, p.7). Scholars consider this as a measure of *innovation input*. I use R&D scientists listed on patents. Scholars consider patents to be a measure of *innovation output*. My study focuses on innovation performance in a broader sense and present results both in terms of quantity and quality (reported as robustness) by measuring the impact of visa restrictions on number of patents as well as recombination novelty. Finally, I expose heterogeneity in the mechanisms operating at the industry level by distinguishing between codified and tacit knowledge as the drivers of geographic dispersion of firm’s R&D organization and their innovation performance emerging from immigration restrictions.

I also demonstrate some important boundary conditions on the “work-from-anywhere” literature that has burgeoned following the COVID-19 pandemic. Recent

work has shown an increase in productivity among high-knowledge workers when they were allowed to choose their work locations following the institution of a work-from-anywhere program (Choudhury et al., 2021). However, I demonstrate that these results may be limited to situations where (a) the MNE chooses to implement geographic flexibility for its high-knowledge workforce, i.e., it is not exogenously imposed by an external agency; and (b) the knowledge being produced is highly codifiable.

From a practical perspective, my study has important implications for managers accountable for achieving R&D and technological innovation objectives in MNEs. The increasingly volatile global environment and proclivity for retaliatory policy making point towards the necessity for safeguarding routines and processes designed to achieve business objectives by MNEs (Cui et al., 2023). Policies that constrain MNEs' ability to mobilize strategic human capital across national boundaries, specifically, are deleterious to their competitive advantage. Managers must therefore plan for such eventualities given the negative effects of such shocks as demonstrated in my study. Such plans could involve purposeful and optimal design of redundant capabilities across the subsidiary network (Ha & Giroud, 2015), instituting mechanisms that encourage home-subsidiary and inter-subsidiary tie formation (Levin & Barnard, 2013; Marino et al., 2020), and 'friend-shoring' (Witt et al., 2023) strategic human capital.

Finally, my study also provides insights for policymakers developing national policies on innovation and entrepreneurship. While workforce training programs and STEM education are essential contributors to future workforce development, they do not address the immediate needs of MNEs operating R&D facilities in the country. My findings suggest that advanced economies, such as the US, must treat high skill

immigration and domestic STEM training as complementary policies to support the innovation efforts of their MNEs.

My study is not without limitations. My focus on the U.S. context renders my findings less generalizable to other countries. For instance, Australia, Singapore, New Zealand, and the UK have implemented restrictive high skilled labor immigration policies in the recent past (see Table 4). Several media reports point to the challenges faced by MNEs in these countries in attracting and recruiting foreign high-skilled workers following such announcements.

Table 4

Global Instance of Immigration Restrictions, 2011 - 2020.

Country	Year	Restrictions
Australia ¹³	2017	Abolished the 457 visa for skilled workers. To be replaced with shorter term visa Fewer skills eligible More difficult to obtain permanent residency
United Kingdom	2011 and 2015	Proposal to reduce immigration across the board including Asylum seekers and high skilled workers. Proposal to abolish EU Human Rights Act and replace it with a British Bill of Rights
Singapore ¹⁴	2016	No new visas issued to Indian IT sector workers without a 'Economic Needs Test.'
New Zealand ¹⁵	2017	Minimum income requirement Limiting the amount of stay in the country

By obtaining data on these countries, future work could explore how MNEs in these countries manage their R&D workforce and whether their immigration restrictions impact

¹³ <https://www.theguardian.com/australia-news/2017/apr/18/australian-government-abolish-457-temporary-work-visa>

¹⁴ https://www.business-standard.com/article/economy-policy/govt-differs-with-singapore-s-logic-to-restrict-access-to-it-professionals-117040300270_1.html

¹⁵ <https://www.reuters.com/article/us-newzealand-immigration/new-zealand-tightens-immigration-rules-in-kiwi-first-crackdown-idUSKBN17L03R>

their innovation outcomes. Moreover, to the extent that high-skilled immigration is a phenomenon involving movement of human capital from countries that are farther away from technological frontier to those that are leading, focusing on the U.S. context also renders my findings less generalizable to immigration in the opposite direction. I also recognize that my treatment of anti-immigration actions such as visa restrictions is a narrow view of populism. Populism is a multi-dimensional construct in which political leaders (Devinney & Hartwell, 2020), voters' threat perception to occupation (Halla et al., 2012; Card et al., 2012; Scheve & Slaughter, 2001; Frey et al., 2018), and socio-cultural assimilation (Mudambi, 2018) interact in a complicated manner. Blanket visa restrictions ignoring skill levels are but one populism-driven policy change in such scenarios and may not represent the entire spectrum of activities, events, behavior, and policies implemented by populist actors such as leaders and nations. Finally, in this paper, I focus on inter-industry heterogeneity in knowledge codification to demonstrate the different mechanisms affecting MNE innovation due to immigration restrictions. However, it is known that knowledge codification can vary even within industries. In Appendix 11, I have made the first tentative steps to demonstrate that my results also hold in the intra-industry context. Future research could undertake a much more detailed analysis of how immigration restrictions affect innovation performance of MNEs within the same industry. Limitations notwithstanding, my study unravels some important effects of restrictive immigration policies on MNEs' R&D organization and innovation outcomes.

CHAPTER 3

H-1B VISA PORTABILITY-LED INVENTOR MOBILITY AND INNOVATION PERFORMANCE

The strategic management of highly-skilled human capital is critical for sustaining competitive advantage and innovation performance, especially in knowledge-intensive industries (Campbell et al., 2012a; Coff, 1997, Lippman & Rumelt, 1982). Consequently, a firm's efforts to organize its human capital towards its performance objectives and sustaining competitive advantage may be jeopardized when knowledge workers depart from the firm. The negative effects of such employee departures may be exacerbated when high-performing employees or those possessing knowledge critical to the firm's competitive position leave voluntarily for alternate employment opportunities. The literature on strategic human capital mobility across firms has demonstrated that interfirm mobility is a key mechanism for sourcing and transferring knowledge across firm boundaries (Almeida & Kogut, 1999; Arrow, 1962; Singh & Agrawal, 2011; Song et al., 2003). These studies highlight knowledge spillovers and exploitation of the new hire's knowledge as the underlying mechanism for superlative innovation performance of destination firms following mobility events.

While research on mobility and knowledge flows overwhelmingly concentrates on the implications for recipient organizations, there has been relatively little attention to how mobility events impact the origin firms and outcomes of the mobile employees themselves. This question takes on additional importance when considering the experiences of immigrant inventors – groups that often face external constraints limiting voluntary turnover as well as assimilation challenges that mute mobility's purported

benefits. For high-skilled immigrants in science and technical occupations, restrictive visa policies tied to a single employer represent one such boundary condition on their mobility relative to native employees (Wright et al., 2017).

To address these issues, in this study I ask: "*do ethnic inventors demonstrate higher mobility and what are the organizational and performance implications for such inventors after passage of ACA 2000?*" I juxtapose two distinct literature streams— one focused on ethnic immigrant inventor productivity which finds superlative performance relative to native peers (Akcigit et al., 2017; Hunt and Gauthier-Loiselle, 2010; Kerr and Lincoln, 2010) and another emphasizing positive inventor outcomes after employer mobility events, namely improved creativity, novel recombinations, and impact (Tzabbar, 2009; Hoisl, 2007; Saxenian, 1996) to answer this question. There is also research demonstrating that adding ethnic inventors to existing teams can negatively impact productivity and performance (Almeida et al., 2017; Ozgen et al., 2013). Integrating these perspectives introduces new theorizing around whether external immigration policy changes can spark mobility events that allow immigrant inventors to improve their invention portfolios. This study further probes differential mobility responses between ethnic and native inventors as well potential negative tradeoffs to mobility-based centrality gains like shifting invention strategies or diminished attention to projects.

I argue that the 2000 change in H-1B visa portability regulation indeed opened alternative employment avenues in the open labor market for foreign high-skilled labor prompting higher interfirm mobility of ethnic inventors over Anglo-Saxon inventors. The relaxation of mobility constraints experienced by foreign inventors therefore increased the bargaining power of such employees vis-à-vis their employers. Consequently, foreign

inventors could negotiate a host of factors pertaining to their career objectives. I argue that this effect is most clearly demonstrated by the change in position in their interfirm collaboration network and in innovation outcomes. Owing to an increase in their bargaining power, foreign inventors collaborate more often, therefore moving to more central positions within the collaboration network. The increase in external opportunities and bargaining power of foreign inventors also bears critical implications for the nature of their inventions. Foreign inventors seek to leverage the increase in external opportunities and therefore generate new knowledge that finds wide application in the relevant domains failing which their knowledge remains limited to their employer. Consequently, I argue that foreign inventors will navigate away from firm-specific knowledge creation by contributing new knowledge that draws largely from external sources as well that finds wider applicability (more generic) complexity of their inventions.

To test my hypotheses, I construct a sample of employment histories of all actively patenting inventors in U.S. public firms between 1990 – 2005. I observe mobility patterns over a three-year period before and after the law change from 1998 to 2003 and use a difference-in-differences estimator to establish mobility patterns following the supply-side shock to ethnic high skilled labor market. I obtain ethnicity of inventors based on their first and last names to construct the treatment group comprising Indian- and Chinese-origin inventors and a control group comprising English ethnicity inventors. My sample is comprised of 48,793 inventors of which 39, 816 belong to the control group and 8,977 belong to the treated group for a total of 228,754 inventor-year observations. My data supports my hypotheses about increased mobility and centrality of

inventors and lower innovation output and complexity of inventions in the treatment group in comparison to the control group after the passage of the H-1B visa portability provision in the AC21 Act.

My study advances our understanding of strategic human capital mobility and innovation performance in three distinct ways. First, it expands our theoretical understanding of how changes in immigration policy can impact the workforce bargaining power, collaboration networks, and invention strategies of high-skilled immigrant employees. Second, while most network studies emphasize firm-specific antecedents (Tortoriello & Krackhardt, 2010), I demonstrate the potential for national policy shocks to restructure collaborative activity. Third, by positing both benefits (e.g. centrality) and costs (e.g. lower firm specificity and invention complexity) of increased immigrant bargaining power, this study presents a balanced perspective on the implications of policy-driven talent mobility.

Theory and Hypotheses

Inventor Turnover in Response to Changes in the Visa Program

The removal of constraints on mobility alters the opportunity landscape for restricted employees (Fallick et al., 2006; Marx et al., 2009; Starr et al., 2021). By expanding options and weakening former barriers, this type of supply-side shock holds implications for turnover, knowledge diffusion, and capability development that generalize across settings. For instance, the literature on non-compete agreements and its impact on mobility suggests that the enforceability and elimination of non-competes exhibits predictive validity for employee mobility likelihoods above and beyond other recognized predictors (Starr et al., 2021; Marx et al., 2009).

Applying this perspective, the elimination of mobility constraints previously imposed through immigration policy may similarly influence inventor turnover by shifting opportunity space dimensions. This expansion of opportunity space is particularly important for high skilled immigrant knowledge workers. First, removing policy and legal restrictions provides awareness that alternative opportunities exist, combating assumptions regarding mobility barriers. Immigrants, in general, move from their countries of origin in pursuit of better career growth options, living standards, and monetary benefits (Czaika & Reinprecht, 2022; Ghatak et al., 1996). Once settled in the destination country, high-skilled immigrants can then experience the benefits of an enlarged opportunity space for career progression by switching employers (Le Grand & Tahlin, 2002; Bidwell & Mollick, 2015). However, local immigration policy in the destination country may artificially prevent free movement by instituting regulations that constrain immigrants' mobility options. The elimination of such regulations should open up the labor market for high skilled immigrant inventors career pursuits.

Second, the freedom to consider external options without waiting periods or other transition costs lowers tangible mobility risks related to income flows, status loss, or disruption of immigrant status or permanent residency processes. Immigrants may then seek external opportunities consistent with the job matching (Jovanovic, 1979) and embeddedness (Feldman & Ng, 2007) perspectives which argue that individuals weigh perceived costs and risks against expected utilities of taking an outside option over current arrangements.

Third, uncertainty prompts organizations and employees to make firm-specific human capital investments tied to firm's objectives (Wang et al., 2009). However, once

firm-specific knowledge investments may get devalued within the firm while gaining demand in external markets. Immigrants knowledge workers experiencing such situations may view the removal of exogenous constraints on mobility as an opportunity to explore a better fit for their skills (Jovanovic, 1979).

In essence, while the elimination of exogenous mobility barriers universally impacts opportunity space, responses are predicted to vary based on cost-benefit assessments of leaving given a worker's career orientation, outside options, and current positional. Thus, I expect that,

Hypothesis 1: Ethnic inventors will demonstrate an increased likelihood of leaving their current employer in comparison to non-ethnic inventors after the passage of AC21 Portability Act owing to an increase in their bargaining power.

Ethnic Inventors' Pursuit of Central Roles

General human capital theory suggests that employees gain bargaining power when there are fewer restrictions on their ability to move between firms (Becker, 1964). Labor mobility allows workers to voluntarily depart from their existing firm to another firm if their current employer does not meet their demands. This fundamentally shifts the balance of power in the employer-employee relationship. While this theory generally applies to all employees, high-skilled immigrant employees on temporary work visas typically face additional constraints that limit their mobility and weaken their bargaining position in many sponsorship-based immigration regimes. Specifically, many skilled immigrants move from their countries of origin to the destination country on work visas that are tied to their employer who sponsors their visa. (Sumption, 2019; Wright et al., 2017). This lack of portability reduces outside options and decreases immigrants' ability

to bargain for tasks and projects that match their career progression objectives and skill levels.

However, policy changes can relax such mobility constraints and improve immigrants' standing. For example, the American Competitiveness in the 21st Century Act (AC21) passed in 2000 created H-1B visa portability which allowed recipients awaiting green card approval to easily change jobs or work locations (USCIS, 2015) thereby expanding their opportunity space that matched their skills and career objectives. With such policy changes, immigrant inventors can credibly negotiate collaborations, resources, and authority within their firms due to an increase in their bargaining power failing which they can exploit outside opportunities and voluntarily depart from their existing firm. Firms employing immigrant inventors and facing such situations, on the other hand, are better off controlling attrition given the knowledge spillover concerns undermining their competitive advantage.

Thus, I argue that increasing leverage allows immigrant inventors to assume more complex, central innovation roles connected to the firm's core research and development priorities. By taking on more central positions in intrafirm collaboration networks, immigrant inventors became more influential in advancing the company's key strategic objectives (Singh et al., 2010) thereby gaining status and having a say in the firm's innovation objectives. In this manner, relaxations in mobility restrictions meaningfully empowers immigrant inventors. With portability provisions, immigrant inventors gained bargaining power to take on critical R&D roles and contribute more directly to firm innovation success. Therefore, I expect that,

Hypothesis 2: Ethnic inventors will occupy more central locations in their firms' collaboration network in comparison to non-ethnic inventors after the passage of AC21 Portability Act owing to an increase in their bargaining power.

Firm Specificity of Innovation

The strategic human capital literature emphasizes the importance of firm-specific human capital in creating value for firms (Coff, 1997; Hatch & Dyer, 2004). Firm-specific human capital refers to the knowledge, skills, and abilities that are unique to a particular firm and are developed through an employee's tenure with the organization (Becker, 1962). In the context of innovation, firm-specific human capital is critical for inventors to effectively utilize the firm's unique technologies, processes, and capabilities to generate novel inventions (Hess & Rothaermel, 2011). However, the bargaining power of employees plays a crucial role in shaping their incentives to invest in firm-specific human capital (Coff, 1999). When employees have limited external labor market opportunities, they are more likely to invest in firm-specific human capital as it increases their value to the current employer (Wang et al., 2009). Conversely, when employees have higher bargaining power and more external labor market opportunities, they may be less inclined to invest in firm-specific human capital as it limits their mobility (Campbell et al., 2012).

In the context of foreign high-skilled knowledge workers, the H-1B visa portability provision in the AC21 Act of 2000 significantly increased their bargaining power by opening up external labor market opportunities. Prior to the AC21 Act, foreign inventors were tied to their sponsoring employer, limiting their ability to switch jobs. This lack of mobility incentivized them to invest in firm-specific human capital, thereby

increasing their usage of firm-specific inventions. However, the passage of the AC21 Act allowed foreign inventors to switch employers more easily, thereby increasing their bargaining power. As a result, foreign inventors may have less incentive to invest in firm-specific human capital, as it may limit their external labor market opportunities. Instead, they may focus on developing more general skills and knowledge that are valued in the external labor market (Lazear, 2009). Thus, I hypothesize:

Hypothesis 3: Ethnic inventors will demonstrate a reduction in usage of firm-specific inventions in comparison to non-ethnic inventors after the passage of AC21 Portability Act owing to an increase in their bargaining power.

The use of external knowledge and the increase in degree centrality within the firm can also affect the nature of foreign inventors' new knowledge. First, when ethnic inventors have increased bargaining power due to the AC21 Act, they may be more inclined to source knowledge from external sources rather than relying solely on firm-specific knowledge. This is because external knowledge is more transferable across firms and can enhance the inventor's value in the external labor market (Rosenkopf & Almeida, 2003). By incorporating a greater proportion of external knowledge in their inventions, ethnic inventors may create more generic inventions that are less specific to their current firm (Nerkar & Paruchuri, 2005). This shift towards external knowledge sourcing can be seen as a strategy to maintain the inventor's marketability and mitigate the risks associated with firm-specific investments (Mawdsley & Somaya, 2016).

Second, an increase in degree centrality within the firm implies that ethnic inventors may collaborate more extensively with their colleagues after the AC21 Act. Degree centrality refers to the number of direct ties an inventor has within the firm's

inventor network (Freeman, 1978). As ethnic inventors gain bargaining power, they may leverage their position to establish more collaborations and access a broader range of knowledge within the firm (Oldroyd & Morris, 2012). While this increased collaboration can facilitate knowledge sharing and innovation, it may also lead to the creation of more generic inventions. As ethnic inventors collaborate with a diverse set of colleagues, they may incorporate knowledge and ideas that are not necessarily specific to the firm's core competencies (Tortoriello et al., 2012). This can result in inventions that are more universally applicable and less firm-specific.

Moreover, when ethnic inventors have increased bargaining power and external labor market opportunities, they may perceive their tenure with the current firm as more uncertain (Carnahan et al., 2012). This shorter time horizon may discourage them from investing in deep, firm-specific knowledge, as the returns on such investments may not be realized if they leave the firm (Wang & Barney, 2006). Instead, ethnic inventors may prioritize the development of more general skills and knowledge that can be easily transferred to other firms, further contributing to the reduction in firm-specific knowledge generation.

In summary, the use of external knowledge, increased degree centrality within the firm, and shorter time horizons can all contribute to the reduction in firm-specific knowledge generation by ethnic inventors when their bargaining power increases. These mechanisms, along with the previously discussed shift towards general skills and external knowledge sourcing, provide a comprehensive theoretical framework for understanding the impact of the AC21 Act on the innovative behavior of ethnic inventors.

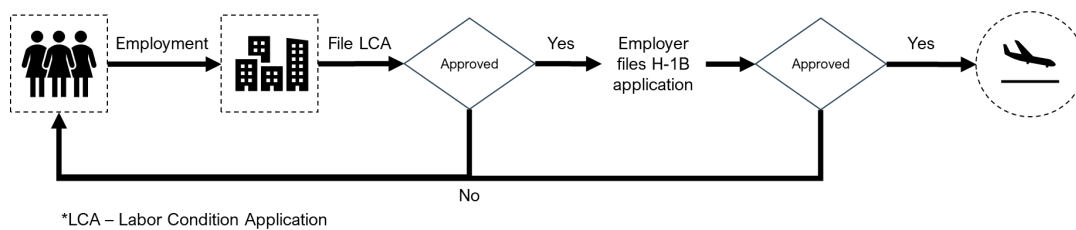
Hypothesis 4: Ethnic inventors will generate lesser firm-specific knowledge in comparison to non-ethnic inventors after the passage of AC21 Portability Act owing to an increase in their bargaining power.

Data and Methods

The context for my study is the United States. Firms operating in the U.S. can employ foreign workers in “specialized positions” at their local offices by transferring them from foreign offices using the H-1B non-immigrant visa (Figure 9). Consequently, the H-1B program has been the most sought-after work visas to employ highly skilled foreign workers in the U.S.¹⁶. As the H-1B visa is an employer sponsored work visa, foreign workers were constrained in leaving their employer and changing jobs before the passage of the AC21 H-1B Portability Act with a waiting time of 3-6 months for the transfer of their H-1B status to their new employer.

Figure 5

The H-1B Visa Grant Process



With the passage of the Portability provision under the AC21 Act, individuals with H-1B visas were allowed to start working for their new employers immediately

¹⁶ Only U.S. companies can apply for H-1B visas to staff ‘specialty occupations’ in U.S. work locations for candidates meeting specific educational and work experience qualifications. Foreign MNEs operating in the U.S. can only file L-1 visas to staff positions in U.S. work locations. L-1 visas are employer specific and, therefore, individuals working in the U.S. on L-1 visa cannot switch employers.

while the transfer of H-1B status happened behind the scenes. This change alleviated mobility constraints of H-1B workers and, therefore, enhanced their bargaining power. Foreign high skilled workers whose knowledge was crucial for their employers' competitive positioning could find employment opportunities in the external labor market if their demands on the nature of projects or other career objectives were not met by the current employer. I leverage this exogenous change in the H-1B visa program to test the effects of increasing bargaining power on ethnic workers' interfirm mobility and subsequent organizational position and innovation performance.

To construct the interfirm mobility dataset to test my hypotheses, I obtained a sample of U.S. public firms active between 1996 to 2005 from the Compustat database and mapped patents produced by these firms using the DISCERN Patent database using the 'gvkey' identifier. Next, I obtained disambiguated inventor information such as first and last names, location, and collaboration on patents from USPTO¹⁷ and mapped them to patents. To identify interfirm mobility events, I detect changes in firm identifiers (gvkey) on inventors' successive patents (Almeida & Kogut, 1999; Song et al., 2003; Singh & Agrawal, 2011). The sample is restricted to inventors who have remained in or moved to the U.S. before 2000 and applied for at least one patent before and after the passage of AC21 Act on 17 October 2000. Following Singh & Agrawal (2011), I infer the move date of an inventor as the midpoint between the last patent application date at the previous firm and first patent application date at the new firm and assign the move to the start of the year of the move date calculated in such a manner. These steps result in a

¹⁷ Made available from www.patentsview.org.

sample comprising 543,373 inventor-year observations for 88,181 inventors over 2,304 firms.

As explained in the following section, I use a difference-in-differences (DD) set up to test my hypotheses. This estimation strategy requires identification of treated and control groups. To do so, I used disambiguated first and last name of inventors from patentsview.org to obtain ethnicity of inventors from Ethnea¹⁸ database (Torvik & Agarwal, 2016), an instance-based ethnicity classifier that has been employed previously used for identifying ethnicity and gender in studies on science and innovation (Ross et al., 2022; Lawson et al., 2019). The Ethnea database assigns a probability for each first and last name combination submitted in the query. The probabilities are calculated based on a nearest neighbor algorithm that accounts for the frequencies of occurrences of those names in respective countries of affiliation from the PubMed database. These co-occurrences are then classified into twenty-six pre-defined ethnicities to obtain a probability score. Although this approach ensures a high accuracy in reporting ethnicities, there remains a possibility that some names are globally distributed due to decades of widespread immigration. To handle such dispersion of ethnic names, Ethnea returns probabilities for each ethnicity that may be associated with a particular first and last name combination along with a 90% cutoff and 60% cutoff for the “best predicted” ethnicity. For example, the name Amit Jain is predicted to be of Indian ethnicity at both 90% and 60% cutoffs although it is associated with a small percentage of occurrences in English and Israeli ethnicities (Fig. 6).

¹⁸ Available at <http://abel.lis.illinois.edu/resources.html>.

Figure 6

Sample Output from the Ethnea Database

First=		Amit		Last=		Jain	
Prediction (cutoff = 90%) = INDIAN							
Prediction (cutoff = 60%) = INDIAN							
Ethnicity	Prob	First	Last	probF	probL		
INDIAN	99.52	Amit	Jain	75.658	97.404		
ENGLISH	0.43	Amit	Jain	10.903	2.596		
ISRAELI	0.05	Amit	Jain	13.439	0.0		

For all my analyses, I used the 90% cutoff to prevent bias arising from misclassification of ethnicities. Further, I used varying levels of “strictness” in defining “ethnic inventors” for consideration in my analyses. The results reported here are based on the strictest classification used to identify treated and control groups. In this classification I assigned only inventors with “INDIAN” and “CHINESE” ethnicities to the former and “ENGLISH” ethnicity to the latter. As robustness check, I report results from a sample in which this criterion is relaxed. My main estimation sample is comprised of 48,793 inventors of which 39, 816 belong to the control group and 8,977 belong to the treated group for a total of 228,754 inventor-year observations.

Estimation Strategy

The H-1B Portability provision passed under the AC21 Act affects only foreign highly skilled workers in the U.S and not native American citizens in terms of increasing their bargaining power thus rendering a setup ideal for DD estimation. Since “ENGLISH” ethnicity inventors far outnumber the “INDIAN” and “CHINESE” ethnicity inventors and since the H-1B visas are largely allocated to the latter group of ethnic inventors, any change in the H-1B visa mobility provisions will affect “INDIAN” and “CHINESE”

inventors over the “ENGLISH” ethnicity inventors. The AC21 was signed into law on 17 October 2000. I test my hypotheses by observing mobility and patenting patterns over the 1998 and 2003 duration to obtain three years pre- and post-shock periods in my DD estimation. Foreign inventors identified by “INDIAN” or “CHINESE” ethnicities comprise the treated group and those identified by “ENGLISH” ethnicity comprise the control group. My estimator is of the form

$$Y_i = \beta_0 + \beta_1 Time_i + \beta_2 Ethnicity_i + \beta_3 Time_i \times Ethnicity_i + XB + \epsilon_i$$

where the coefficient of interest is β_3 which gives the effect of the shock on the dependent variable Y_i .

Dependent Variables

Move Event. To test H1, the dependent variable is a binary indicator corresponding to the interfirm mobility of an inventor. Thus, it takes a value of 1 if inventor i changes employers in year t and is 0 otherwise. I test Logit, Probit and Linear probability specifications with the estimator described previously to determine the effects of H-1B visa mobility provisions on ethnic inventors’ mobility.

Centrality. To test H2, the dependent variable is the degree centrality of the focal inventor in the intrafirm collaboration network each year. This variable takes on non-negative integer values depending on the number of collaborative ties the inventor has in any given year. In years when the inventor does not have a patent application, I set the degree centrality to 0 indicating that the inventor is still part of the organization but may be an isolate for that year.

Knowledge Sourcing. To test H3, the dependent variable is the number of employer-specific patents cited by the focal inventor’s patents in a year. This variable

takes on non-negative integer values. I use a Poisson specification to estimate the effects of H-1B visa mobility provision on this variable.

Complexity. To test H4, the dependent variable is the average complexity of all patents applied by the inventor in that year. Patent-level complexity scores are calculated using Fleming and Sorenson's (2001) approach. The intuition behind this measure is that the higher the frequency of combination of two technology classes in the USPTO universe, the greater their interdependency and greater the number of such high interdependency technology class pairs on a patent, the greater its complexity. Complex inventions may find fewer downstream applications as knowledge specific to the invention is necessary for further recombinations. The complexity of inventions is a continuous variable. I use an OLS specification to determine the effects of H-1B visa mobility provision on complexity of inventions.

Independent Variable

The independent variables in my study pertain to time period over the sample duration and the identification of treatment and control units. Both these variables are indicator variables. The time period variable, *Period*, takes a value of 0 in the years before passage of the H-1B visa mobility provision and 1 afterwards. In other words, this variable is 0 in the years 1998 – 2000 and 1 in the years 2001 – 2003. The variable, *Treatment*, identifies treated and control units. For treated units, i.e., ethnic inventors comprising “INDIAN” and “CHINESE” ethnicities, this variable takes a value of 1 and for control units, i.e., inventors with “ENGLISH” ethnicity, this variable takes on a value of 0. With the DD specification, the coefficient of interest is the interaction between *Period* and *Treatment*.

Control Variables

I control for a variety of factors that affect the centralization tendency and innovation performance of individual inventors. Specifically, I control for the inventive productivity of inventors by distinguishing star inventors from other inventors (Khanna, 2023; Tandon & Toh, 2022; Tzabbar & Kehoe, 2014). *Star* is a binary indicator for inventors that produce more than 1 standard deviation patents from the average patenting output of inventors in the same firm in the same year. Next, I control for the gender of the inventor to account for difference in patenting and career objectives that have been reported in the literature (Koning et al., 2020; Xie et al., 2020). *Male* is a binary indicator that takes on a value of 1 for male and 0 for female inventors. To control for the adoption of inventors' inventions for further recombination in their progression to more central roles, I control for *Complexity* of inventions and productivity as measured by *Number of patents*. Finally, I control for the influence of the inventor in the intrafirm collaboration network by include *Eigen vector centrality* as a control in estimations for productivity and complexity.

Results

Table 5 shows the correlations and descriptive statistics for all variables in the estimation sample. Correlations between key variables are within acceptable range implying that multicollinearity is not an issue in my sample.

Table 5

Descriptive Statistics and Pairwise Correlations.

	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>	<i>11</i>
1 Move event	1										
2 Degree centrality	-0.07	1									
3 Self-citations	-0.05	0.35	1								
4 Average complexity	-0.10	0.17	0.09	1							

Table 5

(continued)

	1	2	3	4	5	6	7	8	9	10	11
5 Period indicator	-0.01	0.01	0.02	-0.01	1						
6 Treated	0.01	0.03	0.01	0.09	0.01	1					
7 Star	-0.06	0.39	0.29	0.12	-0.01	0.03	1				
8 Male	0.02	-0.02	-0.00	-0.00	0.00	-0.16	0.01	1			
9 Eigen vector centrality	-0.04	0.26	0.11	0.04	-0.02	-0.01	0.24	-0.00	1		
10 Number of patents	-0.09	0.79	0.50	0.26	-0.00	0.05	0.55	0.00	0.20	1	
11 Total citations	-0.05	0.35	0.69	0.08	0.02	0.00	0.30	0.01	0.19	0.45	1
Mean	0.05	3.70	3.88	93.06	0.50	0.16	0.08	0.91	0.05	1.23	28.78
Standard deviation	0.23	10.57	17.75	150.31	0.50	0.37	0.27	0.28	0.20	2.56	120.09

Note: N = 221,189.

Table 6 displays results from the tests for H1, namely the DD estimation of the likelihood of an interfirm mobility event by ethnic inventors following the passage of the H-1B portability provision in the AC21 Act. The coefficient on the interaction of *Period* and *Treatment* indicators are positive and highly significant in all models indicating that ethnic inventors indeed demonstrated higher interfirm mobility following the passage of H-1B portability provision. Thus, my data supports Hypothesis 1.

Table 6*DD Estimates of the Likelihood of an Interfirm Mobility Event.*

	Logit	Probit	LPM
Period	-0.135*** (0.021)	-0.063*** (0.010)	-0.007*** (0.001)
Treatment	0.084** (0.035)	0.040** (0.016)	0.005** (0.002)
Period x Treatment	0.148*** (0.049)	0.069*** (0.023)	0.007*** (0.003)
Constant	-2.829*** (0.014)	-1.591*** (0.007)	0.056*** (0.001)
Observations	221,189	221,189	221,189

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Interaction terms in non-linear models cannot be interpreted based on statistical significance of coefficients. However, the coefficient on the interaction term and its significance in the linear probability model is equal to the marginal effects predicted from Logit and Probit models confirming H1.

Table 7

DD Estimates of Network Position, Knowledge Specificity and Complexity.

	Degree centrality Model 1	Self-citations Model 2	Complexity Model 3
Period	0.222*** (0.028)	0.250*** (0.021)	-3.381*** (0.649)
Treatment	-0.177*** (0.058)	0.083*** (0.029)	36.524*** (1.517)
Period x Treatment	0.161** (0.072)	-0.088** (0.039)	-6.164*** (1.850)
Star	-2.640 (1.666)	1.876*** (0.020)	-20.578 (14.590)
Number of patents	3.477*** (0.346)	0.012*** (0.002)	16.194*** (2.959)
Complexity	-0.003** (0.001)	0.001*** (0.000)	
Eigen vector centrality		0.118*** (0.036)	-5.281** (2.583)
Male	-0.849*** (0.056)		6.852*** (1.072)
Total citations		0.001*** (0.000)	
Constant	0.578*** (0.194)	0.531*** (0.014)	64.956*** (2.514)
R-squared	0.635		0.074
Estimator	OLS	Poisson	OLS
Observations	221,189	228,754	221,189

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7 presents results from tests for H2, H3 and H4. Model 1 in table 9 shows results from an OLS DD estimation of effects of portability on network position of ethnic inventors. The interaction term is positive and highly significant indicating that ethnic

inventors take up more central positions after the passage of portability provision, thus supporting H2. Model 2 presents results on self-citation patterns. The interaction term is negative and highly significant indicating that ethnic inventors indeed utilize external knowledge to a greater extent after the passage of H-1B portability provision. Model 3 presents results on complexity of inventions. The interaction term is negative and highly significant indicating that ethnic inventors produce less complex or in other words, more generic patents following an increasing in bargaining power with the passage of portability provision.

To ensure that results discussed above indeed emerge from the passage of H-1B portability provisions under the AC21 Act, I performed placebo tests for periods without any overlap with the year 2001 before and after the shock. Sample duration for the period before passage of the Act is 1996 to 1999 and after is 2001 to 2005. Table 8 shows results from placebo tests for all hypotheses for the pre-shock period. Coefficient on the interaction terms in Model 1 is not significant indicating that interfirm mobility of ethnic inventors was indeed not prevalent before the passage of the AC21 Act. The interaction term in Model 2 is positive and significant. This indicates that ethnic inventors occupied central positions even before passage of the Act. The interaction term in model 3 is positive but not significant, indicating that ethnic inventors had no discernable difference in the usage of firm-specific and external knowledge in the period preceding passage of the Act. Finally, the interaction term in model 4 is negative and non-significant, indicating that complexity of ethnic inventors' patents did not differ in the period prior to passage of the Act.

Table 8.*DD Estimation as Placebo Test in the Pre-Shock Period.*

	H1 Model 1	H2 Model 2	H3 Model 3	H4 Model 4
Period	0.892*** (0.043)	0.145*** (0.039)	-0.054 (0.034)	-25.480*** (1.195)
Treatment	-0.054 (0.103)	-0.179** (0.076)	-0.007 (0.053)	36.772*** (2.673)
Period x Treatment	0.116 (0.112)	0.202** (0.092)	0.088 (0.065)	-0.376 (3.146)
Star		1.073*** (0.342)	1.743*** (0.027)	-33.069*** (8.546)
Number of patents		2.477*** (0.080)	0.017*** (0.003)	16.849*** (1.939)
Complexity		-0.001** (0.000)	0.001*** (0.000)	
Male		-0.786*** (0.060)		8.137*** (1.732)
Eigen vector centrality			0.103** (0.051)	-19.389*** (2.180)
Total citations			0.001*** (0.000)	
Constant	-3.766*** (0.039)	0.972*** (0.095)	0.603*** (0.026)	92.445*** (2.719)
R-squared		0.643		0.073
Observations	102,645	102,645	105,743	102,645

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 9 shows results from placebo tests for all hypotheses in the post-shock period. Coefficient on the interaction terms in Model 1 is not significant indicating no effect of passage of the AC21 Act. The interaction term in Model 2 is not significant indicating no effect on network positions of ethnic inventors in this period. The interaction term in model 3 is not significant indicating that ethnic inventors did not differ in usage of firm-specific and external knowledge in this period. Finally, the interaction term in model 4 is negative and significant, indicating that complexity of ethnic inventors' patents fell in the period after passage of the AC21 act.

Table 9.*DD Estimation as Placebo Test in the Post-Shock Period.*

	H1 Model 1	H2 Model 2	H3 Model 3	H4 Model 4
Period	-0.421*** (0.031)	0.077 (0.061)	0.294*** (0.028)	18.639*** (1.067)
Treatment	0.249*** (0.039)	-0.106 (0.081)	0.042 (0.031)	29.985*** (1.664)
Period x Treatment	-0.107 (0.070)	0.075 (0.101)	-0.025 (0.049)	5.416** (2.410)
Star		-3.988** (1.975)	1.854*** (0.040)	-7.579 (17.648)
Number of patents		3.806*** (0.399)	-0.001 (0.006)	13.604*** (3.456)
Complexity		-0.003** (0.001)	0.001*** (0.000)	
Male		-0.907*** (0.080)		8.236*** (1.401)
Eigen vector centrality			0.079* (0.047)	-12.593*** (2.997)
Total citations			0.001*** (0.000)	
Constant	-2.886*** (0.017)	0.556*** (0.212)	0.795*** (0.019)	59.636*** (2.767)
R-squared		0.653		0.068
Observations	135,272	135,272	139,976	135,272

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Results from my main analyses and placebo tests confirm my theory on increasing bargaining power of ethnic inventors following the passage of H-1B portability provision as part of the AC21 Act.

Robustness Checks

I test robustness of my findings by relaxing the criterion used to compose treated and control groups in the analyses reported previously. The newly defined treatment group is comprised of "CHINESE", "INDIAN", "CHINESE-INDIAN", "INDIAN-CHINESE", "JAPANESE", "KOREAN", "VIETNAMESE", and "ARAB" ethnicities

whereas the newly defined control group is comprised of "ENGLISH", "GERMAN", "SLAV", "HISPANIC", "FRENCH", "NORDIC", "DUTCH", "ITALIAN" and combinations of these ethnicities. Table 10 presents results from robustness tests with an extended sample. Direction and significance of the coefficient on interaction terms in all models in table 10, except for self-citations, follow those from the main analyses lending robust support to my theory.

Table 10

Robustness Check with DD Estimation on an Extended Sample.

	Move Model 1	Degree centrality Model 2	Self-citations Model 3	Complexity Model 4
Period	-0.149*** (0.018)	0.238*** (0.023)	0.227*** (0.025)	-3.895*** (0.535)
Treatment	0.113*** (0.031)	-0.256*** (0.051)	0.085*** (0.029)	34.006*** (1.301)
Period x Treatment	0.142*** (0.044)	0.138** (0.067)	-0.060 (0.042)	-4.986*** (1.638)
Star		-3.590*** (1.283)	1.883*** (0.020)	-12.881 (11.657)
Number of patents		3.691*** (0.268)	0.010*** (0.001)	14.716*** (2.375)
Complexity		-0.004*** (0.001)	0.001*** (0.000)	
Male		-0.910*** (0.053)		5.462*** (0.925)
Eigen vector centrality			0.136*** (0.031)	-6.124*** (2.164)
Total citations			0.001*** (0.000)	
Constant	-2.876*** (0.012)	0.516*** (0.146)	0.557*** (0.023)	67.263*** (1.992)
R-squared		0.664		0.068
Observations	314,166	314,166	323,059	314,166

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Discussion and Conclusion

Firms achieve and sustain their competitive advantage by continuously investing in value creation activities predominantly in the form of technological innovation (Cockburn & Henderson, 2000). The strategic human capital of firms is a critical input in this process (Campbell et al., 2012). To supplement their local workforce and to meet their innovation objectives firms often recruit foreign high-skilled knowledge workers to staff their R&D projects. Such foreign knowledge workers may be subject to mobility constraints in the destination countries due to prevailing immigration policies. In this paper I examine the effects of a regulatory change that facilitates interfirm mobility of foreign knowledge workers as part of updates to the immigration policy. I argue that such change increases the bargaining power of foreign knowledge workers and, consequently, influences their organizational position within the intra-firm collaboration network and innovation characteristics.

I construct a sample of inventors employment history over 1998 – 2003 to study the effects of H-1B visa portability provision as part of the AC21 Act of 2000. I identify a group of ethnic inventors that are most likely to be affected by this exogenous change and compare them with a group of inventors who are not affected by this change using a difference-in-differences setup. My results support my theory that foreign knowledge workers exhibit higher interfirm mobility than local inventors. I also argue that this change increased the bargaining power of foreign knowledge workers affording them a more central position in the intrafirm collaboration network and affected their knowledge sourcing patterns and complexity of inventions negatively in comparison to local inventors.

This study makes several important contributions to the strategic human capital management, immigration policy, and innovation literatures. First, it expands our theoretical understanding of how changes in immigration policy can impact the workforce bargaining power, collaboration networks, knowledge sourcing, and invention strategies of high-skilled immigrant employees. By focusing specifically on the relaxation of mobility restrictions through the AC21 Portability Act, I provide novel evidence that such policy shifts can meaningfully empower immigrant talent and inventors (Wright et al., 2017). This answers recent calls to examine how immigration reforms shape firm-level outcomes (Kerr et al., 2015; Nathan, 2014).

Second, the hypothesized effects speak to the role that exogenous institutional factors outside of the firm play in intra-firm collaboration dynamics, knowledge flows, and inventive outputs. While most network studies emphasize firm-specific antecedents (Tortoriello & Krackhardt, 2010), I demonstrate the potential for national policy shocks to restructure collaborative activity. My arguments suggest that the greater visibility and influence ethnic inventors gained after AC21 altered network centrality based on shifting opportunity costs and bargaining leverage rather than firm-level choices alone (Bidwell & Briscoe, 2009). This highlights an often-overlooked external driver of collaboration patterns.

Third, by positing both benefits (e.g. centrality) and costs (e.g. greater external knowledge sourcing and lower invention complexity) of increased immigrant bargaining power, this study presents a balanced perspective on the implications of policy-driven talent mobility. On one hand, the ability to change jobs without visa loss empowers immigrant scientists and engineers (Saxenian, 2002). But it may also incentivize shifts to

less risky invention strategies and create bandwidth challenges (Lippman & Rumelt, 2003). Examining differentiated responses enhances our understanding of how policy environments link to inventor outcomes (Czaika & Parsons, 2017).

Overall, this study introduces immigration reform as a concrete lever through which institutional factors outside firm boundaries can significantly impact collaboration dynamics and the nature of inventions produced within firms (Powell & Sandholtz, 2012). It also adds much needed empirical context to debates on high-skilled immigration policy impacts (Peri et al., 2015). From a practical view, findings will inform firm leaders on potential downstream effects of ongoing immigration reforms as well as highlight considerations for managing and collaborating with immigrant scientist and engineer talent (Hunt & Gauthier-Loiselle, 2010).

CHAPTER 4

MIGRANTS' HUMAN CAPITAL AND SOCIAL CAPITAL: IMPLICATIONS FOR IMMIGRATION POLICY

A common perspective in immigration policy debates is that migrants can be differentiated based on their human capital, defined as the levels of education, knowledge, and skills they possess (Becker, 1962). It follows that migrants with low human capital are more likely to burden public services in destination countries, while high human capital migrants are more likely to productively contribute and complement native workers (Boeri, 2002). This human capital perspective has become a cornerstone for the analysis of immigration policy (Borjas, 1987). However, I align with an emerging critique contending that the narrow focus on formal credentials and test scores captures only part of the full picture (Bauer et al., 2005).

Human capital theory conventionally relegates migrants' embeddedness within social structures as secondary concerns, if considering social dimensions at all (Kloosterman & Rath, 2018). However, I contend that analyses ignoring migrants' social connections and relational channels as fundamentally biased. The economic contributions uniquely enabled by migrants' social capital routinely surpass those tied directly to only human capital qualifications. This is especially true for high-skilled migrants working in innovation or entrepreneurship.

For example, over 50% of Silicon Valley startups launched between 1995-2005 included migrant founders (Wadhwa et al., 2007). For instance, Indian and Chinese migrants were heavily represented in regional innovation ecosystems. The outsized entrepreneurship rates observed in migrants from specific originating countries cannot be

explained by only viewing their formal educations. Their technical knowledge must be understood as complemented by access to overseas co-ethnic social networks providing vital knowledge resources to enable venture creation, survival, and success (Saxenian, 2002).

Likewise, within multinational corporations, high-skilled migrants often take central roles in global knowledge management and transfer processes precisely due to their bridging potential (Reitz, 2001). Rather than siloed technical contributors, they become linchpins in disseminating best practices between otherwise disconnected organizational units. Their boundary-spanning capabilities are particularly salient in bridging between units in their countries of employment and countries of origin (Marino et al., 2020). In a globally connected innovation setting, ignoring migrants' social capital seriously weakens the explanatory accuracy (Burt, 2000).

Migrants' social capital appears in two mutually reinforcing forms: bonding social capital and bridging social capital (Putnam, 2000). I argue that this duality provides a much more accurate theoretical grounding reflecting the modern reality of globally interconnected innovation systems and entrepreneurship (Kerr et al., 2016). However, in an age of complex interdependence between economic and security realms, immigration policy discourse requires another critical upgrade. As global geopolitical competition increasingly converges across economic and national security domains in areas, balancing knowledge exchange gains from migration against the risks to national security becomes ever more complex (Agrawal et al., 2022).

Destination countries need to formulate calibrated visa policies assessing migrants both by their individual skills and networks as well as by the nature of diplomatic ties

with their origin countries. Therefore, I propose a three-dimensional perspective encompassing human capital, social capital as well as the geopolitical contexts that shape migrants' bridging capacity. Friendly political relationships provide latitude to activate migrants' bridging social capital for mutual benefit. However, adversarial ties warrant caution around risks of inadvertent or intentional knowledge transfer contravening the destination country's interests (Mukherjee, 2022). Incorporating this third vector allows immigration controls to conduct more nuanced screening of individuals and flows based on holistic contributor profiles, rather than resorting to indiscriminate country-based restrictions that fail to capture the multidimensional reality influencing migrants' integration and bridging capacity. My expanded framework integrating human capital, social capital, and geopolitics thus provides a comprehensive foundation for maximizing migration's innovation upside while prudently managing associated security trade-offs. Further developing this model offers possibilities for superior next-generation immigration policies.

The Two Forms of Migrants' Capital

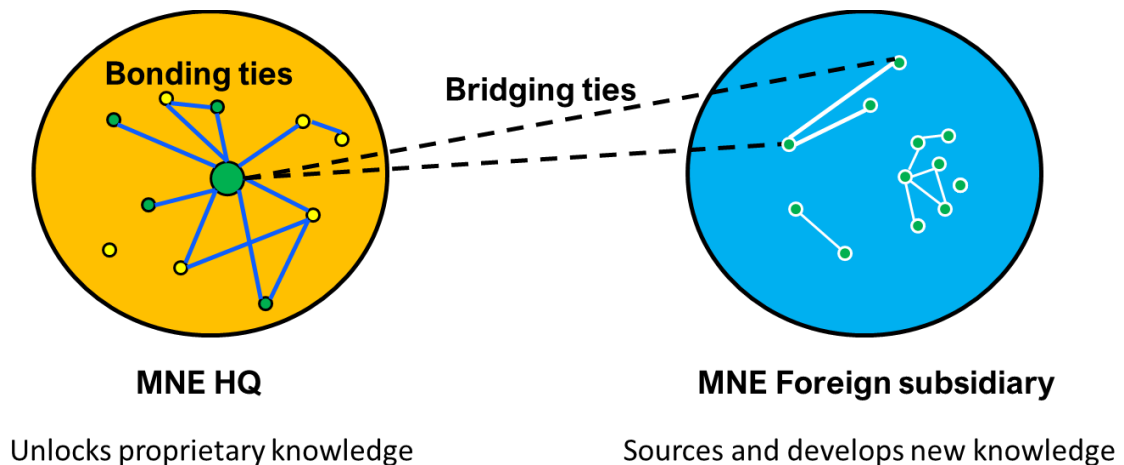
Institutional actors, especially MNEs, rely on high-skilled foreign labor for innovation, primarily due to a shortage of relevant skills in the local labor market (Kerr and Lincoln, 2010; Kerr et al., 2015; Choudhury and Kim, 2019) as well as associated lower transaction costs. A significant proportion of the innovation output from foreign-born STEM workers arises from their contributions to the innovation objectives of these MNEs.

Migrant workers often possess a distinct edge in innovation performance over their local-born STEM counterparts. To examine this pattern, I draw from the multiple

embeddedness perspective of strategic human capital (Granovetter, 1985; Portes & Sensenbrenner, 1993). I argue that foreign-born STEM workers are characterized by dual embeddedness. The duality arises from their embeddedness in the local knowledge production network within their organization and their embeddedness in knowledge production networks in their home countries. Migrant inventors' social capital, encompassing both bonding and bridging ties (Marino et al., 2020), plays a pivotal role in enhancing their innovation performance (Figure 7). It gives them an advantage unavailable to most native-born workers.

Figure 7

Duality of Foreign-Born Inventors' Social Capital



Bonding Social Capital Enables Integration and Productivity Gains

Bonding social capital consists of connections within a community that enable members to function well together (Aldrich & Meyer, 2015). For migrants, bonding social capital manifests in their ability to develop trusting relationships and work effectively alongside native-born colleagues and teammates across a variety of organizational contexts in the destination country (Kanas et al., 2012).

Elevated levels of bonding social capital can have concrete economic impacts by enhancing the productivity of teams and units that include both migrants and native workers. For example, cultural diversity and integration policies have been shown to improve financial performance in sectors like banking by facilitating bonding within mixed teams (Richard, 2000). Migrants' success and rise to prominent decision-making roles in their employing MNEs are likely to be associated with elevated levels of bonding social capital (Nathan, 2014).

In essence, the concentration of human capital within individual migrants says little about their ability to translate knowledge and skills into tangible productivity gains. Migrants may possess impressive educational credentials yet struggle to integrate into the social fabric of local institutions. Bonding social capital thus serves as the conduit enabling human capital to generate economic returns in practice (Kazemipur, 2006). I argue bonding social capital should be considered as an additional dimension for evaluating migrants' potential workforce contributions and shaping associated policy.

Bridging Social Capital Facilitates Knowledge Flows

In contemporary globalized economies marked by high-skill mobility, migrants often retain active connections to professional and social networks in their origin countries long after relocating (Saxenian, 2005). These lasting ties represent bridging social capital back to the migrant's country of origin (Inkpen & Tsang, 2005).

MNEs' knowledge creation increasingly relies on connecting and integrating knowledge from geographically dispersed centers of excellence, often called knowledge hotspots. These locations are peaks in the global knowledge landscape (Florida, 2005). The global city research stream (Sassen, 2004) has conclusively documented that these

knowledge hotspots specialize in complementary knowledge bases. MNEs create value by mobilizing knowledge flows between centers of excellence and integrating them through knowledge arbitrage (Gupta & Govindarajan, 1994). Knowledge conduits are a key resource for enabling these flows. These conduits appear in two forms – organizational pipelines enabled by MNEs, and individual-enabled by personal networks (Lorenzen & Mudambi, 2013). The globally mobile high-skill workforce possessed by the MNE represents a valuable form of personal networks operating within organizational pipelines.

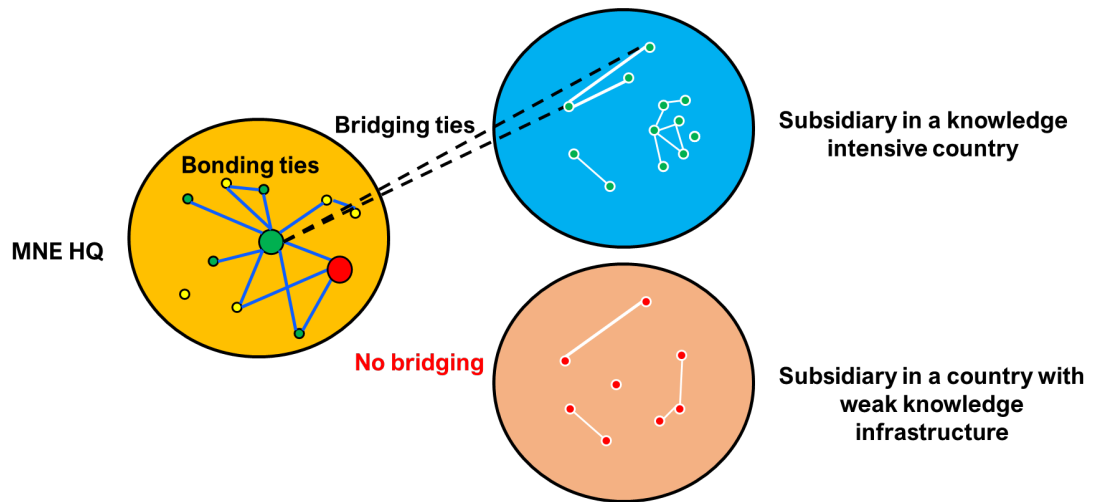
The personal networks of MNEs' migrant knowledge workers are based on their bridging social capital. Therefore, this social capital can be enormously impactful for employers and sectors that rely on innovation, creativity, and cutting-edge knowledge. Migrants with high levels of bridging social capital can tap expertise from worldwide networks to solve complex problems, receive feedback on new ideas, or accelerate research, greatly increasing their value and productivity (Kerr et al., 2016). Further, they can facilitate broader knowledge transfers between teams across different geographies (Agrawal et al., 2011).

However, I note that bridging the social capital of high-knowledge migrants depends on the munificence of the knowledge infrastructure in their countries of origin. Migrants from countries with rich knowledge infrastructure and advanced innovation systems are better positioned for impactful bridging than migrants from countries with weaker domestic institutions and professional networks (Bahar & Rapoport, 2018). For example, software engineers maintaining connections to India's thriving IT sector will

likely provide more value to their MNE employers from their bridging social capital than migrants from countries with limited high-tech presence.

Figure 8

Bridging and Bonding Social Capital of Immigrant Inventors.



Thus, I argue immigration policy should incorporate evaluations of migrants' bridging social capital in addition to formal human capital qualifications. Migrants able to successfully bridge to advanced overseas innovation ecosystems can contribute greatly to domestic employers and the broader economy of their countries of employment (Kerr & Kerr, 2016).

Enabling Innovation Through Social Capital in Multinationals

Within multinational corporations, elevated levels of bonding social capital have been empirically shown to increase innovation rates by facilitating cohesion between culturally diverse teams (Nathan & Lee, 2013). Migrants' embedding within internal social structures enhances trust and communication flows across global R&D centers, widely distributed manufacturing facilities, and interconnected marketing units. The

bridging of geographic and cultural barriers enabled by bonding social capital allows multinationals to fully leverage their global human capital.

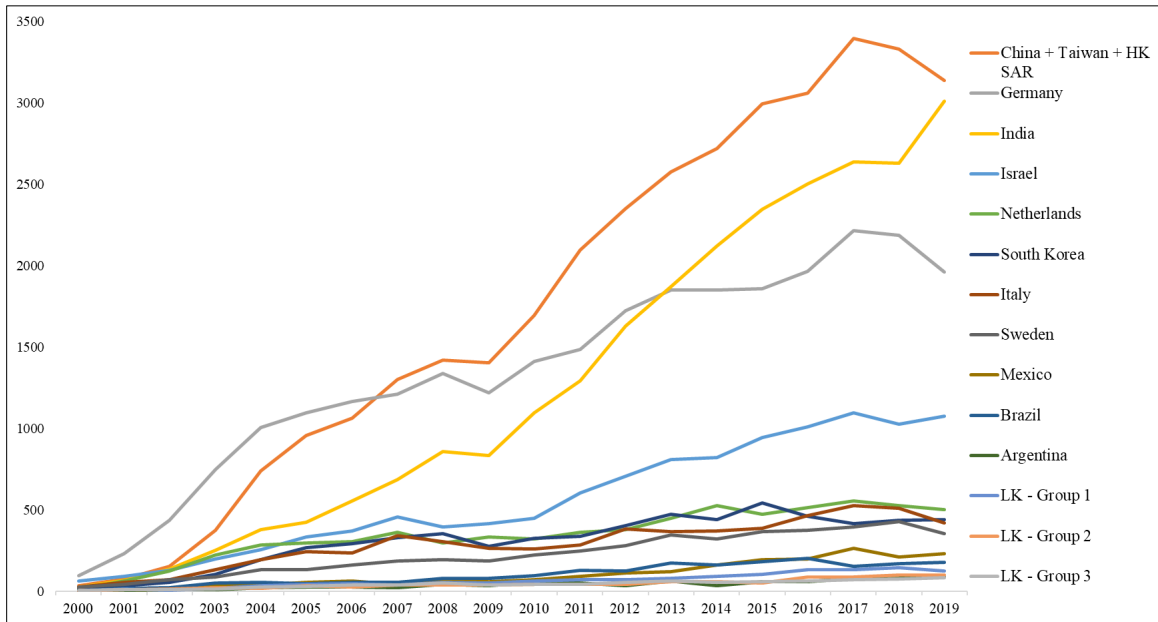
For example, bonding social capital strengthened between Indian migrant engineers and native German automotive designers has been credited for breakthroughs in frugal engineering at companies like Mercedes (Kumaraswamy et al., 2012). The cross-pollination of knowledge and complementary skillsets leads to novel innovations unachievable in siloed work. I argue that bonding social capital provides a hidden linkage turning human capital inputs into innovative outputs within globally dispersed multinational teams.

Likewise, high-skilled migrants' bridging social capital linking worldwide innovation hubs expands multinationals' capacities for technology absorption and knowledge transfer. Over 60% of Silicon Valley immigrants report actively maintained connections back to professional contacts in their countries of origin (Saxenian, 2002). Indian and Chinese migrants in particular leverage ethnic scientific networks to source promising research from leading universities and firms across Bangalore, Beijing, and Shanghai (Agrawal et al., 2011).

Bridging social capital thus does not flow evenly across all migrant groups. Software architects from Hyderabad integrating into Microsoft or Oracle can access India's globally competitive IT talent pools. In contrast, migrants from countries with limited technology ecosystems gain negligible benefits from attempted bridging. I argue that the differentiated focus on migrants' accessible knowledge networks better predicts innovation outputs than views ignoring this key aspect of their social capital.

Figure 9

Bridging Patents - U.S. and Foreign Inventors, 2000 - 2019.



Note: LK abbreviated for Low knowledge infrastructure country. Group 1 includes Philippines, Egypt, Viet Nam, Kenya, Iran, and Nigeria. Group 2 includes Costa Rica, Chile, Colombia, Venezuela, Ecuador, Guatemala, Honduras, Paraguay, El Salvador, and Nicaragua. Group 3 includes Greece and Portugal.

In sum, bonding social capital's facilitation of effective collaboration between disparate cultures and skillsets, combined with bridging social capital's tapping of global expertise, multiplies innovation capacity within leading multinationals above and beyond human capital alone. I contend that analysis of high-skilled migrants' contributions therefore necessitates accounting for these key amplification effects unique to their embedded social capital.

It is important to note that both bonding and bridging social capital can manifest in different forms: narrow, broad, or boundary-spanning. Narrow social capital refers to strong, cohesive ties within a specific group, facilitating the exchange of specialized knowledge (Hansen, 1999). Broad social capital involves weaker ties across different groups, providing access to diverse information and resources (Burt, 1992). Boundary-

spanning social capital connects individuals across organizational and institutional boundaries, enabling the integration of knowledge from disparate domains (Tushman & Scanlan, 1981; Tortoriello & Krackhardt, 2010). MNEs can strategically design their foreign high-skilled knowledge worker recruitment to harness these different types of social capital for specific innovation objectives. As Nahapiet and Ghoshal (1998) argue, the structural, relational, and cognitive dimensions of social capital influence the creation of intellectual capital by affecting the conditions for knowledge exchange and combination. MNEs can target migrants with narrow bonding social capital within specific technical communities to deepen specialized expertise, those with broad bridging social capital across multiple functional areas to enable architectural innovations (Henderson & Clark, 1990), or those with boundary-spanning ties to foreign innovation hubs to facilitate the absorption of distant knowledge (Cohen & Levinthal, 1990). By aligning the social capital profiles of their high-skilled migrants with their innovation strategies, MNEs can systematically enhance their ability to access, assimilate, and exploit relevant knowledge from diverse sources (Zahra & George, 2002).

Geopolitical Considerations

Incorporating human capital and social capital dimensions provides a more complete picture of the total value individual migrants may contribute economically and socially upon arriving in destination countries. From this perspective, policy evaluations of migration impact should encompass analysis beyond simply migrants' educational credentials and numeracy/literacy competencies. I contend that immigration policies should maximize potential benefits to the destination countries by considering migrants'

social capital, represented by the knowledge infrastructure of their countries of origin, besides their human capital.

However, realizing the productive potential of migrants' bonding and bridging social capital hinges on the geopolitical relationship between their origin and destination countries. As globalization faces rising headwinds from rising geopolitical tensions among major powers, resulting in deglobalization and decoupling pressures, immigration policy frameworks need to adapt. An era of weaponized interdependence means the degree of friendliness between origin and destination countries shapes whether migrants' bridging ties boost bilateral exchange or exacerbate security risks.

We suggest incorporating the degree of friendliness in geopolitical relations between an immigrant's origin country and the destination country as the third dimension in the proposed immigration policy framework. As noted by Farrell and Newman (2022), deglobalization forces including economic decoupling are gaining traction as conflictual interstate relationships engender protectionism and undermine cooperative ties. For instance, antagonism between the U.S. and China has fueled debates over reshoring manufacturing, securing supply chains against geopolitical threats, and restricting flows of talent and technologies with potential national security implications (Zhang, 2023). These decoupling dynamics further necessitate incorporating geopolitical considerations when evaluating immigration flows between specific origin-destination pairs. An immigrant's bridging social capital and capacity for bilateral knowledge exchange are shaped by the increasingly contentious geopolitical landscape between major powers. As such, variable and selective immigration policies informed by the shifting geopolitical climate become ever more crucial.

As argued by Moravcsik (1997), geopolitical interests shape states' policy preferences as much as economic factors. When a destination country has cooperative ties with another country, it incentivizes more welcoming immigration policies toward applicants from that country. As seen in Figure 3, with the U.S. as the destination country, Israel, Germany, and India emerge as promising origin countries with high levels of cooperative innovation outputs as well as relatively benign geopolitical profiles relative to American interests. Conversely, when relations are conflictual, security and espionage risks take center stage, necessitating more caution in crafting immigration regulations (Hafner-Burton et al., 2012).

Moreover, the proliferation of dual-use technologies intensifies these security considerations in immigration policymaking. Cutting-edge fields like artificial intelligence, semiconductors, quantum computing, and biotechnology have growing applications in both economic and defense realms. Innovations in these digitized, dematerialized, and demonetized sectors spread rapidly across borders. While bringing economic gains, the diffusion of sensitive techniques also poses risks of inadvertent or deliberate knowledge transfer strengthening adversarial military capabilities.

For example, breakthroughs in AI chip architecture or quantum algorithm design by immigrant scientists in destination country tech firms could potentially aid origin country defense complexes. This is particularly true for authoritarian states with civil-military fusion policies. As emerging technologies continue advancing alongside geopolitical tensions, immigration controls need to balance economic competitiveness interests against national security protections. Policies exonerating or targeting entire ethnic groups are untenable. Instead, granular screening of individuals' expertise areas

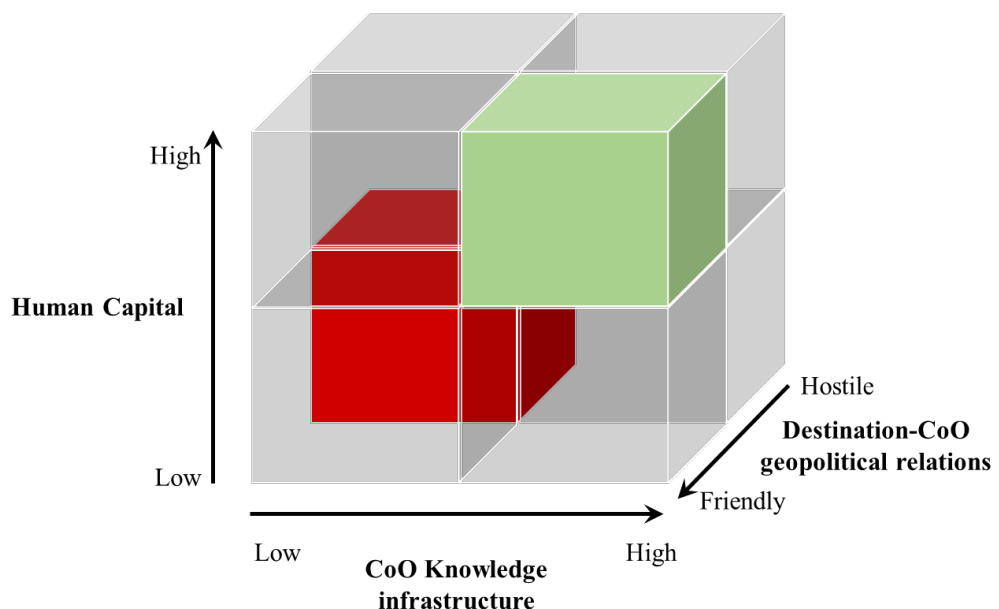
and risk profiles given origin countries' strategic relationships enables balanced policymaking. Beyond security risks, antagonistic interstate relationships also hamper immigrants' capacity to productively bridge the origin and destination countries. As Li and Vashchilko (2010) discuss, economic and knowledge exchange via immigrant networks is politically infeasible when tensions are high. This lowers immigrants' bridging social capital, further diminishing the incentive for destination countries to accept immigrants from hostile nations.

Towards a Three-Dimensional Model for Valuing High-Skill Migrants

I propose a three-dimensional framework conceptualizing high-skill migrants as possessing two key resources, namely, individual human capital and knowledge infrastructure in their country-of-origin for their social capital, and the bilateral geopolitical relations between the destination and country-of-origin as determinants of their potential knowledge contributions and economic impacts in destination countries.

Figure 10

A Three-Dimensional Immigration Policy Framework.



In my framework, human capital is measured conventionally at the individual level through migrants' educational credentials, technical skills, work experience, and language proficiency (Bahar & Rapoport, 2018). These attributes align with common focal points in current high-skill immigration policies implemented across most advanced economies. However, individual productivity enabled by human capital represents only one facet.

To augment individual productivity with bridging capabilities, social capital is measured at the country level, aiming to value the accumulated knowledge repository accessible in migrants' origin countries. The depth and accessibility of these overseas innovation ecosystems critically impact migrants' abilities to productively bridge across teams and geographies after relocating (Agrawal et al., 2011).

As proxy metrics, I propose examining both the quality and quantity of universities in migrants' origin countries. Top global university rankings indicate training quality in developing frontier knowledge and cultivating cutting-edge talent (Kerr, 2008). Meanwhile, the overall count of universities with advanced Science, Technology, Engineering, and Math (STEM) programs provides a measure of scale in generating high-skill talent pools available for bridging (Czaika & Parsons, 2017). For instance, in countries like India and China with expansive university systems including globally elite training institutions like IIT Bombay and Tsinghua, high rates of STEM graduates and academic research outputs become available for tapping through migrants' diaspora connections after relocating abroad. In contrast, migrants originating from countries with few high-quality universities by definition have access to far shallower talent pools for potential bridging. I argue that this second country-level social capital dimension, in

combination with standard individual-level human capital measures, provides immigration agencies a more complete two-dimensional perspective for evaluating high-skill migrants' prospective knowledge contributions and net economic impacts.

Notably, the complementarity between a multinational enterprise's home and foreign R&D capabilities is another key factor that the social capital dimension of this framework helps address. MNEs often strategically locate R&D subsidiaries in countries with knowledge infrastructures that complement their existing strengths (Cantwell & Mudambi, 2005). For example, an MNE with strong applied research capabilities in its home country may establish an R&D subsidiary in a country known for its universities' prowess in basic science research. High-skill immigrants from that country can then serve as invaluable conduits for accessing and integrating the latest scientific advances from their origin country's institutions into the MNE's global R&D efforts. Their deep familiarity with the research happening in their country of origin allows them to identify emerging developments that could synergize with the MNE's existing capabilities. Furthermore, their personal connections to the local scientific community facilitate the formation of collaborative university-industry partnerships that keep the MNE's foreign R&D subsidiary plugged into the origin country's evolving knowledge ecosystem over time (Schiller & Revilla Diez, 2010). In this way, high-skill immigrants with extensive social capital act as strategic linchpins, enabling MNEs to continually calibrate the complementarity between their geographically dispersed R&D units.

Finally, the third dimension of this immigration policy framework centers on the geopolitical relations between immigrants' origin countries and the destination country. Cooperative political and economic ties incentivize destination countries to readily

leverage immigration for bilateral innovation gains. When immigrants additionally have high human capital (advanced expertise) and high social capital (extensive networks), their capacity to bridge complementary knowledge systems is maximized. As Saxenian (2005) discusses, the free flow of ideas, technologies, and talent across borders catalyzed the rise of Silicon Valley as an innovation hub. The concentrated mix of specialized skills and open circulation of knowledge drove synergistic creativity. Therefore, friendly geopolitical environments enabling high-skill, well-networked immigrants to seamlessly maintain professional and cultural connections with origin countries cultivate the diverse, interactive ecosystems necessary for disruptive innovations to emerge rapidly. The unencumbered bidirectional diffusion of capabilities and ideas is key, which such immigrants can broker given receptive destination country policies and positive diplomatic relations.

While more research is certainly needed, preliminary evidence using U.S. patent data suggests a policy focus encompassing immigrants' human capital, social capital, and geopolitical relations between their country of origin and destination country can provide outsized economic benefits relative to narrowly skilled or educated migrants lacking in relational channels for value creation. I believe that further developing multi-dimensional frameworks for migration policy holds promise for research and implementation going forward.

A Descriptive Validation of the Three-Dimensional Framework

The three-dimensional framework for immigration policy making introduced in the previous section is predicated on economic growth of a nation through technological innovation. My core argument is that a nation should design high skilled immigration

policy such that it attracts and retains those knowledge workers who hold the highest promise for contribution to technological advancements (the green quadrant in Figure. 10). However, whether foreign high-skilled workers demonstrate heterogeneity in knowledge contributions needs to be ascertained if such a nuanced immigration policy is to be implemented. In this section, I present descriptive comparisons of knowledge creation patterns by high-skilled foreign workers varying along the three dimensions of the framework. Specifically, I compare the patenting patterns of Iranian, Thai, and Sri Lankan inventors using USPTO patent data from 2000 to 2020. These countries were chosen on the basis of differences between knowledge infrastructure and geopolitical friendliness with the U.S. – Thailand and Iran being countries with strong knowledge infrastructure whereas Sri Lanka has relatively poor knowledge infrastructure¹⁹. UN Trade data presented in Table 11 demonstrates differences in trade between US and the respective country as a proxy for trade relations between those nations. Despite being comparative in terms of land area and GDP, data reveals a much larger scale of trade between the U.S. and Thailand than with Iran, confirming the differences between these two countries’ geopolitical friendliness with the US. .

¹⁹ Sri Lanka, Thailand, and Iran have 2, 13, and 7 universities in the QS Top 1500 universities of the world in 2024. <https://www.topuniversities.com/world-university-rankings>

Table 11*U.S. Trade with Sri Lanka, Iran and Thailand.*

Year	US Bilateral Exports (US \$)		
	Sri Lanka	Iran	Thailand
2000	204,691,696	16,832,507	6,617,492,801
2001	183,014,484	8,084,009	5,989,356,133
2002	171,879,128	31,811,319	4,860,186,150
2003	154,655,509	98,922,677	5,835,277,739
2004	164,060,189	85,119,337	6,368,285,955
2005	197,631,294	95,773,068	7,256,616,259
2006	236,633,925	84,952,918	8,152,469,452
2007	227,159,226	145,609,612	8,444,875,614
2008	283,253,936	683,175,698	9,066,833,766
2009	229,524,541	281,814,642	6,920,200,246
2010	178,740,142	211,398,345	8,976,295,588
2011	303,375,816	233,183,160	10,929,766,591
2012	223,950,414	251,122,746	10,887,757,019
2013	311,911,749	308,142,294	11,797,149,535
2014	350,340,359	186,549,561	11,809,675,061
2015	361,920,786	281,512,074	11,230,091,511
2016	367,855,265	172,454,308	10,500,771,977
2017	336,249,489	136,000,618	11,022,601,042
2018	371,524,793	425,766,084	12,447,467,237
2019	390,338,080	73,141,766	13,307,832,305
2020	354,152,065	36,291,029	11,169,543,489

Moreover, patenting patterns by inventors located in Iran, Sri Lanka, and Thailand exhibit stark differences. While there are comparable number of ethnic inventors in Iran and Thailand, Thai inventors tend to generate more bridging patents. Table 12 shows that Sri Lankan and Thai inventors generate higher number of bridging patents in absolute as well as per capita values in comparison to Iranian inventors. This is despite the similar sized Iranian and Thai diaspora's in the US. These patterns suggest that Iranian inventors tend to co-patent with local inventors whereas Thai and Sri Lankan inventors. Alternatively, Iranian inventions may not be conducive to practical applications. In other words, these

inventions may be more basic in nature and therefore require close interactions between inventors. Table 13 and Figure 11 provide further evidence in this regard.

Table 12

Patenting Patterns of Iranian, Sri Lankan, and Thai Inventors.

Ethnicity	# of ethnic inventors	# of patents	# of bridging patents	Patents per ethnic inventor	Bridging patents per ethnic inventor	Proportion of bridging patents
Iranian	1,238	658.77	29.18	0.53	0.02	0.04
Sri Lankan	266	139.80	25.39	0.53	0.10	0.18
Thai	1,234	1,038.08	148.77	0.84	0.12	0.14

Note: Numbers of patents and bridging patents are not whole numbers due to equal attribution to co-patenting inventors to ensure patents are not doubly counted.

Table 13

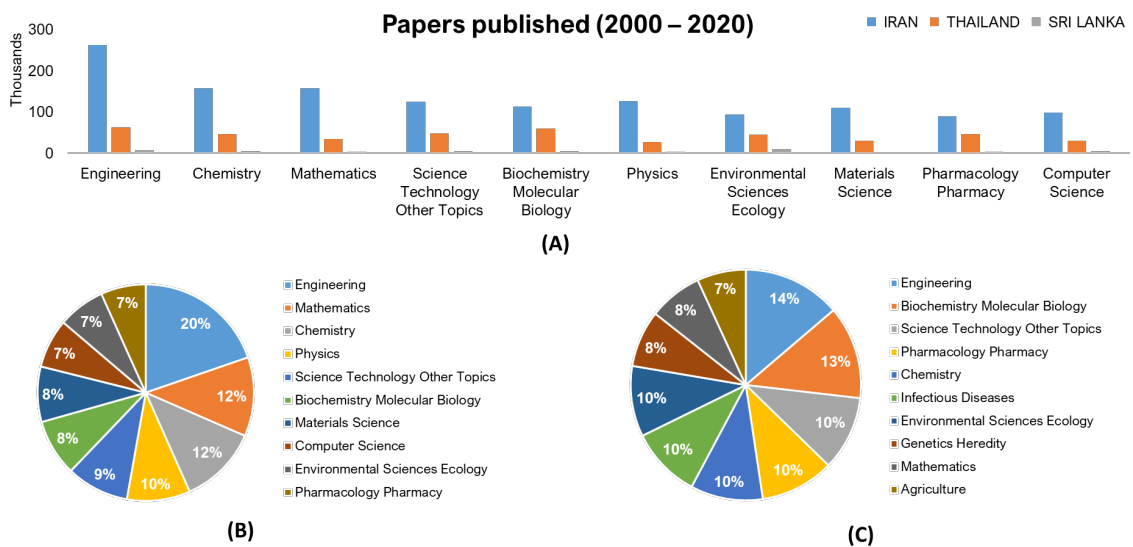
Assignee Types on Iranian, Sri Lankan, and Thai Patents.

	Assignee type				TOTAL
	U.S. assignee		Foreign assignee	Native assignee	
Ethnicity	Corp.	Uni.			
Iranian	13	19	52	59	143
Sri Lankan	29	12	43	15	99
Thai	124	53	148	130	455
TOTAL	166	84	243	204	697

Thai and Sri Lankan inventors patent predominantly for their U.S. employers whereas Iranian inventors patent mainly for their local and U.S-based universities in collaborative efforts. This pattern points to the more basic nature of Iranian inventions in comparison to Thai and Sri Lankan inventions.

Figure 11

Knowledge Domains in Iran and Thailand.



Panel A in Figure 11 presents a graphical representation of papers published by Iranian, Sri Lankan, and Thai knowledge workers in top 10 domains by cumulative counts across these countries. Iran produces a much higher number of papers in basic sciences in comparison to Sri Lanka and Thailand. Panels B and C further demonstrate the spread of papers across domains in Iran and Thailand respectively. These charts confirm my argument that Iran largely produces basic science knowledge whereas Thailand focuses mainly on biological and pharmaceutical domains. In essence, these patterns affirm the larger emphasis of corporate-driven research and development in Thailand and Sri Lanka and university-driven research in Iran. The lack of U.S. corporate patenting activity in Iran could also be attributed to the sanctions and tense geopolitical relations between the two countries.

A balanced approach to basic and applied sciences is essential for driving technological advancement and fostering a nation's growth. While basic science focuses

on fundamental understanding and theoretical knowledge, applied science translates this knowledge into practical applications. Corporates play a significant role in applied sciences, requiring a supply of high-skilled labor, often sourced from foreign nations. However, not all countries prioritize applied science equally, as evidenced by the contrast between Iran and Thailand. Iran appears to have a lower proportion of bridging patents and collaborative patterns with the United States compared to Thailand, suggesting differences in their focus on applied science and international collaboration. Furthermore, when inventors from foreign nations engage in collaborative research with U.S. corporates, there is a risk of knowledge spillovers back to their home countries. This highlights the need for careful management of intellectual property and the implementation of appropriate safeguards to protect cutting-edge knowledge from unintended dissemination.

Conclusion

This essay has argued for an expanded perspective encompassing a combination of individuals' human capital and social capital when evaluating the potential value migrants may contribute economically and socially to their destination countries. Current high-skilled immigration policies overly fixate on formal educational qualifications as the primary criterion for admission and quotas. However, as discussed, bonding social capital allows effective integration while bridging social capital enables global knowledge flows – both of which are critical to sustaining innovation in today's digitized, networked economy. I contend analyzing both formal skills and relational resources provides a more accurate basis for migration policy targeting high-value migrants relative to this conventional narrow focus only on degrees and test scores.

Furthermore, I introduced geopolitical contexts between origin and destination countries as a critical third policy dimension. Friendly relations incentivize leveraging migration for joint gains, while adversarial ones necessitate balanced security protections. This expanded framework better captures immigrants' capacity to participate in the circular creation and diffusion of ideas, capabilities, and technologies vital for advancing frontier innovations in industries like AI, quantum computing, and biotechnology. Incorporating social capital and geopolitical considerations thus opens possibilities for more strategic programs and initiatives to amplify innovation productivity. More research incorporating multi-dimensional perspectives spanning human capital, social capital, and diplomatic contexts can further inform optimal immigration policy design going forward.

Our proposed three-dimensional framework for high-skilled immigration policy, while emphasizing strategic focus on specific geographies, is not opposed to drawing talented individuals from under-represented countries. The framework recognizes that diverse knowledge and perspectives are indeed beneficial for innovation in destination countries. By considering migrants' individual human capital, origin country knowledge infrastructure, and geopolitical relations, policymakers can identify promising talent from a wide range of backgrounds, including those from nations with nascent innovation ecosystems.

However, the framework also highlights the importance of social capital in realizing the potential of diverse human capital. Migrants from countries with less-developed educational systems may face challenges in fully leveraging their skills and connecting destination country organizations to knowledge resources back home. This suggests that, in addition to immigration, providing financial aid and support programs to

strengthen educational infrastructure in underrepresented countries is a promising avenue for sustainably sourcing high-skilled talent in the long run.

By investing in the development of robust universities, research centers, and training programs in origin countries, destination countries can cultivate a diverse and reliable pipeline of skilled workers. This approach empowers potential migrants to build strong foundations of both human and social capital before arriving in destination countries, enhancing their capacity to drive innovation. Furthermore, it fosters a more equitable and mutually beneficial relationship between origin and destination countries.

In sum, while our three-dimensional framework supports selectively drawing talent from specific geographies, it also recognizes the value of diversity and the potential of migrants from underrepresented backgrounds. The framework therefore proposes a long-term, sustainable strategy of coupling strategic immigration policies with investment in origin country educational infrastructure. This balanced approach can enhance destination countries' access to a diverse pool of high-skilled talent while bolstering the global knowledge ecosystem.

CHAPTER 5

CONCLUSION

This dissertation makes several important contributions to our understanding of how firms manage their strategic human capital in response to exogenous regulatory shocks affecting their ability to organize and retain critical knowledge workers.

The first essay examined how immigration restrictions influence multinational enterprises' (MNEs) R&D organization and innovation performance. I found that restricting foreign talent inflows led MNEs to increase the geographic dispersion of their R&D activities rather than replacing foreign inventors with locals. However, the greater dispersion also increased coordination costs and reduced innovation output. These findings enhance our comprehension of the relationship between inventor concentration and communication needs, and they suggest boundaries on the efficacy of work-from-anywhere approaches.

The second essay studied how increased visa portability empowered immigrant inventors, prompting greater interfirm mobility and intrafirm bargaining power. Ethnic inventors occupied more central network positions and the nature of their inventions changed post-policy change. These results highlight how regulatory shifts can affect the relative negotiating leverage between firms and critical knowledge workers.

The third essay proposed a multidimensional perspective incorporating human capital, social capital, and geopolitical considerations to formulate immigration policies supportive of innovation and economic gains. This framework accounts for variations in security risks and bridging potential across origin countries. It allows policies to

differentiate immigrants from allied versus adversarial states. A nuanced approach is vital for immigration regulations to advance national interests.

Together, these three essays further our grasp of firms' strategic human capital management responses to external shocks affecting their innovation objectives. The studies combine insights from strategy, innovation, and international business research with quasi-experimental designs leveraging immigration policy changes.

There are several fruitful avenues for future research building on this dissertation. First, future research could explore other restrictions and provisions that influence high-skilled immigration policies across countries to generalize and validate the conclusions. Second, examining similar regulatory changes in different institutional contexts would shed light on the boundary conditions of my findings. Finally, surveying and interviewing managers and knowledge workers directly impacted by immigration policy shifts would provide invaluable qualitative evidence complementing the quantitative results.

In conclusion, this dissertation underscores how regulatory shocks disrupt the equilibrium between firms and employees in knowledge-based industries. The findings showcase firms' significant reliance on specialized human capital for competitive differentiation. While firms aim to organize and retain strategic workers, regulatory changes can empower employees and make human assets more mobile across employers. Understanding these dynamics is increasingly vital for strategy and policymaking in an era where value creation and capture derive primarily from human intellectual capital.

REFERENCES

- Aggarwal, V. A., Hsu, D. H., & Wu, A. (2020). Organizing knowledge production teams within firms for innovation. *Strategy Science*, 5(1), 1-16.
- Agrawal, A., Cockburn, I., & Rosell, C. (2010). Not invented here? Innovation in company towns. *Journal of Urban Economics*, 67(1), 78-89.
- Agrawal, A., Goldfarb, A., & Teodoridis, F. (2022). Artificial intelligence and geopolitics. In Agrawal A., Goldfarb A., Gans J.S. (Eds.) *The Economics of Artificial Intelligence: An Agenda*. University of Chicago Press.
- Agrawal, A., Kapur, D., McHale, J., & Oettl, A. (2011). Brain drain or brain bank? The impact of skilled emigration on poor-country innovation. *Journal of Urban Economics*, 69(1), 43-55.
- Agrawal, A., McHale, J., & Oettl, A. (2019). Does scientist immigration harm US science? An examination of the knowledge spillover channel. *Research Policy*, 48(5), 1248-1259.
- Ahuja, G., & Morris Lampert, C. (2001). Entrepreneurship in the large corporation: A longitudinal study of how established firms create breakthrough inventions. *Strategic Management Journal*, 22(6-7), 521-543.
- Akcigit, U., Grigsby, J., & Nicholas, T. (2017). Immigration and the rise of American ingenuity. *American Economic Review*, 107(5), 327-331.
- Aldrich, D. P., & Meyer, M. A. (2015). Social capital and community resilience. *American Behavioral Scientist*, 59(2), 254-269.
- Almeida, P., & Kogut, B. (1997). The exploration of technological diversity and geographic localization in innovation: Start-up firms in the semiconductor industry. *Small Business Economics*, 9, 21-31.
- Almeida, P., & Kogut, B. (1999). Localization of knowledge and the mobility of engineers in regional networks. *Management Science*, 45(7), 905-917.
- Almeida, P., Phene, A., & Li, S. (2015). The influence of ethnic community knowledge on Indian inventor innovativeness. *Organization Science*, 26(1), 198-217.
- Ambos, B., Brandl, K., Perri, A., Scalera, V. G., & Van Assche, A. (2021). The nature of innovation in global value chains. *Journal of World Business*, 56(4), 101221.
- Ambos, T. C., & Ambos, B. (2009). The impact of distance on knowledge transfer effectiveness in multinational corporations. *Journal of International Management*, 15(1), 1-14.

- Ambos, T. C., Ambos, B., & Schlegelmilch, B. B. (2006). Learning from foreign subsidiaries: An empirical investigation of headquarters' benefits from reverse knowledge transfers. *International Business Review*, 15(3), 294-312.
- Andersson, R., Quigley, J. M., & Wilhelmsson, M. (2005). Agglomeration and the spatial distribution of creativity. *Papers in Regional Science*, 84(3), 445-464.
- Argyres, N., Rios, L. A., & Silverman, B. S. (2020). Organizational change and the dynamics of innovation: Formal R&D structure and intrafirm inventor networks. *Strategic Management Journal*, 41(11), 2015-2049.
- Arora, A., Belenzon, S., & Sheer, L. (2021). Matching patents to Compustat firms, 1980–2015: Dynamic reassignment, name changes, and ownership structures. *Research Policy*, 50(5), 104217.
- Arora, A., Fosfuri, A., & Gambardella, A. (2001). Markets for technology and their implications for corporate strategy. *Industrial and Corporate Change*, 10(2), 419-451.
- Arrow, K. J. (1962). The economic implications of learning by doing. *The Review of Economic Studies*, 29(3), 155-173.
- Awate, S., Larsen, M. M., & Mudambi, R. (2015). Accessing vs sourcing knowledge: A comparative study of R&D internationalization between emerging and advanced economy firms. *Journal of International Business Studies*, 46, 63-86.
- Bahar, D., & Rapoport, H. (2018). Migration, knowledge diffusion and the comparative advantage of nations. *The Economic Journal*, 128(612), F273-F305.
- Balconi, M. (2002). Tacitness, codification of technological knowledge and the organisation of industry. *Research Policy*, 31(3), 357-379.
- Barnard, H., & Cantwell, J. (2006). Knowledge in the Theory of the Firm and MNC: Asset or Action? A Commentary on Foss N." Knowledge and Organisation in the Theory of the MNC". *Journal of Management & Governance*, 10(1), 21.
- Barnard, H., & Pendock, C. (2013). To share or not to share: The role of affect in knowledge sharing by individuals in a diaspora. *Journal of International Management*, 19(1), 47-65.
- Barnard, H., Deeds, D., Mudambi, R., & Vaaler, P. M. (2019). Migrants, migration policies, and international business research: Current trends and new directions. *Journal of International Business Policy*, 2, 275-288.
- Bartlett, C. A., & Ghoshal, S. (2002). *Managing Across Borders: The Transnational Solution*. Harvard Business Press.

- Bauer, T. K., Lofstrom, M., & Zimmermann, K. F. (2005). Immigration policy, assimilation of immigrants and natives' sentiments towards immigrants: evidence from 12 OECD-countries. *IZA Discussion Paper* No. 187.
- Becker, G. (1964). Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education. *National Bureau of Economic Research*.
- Becker, G. S. (1962). Investment in human capital: A theoretical analysis. *Journal of Political Economy*, 70(5, Part 2), 9-49.
- Belderbos, R., Leten, B., & Suzuki, S. (2013). How global is R&D? Firm-level determinants of home-country bias in R&D. *Journal of International Business Studies*, 44, 765-786.
- Belderbos, R., Leten, B., Nguyen, N. H., & Vancauteran, M. (2023). Multinational firms and the quest for global talent: Employing (skilled) foreign workers at home and abroad. *Journal of International Business Studies*, 1-23.
- Berry, H. (2017). Managing valuable knowledge in weak IP protection countries. *Journal of International Business Studies*, 48, 787-807.
- Bessen, J. (2014). Employers aren't just whining—the “skills gap” is real. *Harvard Business Review*, 25.
- Bidwell, M., & Briscoe, F. (2010). The dynamics of interorganizational careers. *Organization Science*, 21(5), 1034-1053.
- Bidwell, M., & Mollick, E. (2015). Shifts and ladders: Comparing the role of internal and external mobility in managerial careers. *Organization Science*, 26(6), 1629-1645.
- Birkinshaw, J., & Hood, N. (1998). Multinational subsidiary evolution: Capability and charter change in foreign-owned subsidiary companies. *Academy of Management Review*, 23(4), 773-795.
- Blundell, R., Griffith, R., & Van Reenen, J. (1999). Market share, market value and innovation in a panel of British manufacturing firms. *The Review of Economic Studies*, 66(3), 529-554.
- Boeri, T. (2002). Who's afraid of the big enlargement? Economic impacts and policy implications of the European Union's prospective eastern expansion. Center for Economic Policy Research.
- Borjas, G. J. (1987). Self-Selection and the Earnings of Immigrants. *American Economic Review*, 77(4), 531-553.
- Brancati, E., Brancati, R., Guarascio, D., & Zanfei, A. (2022). Innovation drivers of external competitiveness in the great recession. *Small Business Economics*, 58(3), 1497-1516.

- Brandl, K., Darendeli, I., & Mudambi, R. (2019). Foreign actors and intellectual property protection regulations in developing countries. *Journal of International Business Studies*, 50, 826-846.
- Breschi, S., Lissoni, F., & Miguelez, E. (2017). Foreign-origin inventors in the USA: testing for diaspora and brain gain effects. *Journal of Economic Geography*, 17(5), 1009-1038.
- Breschi, S., Lissoni, F., & Miguelez, E. (2018). Return migrants' self-selection: Evidence for Indian inventor (No. w24809). *National Bureau of Economic Research*.
- Bruno, R. L., Crescenzi, R., Estrin, S., & Petralia, S. (2021). Multinationals, innovation, and institutional context: IPR protection and distance effects. *Journal of International Business Studies*, 1-26.
- Buckley, P. (2011). Insights into the global factory. *AIB Insights*, 11(2), 8-12.
- Buckley, P. J., & Casson, M. C. (1998). Analyzing foreign market entry strategies: Extending the internalization approach. *Journal of International Business Studies*, 29, 539-561.
- Buckley, P. J., & Prashantham, S. (2016). Global interfirm networks: The division of entrepreneurial labor between MNEs and SMEs. *Academy of Management Perspectives*, 30(1), 40-58.
- Burt, R. S. (2000). The network structure of social capital. *Research in organizational behavior*, 22, 345-423.
- Burt, R. S. (1992). *Structural Holes: The Social Structure of Competition*. Harvard University Press.
- Campbell, B. A., Coff, R., & Kryscynski, D. (2012). Rethinking sustained competitive advantage from human capital. *Academy of Management Review*, 37(3), 376-395.
- Campbell, B. A., Ganco, M., Franco, A. M., & Agarwal, R. (2012). Who leaves, where to, and why worry? Employee mobility, entrepreneurship and effects on source firm performance. *Strategic Management Journal*, 33(1), 65-87.
- Cano-Kollmann, M., Cantwell, J., Hannigan, T. J., Mudambi, R., & Song, J. (2016). Knowledge connectivity: An agenda for innovation research in international business. *Journal of International Business Studies*, 47, 255-262.
- Cantwell, J. (1989). *Technological Innovation and Multinational Corporations*.
- Cantwell, J. (1995). The globalisation of technology: what remains of the product cycle model? *Cambridge Journal of Economics*, 19, 155-155.

- Cantwell, J. A., & Mudambi, R. (2011). Physical attraction and the geography of knowledge sourcing in multinational enterprises. *Global Strategy Journal*, 1(3-4), 206-232.
- Cantwell, J., & Mudambi, R. (2005). MNE competence-creating subsidiary mandates. *Strategic Management Journal*, 26(12), 1109-1128.
- Card, D., Dustmann, C., & Preston, I. (2012). Immigration, wages, and compositional amenities. *Journal of the European Economic Association*, 10(1), 78-119.
- Carnahan, S., Agarwal, R., & Campbell, B. A. (2012). Heterogeneity in turnover: The effect of relative compensation dispersion of firms on the mobility and entrepreneurship of extreme performers. *Strategic Management Journal*, 33(12), 1411-1430.
- Cassiman, B., Veugelers, R., & Zuniga, P. (2008). In search of performance effects of (in) direct industry science links. *Industrial and Corporate Change*, 17(4), 611-646.
- Castellani, D., Perri, A., & Scalera, V. G. (2022). Knowledge integration in multinational enterprises: The role of inventors crossing national and organizational boundaries. *Journal of World Business*, 57(3), 101290.
- Castellani, D., Perri, A., Scalera, V. G., & Zanfei, A. (Eds.). (2022). *Cross-border Innovation in a Changing World: Players, Places, and Policies*. Oxford University Press.
- Catalini, C. (2018). Microgeography and the direction of inventive activity. *Management Science*, 64(9), 4348-4364.
- Chacar, A. S., Newburry, W., & Vissa, B. (2010). Bringing institutions into performance persistence research: Exploring the impact of product, financial, and labor market institutions. *Journal of International Business Studies*, 41, 1119-1140.
- Chadwick, C. (2017). Toward a more comprehensive model of firms' human capital rents. *Academy of Management Review*, 42(3), 499-519.
- Chang, M. H. (2023). Cascading innovation: R&D team design and performance implications of mobility. *Strategic Management Journal*, 44(5), 1218-1253.
- Chen, J., Hsieh, S., & Zhang, F. (2021). The role of high-skilled foreign labor in startup performance: Evidence from two natural experiments. *Journal of Financial Economics*, 142(1), 430-452.
- Choudhury, P., & Kim, D. Y. (2019). The ethnic migrant inventor effect: Codification and recombination of knowledge across borders. *Strategic Management Journal*, 40(2), 203-229.

- Choudhury, P., Foroughi, C., & Larson, B. (2021). Work-from-anywhere: The productivity effects of geographic flexibility. *Strategic Management Journal*, 42(4), 655-683.
- Coff, R. W. (1997). Human assets and management dilemmas: Coping with hazards on the road to resource-based theory. *Academy of Management Review*, 22(2), 374-402.
- Coff, R., & Raffiee, J. (2015). Toward a theory of perceived firm-specific human capital. *Academy of Management Perspectives*, 29(3), 326-341.
- Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35(1), 128-152.
- Cohendet, P., & Meyer-Krahmer, F. (2001). The theoretical and policy implications of knowledge codification. *Research Policy*, 30(9), 1563-1591.
- Contigiani, A., Hsu, D. H., & Barankay, I. (2018). Trade secrets and innovation: Evidence from the “inevitable disclosure” doctrine. *Strategic Management Journal*, 39(11), 2921-2942.
- Cowan, R., David, P. A., & Foray, D. (2000). The explicit economics of knowledge codification and tacitness. *Industrial and Corporate Change*, 9(2), 211-253.
- Cuervo-Cazurra, A., Gaur, A., & Singh, D. (2019). Pro-market institutions and global strategy: The pendulum of pro-market reforms and reversals. *Journal of International Business Studies*, 50, 598-632.
- Cui, V., Vertinsky, I., Wang, Y., & Zhou, D. (2023). Decoupling in international business: The ‘new’ vulnerability of globalization and MNEs’ response strategies. *Journal of International Business Studies*, 1-15.
- Cumming, D. J., Wood, G., & Zahra, S. A. (2020). Human resource management practices in the context of rising right-wing populism. *Human Resource Management Journal*, 30(4), 525-536.
- Cyert, R. M., & March, J. G. (1963). *A Behavioral Theory of the Firm*. 2(4), 169-187.
- Czaika, M., & Parsons, C. R. (2017). The gravity of high-skilled migration policies. *Demography*, 54(2), 603-630.
- Czaika, M., & Reinprecht, C. (2022). Migration drivers: why do people migrate. *Introduction to Migration Studies: An Interactive Guide to the Literatures on Migration and Diversity*, 49-82.
- Davis, J. G., Subrahmanian, E., & Westerberg, A. W. (2005). The “global” and the “local” in knowledge management. *Journal of Knowledge Management*, 9(1), 101-112.

- Devinney, T. M., & Hartwell, C. A. (2020). Varieties of populism. *Global Strategy Journal*, 10(1), 32-66.
- Doran, K., Gelber, A., & Isen, A. (2022). The effects of high-skilled immigration policy on firms: Evidence from visa lotteries. *Journal of Political Economy*, 130(10), 2501-2533.
- Dunning, J. H., & Lundan, S. M. (2010). The institutional origins of dynamic capabilities in multinational enterprises. *Industrial and Corporate Change*, 19(4), 1225-1246.
- Dunning, J., & Lundan, S. (1993). *Multinational Enterprise and the Global Economy*.
- Facchini, G., Mayda, A. M., & Mishra, P. (2011). Do interest groups affect US immigration policy? *Journal of International Economics*, 85(1), 114-128.
- Fallick, B., Fleischman, C. A., & Rebitzer, J. B. (2006). Job-hopping in Silicon Valley: some evidence concerning the microfoundations of a high-technology cluster. *The Review of Economics and Statistics*, 88(3), 472-481.
- Farndale, E., Thite, M., Budhwar, P., & Kwon, B. (2021). Deglobalization and talent sourcing: Cross-national evidence from high-tech firms. *Human Resource Management*, 60(2), 259-272.
- Farrell, H., & Newman, A. L. (2019). Weaponized interdependence: How global economic networks shape state coercion. *International Security*, 44(1), 42-79.
- Feldman, D. C., & Ng, T. W. (2007). Careers: Mobility, embeddedness, and success. *Journal of Management*, 33(3), 350-377.
- Ferrucci, E., & Lissoni, F. (2019). Foreign inventors in Europe and the United States: Diversity and patent quality. *Research Policy*, 48(9), 103774.
- Filippetti, A., & Archibugi, D. (2011). Innovation in times of crisis: National Systems of Innovation, structure, and demand. *Research Policy*, 40(2), 179-192.
- Fleming, L. (2001). Recombinant uncertainty in technological search. *Management Science*, 47(1), 117-132.
- Fleming, L., & Sorenson, O. (2001). Technology as a complex adaptive system: evidence from patent data. *Research Policy*, 30(7), 1019-1039.
- Florida, R. (2005). *Cities and the Creative Class*. Routledge.
- Freeman, L. C. (1978). Centrality in social networks conceptual clarification. *Social Networks*, 1(3), 215-239.
- Frey, C. B., Berger, T., & Chen, C. (2018). Political machinery: did robots swing the 2016 US presidential election? *Oxford Review of Economic Policy*, 34(3), 418-442.

- Funk, R. J. (2014). Making the most of where you are: Geography, networks, and innovation in organizations. *Academy of Management Journal*, 57(1), 193-222.
- Ge, C., Huang, K. W., & Png, I. P. (2016). Engineer/scientist careers: Patents, online profiles, and misclassification bias. *Strategic Management Journal*, 37(1), 232-253.
- Ghatak, S., Levine, P., & Price, S. W. (1996). Migration theories and evidence: an assessment. *Journal of Economic Surveys*, 10(2), 159-198.
- Ghemawat, P. (2003). Semiglobalization and international business strategy. *Journal of International Business Studies*, 34, 138-152.
- Ghosh, A., Mayda, A. M., & Ortega, F. (2014). *The impact of skilled foreign workers on firms: an investigation of publicly traded US firms*.
- Glennon, B. (2023). How do restrictions on high-skilled immigration affect offshoring? Evidence from the H-1B program. *Management Science*.
- Granovetter, M. (1985). The Problem of Embeddedness. *American Journal of Sociology*, 91(3), 481-510.
- Grant, R. M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal*, 17(S2), 109-122.
- Greening, D. W., & Gray, B. (1994). Testing a model of organizational response to social and political issues. *Academy of Management Journal*, 37(3), 467-498.
- Gupta, A. K., & Govindarajan, V. (1994). Organizing for knowledge flows within MNCs. *International Business Review*, 3(4), 443-457.
- Gupta, A. K., & Govindarajan, V. (2000). Knowledge flows within multinational corporations. *Strategic Management Journal*, 21(4), 473-496.
- Gupta, A., Mattarelli, E., Seshasai, S., & Broschak, J. (2009). Use of collaborative technologies and knowledge sharing in co-located and distributed teams: Towards the 24-h knowledge factory. *The Journal of Strategic Information Systems*, 18(3), 147-161.
- Ha, Y. J., & Giroud, A. (2015). Competence-creating subsidiaries and FDI technology spillovers. *International Business Review*, 24(4), 605-614.
- Hafner-Burton, E. M., Kahler, M., & Montgomery, A. H. (2009). Network analysis for international relations. *International organization*, 63(3), 559-592.
- Hair, J., Anderson, R., Tatham, R. and Black, W. (1998) *Multivariate Data Analysis*. 5th Edition, Prentice Hall.

- Håkanson, L. (2007). Creating knowledge: the power and logic of articulation. *Industrial and Corporate Change*, 16(1), 51-88.
- Hall, B. H., Jaffe, A. B., & Trajtenberg, M. (2001). *The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools*.
- Halla, M., Wagner, A. F., & Zweimüller, J. (2012). Immigration and voting for the extreme right (No. 83 [rev.]). Working paper.
- Hannigan, T. J., Cano-Kollmann, M., & Mudambi, R. (2015). Thriving innovation amidst manufacturing decline: The Detroit auto cluster and the resilience of local knowledge production. *Industrial and Corporate Change*, 24(3), 613-634.
- Hansen, M. T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly*, 44(1), 82-111.
- Hargadon, A., & Sutton, R. I. (1997). Technology brokering and innovation in a product development firm. *Administrative Science Quarterly*, 716-749.
- Hatch, N. W., & Dyer, J. H. (2004). Human capital and learning as a source of sustainable competitive advantage. *Strategic Management Journal*, 25(12), 1155-1178.
- Henderson, R. M., & Clark, K. B. (1990). Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms. *Administrative Science Quarterly*, 35(1), 9-30.
- Hill, C. W. (2022). *Global Business Today*. McGraw Hill.
- Hoisl, K. (2007). Tracing mobile inventors—the causality between inventor mobility and inventor productivity. *Research Policy*, 36(5), 619-636.
- Hud, M., & Hussinger, K. (2015). The impact of R&D subsidies during the crisis. *Research Policy*, 44(10), 1844-1855.
- Hunt, J., & Gauthier-Loiselle, M. (2010). How much does immigration boost innovation? *American Economic Journal: Macroeconomics*, 2(2), 31-56.
- Hurtado-Torres, N. E., Aragón-Correa, J. A., & Ortiz-de-Mandojana, N. (2018). How does R&D internationalization in multinational firms affect their innovative performance? The moderating role of international collaboration in the energy industry. *International Business Review*, 27(3), 514-527.
- Hymer, S. H. (1960). *The International Operations of National Firms, A Study of Direct Foreign Investment* (Doctoral dissertation, Massachusetts Institute of Technology).

- Inkpen, A. C., & Tsang, E. W. (2005). Social capital, networks, and knowledge transfer. *Academy of Management Review*, 30(1), 146-165.
- IOM (Geneva). (2000). *IOM Migration Research Series*. IOM.
- Jaffe, A. B., & Trajtenberg, M. (2002). *Patents, Citations, and Innovations: A Window on the Knowledge Economy*. MIT press.
- Jovanovic, B. (1979). Job matching and the theory of turnover. *Journal of political economy*, 87(5, Part 1), 972-990.
- Kanas, A., Chiswick, B. R., Van Der Lippe, T., & Van Tubergen, F. (2012). Social Contacts and the Economic Performance of Immigrants: A Panel Study of Immigrants in Germany. *International Migration Review*, 46(3), 680-709.
- Kazemipur, A. (2006). The market value of friendship: Social networks of immigrants. *Canadian Ethnic Studies*, 38(2), 47.
- Kerr, S. P., & Kerr, W. R. (2016). Immigrants play a disproportionate role in American entrepreneurship. *Harvard Business Review*.
- Kerr, S. P., Kerr, W. R., & Lincoln, W. F. (2015). Skilled immigration and the employment structures of US firms. *Journal of Labor Economics*, 33(S1), S147-S186.
- Kerr, W. R. (2008). Ethnic scientific communities and international technology diffusion. *The Review of Economics and Statistics*, 90(3), 518-537.
- Kerr, W. R., & Lincoln, W. F. (2010). The supply side of innovation: H-1B visa reforms and US ethnic invention. *Journal of Labor Economics*, 28(3), 473-508.
- Kerr, W. R., Kerr, S. P., Özden, Ç., & Parsons, C. (2016). Global talent flows. *Journal of Economic Perspectives*, 30(4), 83-106.
- Khanna, R. (2023). Passing the torch of knowledge: Star death, collaborative ties, and knowledge creation. *Research Policy*, 52(1), 104649.
- Kloosterman, R., & Rath, J. (2018). Mixed embeddedness revisited: A conclusion to the special issue. *Sociologica*, 12(2), 103-114.
- Kogut, B., & Zander, U. (1993). Knowledge of the firm and the evolutionary theory of the multinational corporation. *Journal of International Business Studies*, 24, 625-645.
- Koning, R., Samila, S., & Ferguson, J. P. (2020, May). Inventor gender and the direction of invention. In *AEA Papers and Proceedings* (Vol. 110, pp. 250-254).

- Kontopantelis, E., Doran, T., Springate, D. A., Buchan, I., & Reeves, D. (2015). Regression based quasi-experimental approach when randomisation is not an option: interrupted time series analysis. *BMJ*, 350.
- Kor, Y. Y., & Leblebici, H. (2005). How do interdependencies among human-capital deployment, development, and diversification strategies affect firms' financial performance? *Strategic Management Journal*, 26(10), 967-985.
- Kotabe, M. (1990). The relationship between offshore sourcing and innovativeness of US multinational firms: An empirical investigation. *Journal of International Business Studies*, 21, 623-638.
- Kumaraswamy, A., Mudambi, R., Saranga, H., & Tripathy, A. (2012). Catch-up strategies in the Indian auto components industry: Domestic firms' responses to market liberalization. *Journal of International Business Studies*, 43(4), 368-395.
- Lahiri, N. (2010). Geographic distribution of R&D activity: how does it affect innovation quality? *Academy of Management Journal*, 53(5), 1194-1209.
- Lane, P. J., & Lubatkin, M. (1998). Relative absorptive capacity and interorganizational learning. *Strategic Management Journal*, 19(5), 461-477.
- Laursen, K., Leten, B., Nguyen, N. H., & Vancauteran, M. (2020). Mounting corporate innovation performance: The effects of high-skilled migrant hires and integration capacity. *Research Policy*, 49(9), 104034.
- Lawson, C., Salter, A., Hughes, A., & Kitson, M. (2019). Citizens of somewhere: Examining the geography of foreign and native-born academics' engagement with external actors. *Research Policy*, 48(3), 759-774.
- Le Grand, C., & Tåhlin, M. (2002). Job mobility and earnings growth. *European Sociological Review*, 18(4), 381-400.
- Leiblein, M. J., & Miller, D. J. (2003). An empirical examination of transaction-and firm-level influences on the vertical boundaries of the firm. *Strategic Management Journal*, 24(9), 839-859.
- Lepak, D. P., & Snell, S. A. (1999). The human resource architecture: Toward a theory of human capital allocation and development. *Academy of Management Review*, 24(1), 31-48.
- Levin, D. Z., & Barnard, H. (2013). Connections to distant knowledge: Interpersonal ties between more-and less-developed countries. *Journal of International Business Studies*, 44, 676-698.
- Li, Q., & Vashchilko, T. (2010). Dyadic military conflict, security alliances, and bilateral FDI flows. *Journal of International Business Studies*, 41, 765-782.

- Lippman, S. A., & Rumelt, R. P. (1982). Uncertain imitability: An analysis of interfirm differences in efficiency under competition. *The Bell Journal of Economics*, 418-438.
- Lorenzen, M., & Mudambi, R. (2013). Clusters, connectivity and catch-up: Bollywood and Bangalore in the global economy. *Journal of Economic Geography*, 13(3), 501-534.
- Lovullo, D., Brown, A. L., Teece, D. J., & Bardolet, D. (2020). Resource re-allocation capabilities in internal capital markets: The value of overcoming inertia. *Strategic Management Journal*, 41(8), 1365-1380.
- Mäkelä, K., Andersson, U., & Seppälä, T. (2012). Interpersonal similarity and knowledge sharing within multinational organizations. *International Business Review*, 21(3), 439-451.
- Malen, J., & Vaaler, P. M. (2017). Organizational slack, national institutions and innovation effort around the world. *Journal of World Business*, 52(6), 782-797.
- March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, 2(1), 71-87.
- Marino, A., Mudambi, R., Perri, A., & Scalera, V. G. (2020). Ties that bind: Ethnic inventors in multinational enterprises' knowledge integration and exploitation. *Research Policy*, 49(9), 103956.
- Marx, M. (2011). The firm strikes back: Non-compete agreements and the mobility of technical professionals. *American Sociological Review*, 76(5), 695-712.
- Marx, M., Strumsky, D., & Fleming, L. (2009). Mobility, skills, and the Michigan non-compete experiment. *Management Science*, 55(6), 875-889.
- Mawdsley, J. K., & Somaya, D. (2016). Employee mobility and organizational outcomes: An integrative conceptual framework and research agenda. *Journal of Management*, 42(1), 85-113.
- Mayda, A. M., Ortega, F., Peri, G., Shih, K., & Sparber, C. (2018). The effect of the H-1B quota on the employment and selection of foreign-born labor. *European Economic Review*, 108, 105-128.
- Minbaeva, D., Pedersen, T., Björkman, I., Fey, C. F., & Park, H. J. (2003). MNC knowledge transfer, subsidiary absorptive capacity, and HRM. *Journal of International Business Studies*, 34, 586-599.
- Moravcsik, A. (1997). Taking preferences seriously: A liberal theory of international politics. *International Organization*, 51(4), 513-553.

- Mudambi, R. (2018). Knowledge-intensive intangibles, spatial transaction costs, and the rise of populism. *Journal of International Business Policy*, 1, 44-52.
- Mudambi, R., Mudambi, S. M., & Navarra, P. (2007). Global innovation in MNCs: The effects of subsidiary self-determination and teamwork. *Journal of Product Innovation Management*, 24(5), 442-455.
- Mudambi, R., Narula, R., & Santangelo, G. D. (2018). Location, collocation and innovation by multinational enterprises: A research agenda. *Industry and Innovation*, 25(3), 229-241.
- Mukherjee, K. (2022). Emerging Technology, Data Flows, and National Security: The India–China Case. *India Review*, 21(3), 324-344.
- Munjal, S., & Kundu, S. (2017). Exploring the connection between human capital and innovation in the globalising world. *Human capital and innovation: Examining the role of globalization*, 1-11.
- Murtha, T. P., & Lenway, S. A. (1994). Country capabilities and the strategic state: How national political institutions affect multinational corporations' strategies. *Strategic Management Journal*, 15(S2), 113-129.
- Nadkarni, S., & Narayanan, V. K. (2007). Strategic schemas, strategic flexibility, and firm performance: The moderating role of industry clockspeed. *Strategic Management Journal*, 28(3), 243-270.
- Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review*, 23(2), 242-266.
- Nathan, M. (2014). The wider economic impacts of high-skilled migrants: a survey of the literature for receiving countries. *IZA Journal of Migration*, 3(1), 1-20.
- Nathan, M., & Lee, N. (2013). Cultural diversity, innovation, and entrepreneurship: Firm-level evidence from London. *Economic Geography*, 89(4), 367-394.
- Nerkar, A., & Paruchuri, S. (2005). Evolution of R&D capabilities: The role of knowledge networks within a firm. *Management Science*, 51(5), 771-785.
- Nieto, M. J., & Rodríguez, A. (2011). Offshoring of R&D: Looking abroad to improve innovation performance. *Journal of International Business Studies*, 42, 345-361.
- Nohria, N., & Gulati, R. (1996). Is slack good or bad for innovation? *Academy of Management Journal*, 39(5), 1245-1264.
- Oettl, A., & Agrawal, A. (2008). International labor mobility and knowledge flow externalities. *Journal of International Business Studies*, 39, 1242-1260.

- Oldroyd, J. B., & Morris, S. S. (2012). Catching falling stars: A human resource response to social capital's detrimental effect of information overload on star employees. *Academy of Management Review*, 37(3), 396-418.
- Ozgen, C., Nijkamp, P., & Poot, J. (2013). The impact of cultural diversity on firm innovation: evidence from Dutch micro-data. *IZA Journal of Migration*, 2, 1-24.
- Papageorgiadis, N., & Sofka, W. (2020). Patent enforcement across 51 countries—Patent enforcement index 1998–2017. *Journal of World Business*, 55(4), 101092.
- Papanastassiou, M., Pearce, R., & Zanfei, A. (2020). Changing perspectives on the internationalization of R&D and innovation by multinational enterprises: A review of the literature. *Journal of International Business Studies*, 51, 623-664.
- Park, W. G. (2008). International patent protection: 1960–2005. *Research Policy*, 37(4), 761-766.
- Patel, P., & Pavitt, K. (1991). Large firms in the production of the world's technology: an important case of “non-globalisation.” *Journal of International Business Studies*, 22, 1-21.
- Patel, P., & Vega, M. (1999). Patterns of internationalisation of corporate technology: location vs. home country advantages. *Research Policy*, 28(2-3), 145-155.
- Pearce, R. D. (1999). Decentralised R&D and strategic competitiveness: globalised approaches to generation and use of technology in multinational enterprises (MNEs). *Research Policy*, 28(2-3), 157-178.
- Penrose, E. T. (1959). *The Theory of the Growth of the Firm*. John Wiley
- Perri, A., Scalera, V. G., & Mudambi, R. (2017). What are the most promising conduits for foreign knowledge inflows? Innovation networks in the Chinese pharmaceutical industry. *Industrial and Corporate Change*, 26(2), 333-355.
- Peteraf, M. A., & Barney, J. B. (2003). Unraveling the resource-based tangle. *Managerial and Decision Economics*, 24(4), 309-323.
- Petralia, S. (2020). Mapping general purpose technologies with patent data. *Research Policy*, 49(7), 104013.
- Phene, A., & Almeida, P. (2008). Innovation in multinational subsidiaries: The role of knowledge assimilation and subsidiary capabilities. *Journal of International Business Studies*, 39, 901-919.
- Porter, M. E. (1980). Industry structure and competitive strategy: Keys to profitability. *Financial Analysts Journal*, 36(4), 30-41.

- Porter, M. E. *The Competitive Advantage: Creating and Sustaining Superior Performance*. NY: Free Press, 1985. (Republished with a new introduction, 1998.)
- Portes, A., & Sensenbrenner, J. (1993). Embeddedness and immigration: Notes on the social determinants of economic action. *American Journal of Sociology*, 98(6), 1320-1350.
- Powell, W. W., & Sandholtz, K. W. (2012). Amphibious entrepreneurs and the emergence of organizational forms. *Strategic Entrepreneurship Journal*, 6(2), 94-115.
- Putnam, Robert D. *Bowling Alone: The Collapse and Revival of American Community*. Simon and Schuster, 2000.
- Rabbiosi, L., & Santangelo, G. D. (2013). Parent company benefits from reverse knowledge transfer: The role of the liability of newness in MNEs. *Journal of World Business*, 48(1), 160-170.
- Reitz, J. G. (2001). Immigrant skill utilization in the Canadian labour market: Implications of human capital research. *Journal of International Migration and Integration*, 2(3), 347-378.
- Richard, O. C. (2000). Racial diversity, business strategy, and firm performance: A resource-based view. *Academy of Management Journal*, 43(2), 164-177.
- Rosenbusch, N., Gusenbauer, M., Hatak, I., Fink, M., & Meyer, K. E. (2019). Innovation offshoring, institutional context and innovation performance: A meta-analysis. *Journal of Management Studies*, 56(1), 203-233.
- Rosenkopf, L., & Almeida, P. (2003). Overcoming local search through alliances and mobility. *Management Science*, 49(6), 751-766.
- Rosenthal, S. S., & Strange, W. C. (2004). Evidence on the nature and sources of agglomeration economies. In *Handbook of Regional and Urban Economics* (Vol. 4, pp. 2119-2171). Elsevier.
- Ross, M. B., Glennon, B. M., Murciano-Goroff, R., Berkes, E. G., Weinberg, B. A., & Lane, J. I. (2022). Women are credited less in science than men. *Nature*, 608(7921), 135-145.
- Rugman A. M. 1981, *Inside the Multinationals: The Economics of Internal Markets*. Columbia University Press.
- Rugman, A. M., & Verbeke, A. (2003). Extending the theory of the multinational enterprise: Internalization and strategic management perspectives. *Journal of International Business Studies*, 34, 125-137.
- Sassen, S. (2004). *The Global City: Introducing a Concept*. *Brown J. World Aff.*, 11, 27.

- Saxenian, A. (1996). Beyond boundaries: Open labor markets and learning in Silicon Valley. *The Boundaryless Career: A New Employment Principle for a New Organizational Era*, 23, 39.
- Saxenian, A. (2002). Silicon Valley's new immigrant high-growth entrepreneurs. *Economic Development Quarterly*, 16(1), 20-31.
- Saxenian, A. (2005). From brain drain to brain circulation: Transnational communities and regional upgrading in India and China. *Studies in Comparative International Development*, 40, 35-61.
- Scalera, V. G., Perri, A., & Hannigan, T. J. (2018). Knowledge connectedness within and across home country borders: Spatial heterogeneity and the technological scope of firm innovations. *Journal of International Business Studies*, 49, 990-1009.
- Scheve, K. F., & Slaughter, M. J. (2001). Labor market competition and individual preferences over immigration policy. *Review of Economics and Statistics*, 83(1), 133-145.
- Schiller, D., & Diez, J. R. (2010). Local embeddedness of knowledge spillover agents: Empirical evidence from German star scientists. *Papers in Regional Science*, 89(2), 275-295.
- Shaffer, A50B. (1995). Firm-level responses to government regulation: Theoretical and research approaches. *Journal of Management*, 21(3), 495-514.
- Singh, J., & Agrawal, A. (2011). Recruiting for ideas: How firms exploit the prior inventions of new hires. *Management Science*, 57(1), 129-150.
- Smith, A. (1937). *The Wealth of Nations* [1776] (Vol. 11937).
- Sofka, W., Shehu, E., & de Faria, P. (2014). Multinational subsidiary knowledge protection—Do mandates and clusters matter? *Research Policy*, 43(8), 1320-1333.
- Song, J., Almeida, P., & Wu, G. (2003). Learning—by—hiring: When is mobility more likely to facilitate interfirm knowledge transfer? *Management Science*, 49(4), 351-365.
- Sosa, M. E., Eppinger, S. D., Pich, M., McKendrick, D. G., & Stout, S. K. (2002). Factors that influence technical communication in distributed product development: an empirical study in the telecommunications industry. *IEEE Transactions on Engineering Management*, 49(1), 45-58.
- Starr, E., Prescott, J. J., & Bishara, N. (2021). Noncompetes in the US labor force. *Journal of Law and Economics*.

- Storper, M., & Venables, A. J. (2004). Buzz: face-to-face contact and the urban economy. *Journal of Economic Geography*, 4(4), 351-370.
- Sumption, M. (2019). Is employer sponsorship a good way to manage labour migration? Implications for post-Brexit migration policies. *National Institute Economic Review*, 248, R28-R39.
- Szulanski, G. (1996). Exploring internal stickiness: Impediments to the transfer of best practice within the firm. *Strategic Management Journal*, 17(S2), 27-43.
- Tandon, V., & Toh, P. K. (2022). Who deviates? Technological opportunities, career concern, and inventor's distant search. *Strategic Management Journal*, 43(4), 724-757.
- Taussig, M. (2017). Foreignness as both a global asset and a local liability: How host country idiosyncrasies and business activities matter. *Journal of International Business Studies*, 48, 498-522.
- Teece, D. J. (1977). Technology transfer by multinational firms: The resource cost of transferring technological know-how. *The Economic Journal*, 87(346), 242-261.
- Teece, D. J. (1986). Transactions cost economics and the multinational enterprise An Assessment. *Journal of Economic Behavior & Organization*, 7(1), 21-45.
- Teece, D. J. (2020). Hand in glove: Open innovation and the dynamic capabilities framework. *Strategic Management Review*, 1(2), 233-253.
- Tijssen, R. J. (2001). Global and domestic utilization of industrial relevant science: patent citation analysis of science–technology interactions and knowledge flows. *Research Policy*, 30(1), 35-54.
- Tortoriello, M., & Krackhardt, D. (2010). Activating cross-boundary knowledge: The role of Simmelian ties in the generation of innovations. *Academy of Management Journal*, 53(1), 167-181.
- Tortoriello, M., Reagans, R., & McEvily, B. (2012). Bridging the knowledge gap: The influence of strong ties, network cohesion, and network range on the transfer of knowledge between organizational units. *Organization Science*, 23(4), 1024-1039.
- Torvik, V. I., & Agarwal, S. (2016, March). Ethnea--an instance-based ethnicity classifier based on geo-coded author names in a large-scale bibliographic database. In *International Symposium on Science of Science*.
- Tsoukas, H. (2005). Afterword: why language matters in the analysis of organizational change. *Journal of Organizational Change Management*, 18(1), 96-104.
- Tung, R. L. (1984). Strategic management of human resources in the multinational enterprise. *Human Resource Management*, 23(2), 129-143.

- Tushman, M. L., & Scanlan, T. J. (1981). Boundary spanning individuals: Their role in information transfer and their antecedents. *Academy of Management Journal*, 24(2), 289-305
- Tzabbar, D. (2009). When does scientist recruitment affect technological repositioning? *Academy of Management Journal*, 52(5), 873-896.
- Tzabbar, D., & Kehoe, R. R. (2014). Can opportunity emerge from disarray? An examination of exploration and exploitation following star scientist turnover. *Journal of Management*, 40(2), 449-482.
- Verbeke, A., & Asmussen, C. G. (2016). Global, local, or regional? The locus of MNE strategies. *Journal of Management Studies*, 53(6), 1051-1075.
- Wadhwa, V., Saxenian, A., Rissing, B. A., & Gereffi, G. (2007). America's new immigrant entrepreneurs: Part I. *Duke Science, Technology & Innovation Paper*, (23)
- Wagner, S., & Goossen, M. C. (2018). Knowing me, knowing you: Inventor mobility and the formation of technology-oriented alliances. *Academy of Management Journal*, 61(6), 2026-2052.
- Walker, G., Madsen, T. L., & Carini, G. (2002). How does institutional change affect heterogeneity among firms? *Strategic Management Journal*, 23(2), 89-104.
- Wang, H. C., He, J., & Mahoney, J. T. (2009). Firm-specific knowledge resources and competitive advantage: the roles of economic-and relationship-based employee governance mechanisms. *Strategic Management Journal*, 30(12), 1265-1285.
- Williamson, O. E. (1981). The economics of organization: The transaction cost approach. *American Journal of Sociology*, 87(3), 548-577.
- Witt, M. A., Lewin, A. Y., Li, P. P., & Gaur, A. (2023). Decoupling in international business: Evidence, drivers, impact, and implications for IB research. *Journal of World Business*, 58(1), 101399.
- Wooldridge, J. M. (2013). *Introductory Econometrics: A Modern Approach*. Cengage learning.
- Wright, C. F., Groutsis, D., & Van Den Broek, D. (2017). Employer-sponsored temporary labour migration schemes in Australia, Canada and Sweden: enhancing efficiency, compromising fairness? *Journal of Ethnic and Migration Studies*, 43(11), 1854-1872.
- Wuchty, S., Jones, B. F., & Uzzi, B. (2007). The increasing dominance of teams in production of knowledge. *Science*, 316(5827), 1036-1039.

- Xie, L., Zhou, J., Zong, Q., & Lu, Q. (2020). Gender diversity in R&D teams and innovation efficiency: Role of the innovation context. *Research Policy*, 49(1), 103885.
- Xu, S. J. (2018). Skilled Labor Access, Hiring Uncertainty, and Corporate Investment: Evidence from the H-1B Visa Program. Hiring Uncertainty, and Corporate Investment: Evidence from the H-1B Visa Program (June 1, 2018).
- Yan, Y., Li, J., & Zhang, J. (2022). Protecting intellectual property in foreign subsidiaries: An internal network defense perspective. *Journal of International Business Studies*, 53(9), 1924-1944.
- Zahra, S. A., & George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. *Academy of Management Review*, 27(2), 185-203.
- Zander, U., & Kogut, B. (1995). Knowledge and the speed of the transfer and imitation of organizational capabilities: An empirical test. *Organization Science*, 6(1), 76-92.
- Zanfei, A. (2000). Transnational firms and the changing organisation of innovative activities. *Cambridge Journal of Economics*, 24(5), 515-542.
- Zhang, K. H. (2023). US-China Economic Links and Technological Decoupling. *The Chinese Economy*, 1-13.
- Zhao, M. (2006). Conducting R&D in countries with weak intellectual property rights protection. *Management Science*, 52(8), 1185-1199.

APPENDIX A

CHECKS ON SAMPLE COMPOSITION

In drawing my sample of U.S. public firms from Compustat and to ensure validity of my findings, I perform three checks to confirm that the firms drawn are indeed MNEs.

First, I drew a stratified sample of inventors located in non-US foreign countries from patents comprising my sample. The stratification was performed on the basis of strength of firms in each industry in my sample resulting in 74 unique inventors. I located LinkedIn profiles and confirmed that the self-reported employment affiliations matches the assignees named on patents applied in a particular sample year for each corresponding foreign inventor in the stratified sample. The use of LinkedIn profiles is a procedure that has been used by several scholars in the strategy and IB literature (Ge et al., 2016; Breschi et al., 2018, etc.) The information collected from this exercise is summarized and tabulated in Table A1.1 below. I confirmed that all of the inventors are employed by assignees of the respective patents. This gives me the confidence to claim that the MNEs in my sample indeed had R&D with local employees in the relevant countries.

Table A.1

Employment Affiliations Confirmed for Inventors Located in Foreign Countries Using LinkedIn Profiles.

SIC	Number of patents	Companies represented	Company - Inventor match
36	16	13	16
28	15	13	15
73	10	10	10
35	9	7	9
38	9	8	9
37	3	2	3
13	1	1	1
20	1	1	1

Table A.1

(continued)

SIC	Number of patents	Companies represented	Company - Inventor match
25	1	1	1
26	1	1	1
30	1	1	1
33	1	1	1
34	1	1	1
39	1	1	1
48	1	1	1
67	1	1	1
87	1	1	1
99	1	1	1
Total	74	65	74

Note: Detailed information collected is presented at the end of Appendix A in Table A.4.

Second, I checked the headquarter locations of firms in my sample. Table A.2 presents that 706 out of 707 firms in my sample are headquartered in the U.S. The one company that is headquartered in Great Britain is “Linde PLC” which is a true multinational company with presence in almost all countries of the world independently as well as through the pre-merger entities, namely, Praxair of the U.S. and Linde AG of Germany, both of which are century-old companies.

Table A.2

Distribution of Headquarter Locations of Firms in Sample.

HQ Country	Frequency	Percentage	Cumulative
United States (USA)	706	99.86	99.86
Great Britain (GBR)	1	0.14	100.00
Total	707	100.00	

Next, I checked the international spread of inventors across all firms in a ten-year window preceding each focal year in my sample. In other words, if inventors named on firms’ patents are located internationally in each 10-year window across my sample, then I

infer that those inventors are working in foreign R&D labs, thereby confirming that my sample is indeed comprised of MNEs. Importantly, the fact that the patent data provide the location of the home address of the individual inventors implies that I can unambiguously identify companies that have R&D operations in foreign countries. From the perspective of global R&D investments performed by MNEs, this is an important criterion to identify my sample meaningfully. This test reveals that firms in my sample have inventors in 2.78 countries on an average during any 10-year window during my sample period. So, I am confident that my sample consists of American listed MNEs with operations in other countries.

Table A.3

Number of Foreign Subsidiaries of a Randomly Drawn Subsample of Firms.

Gvkey	Company Name	Cik	Date Reported	Foreign Subsidiaries (As Per Exhibit 21 Of 10-K)
007257	MERCK & CO	0000064978	31-Dec-99	119
025676	PERCEPTRON INC	0000887226	29-Mar-99	2
127481	MAXYGEN INC	0001068796	25-Mar-02	2
141496	DYNAVAX TECHNOLOGIES CORP	0001029142	30-Mar-04	1
009778	SNAP-ON INC	0000091440	01-Apr-99	15
005764	HUBBELL INC	0000048898	27-Mar-00	2
113609	ENTRUST INC	0001031283	30-Mar-99	3
003502	COOPER TIRE & RUBBER CO	0000024491	22-Mar-01	37
008358	PARKER-HANNIFIN CORP	0000076334	24-Sep-99	62

As a third check, I provide more descriptive data on the international presence of the MNEs in my sample. I randomly selected approximately 2% (9 firms) from my sample and looked at Exhibit 21 of their earliest accessible annual report. This exhibit requires firms to report their subsidiaries, including those located in foreign countries,

where the firm has a majority share. The table A1.3 below lists the number of foreign subsidiaries reported by MNEs in my sample.

With these three checks, I am confident that my sample indeed comprises MNEs that were affected by H-1B visa restrictions.

Table A.4*Verification of Inventors' Self-reported Employment Using LinkedIn Data.*

Gvkey	Patent Assignee name	2 digit SIC	Patent #	Application year	Inventor first name	Inventor last name	Inventor city	Inventor Country	LinkedIn Profile	LinkedIn employer in appl. year
009465	SCHLUMBERGER LTD	13	7895241	2007	Herman	Veldhuizen	Kolsaas	NO	LinkedIn Profile	Schlumberger
021487	B/E AEROSPACE INC	25	7503571	2007	Victor	Cromie	County Down	IE	LinkedIn Profile	B/E Aerospace
264265	ALNYLAM PHARMACEUTICALS INC	28	8124752	2007	Birgit	Bramlage	Kulmbach	DE	LinkedIn Profile	Alnylam Pharmaceuticals
133885	EXELIXIS INC	28	8481269	2005	Lynn Margaret	Bjerke	Sutton	GB	LinkedIn Profile	Exelixis Inc.
127481	MAXYGEN INC	28	7371543	2004	Anders Hjelholt	Pedersen	Lyngby	DK	LinkedIn Profile	CMC Biopharmaceuticals A/S
009217	ROHM AND HAAS CO	28	7138139	2003	Francois	Gauthier	Peymeinade	FR	LinkedIn Profile	Rohm and Haas
008762	PROCTER & GAMBLE CO	28	8277935	2006	Iris	Bogaerts	Mechelen	BE	LinkedIn Profile	Procter & Gamble
008530	PFIZER INC	28	7786131	2003	Annette Marian	Doherty	Paris	FR	LinkedIn Profile	Pfizer
001078	ABBOTT LABORATORIES	28	7837701	2005	Padraig	Maher	Birr	IE	LinkedIn Profile	Abbott Vascular
003170	COLGATE-PALMOLIVE CO	28	6187734	2000	Chantal	Gallant	Cheratte	BE	LinkedIn Profile	Colgate Palmolive R&D
065142	COMMSCOPE INC	33	7436355	2006	Neil	Harper	Mangerton	AU	LinkedIn Profile	CommScope

Table A.4

(continued)

Gvkey	Patent Assignee name	2 digit SIC	Patent #	Application year	Inventor first name	Inventor last name	Inventor city	Inventor Country	LinkedIn Profile	LinkedIn employer in appl. year
001704	APPLIED MATERIALS INC	35	6380546	2000	Bezalel	Rechav	Nes Ziona	IL	LinkedIn Profile	Applied Materials
001074	APPLIED MATERIALS INC	35	6309977	2000	Janet	Yu	Chanhaw	TW	LinkedIn Profile	Applied Materials
002255	BLACK & DECKER CORP	35	7134208	2003	Phillip T.	Cassidy	Kemptville	CA	LinkedIn Profile	Stanley Black & Decker Inc.
002817	CATERPILLAR INC	35	7357126	2005	Ajey Janardan	Kulkami	Saint Ismier	FR	LinkedIn Profile	Caterpillar Inc.
005878	ILLINOIS TOOL WORKS	35	8166908	2006	Felix	Mauchle	Abtwil	CH	LinkedIn Profile	ITW Gema AG
001072	AVX CORP	36	7532457	2007	Stanislav	Zednicek	Lanskroun	CZ	LinkedIn Profile	AVX Corporation
001161	ADVANCED MICRO DEVICES	36	6821796	2002	Zhihong	Mai	Singapore	SG	LinkedIn Profile	Advanced Micro Devices
003333	ARTESYN TECHNOLOGIES INC	36	6786736	2002	John C.	Flannery	Cork	IE	LinkedIn Profile	Artesyn Technologies
004321	EMERSON ELECTRIC CO	36	6906609	2000	John	Piechnick	Pasig	PH	LinkedIn Profile	Emerson Network Power
006008	INTEL CORP	36	7802077	2000	Lihu	Rappoport	Haifa	IL	LinkedIn Profile	Intel Corporation
006008	INTEL CORP	36	7154257	2002	Teik Sean	Toh	Sungai Petani	MY	LinkedIn Profile	Intel Corporation

Table A.4

(continued)

Gvkey	Patent Assignee name	2 digit SIC	Patent #	Application year	Inventor first name	Inventor last name	Inventor city	Inventor Country	LinkedIn Profile	LinkedIn employer in appl. year
007291	METHODE ELECTRONICS INC	36	7446269	2002	Evan	Stringos	G'Mangia	MT	LinkedIn Profile	Method Electronics Malta Limited
007585	MOTOROLA SOLUTIONS INC	36	7230930	2004	Satyanarayana	Tummalapenta	Bangalore	IN	LinkedIn Profile	Motorola India
003734	DANA INC	37	7082984	2004	Norberto	Rizzo	Carabobo	VE	LinkedIn Profile	S.H Fndiciones DANA Foundry Dana Div. Venezuela
001300	HONEYWELL INTERNATIONAL INC	38	7446803	2003	Hai Seng Michael	Liew	Singapore	SG	LinkedIn Profile	Honeywell
002111	BECTON DICKINSON & CO	38	8377008	2007	Lionel	Maritan	Pierre-Chatel	FR	LinkedIn Profile	BD (Also known as Becton Dickson & Company)
004145	PERKINELMER INC	38	7211440	2002	Kaj	Blomberg	Abo	FI	LinkedIn Profile	PerkinElmer
006158	INVACARE CORP	38	8109572	2006	Simon Bruce Laurence	Watterton	Hofstetten	CH	LinkedIn Profile	Invacare Corporation
022815	TRIMBLE INC	38	7930835	2007	Nick	Mein	Christchurch	NZ	LinkedIn Profile	Trimble
012206	DIRECTV	48	7925231	2006	Eduardo	Cavanagh	Buenos Aires	AR	LinkedIn Profile	Directv Panamericana
001878	AUTODESK INC	73	6918121	2001	Tomas	Rokos	Decin	CZ	LinkedIn Profile	Autodesk
011636	XEROX HOLDINGS CORP	73	6372030	2000	Shadi L.	Malhotra	Mississauga	CA	LinkedIn Profile	Xerox (Inventor is the father of popular NHL player)

Table A.4

(continued)

Gvkey	Patent Assignee name	2 digit SIC	Patent #	Application year	Inventor first name	Inventor last name	Inventor city	Inventor Country	LinkedIn Profile	LinkedIn employer in appl. year
012142	ORACLE CORP	73	8161118	2006	Rajmund	Paczkowski	Marki	PL	LinkedIn Profile	Oracle
012884	COMVERSE TECHNOLOGY INC	73	6996531	2001	Toby	Korall	Herzlya	IL	LinkedIn Profile	Comverse
014650	BMC SOFTWARE INC	73	7996501	2007	Johan	Eriksson	Orebro	SE	LinkedIn Profile	BMC Software
142812	SENOMYX INC	87	7476399	2004	Ming	Qi	Shanghai	CN	LinkedIn Profile	Senomyx Inc.
005071	GENERAL MILLS INC	20	8029847	2004	Venkatachalam	Narayanaswamy	Mumbai	IN	LinkedIn Profile	General Mills
001913	AVERY DENNISON CORP	26	7709071	2003	Martin	Utz	Munchen	DE	LinkedIn Profile	Avery Dennison
141846	ACADIA PHARMACEUTICALS INC	28	7790899	2007	Nathalie	Schlienger	Frederiksberg	DK	LinkedIn Profile	ACADIA Pharmaceuticals
133871	SANGAMO THERAPEUTICS INC	28	7947469	2002	Yen	Choo	London	GB	LinkedIn Profile	Gendaq Ltd (Sangamo Biosciences Inc.)
024344	VERTEX PHARMACEUTICALS INC	28	6635644	2001	Ghotas	Evindar	Toronto	CA	LinkedIn Profile	None. Employed by Vertex till Sep 2000.
008762	PROCTER & GAMBLE CO	28	8835511	2007	Mariangela	Caputi	Molfetta	IT	LinkedIn Profile	Procter & Gamble

Table A.4

(continued)

Gvkey	Patent Assignee name	2 digit SIC	Patent #	Application year	Inventor first name	Inventor last name	Inventor city	Inventor Country	LinkedIn Profile	LinkedIn employer in appl. year
008530	PFIZER INC	28	7649002	2005	Mark Ian	Lansdell	Sandwich	GB	LinkedIn Profile	Pfizer
007257	MERCK & CO	28	7781422	2007	Frank	Narjes	Rome	IT	LinkedIn Profile	Merck
001602	AMGEN INC	28	8101612	2007	Partha P.	Chakrabarti	Nagpur	IN	LinkedIn Profile	Amgen
015459	TREDEGAR CORP	30	7601415	2004	Antonietta	Splendiani	Pescara	IT	LinkedIn Profile	Tredeggar Film Products Italia
009778	SNAP-ON INC	34	6728609	2002	Patrick M.	Murray	Cork	IE	LinkedIn Profile	Snap-on Tools
001704	APPLIED MATERIALS INC	35	6583018	2001	Yasuhiko	Matsunaga	Narita	JP	LinkedIn Profile	Applied Materials
001706	ENERPAC TOOL GROUP CORP	35	7055637	2001	Roeland	Mallan	Enschede	NL	LinkedIn Profile	Power-Packer (subsidiary of Enerpac)
002817	CATERPILLAR INC	35	6976418	2004	Vincent	Triffaux	Strepy-Bracquegnies	BE	LinkedIn Profile	Caterpillar Inc.
003835	DEERE & CO	35	7040428	2001	Arto	Huhmarkangas	Tampere	FI	LinkedIn Profile	John Deere
001013	ADC TELECOMMUNICATIONS INC	36	6614668	2002	Delfino	Hernandez	Juarez	MX	LinkedIn Profile	ADC
001161	ADVANCED MICRO DEVICES	36	6331951	2000	Weng Fook	Lee	Penang	MY	LinkedIn Profile	Advanced Micro Devices

Table A.4

(continued)

Gvkey	Patent Assignee name	2 digit SIC	Patent #	Application year	Inventor first name	Inventor last name	Inventor city	Inventor Country	LinkedIn Profile	LinkedIn employer in appl. year
001690	APPLE INC	36	8400494	2006	Aviad	Malzels	Tel Aviv	IL	LinkedIn Profile	Was Prime Sense (Acquired by Apple Inc.)
003532	CORNING INC	36	7304008	2001	Mikhail Dmitrievich	Mikhailov	St.Petersburg	RU	LinkedIn Profile	Corning Incorporated
005791	HUTCHINSON TECHNOLOGY INC	36	6923435	2002	Thierry	Pizanti	La Ferte Villeneuveil	FR	LinkedIn Profile	Hutchinson
006008	INTEL CORP	36	8185723	2001	Alexander	Isaev	Nizhny Novgorod	RU	LinkedIn Profile	Intel Corporation
006109	INTL RECTIFIER CORP	36	8384157	2007	Sergio	Morini	Pavia	IT	LinkedIn Profile	International Rectifier
007343	MICRON TECHNOLOGY INC	36	7038521	2005	Kenneth Stephen	Hunt	Berkshire	GB	LinkedIn Profile	Micron Europe Ltd
003734	DANA INC	37	6655697	2002	William E.	Spengler	Triel sur Seine	FR	LinkedIn Profile	Mahle Engine Components USA / Dana Corp
005073	GENERAL MOTORS CO	37	7188498	2005	Vidyashankar R.	Buravalla	Banglore	IN	LinkedIn Profile	GM Research and Development Center
001300	HONEYWELL INTERNATIONAL INC	38	7198981	2004	Cornel	Cobianu	Bucharest	RO	LinkedIn Profile	SC Honeywell Romania SRL
002220	BIO-RAD LABORATORIES INC	38	7492372	2006	Karl	Nedwed	Graz	AT	LinkedIn Profile	Bio-Rad Laboratories Inc.
004194	EASTMAN KODAK CO	38	7096073	2003	Vitaly	Burkatovsky	Rishon Lezion	IL	LinkedIn Profile	Eastman Kodak

Table A.4

(continued)

Gvkey	Patent Assignee name	2 digit SIC	Patent #	Application year	Inventor first name	Inventor last name	Inventor city	Inventor Country	LinkedIn Profile	LinkedIn employer in appl. year
006304	KLA CORP	38	7433039	2004	Vladimir	Levinski	Nazareth Ilit	IL	LinkedIn Profile	KLA-Tencor
007116	MATTEL INC	39	6881122	2004	Kenlip	Ong	Singapore	SG	LinkedIn Profile	Mattel
006100	INTERDIGITAL INC	67	7443823	2004	Maged	Zaki	Pierrefonds	CA	LinkedIn Profile	InterDigital Communications
006066	INTL BUSINESS MACHINES CORP	73	6311125	2000	Takashi	Yonezawa	Yamato	JP	LinkedIn Profile	IBM
012141	MICROSOFT CORP	73	7587722	2004	Rajesh	Jalan	Hyderabad	IN	LinkedIn Profile	Microsoft
012540	ADOBE INC	73	7310769	2003	Sambit Kumar	Dash	Noida	IN	LinkedIn Profile	Adobe
013421	CADENCE DESIGN SYSTEMS INC	73	7197738	2004	Etienne	Jacques	Bristol	GB	LinkedIn Profile	Cadence design systems
031607	NATIONAL INSTRUMENTS CORP	73	7137855	2005	Michel	Haddad	Beirut	LB	LinkedIn Profile	National Instruments
005047	GENERAL ELECTRIC CO	99	6377659	2000	Eric	Chabin	Bangalore	IN	LinkedIn Profile	GE Healthcare

APPENDIX B

EXOGENEITY OF THE H1-B VISA RESTRICTION

To test the exogeneity of the H-1B visa restriction, I compose a control group comprising MNEs that did not file Labor Condition Applications (LCAs) implying that they did not intend to mobilize R&D workers from foreign subsidiary locations. Next, I interacted the variable identifying treated and control group MNEs with indicator variables for years. The table below shows the results.

	Global dispersion	Number of patents	Novel recombination patents
Treated X 2001	-0.027 (0.109)	-0.039 (0.559)	0.032 (0.680)
Treated X 2002	-0.015 (0.481)	0.041 (0.546)	0.089 (0.302)
Treated X 2003	-0.003 (0.888)	-0.033 (0.781)	-0.131 (0.323)
Constant	-7.875 (0.242)		
Controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
R-squared	0.028		
Log pseudolikelihood		-21989	-7508
Observations	4,706	4,550	4,098
Number of firms	922	766	687

Note: Fixed effects OLS regressions for global dispersion and fixed effects Poisson regressions for number of patents and novel recombination patents. *p*-values in parentheses.

The interaction term is not statistically significant in any year before the visa restrictions are implemented. In other words, the treated and control groups behave similarly in the pre-shock period lending confidence to my assumption that the visa restriction was an exogenous variation.

APPENDIX C

RESULTS FOR NOVEL RECOMBINATION

We test hypotheses 2 and 3 using an alternative measure of innovation performance, namely, the number of patents with novel recombinations. While innovation performance of MNEs, as measured by number of patents, suffers when their home countries impose immigration restrictions, MNEs also face challenges in introducing the requisite diversity of knowledge in their innovation objectives. As a result, both planned and serendipitous discovery of ideas reduce. Thus, I argue that when MNEs are constrained from collocating R&D workers from their foreign subsidiaries, the innovation performance also suffers due to reduction in the number of novel ideas.

Empirically, whereas number of patents is a quantitative measure of innovation performance, the number of patents with novel recombinations is a qualitative measure of a MNE's innovation performance. I use the count of patents containing combinations of patent technology classes that were hitherto uncombined in patents filed by the MNE as the relevant dependent variable. Patents generated by novel combinations of extant technology classes can be considered breakthrough advances and can potentially lead to a fruitful line of inquiry for the MNE (Hargadon & Sutton, 1997; Funk, 2014). The CPC scheme adopted by the USPTO allows the classification of patents into 674 sub-classes of technologies. To construct Novel recombination patents, I considered the patenting history of all MNEs in my sample from 1980 till 2007 and counted the number of patents with novel recombinations of CPC technology classes that each MNE had not explored in their patents before the focal year.

The table below presents results from tests of H2 and H3 considering number of patents with novel recombinations of technology classes as the dependent variable.

Model 1 shows that, in the full sample, there is indeed a negative effect of immigration restriction on novel recombination patents ($\beta = -0.210, p < 0.01$) supporting H2.

However, in models 2 and 3 I do not observe such an effect suggesting that MNEs in both the high and low codification industries might be pursuing novel innovation projects at the expense of overall innovation output.

	Model 1	Model 2	Model 3
	H2	H3	
	Novel recombination patents	SIC 36 & 73	SIC 28
Post shock	-0.210 (0.000)	-0.160 (0.246)	-0.007 (0.973)
Global dispersion	0.329 (0.001)	0.510 (0.006)	0.480 (0.004)
Number of inventors [§]	4.436 (0.000)	3.010 (0.000)	19.263 (0.000)
Patent stock [§]	-1.007 (0.000)	-0.989 (0.002)	-5.182 (0.000)
Average team size	-0.021 (0.093)	-0.009 (0.617)	-0.021 (0.302)
Technological diversity [§]	67.106 (0.000)	97.902 (0.000)	69.160 (0.007)
R&D intensity [†]	0.024 (0.629)	-0.091 (0.297)	0.068 (0.470)
Revenue [†]	0.174 (0.000)	0.173 (0.014)	0.006 (0.941)
RoA [†]	0.175 (0.435)	-0.089 (0.603)	0.372 (0.069)
Slack [†]	-0.006 (0.931)	-0.129 (0.293)	0.043 (0.739)
Firm growth [§]	0.045 (0.108)	-0.117 (0.242)	0.063 (0.447)
Market share	-0.472 (0.805)	-1.889 (0.781)	14.702 (0.000)
International spread	0.008 (0.114)	-0.012 (0.234)	0.025 (0.086)
International experience	0.019 (0.711)	0.057 (0.528)	-0.001 (0.992)
Ratio of scientific citations [§]	9.052 (0.687)	29.066 (0.765)	3.622 (0.868)
Ratio self-citations	-1.325 (0.000)	-2.430 (0.000)	-0.995 (0.008)

	Model 1	Model 2	Model 3
	H2	H3	
	Novel recombination patents	SIC 36 & 73	SIC 28
Ratio technology self-citations	-0.021 (0.867)	0.106 (0.665)	-0.377 (0.140)
Product market competition	4.170 (0.044)	13.986 (0.049)	8.437 (0.407)
Industry growth [§]	0.003 (0.231)	0.003 (0.584)	-0.012 (0.292)
Industry avg. complexity [§]	-21.434 (0.041)	33.923 (0.087)	216.145 (0.238)
Ind. avg. technology self-citations	0.303 (0.265)	-0.015 (0.992)	-2.820 (0.196)
Subsidiary IPR strength	0.007 (0.957)	-0.453 (0.056)	0.640 (0.007)
Subsidiary avg. GDP per capita [†]	-0.111 (0.320)	0.422 (0.061)	-0.329 (0.121)
Avg. FDI ^{§†}	-251.203 (0.200)	133.831 (0.698)	-266.391 (0.580)
Avg. tax rate [§]	10.159 (0.611)	15.534 (0.757)	-25.325 (0.586)
Inventive quality	0.159 (0.000)	0.199 (0.000)	0.093 (0.013)
Year fixed effects	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Log pseudolikelihood	-7281	-2315	-1346
Observations	3,924	1,310	846
Number of firms	628	219	138

Notes: Fixed effects Poisson regressions. *p*-values in parentheses. [†]Variables transformed by taking natural logarithms. [§]variables scaled to facilitate interpretation of coefficients. All variables except Number of inventors lagged by one year in all models.

APPENDIX D

BASELINE DIFFERENCE-IN-DIFFERENCES ESTIMATION

As robustness, I perform a difference-in-differences estimation of the effects of the H-1B visa restriction as hypothesized by constructing a control group comprising MNEs that did not file a LCA during my sample duration. I present the results from this analysis as robustness because the visa restriction applies to all firms operating the U.S. simultaneously. Thus, I do not have a clean control group which could raise endogeneity concerns.

The table below presents results from a simple difference-in-differences in means across the treatment and control groups before and after the H-1B visa shock.

	Global Dispersion	Number of patents	Novel recombination patents
	H1a		H2
<i>Pre-shock</i>			
Mean control group	0.0537	-0.487	1.897
Mean treatment group	0.128	0.525	5.761
Difference in means	0.0745	1.012	3.864
<i>Post-shock</i>			
Mean control group	0.0940	-2.569	1.812
Mean treatment group	0.185	-6.375	3.952
Difference in means	0.0911	-3.806	2.140
Difference-in-differences	0.0166 (0.0845)	-4.818 (0.0202)	-1.725 (0.000184)
R-squared	0.079	0.940	0.539
Observations	6,582	6,582	5,744

Note: *p*-values in parentheses.

Results suggest that dispersion increased, and innovation productivity and novelty decreased after the implementation of visa restrictions. Thus, results from the difference-in-differences estimation are aligned to my main results. However, I do not assign any economic significance to these coefficients given the concerns mentioned previously.

APPENDIX E

ALTERNATE SAMPLE EXCLUDING INFORMATION TECHNOLOGY FIRMS

	H1a		H1b		H2		H3		H3	
	SIC 36		Sic 28				SIC 36 Sic 28		SIC 36 Sic 28	
					Number of patents	Novel recombination patents	Number of patents		Novel recombination patents	
Post shock	0.028 (0.031)	0.025 (0.432)	-0.022 (0.618)	-0.318 (0.000)	-0.248 (0.000)	-0.194 (0.025)	-0.426 (0.001)	-0.144 (0.148)	-0.007 (0.973)	
Global dispersion					0.480 (0.009)	0.274 (0.010)	0.231 (0.507)	0.708 (0.004)	0.401 (0.082)	0.480 (0.004)
Number of inventors [§]	0.660 (0.042)	0.698 (0.346)	2.911 (0.003)	10.651 (0.000)	10.650 (0.000)	9.756 (0.000)	17.135 (0.000)	15.404 (0.000)	19.263 (0.000)	
Patent stock [§]	0.117 (0.315)	-0.176 (0.458)	-0.754 (0.140)	-0.410 (0.390)	-0.981 (0.102)	-0.967 (0.222)	-0.247 (0.792)	-2.988 (0.000)	-5.182 (0.000)	
Average team size	-0.001 (0.764)	-0.002 (0.702)	0.001 (0.603)	0.003 (0.898)	-0.022 (0.082)	-0.067 (0.005)	0.049 (0.252)	0.008 (0.682)	-0.021 (0.302)	
Technological diversity [§]					0.004 (0.679)	0.004 (0.849)	0.011 (0.823)	0.004 (0.000)	0.006 (0.000)	0.007 (0.007)
R&D intensity [†]	0.018 (0.019)	0.015 (0.324)	0.024 (0.054)	0.025 (0.660)	0.020 (0.665)	-0.017 (0.864)	0.029 (0.713)	-0.058 (0.506)	0.068 (0.470)	
Revenue [†]	-0.000 (0.959)	-0.014 (0.400)	0.013 (0.447)	0.263 (0.000)	0.159 (0.001)	0.233 (0.019)	-0.065 (0.638)	0.094 (0.189)	0.006 (0.941)	
RoA [†]	0.045 (0.000)	0.011 (0.901)	0.046 (0.000)	-0.014 (0.965)	0.555 (0.113)	0.070 (0.909)	-0.182 (0.244)	0.658 (0.287)	0.372 (0.069)	
Slack [†]	0.019 (0.088)	0.029 (0.198)	0.016 (0.395)	-0.040 (0.591)	-0.006 (0.913)	-0.032 (0.810)	0.091 (0.466)	-0.084 (0.384)	0.043 (0.739)	
Firm growth [§]	-0.014 (0.087)	0.005 (0.887)	-0.013 (0.462)	-0.024 (0.371)	0.006 (0.816)	0.127 (0.073)	-0.075 (0.079)	0.080 (0.301)	0.063 (0.447)	
Market share	0.859 (0.051)	0.955 (0.632)	3.670 (0.189)	-1.194 (0.446)	2.856 (0.195)	-12.498 (0.117)	5.185 (0.197)	-1.581 (0.808)	14.702 (0.000)	
International spread	0.005 (0.004)	0.013 (0.001)	0.002 (0.716)	0.008 (0.205)	0.009 (0.124)	-0.008 (0.352)	0.022 (0.028)	-0.006 (0.626)	0.025 (0.086)	
International experience	-0.015 (0.139)	0.015 (0.343)	-0.020 (0.396)	0.160 (0.009)	0.034 (0.545)	0.084 (0.388)	0.055 (0.698)	0.033 (0.747)	-0.001 (0.992)	
Ratio of scientific citations [§]	-0.000 (0.587)	0.001 (0.303)	-0.000 (0.161)	-0.006 (0.381)	0.001 (0.752)	-0.001 (0.949)	-0.007 (0.266)	-0.005 (0.653)	0.000 (0.868)	
Ratio self-citations	-0.004 (0.908)	-0.070 (0.424)	0.015 (0.763)	-0.512 (0.077)	-1.070 (0.000)	-0.474 (0.358)	-0.346 (0.253)	-0.907 (0.116)	-0.995 (0.008)	
Ratio technology self-citations	-0.032 (0.123)	-0.040 (0.335)	-0.077 (0.016)	-0.185 (0.263)	-0.084 (0.541)	-0.160 (0.451)	-0.408 (0.217)	-0.068 (0.808)	-0.377 (0.140)	
Product market competition	-0.127 (0.780)	0.662 (0.233)	2.848 (0.302)	2.168 (0.149)	2.135 (0.299)	-1.317 (0.856)	-4.773 (0.685)	9.702 (0.206)	8.437 (0.407)	
Industry growth [§]	-0.000 (0.028)	0.000 (0.358)	-0.000 (0.887)	-0.000 (0.809)	0.000 (0.125)	-0.000 (0.477)	0.000 (0.561)	-0.000 (0.670)	-0.000 (0.292)	

	H1a		H1b		H2		H3		H3	
	SIC 36	Sic 28	SIC 36	Sic 28	Number of patents	Novel recombination patents	SIC 36	Sic 28	SIC 36	Sic 28
Industry avg. complexity [§]	0.000	0.005	0.008	-0.002	-0.002	-0.003	0.008	0.025	-0.011	0.022
	(0.209)	(0.342)	(0.012)	(0.113)	(0.002)	(0.457)	(0.149)	(0.479)	(0.238)	
Ind. avg. technology self-citations	-0.145	-1.227	0.261	-0.430	0.216	0.306	0.063	0.476	-2.820	
	(0.111)	(0.159)	(0.661)	(0.241)	(0.434)	(0.909)	(0.961)	(0.897)	(0.196)	
Subsidiary IPR strength	-0.029	0.023	-0.107	-0.297	-0.036	-0.780	0.103	-0.499	0.640	
	(0.330)	(0.724)	(0.035)	(0.009)	(0.750)	(0.006)	(0.527)	(0.072)	(0.007)	
Subsidiary avg. GDP per capita [†]	0.010	0.029	0.079	-0.051	-0.082	0.124	0.084	0.401	-0.329	
	(0.707)	(0.625)	(0.078)	(0.573)	(0.432)	(0.585)	(0.626)	(0.134)	(0.121)	
Avg. FDI ^{§†}	-0.001	-0.004	-0.000	0.002	-0.040	0.005	0.003	0.005	-0.027	
	(0.875)	(0.688)	(0.983)	(0.907)	(0.041)	(0.805)	(0.951)	(0.903)	(0.580)	
Avg. tax rate [§]	0.000	0.000	0.001	-0.003	0.000	0.002	-0.004	0.003	-0.003	
	(0.679)	(0.998)	(0.611)	(0.077)	(0.912)	(0.512)	(0.253)	(0.670)	(0.586)	
Innovation quality					0.140			0.184	0.093	
					(0.000)			(0.000)	(0.013)	
Constant	-0.218	-0.717	-1.636							
	(0.338)	(0.468)	(0.006)							
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.030	0.064	0.048							
Log pseudolikelihood				-16168	-6519	-4544	-2981	-1633	-1346	
Observations	3,800	988	892	3,767	3,509	982	883	895	846	
Number of firms	610	158	152	577	549	152	143	140	138	

Note: Fixed effects OLS regressions for H1a and H1b. Fixed effects Poisson regressions for H2a, H2b, H3a and H3b. *p*-values in parentheses. †Variables transformed by taking natural logarithms. §variables scaled to facilitate interpretation of coefficients. All variables except number of inventors lagged by one year in all models.

APPENDIX F

ANALYSIS OF EXTENDED SUBSAMPLES

The following analysis pertains to an extended subsample drawn from the top three deciles of industries based on knowledge codification proxies. This serves as a robustness for the main analyses reported in Hypotheses 1b and 3b.

	H1b		H3 (Number of patents)		H3b (Novel recombination patents)	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	SIC 36, 73, 35, 38	SIC 28	SIC 36, 73, 35, 38	SIC 28	SIC 36, 73, 35, 38	SIC 28
Post shock	0.062 (0.000)	-0.022 (0.618)	-0.367 (0.000)	-0.426 (0.001)	-0.209 (0.007)	-0.007 (0.973)
Global dispersion			0.734 (0.002)	0.708 (0.004)	0.396 (0.003)	0.480 (0.004)
Number of inventors [§]	0.052 (0.812)	2.911 (0.003)	3.713 (0.000)	17.135 (0.000)	3.888 (0.000)	19.263 (0.000)
Patent stock [§]	0.009 (0.920)	-0.754 (0.140)	-0.422 (0.144)	-0.247 (0.792)	-1.012 (0.001)	-5.182 (0.000)
Average team size	-0.003 (0.363)	0.001 (0.603)	-0.008 (0.697)	0.049 (0.252)	0.002 (0.880)	-0.021 (0.302)
Technological diversity [§]	0.000 (0.353)	-0.000 (0.823)	0.008 (0.000)	0.004 (0.052)	0.008 (0.000)	0.007 (0.007)
R&D intensity [†]	0.012 (0.253)	0.024 (0.054)	0.005 (0.949)	0.029 (0.713)	-0.052 (0.415)	0.068 (0.470)
Revenue [†]	0.004 (0.724)	0.013 (0.447)	0.474 (0.000)	-0.065 (0.638)	0.204 (0.000)	0.006 (0.941)
RoA [†]	0.018 (0.364)	0.046 (0.000)	0.067 (0.709)	-0.182 (0.244)	-0.022 (0.917)	0.372 (0.069)
Slack [†]	0.010 (0.537)	0.016 (0.395)	-0.040 (0.707)	0.091 (0.466)	-0.052 (0.566)	0.043 (0.739)
Firm growth [§]	-0.024 (0.137)	-0.013 (0.462)	-0.004 (0.910)	-0.075 (0.079)	0.020 (0.794)	0.063 (0.447)
Market share	-0.093 (0.881)	3.670 (0.189)	-5.163 (0.120)	5.185 (0.197)	-1.258 (0.758)	14.702 (0.000)
International spread	0.008 (0.000)	0.002 (0.716)	0.001 (0.943)	0.022 (0.028)	-0.004 (0.468)	0.025 (0.086)
International experience	-0.030 (0.009)	-0.020 (0.396)	0.160 (0.026)	0.055 (0.698)	0.071 (0.292)	-0.001 (0.992)
Ratio of scientific citations [§]	0.002 (0.345)	-0.000 (0.161)	0.026 (0.223)	-0.007 (0.266)	0.006 (0.589)	0.000 (0.868)
Ratio self-citations	0.018 (0.740)	0.015 (0.763)	-1.353 (0.001)	-0.346 (0.253)	-1.903 (0.000)	-0.995 (0.008)
Ratio technology self-citations	-0.005 (0.841)	-0.077 (0.016)	0.110 (0.589)	-0.408 (0.217)	0.245 (0.157)	-0.377 (0.140)

	H1b		H3 (Number of patents)		H3b (Novel recombination patents)	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	SIC 36, 73, 35, 38	SIC 28	SIC 36, 73, 35, 38	SIC 28	SIC 36, 73, 35, 38	SIC 28
Product market competition	-0.548 (0.444)	2.848 (0.302)	2.627 (0.621)	-4.773 (0.685)	4.963 (0.283)	8.437 (0.407)
Industry growth [§]	-0.000 (0.286)	-0.000 (0.887)	-0.000 (0.177)	0.000 (0.561)	0.000 (0.893)	-0.000 (0.292)
Industry avg. complexity [§]	-0.001 (0.198)	0.008 (0.012)	0.002 (0.308)	0.025 (0.149)	0.001 (0.533)	0.022 (0.238)
Ind. avg. technology self-citations	-0.110 (0.561)	0.261 (0.661)	-0.773 (0.269)	0.063 (0.961)	0.200 (0.800)	-2.820 (0.196)
Subsidiary IPR strength	0.010 (0.813)	-0.107 (0.035)	-0.237 (0.267)	0.103 (0.527)	-0.215 (0.207)	0.640 (0.007)
Subsidiary avg. GDP per capita [†]	-0.006 (0.867)	0.079 (0.078)	-0.170 (0.265)	0.084 (0.626)	0.050 (0.754)	-0.329 (0.121)
Avg. FDI ^{§†}	-0.003 (0.560)	-0.000 (0.983)	0.046 (0.091)	0.003 (0.951)	-0.013 (0.617)	-0.027 (0.580)
Avg. tax rate [§]	0.001 (0.328)	0.001 (0.611)	-0.002 (0.495)	-0.004 (0.253)	0.002 (0.554)	-0.003 (0.586)
Inventive quality					0.155 (0.000)	0.093 (0.013)
Constant	0.115 (0.709)	-1.636 (0.006)				
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.040	0.048				
Log pseudolikelihood			-13725	-2981	-4445	-1346
Observations	2,685	892	2,664	883	2,419	846
Number of firms	439	152	418	143	386	138

Notes: Fixed effects Poisson regressions. *p*-values in parentheses. [†]Variables transformed by taking natural logarithms. [§]variables scaled to facilitate interpretation of coefficients. All variables except number of inventors lagged by one year in all models.

APPENDIX G

RESULTS EXCLUDING OUTLIER FIRMS

My sample on which the main analyses are reported comprises MNEs with varying patenting tendencies. Figure G.1 below shows the distribution of granted patents to all MNEs in my sample. Clearly, there are outliers with more than 10,000 patents granted over the sample period. These MNEs are listed in table G.1 below.

Figure G.1

Distribution of MNEs Based on Number of Patents Granted Over the Sample Duration.

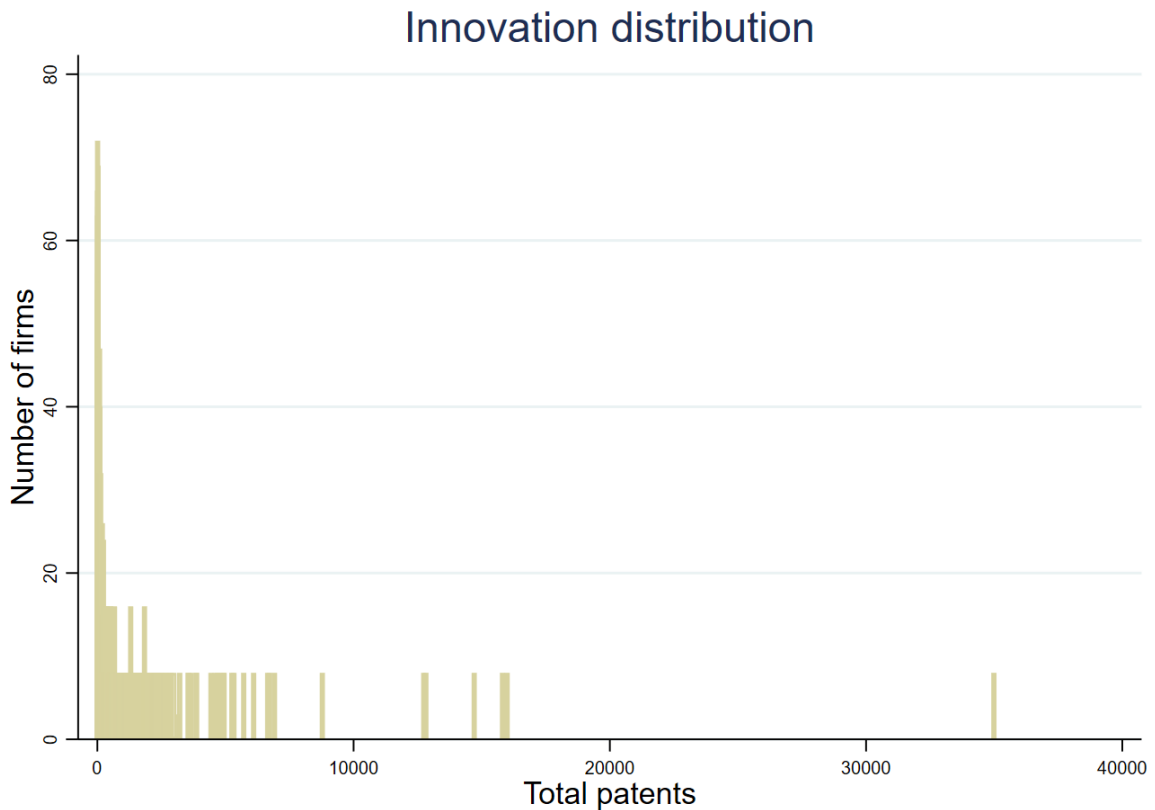


Table G.1.

Outlier Firms Granted More Than 10,000 Patents During the Sample Period.

GVKEY	MNE NAME	TOTAL PATENTS
006066	INTL BUSINESS MACHINES CORP	34,987
012141	MICROSOFT CORP	15,992

Table G.1.

(continued)

GVKEY	MNE NAME	TOTAL PATENTS
005606	HP INC	15,811
006008	INTEL CORP	14,707
007343	MICRON TECHNOLOGY INC	12,821
005047	GENERAL ELECTRIC CO	12,738

Despite these outliers, the distribution of MNEs in each decile based on the number of patents granted is more or less uniform as shown in Figure G.2 below.

Figure G.2

Distribution of MNEs into Deciles Based on Number of Patents Granted Over Sample Duration.

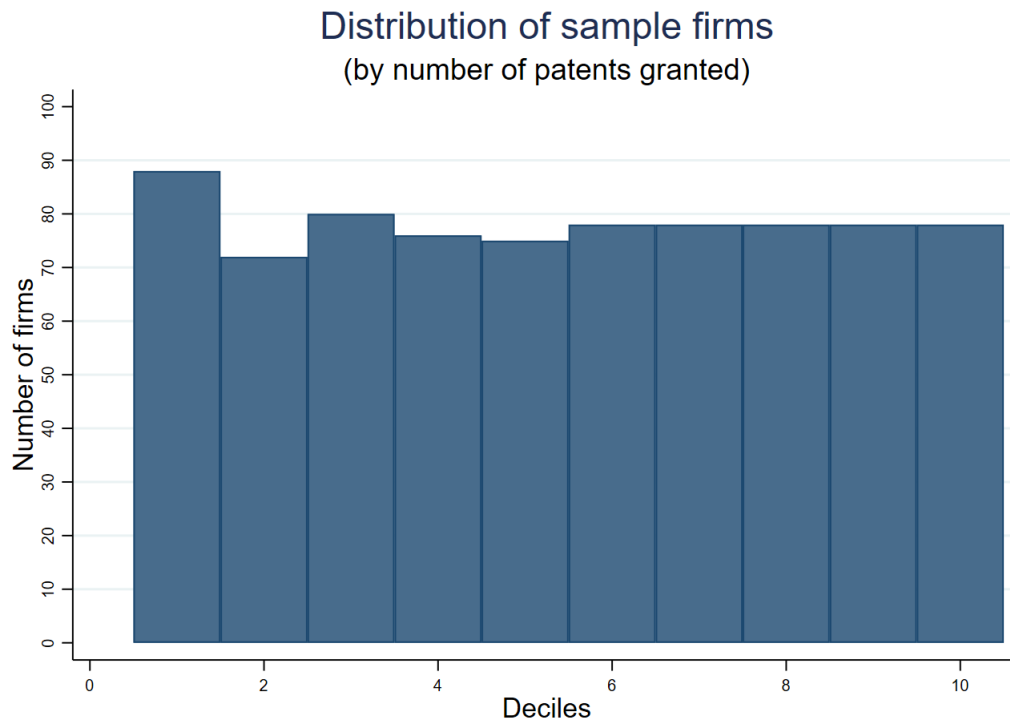


Figure G.2 suggests that the presence of outliers should not be of great concern.

Next, I repeat my analyses for H1a, H2a, and H2b by removing the outlier firms from my estimation sample. Table G.2 reports results from the analyses. Model specification

remains the same as reported in my main results with the only difference being the removal of outlier firms from the sample.

Table G.2

Regression Results Excluding Outliers Listed in Table G.1.

	H1a	H2 (Number of patents)	H2 (Novel recombination patents)
Post shock	0.034 (0.008)	-0.309 (0.000)	-0.254 (0.000)
Global dispersion		0.467 (0.005)	0.217 (0.031)
Number of inventors [§]	1.051 (0.001)	14.734 (0.000)	14.978 (0.000)
Patent stock [§]	-0.154 (0.297)	-1.284 (0.114)	-3.233 (0.000)
Average team size	-0.001 (0.747)	-0.002 (0.928)	-0.022 (0.068)
Technological diversity [§]	0.000 (0.609)	0.004 (0.001)	0.003 (0.006)
R&D intensity [†]	0.015 (0.058)	0.043 (0.439)	0.020 (0.679)
Revenue [†]	0.001 (0.888)	0.270 (0.000)	0.146 (0.002)
RoA [†]	0.037 (0.005)	0.027 (0.818)	0.126 (0.528)
Slack [†]	0.015 (0.172)	-0.043 (0.564)	-0.016 (0.786)
Firm growth [§]	-0.020 (0.053)	-0.028 (0.486)	-0.014 (0.721)
Market share	0.849 (0.064)	-1.841 (0.390)	2.604 (0.271)
International spread	0.006 (0.002)	0.014 (0.010)	0.017 (0.001)
International experience	-0.022 (0.019)	0.148 (0.008)	0.005 (0.923)
Ratio of scientific citations [§]	-0.000 (0.741)	-0.005 (0.474)	0.002 (0.475)
Ratio self-citations	-0.005 (0.878)	-0.364 (0.171)	-0.837 (0.001)
Ratio technology self-citations	-0.021 (0.283)	-0.152 (0.308)	-0.035 (0.785)
Product market competition	-0.346 (0.449)	0.355 (0.839)	-0.024 (0.990)

Table G.2

(continued)

	H1a	H2 (Number of patents)	H2 (Novel recombination patents)
Industry growth [§]	-0.000 (0.047)	-0.000 (0.118)	0.000 (0.353)
Industry avg. complexity [§]	0.000 (0.734)	0.001 (0.576)	0.000 (0.843)
Ind. avg. technology self-citations	-0.189 (0.033)	-0.807 (0.042)	0.129 (0.753)
Subsidiary IPR strength	-0.025 (0.392)	-0.227 (0.040)	0.016 (0.884)
Subsidiary avg. GDP per capita [†]	0.022 (0.391)	0.028 (0.708)	-0.022 (0.814)
Avg. FDI ^{§†}	-0.001 (0.766)	0.002 (0.902)	-0.037 (0.062)
Avg. tax rate [§]	0.000 (0.559)	-0.002 (0.275)	0.002 (0.371)
Inventive quality			0.125 (0.000)
Constant	-0.235 (0.302)		
Year fixed effects	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
R-squared	0.031		
Log pseudolikelihood		-17135	-6905
Observations	4,243	4,202	3,876
Number of firms	701	660	622

Notes: Fixed effects OLS estimation for H1a and fixed effects Poisson regressions for H2a and H2b. *p*-values in parentheses. [†]Variables transformed by taking natural logarithms. [§]variables scaled to facilitate interpretation of coefficients. All variables except number of inventors lagged by one year in all models.

Results presented in table G.2 suggest no qualitative difference in the hypothesized results lending confidence to my main results.

APPENDIX H

CITATION-WEIGHTED PATENT COUNT

Results are robust with citation-weighted patent count as the dependent variable.

	H2	H3 (Number of patents)	H3 (Novel recombination patents)
	Full sample	SIC 36 & 73	SIC 28
Post shock	-1.386 (0.000)	-1.198 (0.003)	-1.638 (0.000)
Global dispersion	0.930 (0.236)	-0.039 (0.976)	0.233 (0.604)
Number of inventors [§]	6.954 (0.000)	6.928 (0.000)	36.599 (0.000)
Patent stock [§]	-0.575 (0.148)	-0.520 (0.434)	0.533 (0.782)
Average team size	0.070 (0.356)	-0.223 (0.000)	-0.043 (0.410)
Technological diversity [§]	0.009 (0.000)	0.014 (0.000)	-0.010 (0.017)
R&D intensity [†]	0.206 (0.308)	-0.489 (0.037)	0.109 (0.327)
Revenue [†]	0.871 (0.000)	1.081 (0.001)	-0.222 (0.492)
RoA [†]	1.463 (0.392)	-0.100 (0.917)	0.493 (0.847)
Slack [†]	0.314 (0.139)	-0.674 (0.050)	0.052 (0.907)
Firm growth [§]	0.088 (0.159)	-0.045 (0.659)	-0.185 (0.008)
Market share	-13.271 (0.005)	5.945 (0.551)	33.346 (0.019)
International spread	-0.025 (0.006)	-0.063 (0.000)	0.060 (0.001)
International experience	0.514 (0.068)	0.777 (0.018)	0.283 (0.503)
Ratio of scientific citations [§]	0.021 (0.399)	0.535 (0.085)	-0.017 (0.060)
Ratio self-citations	-1.365 (0.317)	-5.517 (0.000)	-0.082 (0.925)
Ratio technology self-citations	3.463 (0.008)	0.290 (0.847)	-1.595 (0.048)

	H2	H3 (Number of patents)	H3 (Novel recombination patents)
	Full sample	SIC 36 & 73	SIC 28
Product market competition	18.227 (0.004)	42.803 (0.040)	25.772 (0.072)
Industry growth [§]	-0.000 (0.004)	-0.000 (0.002)	0.000 (0.000)
Industry avg. complexity [§]	-0.000 (0.925)	0.010 (0.006)	0.092 (0.000)
Ind. avg. technology self-citations	0.236 (0.660)	-2.652 (0.199)	2.749 (0.385)
Subsidiary IPR strength	0.014 (0.980)	-1.373 (0.002)	-0.387 (0.404)
Subsidiary avg. GDP per capita [†]	-0.955 (0.007)	-0.398 (0.485)	1.099 (0.072)
Avg. FDI ^{§†}	0.188 (0.023)	0.067 (0.412)	0.068 (0.414)
Avg. tax rate [§]	-0.013 (0.161)	0.034 (0.002)	-0.007 (0.424)
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Log pseudolikelihood	-5.530e+07	-1.930e+07	-801363
Observations	4,246	1,463	883
Number of firms	664	240	143

Notes: Fixed effects Poisson regressions. *p*-values in parentheses. [†]Variables transformed by taking natural logarithms. [§]variables scaled to facilitate interpretation of coefficients. All variables except number of inventors lagged by one year in all models.

APPENDIX I

PLACEBO TESTS (SENSITIVITY) FOR ALL HYPOTHESES

We test for sensitivity to the shock occurring in 2004 to rule out the possibility of observing hypothesized effects in the pre- and post-shock periods. Tables I.1.a and I.1.b report placebo test results in the pre-shock period and tables I.2.a and I.2.b report placebo test results in the post-shock period.

Table I.1.a

Placebo Tests in the Pre-Shock Period for H1a and H2.

	H1a	H2	H2
	Global dispersion	Number of patents	Novel recombination patents
Placebo pre-shock	-0.036 (0.003)	0.059 (0.128)	0.111 (0.018)
Year & Firm fixed effects	Yes	Yes	Yes
Observations	2,181	2,140	1,975
Number of firms	624	583	545

Notes: Fixed effects OLS regressions for H1a. Fixed effects Poisson regressions for H2. All placebo tests follow the exact same specification and include all controls reported in the corresponding main results. *p*-values in parentheses.

Table I.1.b

Placebo Tests in the Pre-Shock Period for H1b and H3

	H1b		H3		H3	
	Global dispersion		Number of patents		Novel recombination patents	
	SIC 36 & 73	SIC 28	SIC 36 & 73	SIC 28	SIC 36 & 73	SIC 28
Placebo pre-shock	-0.080 (0.176)	-0.030 (0.539)	-0.073 (0.776)	0.054 (0.652)	-0.129 (0.646)	-0.097 (0.575)
Year & Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	754	461	734	453	644	433
Number of firms	226	131	206	128	183	117

Notes: Fixed effects OLS regressions for H1b. Fixed effects Poisson regressions for H3. All placebo tests follow the exact same specification and include all controls reported in the corresponding main results. *p*-values in parentheses.

In table I.1.a and I.1.b, pertaining to a placebo test in the pre-shock period, I assume that visa restrictions occurred in 2002 and in table I.2.a and I.2.b, pertaining to a placebo test in the post-shock period, I assume that the visa restrictions occurred in 2006. We find no evidence of hypothesized effects in the pre-shock placebo tests.

Table I.2.a

Placebo Tests in the Post-Shock Period for H1a and H2.

	H1a		H2		H2	
	Global dispersion		Number of patents		Novel recombination patents	
Placebo post	-0.011		-0.180		-0.104	
	(0.446)		(0.003)		(0.092)	
Year & Firm fixed effects	Yes		Yes		Yes	
Observations	2110		2035		1841	
Number of firms	639		564		516	

Notes: Fixed effects OLS regressions for H1a. Fixed effects Poisson regressions for H2. All placebo tests follow the exact same specification and include all controls reported in the corresponding main results. *p*-values in parentheses.

Table I.2.b.

Placebo Tests in the Post-Shock Period for H1b and H3.

	H1b		H3		H3	
	Global dispersion		Number of patents		Novel recombination patents	
	Sic 36 & 73	Sic 28	Sic 36 & 73	Sic 28	Sic 36 & 73	Sic 28
Placebo post	0.019	-0.010	-1.000	-0.294	-0.967	0.205
	(0.884)	(0.921)	(0.027)	(0.193)	(0.088)	(0.594)
Year and Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	725	431	696	416	625	388
Number of firms	224	132	195	117	178	110

Notes: Fixed effects OLS regressions for H1b. Fixed effects Poisson regressions for H3. All placebo tests follow the exact same specification and include all controls reported in the corresponding main results. *p*-values in parentheses.

In the post-shock placebo tests, I find evidence of hypothesized results for number of patents but not for dispersion and novel recombination patents. These findings cumulatively lend support to my hypotheses that visa restrictions are associated with a

change in global dispersion of R&D workforce and lower innovation performance of MNEs affected by the shock.

APPENDIX J

MODERATION BY IPR STRENGTH

We also test for moderation of the hypothesized effects by institutional factors. MNEs may increasingly innovate from their subsidiary locations depending on the host country's IPR protection regime (Bruno et al., 2021; Yan et al., 2021; Sofka et al., 2014). In such, I expect the average IPR strength across MNE subsidiary network to positively moderate the relationship between visa restrictions and global dispersion and negatively moderate the relationship between visa restrictions and innovation performance. In other words, higher IPR strength in the subsidiary network should increase the likelihood of MNEs' pursuing R&D projects globally. Consequently, negative innovation performance after visa restrictions should be attenuated as the MNE can pursue innovation projects with dispersed teams as well as it could from its home country. I test if average IPR strength across MNEs' subsidiary network moderates the relationships between the visa restriction, global dispersion, and innovation performance and present the results below.

	H1a	H2	H2
	Global dispersion	Number of patents	Novel recombination patents
Post-shock	0.333 (0.012)	0.402 (0.413)	0.678 (0.123)
Subsidiary IPR strength	-0.348 (0.000)	-0.659 (0.000)	-0.262 (0.008)
Post-shock X Subsidiary IPR strength	-0.063 (0.024)	-0.152 (0.166)	-0.197 (0.041)
Year and Firm fixed effects	Yes	Yes	Yes
R-squared	0.212		
Log pseudolikelihood		-20123	-7254
Observations	4,291	4,250	3,924
Number of firms	707	666	628

Notes: Fixed effects OLS regressions for H1a. Fixed effects Poisson regressions for H2. All estimations tests follow exactly the same specification and include all controls reported in the corresponding main results. *p*-values in parentheses.

Contrary to my expectations, results for H1a from the table above suggest that average subsidiary IPR strength negatively moderates the relationship between visa restrictions and global dispersion. In other words, the greater the average subsidiary IPR strength, the fewer the subsidiary locations across which MNEs pursue innovation projects after visa restrictions are implemented. This is a possibility if MNEs decide to consolidate entire projects in high IPR subsidiary countries instead of operating R&D projects in low IPR subsidiary countries (Zhao, 2006) or splitting projects across locations. As a thought experiment, consider a MNE that intends to move an inventor from Germany (high-IPR) to the U.S. for a project that will be executed by a mixed nationality team comprising Germans located in Germany, Germans located in the U.S. and Americans located in the U.S. This would result in high-dispersion. After visa restrictions are implemented, the MNE may instead decide to ‘ship’ the entire project to Germany to overcome restrictions in moving the focal German inventor to the U.S. This will cause a negative moderation of global dispersion. A t-test comparing mean percentage of single country inventor teams located in high-IPR countries and low-IPR countries revealed that MNEs indeed tend to pursue innovation projects with teams entirely collocated in high-IPR countries ($p < 0.01$) and that this tendency increases after visa restrictions are implemented ($p < 0.01$). This finding explains the contrasting results reported in the table above and is aligned with literature concerning MNE innovation strategies and IPR regimes (Brandl et al., 2019; Bruno et al., 2021).

APPENDIX K

HETEROGENEITY IN INTRA-INDUSTRY KNOWLEDGE CODIFICATION

My study explores industry-specific differences in knowledge codification and their impact on MNE innovation under immigration restrictions. However, I recognize that even MNEs within the same industry can vary dramatically in terms of the extent of their knowledge codification. I undertake preliminary and simple analysis of the intra-industry context and find that my results continue to hold as reported below.

Table K.1 below presents descriptive statistics for the four knowledge codification proxies used in my study. Note that the coefficient of variation (SD/mean) is almost always higher than 1 for all sectors indicating that the intra-industry variance is large relative to the mean. Further, the low codification industry (SIC 28) exhibits dramatically higher variability in all four of my knowledge codification metrics as measured by both range (max – min) and standard deviation. This provides prima facie evidence that intra-industry variability in knowledge codification exists and is higher in sectors where codifiability is lower.

I further examined the intra-industry context. I find that even within an industry, firms with higher knowledge codification (higher values for knowledge codification proxies) demonstrate greater geographic dispersion after implementation of the visa restriction. I examined both high (SIC 36) and low (SIC 28) knowledge codification industries. To perform this test, I randomly selected two firms each from the same industry, one with high values for the knowledge codification proxies and one with low values. Then I compared their dispersion in the post-shock period. Firms in the same industry with higher values of knowledge codification proxies demonstrated greater

dispersion (SIC 28: $p < 0.01$; SIC 36: $p < 0.01$) in the post-shock period, confirming that my theory holds even in within-industry settings.

Table K.1.

Heterogeneity in Intra-Industry Knowledge Codification.

Knowledge codification proxy	Two-digit SIC	Std. dev.	Coefficient of variation	Min	Max	N
Ratio of citations to scientific publications to patents	36	1.15	3.44	0	29.09	988
	73	1.95	2.26	0	31.00	491
	28	8.60	2.17	0	168.00	892
Ratio of self-citations to total citations	36	0.08	1.08	0	0.88	988
	73	0.08	1.42	0	1.00	491
	28	0.14	0.97	0	1.00	892
Ratio of citations to same technology to total citations	36	0.18	0.33	0	1.00	988
	73	0.19	0.36	0	1.00	491
	28	0.19	0.44	0	1.00	892
Number of General-Purpose Technology patents	36	158.85	3.02	0	1,505.00	976
	73	278.52	4.20	0	3,224.00	468
	28	26.19	2.60	0	315.00	881

In sum, I explicitly acknowledge that knowledge codification can vary as much within as between industries. However, my tests do provide some preliminary evidence for the robustness of my theory in within-industry settings.