Did Western CEO Incentives Contribute to China's Technological Rise?*

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Abstract

We study the role of Western CEO incentives in fostering the technological rise of China. Due to China's quid pro quo policy, foreign multinationals face a trade-off between the short-term benefits of accessing China's vast market and the long-term costs of transferring technology to China. Leveraging microdata on the global patent network, we construct multiple measures to describe technological interactions between US firms and over 70 countries. We find that firms managed by CEOs with high-powered incentive contracts form more partnerships with China and transfer more technology to China. These firms subsequently lose R&D human capital to China and face more patenting competition from China, suggesting negative long-term consequences in innovation. We provide evidence consistent with the myopia-inducing instead of the effort-inducing property of high-powered CEO incentives. The paper reveals an important real effect of CEO incentives and highlights a novel channel behind China's technological catch-up. Our findings have wide policy implications, informing both the future design of CEO compensation packages and the regulatory architecture concerning technological interactions with China.

Keywords: Managerial compensation, CEOs, myopia, innovation, technology transfer, patents, China.

JEL classification: F21, F23, F61, G34, O33, O34

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1 Introduction

China's quid pro quo policy (QPQP) is at the center of conflicts between China and Western countries. Foreign multinational corporations (MNCs) face a trade-off between the short-term benefits of accessing China's vast market and the long-term costs of transferring technology to China. In particular, foreign firms are often required to establish joint ventures (JVs) in China to facilitate such technology transfer. While any company doing business abroad will naturally engage in some technology transfer, China's QPQP typically requires firms to transfer technology over and above the level that would occur under free market conditions, especially due to the JV requirements. As a result, over time globally competitive Chinese firms have emerged in many technology-intensive sectors, such as renewable energy, high-speed trains, and turbines. Many foreign business executives, policymakers, and academics attribute China's technological rise to its QPQP.[1]

However, are there any Western-driven factors that may have contributed to China's technological rise? We study foreign MNCs and examine frictions within them that may affect their responses to China's QPQP. A key friction that corporations face is the misalignment of interests between managers and shareholders. To address such misalignment, CEO compensation has undergone a strong shift in its structure, placing more weight on components that are sensitive to financial yardsticks. This development is part of a broader trend towards "financialized governance" (Admati, 2017). In light of the US-China technology conflict, we ask how this shift in CEO compensation structure affects technology transfer to China by shaping the incentives and decision-making of CEOs.

We investigate S&P 1500 firms from 1993 to 2016 and measure CEO incentives using portfolio delta (while controlling for the level of CEO pay), which equals the dollar change

[1]Financial Times (2010): "German Industrialists Attack China," July 18, ft.com/content/e57a722a-928f-11df-9142-00144feab49a. U.S. Chamber of Commerce (2019): "U.S. Chamber Statement on U.S.-China Trade Negotiations", May 10, uschamber.com/press-release/us-chamber-statement-us-china-trade-negotiations. The Economist (2020): "China's Nuclear Industry and High-speed Trains are World Class," January 4, economist.com/technology-quarterly/2020/01/02/chinas-nuclear-industry-and-high-speed-trains-are-world-class (all accessed June 5, 2021).

in the CEO's equity portfolio value for a 1% increase in stock price (Core and Guay, 2002; Coles, Daniel, and Naveen, 2006). We find that US firms managed by CEOs with stronger equity incentives transfer more technology to China than to other countries. The magnitude of the effect is large: a one standard deviation increase in delta translates into 10% more technology transfer to China. To facilitate the transfer of technology, firms form partnerships with Chinese firms. If the CEO has one standard deviation higher equity incentives, the firm is three times more likely to establish JVs and strategic alliances (SAs), including technology-oriented ones, in China. These JVs and SAs are the channel through which the technology transfer is occurring "on the ground." Are these findings of first order importance? If all the firm-years in our sample have a one standard deviation lower delta, 187 fewer JVs in China would be created, corresponding to 36% of all US-Chinese JVs by S&P 1500 firms.

To establish the above findings, we build a firm-country panel describing the technological and investment relationships that US firms form with over 70 countries. We leverage detailed patenting information from PATSTAT Global and USPTO to create measures of technological interactions. First, we follow the work by Lanjouw and Mody (1996) and Eaton and Kortum (1999) in leveraging patent priority rights to trace technology transfer. We consider the number of technologies developed and first patented by a US firm in its home country and subsequently patented in another country as an indicator of the technology transfer from the firm to another country. We call this "duplicate patenting." The main reason for using this measure is that all three major technology transfer channels (trade, FDI, and licensing) result in duplicate patenting (Keller, 2004). So although duplicate patenting itself may not directly measure technology transfer, we show that changes in duplicate patenting track changes in technology transfer, and can therefore be considered a proxy. Second, to assess long-term consequences in an innovation context, we construct three novel measures, all varying at the firm-country-year level: technology sourcing by foreign countries, international migration of R&D human capital, and exposure to foreign competition in patenting. These three variables reflect a firm's global competitive advantage in the technology space.

This comprehensive firm-country panel allows for a difference-in-differences design with an extensive set of fixed effects. By adding firm-year fixed effects, we absorb firm-specific shocks and therefore address concerns related to firm-level unobservables. We also add destination country-industry-year fixed effects, to difference out any country- and industry-specific shocks. Our empirical strategy then compares the differential responses in technology transfer to China and to other countries between firms with different CEO incentives.

To help rule out alternative explanations, we use a quasi-natural experiment that made some firms in our sample change the structure but not the level of CEO compensation. In particular, during the early years of the presidency of Bill Clinton, a legislative change made some firms lower the portion of cash pay and increase the equity-based part of CEO compensation, leading to a rise in portfolio delta. For the firms that were "treated" by this policy change, we find a subsequent increase in technology transfer to China.

There are two potential interpretations for why CEOs with high equity incentives transfer more technology to China. On the one hand, equity incentives can induce effort from CEOs. Entering China and expanding business there likely requires additional effort. Technology transfer may be inevitable during the expansion to China, especially if local production facilities are built. Then our results are consistent with the effort-inducing property of high equity incentives and providing such incentives should be optimal for the firm. On the other hand, since equity incentives tend to vest in the short run, high-powered CEO contracts could have the (unintended) side effect of inducing myopia (Cheng and Warfield, 2005; Bergstresser and Philippon, 2006). CEOs may be more willing to exchange technology for short-term profits in China, which is in the CEOs' personal interest but can hurt the firm in the long run. These two predictions are in line with the theoretical evidence in Goldman and Slezak (2006), which shows that stock-based compensation is a double-edged sword, inducing managers to exert effort but also to be myopic.

We mainly use cross-sectional tests to distinguish between the "effort" and "myopia" interpretations. First, we find that in family firms (which are likely to be long-term oriented) the effect of high equity incentives on technology transfer to China is muted, pointing to the myopia interpretation. Second, we compare CEOs with a long employment history with their firm versus "hired gun" CEOs. The idea is that a long-term employee might care more about the long-run performance of a firm, weakening the incentives of high delta CEOs to transfer technology to China under the myopia interpretation. In contrast, the opposite should be true under the effort interpretation. Our findings are consistent with the myopia interpretation. Third, we consider the corporate governance of firms using the G-index (Gompers, Ishii, and Metrick, 2003). If in our setting the portfolio delta induces myopia (effort), in good corporate governance firms the effect on technology transfer should be weakened (strengthened). Again, we find evidence supporting the myopia story.

Moreover, we explore industry differences by comparing strategic emerging industries (SEIs) that the Chinese government prioritizes versus non-SEIs. In SEIs, the Chinese government likely requires even more technology transfer for market access. Under the effort interpretation, CEOs with high-powered contracts would resist demands for more technology transfer and try their best to reduce the transfer in SEIs. CEOs understand that their firms cannot afford to lose technology–especially in industries prioritized by the Chinese government. Under the myopia interpretation, CEOs would give in to Chinese demands for more technology transfer, since this may boost firm performance quickly and is in line with their personal short-term interest. We find that high delta CEOs transfer even more technology to China in SEIs, providing additional evidence for the myopia interpretation.

A subset of firms offer fixed-length CEO employment contracts. This allows us to directly measure CEO horizon by calculating how many years the CEO has left on the employment contract. Consistent with the myopia interpretation, we find that towards the end of their contracts CEOs transfer more technology to China than earlier in their contracts.

What are the long-term consequences? One may argue that duplicate patenting leads to better protection of firms' intellectual property rights (IPR) in China, and therefore more duplicate patenting benefits, rather than hurts, US firms' long-term prospects. If true, this would cast doubt on our technology transfer measure as well as the myopia interpretation. Evidence on negative long-run implications, on the contrary, would alleviate the concern that duplicate patenting could be capturing the strength of IPR protection. Moreover, it would further invalidate the effort interpretation, which predicts better long-term outcomes when CEOs increase their effort provision in the presence of high equity incentives.

We compare future technological catch-up from China versus other countries for firms with different CEO incentives. Our findings suggest large, negative long-term consequences. First, when producing its own innovation, China sources more knowledge from firms with high equity incentives. Second, we observe more inventors ending their US-based employment for these firms and moving to China to work for a new employer in the next five or ten years. Third, firms managed by high-delta CEOs face stronger future competition from China in the technology space–a one standard deviation increase in delta corresponds to an almost 40% increase in US firms' exposure to Chinese competition in patenting in the next five years. These results highlight that CEOs with high equity incentives play an important role in China's technological rise and may negatively affect the long-term survival of their firms.

We conduct further validation tests for the technology transfer measure. First, duplicate patenting is followed by an increase in both the probability of a citation and the number of citations made to the respective technology from patents developed within the destination country. This result highlights the importance of duplicate patenting in facilitating learning and knowledge transfer. Second, a measurement concern is whether duplicate patenting reflects commercialization of inventions rather than technology transfer. Commercialization should be captured by product innovation, while process innovation is tied to production technology. If patent priority is capturing commercialization (technology transfer), the results should be driven by product (process) innovation. Our results are stronger for process than for product innovation, implying that duplicate patenting is more likely to capture technology transfer than commercialization. Third, one can consider our "channel" results on JVs and SAs as alternative outcome variables for technology transfer.

For robustness, we first show that the results are robust to different econometric approaches to deal with count-based outcome variables. Second, we detect little influence of CEO incentives on technology transfers to other large developing countries or to other Asian countries, further suggesting that China is unique. Third, we demonstrate robustness to the inclusion of an extended list of interaction terms between firm-level or country-level observables and the indicator for China as additional control variables. Last, all results are robust to using two alternative measures of CEO incentives: scaled wealth-performance sensitivity of CEO pay and the share of CEO compensation that is equity- and option-based.

We also provide some prominent examples that are consistent with our quantitative evidence. The highest delta in our sample is for Jack Welch at General Electric (GE) just before his retirement as CEO in 2001. The mean level of technology transfer by GE to China is above the 99^{th} percentile in our sample and it is also the firm with the largest number of JVs in China. Another example is Boeing in 2015. At the end of the CEO's tenure and after he experienced an increase in his delta of 0.8 standard deviations, Boeing announced that for the first time ever it would build a factory outside the US and in exchange it received an order over 300 planes worth $38 bn from China. This factory would be part of a JV with a state-owned Chinese company that has been designated by the Chinese government to one day compete head-to-head with Boeing.

One open question is whether, despite the long-term costs in the technology space, the net present value (NPV) of technology transfer to China can still be positive if the short-term benefits are sufficiently large. Additional evidence on the impact of past technology transfer on future sales growth, on the dynamics of the technology transfer, and from some of the cross-sectional tests points to large additional costs of technology transfer. We acknowledge however that the evidence for the overall effect being negative is only suggestive.

We also argue that the stock market is unlikely to incorporate information about the technology transfer to China into firms' stock prices in a timely manner. First, Cohen, Diether, and Malloy (2013), Hirshleifer, Hsu, and Li (2013), and Edmans, Fang, and Huang

(2022) document that the stock market is not good at pricing the innovative activities of firms. Second, QPQP agreements and technology transfer are not disclosed by firms. In particular, technology transfer is only observable through proxies such as duplicate patenting with a considerable time lag, since no real-time data about technology transfer exists.

Overall, this paper reveals an important real effect of CEO incentives and highlights a novel microeconomic channel behind China's growth and technological rise. Our findings have wide policy implications, informing both the future design of CEO compensation packages and the regulatory architecture concerning technological interactions with China.

Related Literature. Our research contributes to four literatures. First, the paper adds to the literature on CEO compensation. We move away from the typical US firm-level setting and analyze the extensive technological and investment relationships US firms have with other countries. We highlight an important real effect of CEO incentives – technology transfer to China and the implications for Western firms' long-term competitive advantages. Cheng and Warfield (2005) and Bergstresser and Philippon (2006) document a positive relationship between stock and option holdings and myopic behavior in the form of earnings management. Edmans, Fang, and Lewellen (2017) link the quantity of equity vesting in a given period to changes in investment, especially in R&D. Gonzalez-Uribe and Groen-Xu (2017) study the effect of CEO contract horizon on corporate innovation. Edmans, Fang, and Huang (2022) show that CEOs' short-term incentives can have negative consequences for their firms up to four years into the future.

Second, a burgeoning literature on technology transfer and diffusion in a global setting has emerged. Prior work usually focuses on country-level data, while we exploit firm-level data. We focus on knowledge-exporting firms and document that their decisions on technology transfer depend on CEO incentives. We uncover an important micro-channel behind global technology transfer. Previous research has shown the role of foreign direct investment (FDI) (Aitken and Harrison, 1999; Javorcik, 2004; Branstetter, 2006; Keller and Yeaple, 2009), intellectual property rights (Branstetter, Fisman, and Foley, 2006), financial development

(Comin and Nanda, 2019), geography (Comin, Dmitriev, and Rossi-Hansberg, 2012), and legal institutions (Bian, Meier, and Xu, 2020).

This paper also contributes to the literature on China's growth and its technological catch-up. Our paper deviates from prior work by studying firm-specific factors in technology-exporting countries. Song, Storesletten, and Zilibotti (2011) theoretically analyze the role of productive entrepreneurial firms and reallocation. Holmes, McGrattan, and Prescott (2015) assess the impact of China's QPQP on its growth and global innovation in a multi-country dynamic general equilibrium model. Studying the Chinese automobile industry, Bai, Barwick, Cao, and Li (2020) document the role of FDI via quid pro quo in facilitating knowledge spillover. Baslandze, Han, and Saffie (2021) show industry heterogeneity in foreign knowledge spillovers in China.

Last, a nascent literature studies the interaction between the US and China in innovation. We document how US corporations foster future Chinese technological competitors. Hombert and Matray (2018), Bena and Simintzi (2019), and Hoberg, Li, and Phillips (2019) focus on the opposite direction–how the rise of China affects US firms' innovation. Han, Jiang, and Mei (2022) show the variation in Chinese decoupling from and dependence on US innovation over time. Jia, Roberts, Wang, and Yang (2022) document that US-China tensions have affected the productivity of US scientists that collaborate with Chinese ones.

2 Institutional Background

The Chinese Quid Pro Quo Policy. If a foreign MNC wants to do business in China, the usual "price" for market access is technology transfer. In many industries China limits the ownership stake of foreign MNCs in their Chinese subsidiaries to 50%, thereby requiring them to have a local JV partner. Any company doing business in a foreign country will naturally engage in some form of technology transfer, especially if the company not only sells its products and services there but also produces them locally. China's QPQP, however, requires firms to transfer technology over and above the level of technology transfer that would inevitably occur under free market conditions–especially since the JV requirements often force companies to share their technologies and business practices with local firms, thereby training future competitors. Moreover, in many industries it is difficult for foreign MNCs to service the Chinese market only through exports (Chen, Hsieh, and Song, 2022).

An "agreement" of technology transfer in exchange for market access is not formally negotiated in a written contract. Neither is the QPQP encoded in laws or regulations. If China had an official QPQP, it would be easier for Western firms and in particular governments to work against it–for instance, by suing China at the World Trade Organization. Instead the QPQP's existence is not officially acknowledged. This approach also makes it easier for China to deny the practice of forced technology transfer and restricted market access.

What is known about the QPQP usually comes from the on-the-ground experience of foreign businesses or has been pieced together by Western academics and government officials from documents and communications by the Chinese government and the Chinese Communist Party (CCP) (Pillsbury 2015; Doshi 2021). Foreign MNCs are hesitant to publicly criticize this policy, because they are afraid of being singled out for punishment. Instead, foreign companies usually hide behind and voice their criticism of the QPQP (and the theft of intellectual property) through business lobbies such as the US Chamber of Commerce or the European Union Chamber of Commerce in China.[2]

In practice, MNCs that comply with the QPQP are allowed to pursue their business. Companies that are particularly willing to engage in technology transfer are rewarded with access to the vast market for government procurement and by government entities or state-owned enterprises (and potentially even private companies) being directed to do business with them. Companies that are not seen as compliant may be punished by, e.g., the withholding of construction permits or product licenses, or environmental or tax audits. For more detail on the QPQP, including examples, foreign criticism of the QPQP, "Made in China 2025," and a discussion of whether such a forced technology transfer policy is unique to China, see

[2]For example, see European Union Chamber of Commerce in China and Roland Berger 2021.

Appendix A.

The above discussion illustrates a powerful trade-off faced by MNCs intending to do business in China. On the one hand, the MNC can reap vast short-term profits if it concedes to the QPQP. On the other hand, in the long-run the MNC is nurturing its future technological competitors. In several industries where consumers in North America and Western Europe are nowadays used to the dominance of Chinese firms, China slowly built up its technological capabilities in the 1990s and 2000s, usually with the help of Western joint venture partners. Chinese firms then out-competed Western firms in the Chinese market before eventually dominating the world markets in these industries. Examples include consumer electronics and household appliances. In more high-tech industries, for example, such as telecommunications equipment and information technology, the Chinese company Huawei (which in the past had numerous JVs with Western firms) is now at the technological frontier.

3 Data, Measurement, and Empirical Strategy

Combining several international data sources, we build a firm (i) × country (c) panel describing the technology and investment relationships a US public firm forms with each country over time (t). Below we discuss variable measurement and sample construction in detail, leveraging data sources described in Appendix B.

3.1 Measurement

CEO Incentives. We mainly measure CEO incentives using CEO equity portfolio delta, which captures CEO equity-related incentives and their wealth-performance sensitivity. Specifically, delta is defined as the dollar change in equity portfolio value for a 1% increase in stock price. To calculate this measure, we follow the approach used in Core and Guay (2002), and Coles, Daniel, and Naveen (2006). Since the typical vesting period of equity-related incentives for CEOs is just three years, while the negative effects of technology transfer only manifest over a longer time horizon, equity incentives can tilt CEOs' trade-off between the short-term benefits of accessing the Chinese market and the long-term costs of transferring technology to China (Cheng and Warfield, 2005; Bergstresser and Philippon, 2006).[3] We standardize the equity portfolio delta measure so that it has a mean of 0 and a standard deviation of 1 to ease the interpretation of the results. Nevertheless, we also use raw values (in thousand $) to ensure the robustness of our results (see Table A.7). Importantly, we also adopt alternative measures, including CEO compensation mix (Harris and Bromiley, 2007; Larcker, Richardson, and Tuna, 2007), scaled wealth-performance sensitivity (Edmans, Gabaix, and Landier, 2009), and the time remaining until the end of fixed-term CEO employment contracts (Cziraki and Groen-Xu, 2020; Gonzalez-Uribe and Groen-Xu, 2017).

Technology Transfer. We measure technology transfer using data on patent priority rights. A priority right is triggered by the first filing of a patent application. The claimant can file a subsequent patent application in another country for the same invention, effective as of the filing date of the first application. The number of technologies developed and first patented by firm i in the US and subsequently patented in country c is used as an indicator of the number of inventions transferred from firm i to country c. This approach of leveraging patent priority rights to trace technology transfer has been established by Archibugi and Michie (1995), Lanjouw and Mody (1996), Eaton and Kortum (1999), Dechezlepretre, Glachant, Hascic, Johnstone, and Meniere (2011), and Bian, Meier, and Xu (2020). Relatedly, Branstetter, Fisman, and Foley (2006) show that royalty payments by foreign affiliates of US MNCs to their parent companies and patent filings by these MNCs in the host countries of their foreign affiliates are highly positively correlated, which Branstetter, Fisman, and Foley (2006) interpret as technology transfer from the US to abroad. The fact that firm i patents its existing technology in country c ("duplicate patenting") indicates a transfer, because patenting offers the exclusive right to commercially exploit the technology in the country where the patent is filed. The patents underpinning the same technology together

[3] It takes time for China to digest, adapt, and advance foreign technology. An example is mechanical engineering, such as the production of (heavy) construction equipment, where despite working with Western joint venture partners such as Caterpillar or Liebherr, it took Chinese companies such as Sany and XCMG more than two decades to develop a significant presence outside the Chinese market.

form a patent family.

To create our technology transfer measure, we start with all patents by firm i and identify foreign applications with the same underlying technology (i.e., in the same patent family), using PATSTAT Global. We then count the (citation-weighted) number of patents in each country-year with priority traced back to firm i.

We argue that duplicate patenting is a good measure of technology transfer. Keller (2004) identifies three channels of technology transfer and diffusion: trade, foreign direct investment (FDI), and licensing. There is a partial "trace" of all three transfer channels in duplicate patenting. Firms rely on patent protection in foreign countries since any type of technology transfer would raise the risk of leakage and imitation in destination countries. In fact, previous studies document a highly positive correlation between trade and duplicate patenting. Moreover, duplicate patenting is often used conditional on the existence of a licensing agreement. So although duplicate patenting itself may not be a direct measure of technology transfer, its changes will closely track the changes in technology transfer, and can therefore be considered a proxy.

To further validate the measure, we perform a couple of comparisons that relate Keller's three channels of technology transfer and diffusion with duplicate patenting. First, we correlate duplicate patenting with trade and FDI, respectively. Figure 1a shows that the number of duplicate patents by US firms in China and the value of Chinese imports from the United States increase in tandem. Figure 1b similarly shows that the number of duplicate patents by US firms in China and the cumulative amount of FDI from the US in China move in lockstep. Second, we examine the number of S&P 1500 firms that invest or patent in China over time. Figure 2 shows that the number of firms with duplicate patenting in China tracks closely with the number of firms forming partnerships with China. This holds when we include a wide range of cross-border partnerships including JVs, SAs, and any technology-driven relationships (Figure 2a) or when we restrict to technology-driven relationships only (Figure 2b). Third, we look at the cross-sectional dimension of the time-series relationship in the prior figure. Figure 3 plots the number of unique S&P 1500 firms that invest in China against the number of S&P 1500 firms that file for duplicate patents in China across different two-digit SIC industries from 1993 to 2016. Figure 3a includes all cross-border partnerships, including JVs, SAs, and any technology-driven relationships. Figure 3b includes only technology-driven relationships. In both cases, the fitted line shows a strong positive correlation between the two variables.

We also provide evidence that duplicate patenting is followed by a surge in technology sourcing from destination countries. More specifically, we compare citations to the same patent family from destination countries with and without duplicate patenting (or with earlier and later duplicate patenting) of the same underlying technology. The results are presented in Table A.1. After the duplicate filing, we detect an increase in both the probability and the number of citations made to the respective patent family from patents developed within the destination country. This finding illustrates the importance of duplicate patenting in facilitating learning and knowledge transfer, further supporting the close relationship between duplicate patenting and technology transfer.

Why do firms not always file for duplicate patents around the world? The World Intellectual Property Organization estimates that obtaining and maintaining the patent protection on a single invention in the 50+ most important countries costs approximately half a million US-dollar over the 20-year life of a patent family.[4] On the one hand this cost is not insignificant. On the other hand, this expense is also not prohibitively high, especially for an S&P 1500 firm. The costs of duplicate patenting make it likely that a firm only pays for it in those markets in which it transfers the technology to, but not in other countries. This is further supported by the evidence in Bian, Meier, and Xu (2020). They show that filing a duplicate patent for a medical drug in a country increases the probability of introducing a drug in that country by 6.2 times. Conversely, launching a drug in a country increases the probability of a duplicate patent filing in that country by 3.5 times.

[4] World Intellectual Property Organization: "Where in the World Should I File?" wipo.int/export/sites/www/pct/en/pct$_{s}$*trategies/filing.pdf* (accessed February 5, 2023).

Cross-Border Partnerships. To explore the potential channels through which technology transfer takes place, we construct dummy variables indicating different types of partnerships that are formed between firm i and country c at year t. We focus on JVs, SAs, and technology-oriented partnerships.[5]

Technology Sourcing by Foreign Countries. To assess the long-term consequences in an international and R&D context, we construct novel measures based on granular patenting data, all varying at the firm-country level. We first count the number of (granted) patent applications by country c in each year that cite US firm i's existing patent portfolio. Thereby, we determine the usage of firm i's technology by country c in producing its own innovation. We can interpret this measure as the amount of technology a country sources from a US firm when generating new knowledge of its own.

International Inventor Migration. Using the comprehensive information on US inventors' locations from USPTO PatentsView, we next count the number of inventors who were affiliated with firm i and move from the US to country c in each year. We double check that, after moving, these inventors are no longer affiliated with firm i. Furthermore, to take into account that inventors differ vastly in their productivity levels, we value weight the migrating inventors according to their pre-migration patenting output.[6]

Exposure to Foreign Competition in Patenting. To calculate this measure, we start by computing the share of each country's patents in every technological area (3-digit or 4-digit international patent classification or IPC codes), denoted by $\omega_{c,ipc,t}$. We then identify the areas of expertise of each firm by examining its patent portfolio and calculating the share of each IPC code in this portfolio, denoted by $\alpha_{i,ipc,t}$. Finally, we aggregate it to firm-country-level according to this equation:

$$Exposure_{i,c,t} = \sum_{ipc} \omega_{c,ipc,t} \times \alpha_{i,ipc,t} \tag{1}$$

Therefore $Exposure_{i,c,t}$ captures the share of country c's patents in a US firm's areas of ex-

[5]Technology-oriented partnerships include any licensing, technology transfer, and R&D collaborations.

[6]See Akcigit, Baslandze, and Stantcheva (2016) and Akcigit, Caicedo, Miguelez, Stantcheva, and Sterzi (2018) for a discussion of star inventors and their productivity.

pertise. Equivalently, this measure captures firm-specific technology catch-up or competition pressure in patenting from each country.

3.2 Summary Statistics

Our firm-country panel is from 1993 to 2016, covering all S&P 1500 firms with no missing information in ExecuComp and Compustat. For partner countries, or transfer destination, we end up with 73 countries with significant patent offices – having issued more than 1,000 patents in PATSTAT Global by 2016. We start the sample from 1993, since the coverage on executive compensation in 1992 and earlier years is sparse. We end the sample in 2016 to avoid truncation bias issues in patenting data.

Panel A of Table 1 shows summary statistics for CEO compensation and firm characteristics. For an average firm in our sample, the CEO receives total annual compensation of 5 million USD. Equity portfolio delta is around 0.65 million USD, implying that for a 1% increase in stock price, the CEO's equity portfolio value goes up, on average, by 650,000 USD. Delta varies substantially across firms and over time, with a standard deviation of 1.56. These summary statistics are close to the ones in previous studies on CEO compensation, such as Coles, Daniel, and Naveen (2006). S&P 1500 firms are large and the value of their total assets is over 12 billion USD on average. They have a moderate level of debt, with an average book leverage ratio of 0.229. The sample firms also seem to have good growth opportunities, with an average Tobin's q of 1.97. Concerning other firm characteristics, profitability has a mean of 0.124, Capex (capital expenditure to total assets ratio) has a mean of 0.054, and R&D intensity (R&D expense to total asset ratio) has a mean of 0.031.

Panels B and C of Table 1 present summary statistics for outcome variables. Our final sample includes close to 3 million firm-country-year observations. For duplicate patenting, we take the log of raw patent count or citation-weighted count since the distribution of raw values is skewed. The mean values after taking logs are 0.0518 and 0.136, respectively, for the raw count and citation-weighted patent count. The unconditional probability of a sample firm forming new partnerships with local players in each year is low, around 0.1% to 0.2% depending on the type of partnerships. Panel C covers variables we use to examine long-term technological outcomes. Similarly, we take log values for technology sourcing and international inventor migration. For exposure to foreign competition in patenting, we report an average value of 0.414 at the IPC 3-digit level. This means that for a typical sample firm, in the technological area it specializes in, 0.414% of all patents in the next five years are filed by an average foreign country. The statistics are similar when we calculate this exposure measure using technology classes defined at a more granular, IPC 4-digit level.

3.3 Empirical Strategy

To trace the effect of CEO incentives on technological and investment interactions with China, we conduct regressions with high dimensional fixed effects. In spirit, our approach is similar to a differences-in-differences (DID) research design. The regression equation is

$$Y_{i,c,t\ (or\ \ t+T)} = \boldsymbol{\gamma_{i,t}} + \boldsymbol{\alpha_{c,t}} + \beta Delta_{i,t} \times CN_c + \boldsymbol{\theta' X_{i,t}} \times CN_c + \varepsilon_{i,c,t} \quad (2)$$

where i denotes firm, c denotes country, and t denotes year. The dependent variable $Y_{i,c,t}$ is a measure of technology transfer from firm i to country c in year t, or one of the future technological outcome measures between country c and firm i (T years after t, hence the subscript t+T). The variable of interest is $Delta_{i,t} \times CN_c$, which is an interaction term between the measure of CEO incentives, or portfolio delta, and a dummy variable that equals one when the destination country is China and zero otherwise. Variables capturing firm-level characteristics are summarized in $X_{i,t}$ and can include CEO total salary, firm size, profitability, leverage, Tobin's q, capital expenditure, and R&D intensity, depending on the specification. For easier interpretation of the results, delta and other firm-level variables are standardized to have a mean value of zero and a standard deviation of 1.

Importantly, we include two sets of fixed effects. One is $\gamma_{i,t}$, or firm-year fixed effects, which absorb firm-specific shocks such as time-varying investment opportunities at the firm level. The other is $\alpha_{c,t}$, or country-year fixed effects, which absorb country-specific shocks such as changing regulatory or macroeconomic environment (Donges, Meier, and Silva, 2022). We further include more granular country-industry-year fixed effects, or $\alpha_{k,c,t}$, to difference out any shocks affecting a specific industry (measured at the 3-digit SIC level) in any country. These fixed effects substantially limit the set of confounders that can plausibly explain our findings. We double cluster standard errors at both the firm level and country level.

Our coefficient of interest, beta, reflects the differential responses in technology transfer, or other outcome variables, to China and to other countries, between firms with different CEO incentives. To ensure comparability, instead of including all other countries, we compare China with other large developing countries or countries in the same region. In particular, we compare China with other countries in BRIC (an acronym standing for Brazil, Russia, India, and China), and the regression equation becomes:

$$Y_{i,c,t\ (or\ \ t+T)} = \boldsymbol{\gamma_{i,t}} + \boldsymbol{\alpha_{k,c,t}} + \beta Delta_{i,t} \times CN_c + \rho Delta_{i,t} \times BRIC_c + \boldsymbol{\theta' X_{i,t}} \times CN_c + \varepsilon_{i,c,t} \quad (3)$$

We use this as the main setting to study all outcome variables, including technology transfer, cross-border partnerships, and future technological outcomes.

4 Technology Transfer Results

4.1 Baseline Effects

We start by quantitatively analyzing the effect of CEO incentives on technology transfer to China. For anecdotal evidence, see Appendix A. Using the specification in Equation 2, columns (1) and (2) of Panel A in Table 2 report OLS regression results for the amount of duplicate patenting by US firms in foreign patent offices. We include country-year fixed effects to control for country-specific shocks and firm-year fixed effects to difference out all time-varying unobserved firm heterogeneity. The positive coefficient on $Delta \times CN$ suggests that US firms managed by CEOs with higher equity incentives transfer a larger amount of technology to China compared with technology transfer to other countries. This effect holds when we use either a simple count of duplicate patenting (column (1)) or a citation-weighted count (column (2)). According to column (2), the magnitude of the effect is economically significant: a one standard deviation increase in CEO equity incentives results in over 10% more technology transfer to China.

One identification concern is that our results could be driven by time-varying investment opportunities within a given sector in China. If this is true, comparing technology transfer to China versus other countries across firms in different industries would lead to a spurious relationship between CEO incentives and technology transfer to China. To address this concern, in columns (3) and (4), we add more granular country-industry-year fixed effects to control for any industry-specific shocks in a given transfer destination country. Since shocks in unobserved investment or growth opportunities of any market tend to be industry- rather than firm-specific, these fixed effects greatly reduce estimation biases from omitted variables. We therefore include them in all subsequent regressions.

One may worry that the size of CEO pay rather than its composition explains our findings. In columns (5) and (6), we further add the interaction term between total CEO compensation and the indicator for China to the regression. We still observe a highly significant coefficient on $Delta \times CN$, and the magnitude only goes down by around a quarter, suggesting that our results are predominately driven by the equity incentives embedded in the CEO compensation package rather than the total size of it. Going forward, all regression models include an interaction term of ln(TotalPay) and China.

Across all specifications, we observe a larger effect when the dependent variable is the citation-weighted number of patents than we do when it is a simple count. This suggests that US firms managed by CEOs with high equity incentives transfer not only a larger quantity of technology but also more impactful and valuable technology to China.

To improve comparability, we examine China versus other large developing countries or countries in the same region in Panel B of Table 2. The regressions follow the specification in Equation 3. In columns (1) and (2), we detect little influence of CEO incentives on technology transfers to other BRIC countries since the coefficient on $Delta \times BRIC$ is small and insignificant. In contrast, the coefficient on $Delta \times CN$ remains highly significant and is quantitatively very similar to that in columns (5) and (6) in Panel A. In addition to comparing China with other BRIC countries, we use economies in the same geographical area as China as an alternative benchmark group. Columns (3) and (4) present the results. We find that CEO incentives do not affect technology transfer to other Asian countries, but the point estimates remain large and quantitatively similar for the variable of interest. Taken together, this suggests that our results are likely to be driven by China's unique QPQP and foreign firms' heterogeneous responses to this policy.

4.2 A Quasi-Natural Experiment for the Structure of CEO Pay

One may be concerned that technology transfer to China and CEO compensation are endogenously determined by unobservable factors that cannot be controlled for by the large set of fixed effects in the above analysis. To address this concern, ideally one needs random variations in the structure of CEO compensation. However, since firms do not set CEO compensation randomly, the second best is to use a quasi-natural experiment that would generate plausibly exogenous variations in CEO incentives. We exploit a legislative change in the US that caused a change in the structure of CEO compensation, but little change in the level, for a specific subset of firms.

In 1992-1993, the SEC required enhanced disclosure on executive compensation and the US Congress enacted tax legislation limiting the deductibility of non-performance related compensation over *one million dollars* through Internal Revenue Code Section 162(m). Perry and Zenner (2001) document that the structure of CEO pay moved substantially from cash- to equity-based compensation (stock and option awards) for affected million-dollar-pay firms after 1993.[7] Leveraging this strong observation in Perry and Zenner (2001), we design a differences-in-differences strategy in which we compare firms that are affected by this legislative change versus those unaffected or less affected, before and after the implementation

[7] In the sample of Perry and Zenner (2001) the mean and median levels of total CEO compensation for 1992 are \$1.77 and \$1.08 million, respectively.

year. Treatment is determined by a million-dollar-firm (MDF) measure. Following Perry and Zenner (2001), we first define a continuous treatment variable that equals one if the cash pay in 1993 is above $1 million, and the raw dollar amount (in millions) otherwise. The idea is that the closer the CEO pay to the $1 million threshold, the more likely it is that the firm is affected. Second, we also define an indicator that equals one if the cash pay in 1993 is between $0.9 and $1.5 million, as Perry and Zenner (2001) argue that this group of firms is most likely to react to the legislative change. Treated firms are expected to experience an increase in their technology transfer to China after 1993, since their CEO compensation shifts from cash- to equity-based, driving up the portfolio delta.

Implementing the above test requires outcome measures before 1993, while in our main analysis the sample starts from 1993 since the coverage of CEO compensation by ExecuComp only starts around then.[8] For our outcome variable on technology transfer, however, we are not constrained by 1993 as a starting year. We thus further calculate the technology transfer measures for 13 more years, going back to 1980. We choose 1980 as the start year because this is when China opened its economy to the outside world after Deng Xiaoping established his position as China's paramount leader.

Table 3 reports the regression results. In columns (1) and (2), we use the continuous treatment variable. We detect a positive and significant coefficient on the triple interaction term, suggesting that treated MDFs transfer a disproportionally large amount of technology to China relative to other countries after 1993 compared with non-MDFs.[9] Moving to columns (3) and (4), we use a dummy variable indicating a cash pay in the year 1993 between $0.9 million and $1.5 million. Again, we observe a highly significant and positive coefficient on the triple interaction term. Throughout the table we control for the effect of the level of pay by including a triple interaction term between the log of total pay in the

[8]The treatment status is determined by the CEO compensation in the year 1993 and we do not need earlier CEO compensation data to determine treatment status.

[9]According to the point estimate in column (1), moving from $0.8 million to $1.2 million cash pay in 1993, the increase in technology transfer to China around the legislative change is 0.2×0.582=11.6% higher compared with the increase in other countries.

year 1993, a post-1993 indicator, and a China indicator. Taken together, this test sharpens the identification of the effect of CEO incentives on technology transfer to China.

4.3 Measure Validation and Robustness Tests

We conduct a validation test of the outcome variable and a battery of robustness checks to further strengthen our baseline findings.

Commercialization vs. Technology Transfer. A measurement concern is that duplicate patenting might capture the commercialization of inventions in the destination countries rather than technology transfer to these countries. To address this concern, we leverage data from Bena and Simintzi (2019) that distinguish between product and process innovation. The idea is that product innovation is tied to commercialization of products and services. In contrast, process innovation is more about production technology and the potential transfer of such technology. If duplicate patenting is exclusively about commercialization in China, the effect of CEO incentives should be driven by product innovation rather than process innovation. If duplicate patenting instead captures technology transfer, we should observe the opposite. We interact the share of process innovation with $Delta \times CN$ in a triple differences research design.[10] In columns (1) and (2) of Table A.2, process share is calculated using all claims in a patent application. In columns (3) and (4), we take into account only independent claims. In all four specifications, the triple interaction term has a positive and significant coefficient, suggesting that the increase in duplicate patenting is more driven by firms that specialize in process innovation. Therefore, duplicate patenting is more likely to capture technology transfer than commercialization, providing validation for our measure.

Poisson Regression. In our baseline specification, we use log of 1 plus duplicate patenting as the outcome variable. While this allows us to include high dimensional fixed effects, such as country-industry-year and firm-year fixed effects, Cohn, Liu, and Wardlaw (2022) point out that estimates using this approach may suffer from inherent biases. Following

[10] For data availability reasons the share of process innovation for each firm is defined at the 2-digit SIC code level.

their suggestions, we implement Poisson regressions using the raw count data. The results are reported in Table A.3, in which we include specifications with different controls. The coefficients on the interaction term are consistently positive and significant, suggesting that US firms managed by CEOs with high-powered incentives transfer more technology to China.

Additional Controls. One may argue that other firm-level characteristics such as R&D intensity might determine firms' global technology policy instead of CEO incentives. At the same time, these characteristics could be correlated with CEO compensation, leading to a spurious relationship between CEO incentives and technological interactions with China. Another concern is that Western multinationals might incentivize CEOs to transfer technology to large and fast-growing markets to better exploit the growth opportunities offered by these markets, while the role of government investment policy in emerging markets might only be of secondary importance. To address these concerns, we add an extended list of interaction terms between firm-level or country-level observables and the indicator for China as additional control variables. [11] The coefficients on $Delta \times CN$ remain similar, both quantitatively and qualitatively, to those in the baseline model, as shown in Table A.4.

Other Incentive Measures. We rerun our main analysis using scaled wealth-performance sensitivity (WPS) and equity pay share as alternative measures for CEO incentives. Columns (1) and (2) of Panel A in both Table A.5 and Table A.6 show that firms with a higher WPS or a greater share of equity-linked CEO pay transfer more technology to China. Our findings are also robust to using the raw values of CEO equity portfolio delta (in thousand $), instead of a standardized measure, as can be seen in columns (1) and (2) of Panel A in Table A.7.

Alternative Samples and Industry Definition. We focus on large MNCs by excluding firms with total assets below 1 billion USD from the analysis. We also drop all European countries from the sample. This is because within the European Union firms can file for patent protection either with national patent offices or the European Patent Office (EPO), complicating the measurement of destination countries for any technology transfer. Our

[11] Firm-level variables include size, profitability, leverage, Tobin's q, capex, and R&D intensity. Country-level variables include GDP per capita, GDP per capita growth, population, and population growth.

baseline results are robust to these alternative sampling criteria, as shown in Panel A of Table A.8. We further show that our results are robust to alternative industry definitions at the 2-digit or 4-digit SIC level (see Panel B of Table A.8).

4.4 Effort Interpretation vs. Myopia Interpretation

There are two potential interpretations for why CEOs with high equity incentives transfer more technology to China. On the one hand, equity incentives can induce effort from CEOs. Since developing China's market likely requires extra effort from executives, firms could give their CEOs high equity incentives to induce this effort. At the same time, technology transfer may be inevitable during expansion to China, especially if the firm sets up production facilities there. Then the relationships we observe are consistent with the effort interpretation and providing such incentives could be optimal for the firm.

On the other hand, since equity incentives tend to vest in the short term, high-powered CEO contracts could have the (unintended) side effect of inducing myopia.[12] CEOs may be more willing to exchange technology for short-term profits in China, which is in the CEOs' personal interest but can hurt the firm in the long run. For instance, the Chinese government can ease a firm's access to the government procurement market or lean on state-owned enterprises to redirect purchases to particular Western MNCs. Such actions can quickly boost a Western multinational's sales and profits. Interestingly, in a survey by Graham, Harvey, and Rajgopal (2005), 78% of executives admit that they would be willing to harm long-run firm value if this would help to meet short-term earnings targets.

We mainly use cross-sectional tests to distinguish between the effort interpretation and the myopia interpretation, including three tests exploiting variation at the firm level and one test with variation at the industry level. These cross-sectional variations point to different predictions under the effort interpretation and the myopia interpretation. We additionally provide a more direct test to disentangle the two interpretations using variations in CEO

[12] Cheng and Warfield (2005) and Bergstresser and Philippon (2006) document a positive relationship between equity-based pay and myopic behavior.

contractual time horizon.

A. Family Ownership. We first examine the ownership structure of firms. We define family firms as those partly owned by the family of the firm's founder, including heirs and the founders themselves. These firms tend to have more long-term oriented investment horizons. The "family" might monitor the CEO's actions, and their presence may mitigate the effects of CEO short-termism under the myopia interpretation. In contrast, under the effort interpretation a more long-term orientated shareholder base should induce CEOs with high equity incentives to transfer even more technology to China. We use data on family ownership from Anderson and Reeb (2004) and Anderson, Reeb, and Zhao (2012).[13] Columns (1) and (2) of Table 4 present our findings with a triple-difference empirical design, in which the indicator variable $Family\ Ownership$ equals one if family ownership is above 5%. The coefficient on the triple interaction term $Delta \times CN \times Family\ Ownership$ is negative and significant, suggesting that CEOs become less responsive to their equity incentives if their employers are family firms. This finding is consistent with the myopia interpretation.

Interestingly, the previous literature has frequently pointed out negative aspects of family ownership, especially with respect to the corporate governance of family firms (see Villalonga, Amit, Trujillo, and Guzmán (2015) for a survey). The above finding unearths a previously undocumented and likely positive aspect of family firms.

B. CEO Employment History. We next investigate the CEO's employment history with the firm. The idea is that if one works for a firm for a long time, one might form a personal attachment with the firm that creates additional incentives to always act in the best interest of the firm. In the effort interpretation, a "life-long" employee turned CEO with a high delta should transfer more technology to China than a "hired-gun" CEO with a similar delta, since more technology transfer is optimal for the firm. In contrast, if the myopia interpretation applies and more technology transfer to China hurts the firm in the long run, a CEO with

[13] Anderson, Reeb, and Zhao have extended the data on family firms beyond the data used in Anderson, Reeb, and Zhao (2012), so the combination of these two papers provides us with data on family ownership for our entire sample period from 1993 to 2016.

a longer employment history would transfer less technology to China. We consider not just the time as CEO, but the total length of the employment history of a CEO with the firm. Data on when a CEO joined a firm is reported by ExecuComp. We compute a dummy if the length of a CEO's employment history is above the median for all CEOs in our sample. As can be seen from columns (3) and (4) of Table 4, the point estimates for the triple interaction term are negative, supporting the myopia interpretation.

C. Corporate Governance. Third, we consider the role of corporate governance. If portfolio delta induces myopia, the effect on technology transfer should be weakened in firms with good corporate governance. In contrast, under the effort interpretation, in firms with good corporate governance the effect of delta on technology transfer should be even stronger. We use data by Gompers, Ishii, and Metrick (2003) on the corporate governance of firms. They call firms with a G-index of 5 or less the "democracy" portfolio–firms with very good corporate governance. We thus create a dummy that equals 1 if a firm falls into the "democracy portfolio" and 0 otherwise.[14] Columns (5) and (6) of Table 4 present our findings, using a triple-difference design with *Governance* interacted with $Delta \times CN$. The negative point estimate is in line with the myopia interpretation.

D. China's Strategic Emerging Industries. We continue by exploiting industry-level heterogeneity. We compare strategic emerging industries (SEIs), which are at the center of the Chinese government's industrial policy, to non-SEIs. In SEIs, the Chinese government likely requires even more technology transfer in exchange for market access–a more stringent QPQP. Under the effort interpretation, CEOs with high-powered contracts would resist Chinese demands for more technology transfer and try their best to reduce the transfer in SEIs. CEOs understand that their firms cannot afford to lose technology to China, especially in industries prioritized by the Chinese government since Chinese efforts to catch up with Western firms will be particularly intense in these industries. On the contrary, under the

[14]We follow standard practices in the literature to deal with data availability issues with the G index. From 1990 to 2006 the data is available every two or three years. If the data on the G index of a firm is not available for a given firm year, we use data on the last year data was available. For firms for which the data is available for 2006, we also use this data for 2007 to 2010.

myopia interpretation, CEOs would give in to Chinese demands for more technology transfer, since this may boost firm performance quickly and is in line with their personal short-term interest. Moreover, for SEIs the Chinese government might be more willing to reward (or punish) Western firms, e.g., with favored access to the government procurement market. This would increase the short-term incentives for Western firms to engage in technology transfer in these industries.

We classify industries into SEIs and non-SEIs according to the strategic emerging industries catalogue compiled by State Council ministries in China.[15] The dummy variable SEI indicates firms that specialize in these strategic emerging industries. Columns (7) and (8) of Table 4 report our findings. The positive and significant coefficient on the triple interaction term $Delta \times CN \times SEI$ supports the myopia interpretation since the estimate suggests that CEOs react to their short-term incentives by transferring even more technology to China in SEIs. Since we observe a stronger effect where this policy has more bite, this cross-industry test highlights the role of China's foreign investment policy and managerial incentives of Western firms in technology transfer decisions.

E. CEO Horizon. Using fixed-term CEO contracts, one can directly measure CEO horizon by calculating the time remaining until the end of the contract. One drawback is that such contracts are rather rare and skew towards smaller firms (Cziraki and Groen-Xu, 2020). Nevertheless, we conduct tests using the CEO contractual horizon measure from Cziraki and Groen-Xu (2020). This alternative measure allows us to exploit within-firm variation in how many years a CEO has left on their employment contract. Table 5 shows evidence consistent with the myopia interpretation. More years left on the contract translate into less technology transfer to China, as evidenced by the negative coefficients on the interaction term throughout all specifications.

Taken together, all the above tests support the myopia interpretation. Alternative stories must explain (1) why high CEO equity incentives are associated with a greater amount of

[15] See Kenderdine (2017) and documents from the US-China Business Council.

technology transfer to China than to other countries, (2) why this relationship is more pronounced in firm- and industry-subsamples for which the myopia interpretation applies, and (3) why this relationship is weakened when CEOs have more years left on their contracts.

4.5 Dynamics

We continue by investigating the dynamics of the effect of CEO incentives on technology transfer to China over time. There are two opposing predictions. On the one hand, Western multinationals might have initially underestimated how successful China is in appropriating Western technology and using the technology transfer to create globally competitive firms. On the other hand, the ability of the Chinese government to extract concessions from Western multinationals in the form of technology transfer is likely correlated with the size of the Chinese market and thus increasing over time.

In Table 6, we divide our sample period from 1993 to 2016 into six equal sub-periods of four years. Panel A reports the results for the equally-weighted duplicate patenting variable, while Panel B reports the citation-weighted duplicate patenting variable. The pattern in the estimates is very similar across the two panels. In Panel A, the point estimates for the six periods are, in chronological order, 0.011, 0.057, 0.076, 0.086, 0.063, and 0.026. These point estimates are all statistically significant at the 1% level and most point estimates are statistically significantly different from each other. The dynamics of the estimated effect indicate an inverse "U"-shaped relationship, with the effect of CEO incentives on technology transfer to China peaking in the 2000s. The dynamics reveal the changing balance of power in the interactions between Western firms and the Chinese government. This inverse "U"-shaped pattern is consistent with the evidence in Han, Jiang, and Mei (2022) that Chinese technological integration with the United States peaked around the 2008/9 financial crisis.

4.6 Channels: Cross-Border Investment Partnerships

To explore the channels through which technology transfer takes place, we study the foreign investments made by our sample firms. We track cross-border partnerships formed by US firms and local players in each country and ask if CEO incentives differentially affect the likelihood of establishing partnerships with China versus other countries. Our regression specification follows Equation 3 and the dependent variables are indicators for the formation of a new JV, SA, or technology-driven relationship by the respective US firm in a foreign country in any given year. Table 7 reports the results.

The coefficient on $Delta \times CN$ in column (1) is positive and significant, suggesting that US firms managed by CEOs with high equity incentives are more likely to form JVs in China than in other countries. We move to SAs in column (2) and observe the same pattern. In column (3), we focus exclusively on technology-related partnerships, including licensing, technology transfer, and R&D collaborations. Again, we observe more technology-driven relationships formed with local partners in China when firms are managed by CEOs with high equity incentives. According to the point estimates, a one standard deviation increase in *Delta* can more than triple the likelihood of US firms establishing JVs or SAs, including technology-related relationships, with China.[16] These organizational vehicles facilitate the transfer of valuable technology from US firms to their Chinese partners.

We quantify the importance of our results. How many fewer JVs would there be, if all firm-years in our sample have a one standard deviation lower delta? The calculation is $37,481 \cdot 1 \cdot 0.005 = 187$ fewer JVs. The regression coefficient we are interested in ($Delta \times CN$) is at the firm × country × year level. But since the estimated coefficient is specific to China, this corresponds to the firm × year level. 37,481 is the number of firm-years in our sample (see Panel A of Table 1). Delta is standardized to a mean of 0 and a standard deviation of 1. 0.005 is the point estimate for delta in column 1 of Table 7, where the creation of a new JV is the dependent variable. Relative to a total of 516 JVs created in China by the firms in our sample, this corresponds to a 36% decline. The 36% decline in this back-of-the-envelope calculation suggests that the effect of Western CEO incentives on China's technological rise

[16]The findings in columns (3) to (5) of Panel A in Table A.5, Table A.6, and Table A.7 show that the results are robust to the use of the wealth-performance sensitivity, the equity-linked pay share, and the raw equity portfolio delta in thousands of dollars as alternative measures of CEO incentives.

is quantitatively large.[17]

5 Long-Term Technological Outcomes

So far we have presented evidence on technology transfer to China and cross-border partnerships formed with Chinese local partners. An important question for businesses and their owners, policymakers, and the stakeholders of firms is what the long-term consequences of this technology transfer are. One may argue that duplicate patenting actually leads to better protection of US firms' intellectual property rights in China and therefore more duplicate patenting can benefit, rather than hurt, US firms' long-term prospects. If true, this would invalidate the myopia interpretation of the effects of high equity incentives. Evidence on negative long-run implications, on the contrary, would support our interpretation that high equity incentives lead to managerial myopia, pinpointing the trade-off between the *short-term benefits* of accessing the vast Chinese market and the *long-term costs* of transferring technology to China. Furthermore, it would help rule out the effort interpretation, which predicts better long-term outcomes for the firm when CEOs increase their effort provision in the presence of high equity incentives.

We examine long-term technological outcomes of US firms by leveraging three novel firm *times* destination country level measures. These measures allow us to compare future technological catch-up from China versus catch-up from other countries for US firms with different CEO incentives. The regression specification follows Equation 3. However, unlike in previous regressions, we use data points in future years and create measures of technological outcomes in the next five or ten years. Thereby, we capture the medium- to long-term nature of innovation related consequences. Our findings suggest large, negative long-term consequences in the technology space for US firms with high equity incentives for CEOs.

[17]The above calculation is based on summing up the dependent variable in column 1 of Table 7. In a small number of cases, some firms open more than 1 JV in a given year in China. We rerun the regression in column 1 of Table 7 with the count of the JVs opened in a given country as the dependent variable and we also aggregate the total number of JVs in China over this count variable. Adjusting the back-of-the-envelope calculation for these inputs gives a decline in the number of JVs of 39%.

5.1 Technology Sourcing by Foreign Countries

Utilizing international patent citation records, we first study future technology sourcing by China versus technology sourcing by other (BRIC) countries. Table 8 reports the regression results. In columns (1) to (3), the outcome variable is the log number of patent applications in a foreign country – either China or any other sample country – that cite the respective US firm's patents one, three, or five years into the future. The positive coefficient on $Delta \times CN$ implies that when producing its own innovation in the future, China sources more knowledge from firms with higher CEO portfolio delta. This effect gets stronger over time, from 1 year to 5 years into the future. In columns (4) to (6), we study the log number of granted patents. The results are very similar. In other words, when generating new knowledge of their own, Chinese firms rely on and build upon the knowledge created by US firms managed by CEOs with high equity incentives.

5.2 International Inventor Migration

Second, we find that these US firms lose important R&D human capital to China in the long run. We construct measures to capture the flow of inventors from the US firms in our sample to organizations in other countries. In columns (1) and (2) of Table 9, we use a simple count of migrating inventors from each US firm who end their US-based employment with a firm and move abroad to work with a new employer. We find a positive and significant coefficient on $Delta \times CN$, suggesting that more inventors are moving from firms with higher CEO portfolio delta to China in the five or ten years after the initial technology transfer took place. The larger coefficient in column (2) implies that the loss of R&D talents to China happens gradually over a rather long period of time. In addition, to take into account the fact that inventors differ vastly in their productivity levels, in columns (3) and (4) we value weight the migrating inventors according to their pre-migration patenting output. We observe an even stronger effect, suggesting that the inventors moving to China are likely to be highly productive researchers.

We do not interpret the above evidence as a short-termist CEO causing an inventor to leave their firm and move to China. Our preferred interpretation is that Chinese competitors that emerged as a result of the technology transfer target these US-based inventors and offer them attractive financial incentives to move to China. This is occurring more for firms with short-term oriented CEOs, since these firms are closer to Chinese firms in the technology space due to their initial technology transfer. This interpretation is supported by the existence of the Chinese "Thousand Talents Plan", which also has a sub-plan called the "Foreign 1000 Talents Plan" (Jia, 2018).[18]

5.3 Exposure to Foreign Competition in Patenting

With Chinese firms sourcing more knowledge and poaching R&D talents from certain US firms, we expect US firms to lose their global competitive advantage, in particular in terms of future innovative activities. To test this prediction, we calculate another firm-country level measure that captures the share of each foreign country's patents in any US firm's area of expertise. This measure reflects the exposure to competition from China or any other country in patenting. To capture the long-term nature of R&D related activities, we examine five or ten years into the future. Regression results are presented in Table 10. The coefficient on $Delta \times CN$ is 0.175 in column (1) and is highly significant. According to this point estimate, a one standard deviation increase in delta corresponds to an almost 40% increase in US firms' exposure to Chinese competition in patenting in the next five years. Moreover, this effect becomes even stronger over time, as evidenced by a larger coefficient in column (2) when we look further into the future. These findings are robust to calculating this exposure measure at a more granular technology class level (IPC 4-digit level rather than 3-digit level), suggesting that in the very narrowly-defined areas in which these US firms specialize, China is catching up faster, imposing stronger future competition on these firms in the technology space.

[18] Our argument that China benefits from this inventor migration is supported by Giannetti, Liao, and Yu (2015), who document that Chinese firms that hire board members with foreign experience subsequently experience an increase in performance.

Taken together, these results all point to negative long-term technological outcomes, painting a consistent picture that CEOs with high equity incentives seem to contribute to China's technological rise, which undermines the long-term competitive position of their own firms. At the same time, these negative implications help us address some of the remaining measurement and interpretation issues since these results point more towards the myopia than the effort interpretation. It is worth noting that the findings in this section are robust to the use of the wealth-performance sensitivity, the equity-linked pay share, and the raw equity portfolio delta in thousands of dollars as alternative measures of CEO incentives. The results are shown in Panel B of Table A.5, Table A.6, and Table A.7.

6 Additional Results and Discussions

6.1 Global Evidence

To establish external validity, we provide global evidence at the country-pair level using global compensation data from BoardEx. We detect a positive relationship between a country's average equity incentives given to CEOs and its technology transfer to China (Figure 4). Since the US has the most high-powered CEO incentives among all developed countries (Fernandes, Ferreira, Matos, and Murphy, 2013), this finding is helpful in explaining why the US seems to be affected the most by China's technological rise. Appendix C provides more details on the data, research design, and regression results for the global evidence.

6.2 NPV of Technology Transfer

One may argue that despite the documented long-term costs in the technology space in Section 5, the NPV of technology transfer to China can still be positive if the short-term benefits are sufficiently large. Estimating this NPV would require many assumptions, but additional evidence points to large costs of technology transfer beyond those documented in the technology space. To assess the impact on future sales, we regress yearly sales growth of firms on their technological interactions with China in the past 10 years. Suggestive evidence is presented in Table 11. The negative coefficients in columns (1) to (4) indicate that setting up a joint venture in China or having duplicate patenting in China negatively predicts future sales growth. In columns (5) and (6), we further show that this negative correlation seems to be China-specific. The variable of interest is a ratio that captures the share of a firm's cumulative duplicate patenting activities in China out of total cumulative duplicate patenting activities in all foreign countries in the past 10 years. We again find a negative and significant coefficient.

Furthermore, the dynamic effect in Section 4.5 is consistent with the NPV of the technology transfer being negative. The size of the Chinese market and thus the short-term benefits of doing business in China likely increase over time. If the NPV of the technology transfer to China is indeed positive for firms, the technology transfer should have continued to grow over time instead of following an inverse "U"-shaped pattern.

Third, some of the cross-sectional tests used to distinguish between the myopia interpretation and the effort interpretation also point towards a negative net effect. In particular, family firms are typically long-term oriented. If the NPV of the technology transfer to China is indeed positive, it should be in the interests of family firms to organize more technology transfer, but instead we find that these firms push for less technology transfer to China.

While the above arguments provide evidence that the net effect of the technology transfer to China by high delta CEOs tends to be negative, we acknowledge that the evidence is only suggestive in nature. However, independent of the sign of the net effect, our results are important for Western firms and their stakeholders. These stakeholders can suffer from the externalities of this technology transfer (e.g., by it affecting employment, tax revenue, or national security), especially since firms are unlikely to internalize these externalities.

6.3 Technology Transfer and Market Efficiency

Under Gene Fama's "efficient capital markets" hypothesis (Fama, 1991), the stock market should instantly price the long-term consequences of a firm's technology transfer. In an efficient capital market, it also seems plausible that investors would instantly fire a CEO or revert a corporate policy that destroys long-term firm value. In fact, CEOs with high portfolio delta would have no incentive to exchange technology for market access in China, in conflict with our findings. A key question therefore emerges—is the stock market efficient with respect to the pricing of the technology transfer from Western firms to China? We argue that this is unlikely to be the case for at least two reasons.

First, Cohen, Diether, and Malloy (2013), Hirshleifer, Hsu, and Li (2013), and Edmans, Fang, and Huang (2022) document that the stock market is not particularly efficient in pricing the innovative activities of firms. Second, technology transfer is not disclosed by firms in their regulatory filings with the Securities and Exchange Commission or in any other form of capital market communication. The difficulty in observing or measuring a firm's technology transfer is also why we have to rely on a reasonable but imperfect proxy of duplicate patenting to capture the timing and amount of potential technology transfer. This measure cannot be constructed in real time since patent applications are disclosed with a considerable delay. Only recently has the financial services firm Moody's, through its subsidiary Bureau van Dijk, offered a new data product called "Orbis Intellectual Property", which allows for systematic tracking of global patenting activities for MNCs with technology footprints across the world. Moreover, as discussed in Section 2, there is no paper trail for the technology transfer to China. This is because the QPQP agreement for a firm is not formally negotiated in a contract, since the QPQP is an unofficial Chinese policy.[19]

Thus, even for sophisticated capital market participants, collecting information on technology transfer during most of our sample period (1993-2016) is challenging, let alone having such information incorporated into the stock price in a timely and efficient manner. In contrast, it seems plausible that a CEO, due to their intimate inside knowledge of the firm, is able to correctly understand the long-term implications of technology transfer to China.

[19]The only innovation-related outcome variable that can be observed easily and in "real-time" by outside observers such as analysts is the creation of a new JV or SA, which due to their size and significance are usually associated with corporate press releases and regulatory filings with capital market regulators.

6.4 Policy Implications

Our paper has important implications not only for the firms themselves, but also for other stakeholders such as employees, local communities, and the government, given the externalities of technology transfer.[20] One potential solution is to adjust executive compensation in light of our findings (see, e.g., Bebchuk and Fried (2010) on how to pay for long-term performance). The challenge, however, is that changes to executive compensation, or corporate governance more broadly, that are designed to reduce technology transfer to China (e.g., higher voting rights for long-term shareholders) can have other unintended consequences.

Western policymakers also have tools beyond changes to corporate governance to influence Western technology transfer to China. They could extend the powers of national security oriented bodies such as the Committee on Foreign Investment in the United States (CFIUS), which reviews the national security implications of foreign investments. One option is to define a set of industries in which firms would have to seek approval from a domestic government agency for a JV or SA in China. A less intrusive solution is to give such a government agency a certain amount of time, once it has been informed of a potential JV, to veto it based on national interests. Such an approval or veto mechanism does not directly target technology transfer to China, but is easier to implement than an approval mechanism at the technology level. Moreover, since JVs and SAs are a key mechanism for how technology transfer to China takes place, restricting this mechanism should also limit the technology transfer.[21] Because of heightened awareness among US policymakers of the technological competition from China, the powers of CFIUS did indeed increase in 2018 through the "Foreign Investment Risk Review Modernization Act" (FIRRMA). Among other things, JVs that foreign firms form with US firms *in the US* (but not abroad) can now be blocked

[20] Cen, Fos, and Jiang (2022) show that the creation of Chinese firms predicts same-industry firm exits and reduced employment in the US.

[21] As part of the 2022 "CHIPS Act" and related regulations the US government is imposing restrictions on the activities of semiconductor manufacturers in China (including on JVs); policymakers' aim is to prevent or slow the technology transfer to China. PwC (2022): "The CHIPS Act: What it means for the Semiconductor Ecosystem," no date, pwc.com/us/en/industries/tmt/library/chips-act.html (accessed September 23, 2022).

on national security grounds.[22]

Another avenue might be for firms to set up internal "technology transfer review committees". Such a committee could evaluate the (long-term) consequences of a firm's technology transfer to China. Institutionalizing the process of thinking through the consequences of technology transfer to China could raise awareness inside the firm of the risks associated with it. Since such a technology transfer review committee would be part of the firm and could be overruled by the firm's top executives, the room for unintended consequences from this proposal might be smaller than from other proposals.

7 Conclusion

This paper studies the role of CEO incentives in shaping firms' strategies on global technology transfer–a key determinant of not only long-term firm-level outcomes but also national and even global welfare. Due to China's QPQP, Western firms face a trade-off between the short-term benefits of accessing China's vast market and the long-term costs of transferring technology to China. CEOs with high-powered incentive contracts engage more in forming cross-border partnerships with China and transferring technology to China compared with other large, developing countries. Our results are also quantitatively important. If all the firm-years in our sample have a one standard deviation lower delta, 187 fewer JVs in China would be created, corresponding to 36% of all US-Chinese JVs by the S&P 1500 firms in our sample. Our baseline effect is less pronounced for family firms and for firms managed by CEOs who have a long employment history with the firm (as compared to "hired-guns"). Moreover, in industries that the Chinese government classifies as strategically important, we observe a stronger effect. These results are consistent with the myopia-inducing property of high-powered CEO incentive contracts, rather than the effort-inducing property of these compensation packages. Crucially, firms managed by these CEOs lose R&D human capital to

[22] New York Times (2018): "Congress Strengthens Reviews of Chinese and Other Foreign Investments," August 1, nytimes.com/2018/08/01/business/foreign-investment-united-states.html (accessed June 26, 2022).

China and face more patenting competition from China in future years, suggesting negative long-term consequences in innovation.

In addition to revealing an important real effect of CEO incentives, our findings highlight a novel microeconomic channel behind China's growth and technological rise. Investigating the policy implications of our results, including the effects on national security and geopolitical considerations, and how to best address them, considering the potential unintended consequences of different remedies, is a task for future research.

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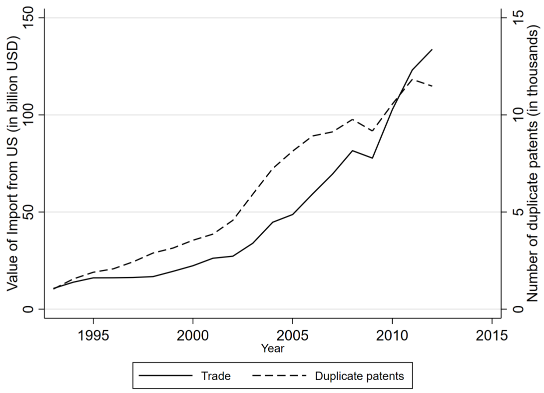
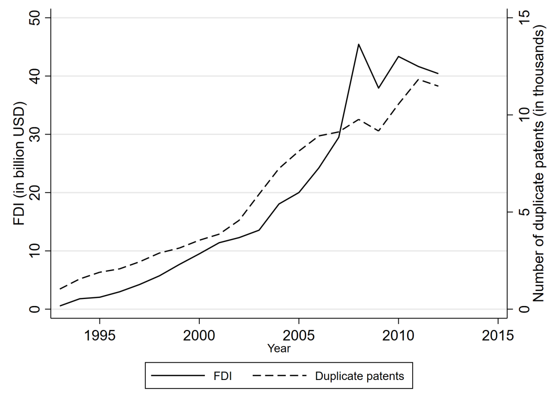
Figure 1: Trade, FDI, and Duplicate Patenting Over Time



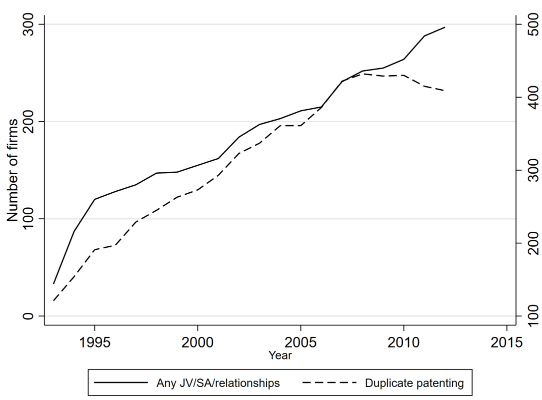
(a) Trade



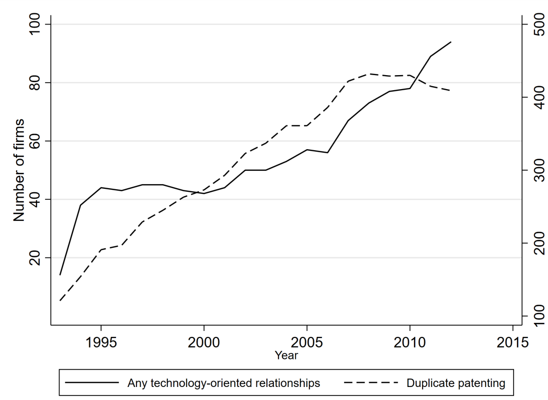
(b) FDI

Figure 1 plots the dollar value of trade or FDI (left y-axis) and the number of duplicate patents (right y-axis) in China over time. Figure 1a shows the value of imports from the US (in billion USD). Figure 1b shows the cumulative amount of FDI from the US (in billion USD). Data on trade is from UN Comtrade. Data on FDI is from the OECD.

Figure 2: Cross-Border Partnerships and Duplicate Patenting Over Time



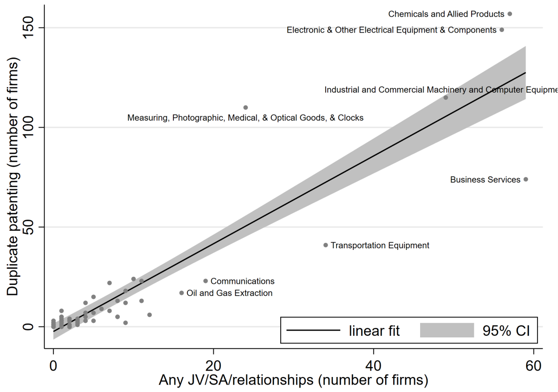
(a) All Relationships



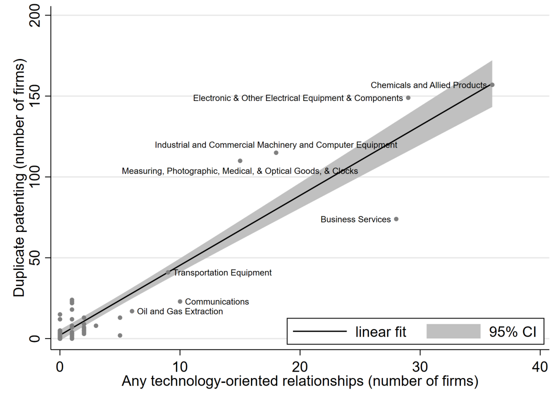
(b) Technology-oriented Relationships

Figure 2 plots the number of unique S&P 1500 firms that invest (left y-axis) or patent (right y-axis) in China over time. Figure 2a includes all cross-border partnerships including joint ventures, strategic alliances, and any technology-driven relationships. Figure 2b includes only technology-driven relationships.

Figure 3: Cross-Border Partnerships and Duplicate Patenting Across Industries



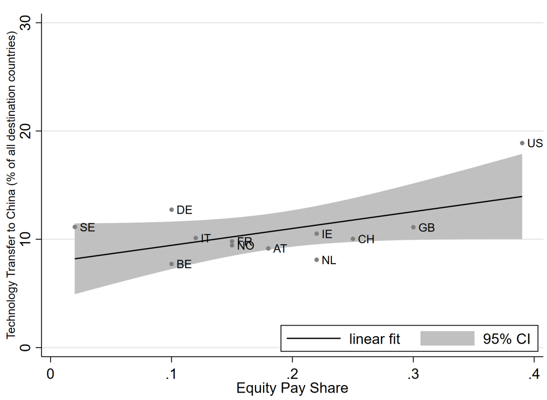
(a) All Relationships



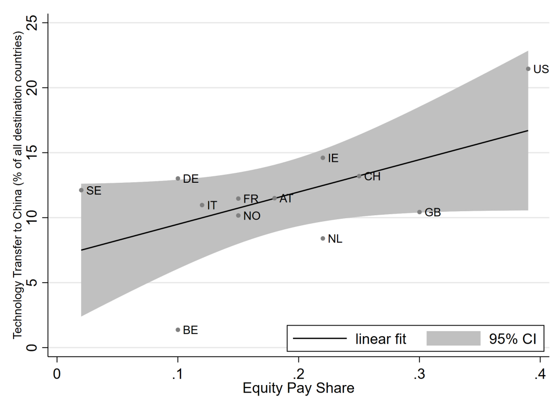
(b) Technology-oriented Relationships

Figure 3 plots the number of unique S&P 1500 firms that invest in China (x-axis) against the number of unique S&P 1500 firms that file for duplicate patents in China (y-axis) across different two-digit SIC industries from 1993 to 2016. Figure 3a includes all cross-border partnerships, including joint ventures, strategic alliances, and any technology-driven relationships. Figure 3b includes only technology-driven relationships.

Figure 4: Global Evidence – Technology Transfer to China vs. Equity Pay Share



(a) Patent Counts



(b) Citation Weighted Patent Counts

Figure 4 plots the amount of technology transfer to China from developed countries in Europe and from the US against the average equity pay share in each country in 2006. On the x-axis, average equity pay share is from Table 1 of Fernandes, Ferreira, Matos, and Murphy (2013), which uses 2006 fiscal year CEO pay data. On the y-axis, the technology transfer measure is the percentage share of duplicate patenting in China with priority traced back to the respective developed country out of all duplicate patenting worldwide that can be traced back to this country.

Table 1: Summary Statistics

Panel A: CEO Incentives and Firm Characteristics (Firm-Year Level)

Variable	N	Mean	Median	Std. Dev.
Total CEO Compensation (mil $)	37,481	4.99	2.73	9.34
Equity Portfolio Delta (mil $)	37,481	0.649	0.184	1.56
Scaled WPS ($)	37,411	88.7	6.1	2164
Total Asset (mil $)	37,481	12,641	1,587	78,060
Profitability (EBITDA)	37,481	0.124	0.125	0.129
Leverage	37,481	0.229	0.207	0.205
Tobin's q	37,481	1.97	1.47	2.02
Capex	37,481	0.0534	0.0375	0.0576
R&D Intensity	37,481	0.0305	0	0.0702

Panel B: Technology Transfer & Partnerships (Firm-Country-Year Level)

Variable	N	Mean	Median	Std. Dev.
Duplicate Patenting				
ln(N+1)	2,962,194	0.0518	0	0.339
ln(citN+1)	2,962,194	0.136	0	0.805
Partnerships (Indicator Variable)				
JV (joint venture)	2,962,194	0.0014	0	0.0374
SA (strategic alliance)	2,962,194	0.002	0	0.0446
Tech-related JV/SA	2,962,194	0.001	0	0.0308

Panel C: Future Technological Outcomes (Firm-Country-Year Level)

Variable	N	Mean	Median	Std. Dev.
Technology Sourcing by Foreign Countries				
ln(N+1), application	2,962,194	0.112	0	0.52
ln(N+1), grant	2,962,194	0.0914	0	0.46
International Inventor Migration, ln(N+1)				
Equal-weighted, 1-5 years	2,962,194	0.00403	0	0.0705
Equal-weighted, 6-10 years	2,962,194	0.00443	0	0.0744
Value-weighted, 1-5 years	2,962,194	0.00374	0	0.0986
Value-weighted, 6-10 years	2,962,194	0.00462	0	0.111
Exposure to Foreign Competition in Patenting				
IPC 3 digit, 1-5 years	2,962,194	0.414	0	1.88
IPC 3 digit, 6-10 years	2,962,194	0.382	0	1.82
IPC 4 digit, 1-5 years	2,962,194	0.408	0	1.89
IPC 4 digit, 6-10 years	2,962,194	0.376	0	1.82

The table presents summary statistics for the main variables used in our analysis. Panel A summarizes firm characteristics and variables on CEO compensation. Panel B summarizes measures of technology transfer and cross-border partnerships. Panel C summarizes variables describing future technological outcomes.

Table 2: The Effect of CEO Incentives on Technology Transfer

Panel A: Compare China with All Other Countries

	(1)	(2)	(3)	(4)	(5)	(6)
	Technology Transfer					
Dep. Var.	ln(N+1)	ln(citN+1)	ln(N+1)	ln(citN+1)	ln(N+1)	ln(citN+1)
Delta × CN	0.057***	0.108***	0.082***	0.156***	0.058***	0.111***
	[0.003]	[0.006]	[0.004]	[0.008]	[0.003]	[0.006]
ln(TotalPay) × CN					0.152***	0.279***
					[0.006]	[0.012]
Country × Year FE	YES	YES	-	-	-	-
Country × Industry × Year FE	NO	NO	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES	YES	YES
Obs	3,036,873	3,036,873	2,962,194	2,962,194	2,962,194	2,962,194
Adj R2	0.282	0.298	0.379	0.397	0.382	0.398

Panel B: Compare China with Other BRIC and Asian Countries

	(1)	(2)	(3)	(4)
	Technology Transfer			
Dep. Var.	ln(N+1)	ln(citN+1)	ln(N+1)	ln(citN+1)
Delta × CN	0.058***	0.112***	0.049***	0.093***
	[0.004]	[0.007]	[0.005]	[0.012]
Delta × BRIC	0.017	0.036		
	[0.013]	[0.027]		
Delta × Asian			0.022	0.002
			[0.019]	[0.002]
Control Countries	BRIC		Asian Countries	
Country × Industry × Year FE	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES
Obs	2,962,194	2,962,194	2,962,194	2,962,194
Adj R2	0.382	0.398	0.382	0.399

This table shows how CEO incentives affect US firms' technology transfer to China versus other countries. The unit of observation is a firm-country-year. Panel A compares China with all other countries, while Panel B compares China with other BRIC or Asian countries. *Delta* measures CEO incentives and is defined as the dollar change in equity portfolio value for a 1% increase in stock price. *CN* is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. *BRIC* (*Asian*) is an indicator variable for other BRIC (Asian) countries, and equals 1 when the destination country is Brazil, Russia, India (or in Asia). An interaction term of ln(TotalPay) and CN is included in all models in Panel B. The outcome variables are two duplicate patenting measures – log (citation-weighted) number of patents in the corresponding country-year with priority traced back to the respective firm. Robust standard errors double clustered at the country level and the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 3: A Quasi-Natural Experiment for CEO Compensation Structure

	(1)	(2)	(3)	(4)
	Technology Transfer			
Dep. Var.	ln(N+1)	ln(citN+1)	ln(N+1)	ln(citN+1)
MDF × After1993 × CN	0.582***	0.831***	0.062***	0.064***
	[0.024]	[0.045]	[0.011]	[0.019]
Million Dollar Firm (MDF) Measure	Continuous		Indicator for [0.9m, 1.5m]	
Country × Industry × Year FE	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES
Obs	2,055,388	2,055,388	2,055,388	2,055,388
Adj R2	0.426	0.433	0.426	0.433

This table shows the results of a quasi-natural experiment based on Perry and Zenner (2001) that leads to a change in the structure of CEO pay for a subset of firms. The unit of observation is a firm-country-year. The variable of interest is the triple interaction term between the *MDF* measure, *After 1993*, and *CN*. In columns (1) and (2), MDF is a continuous variable that equals 1 if the cash pay to the CEO in 1993 is above $1 million, and the raw dollar amount (in millions) otherwise. In columns (3) and (4), MDF is a dummy variable that equals 1 if the cash pay to the CEO in 1993 is between $0.9 million and $1.5 million. CN is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. The outcome variables are two duplicate patenting measures – log (citation-weighted) number of patents in the corresponding country-year with priority traced back to the respective firm. The triple interaction term *ln (total pay in the year 1993)* × *After 1993* × *CN* is added as a control in all specifications. The sample is from 1980 to 2016. Robust standard errors double clustered at the country level and the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 4: The Effect of CEO Incentives on Technology Transfer – Heterogeneity Across Firms & Industries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Technology Transfer							
Dep. Var.	ln(N+1)	ln(citN+1)	ln(N+1)	ln(citN+1)	ln(N+1)	ln(citN+1)	ln(N+1)	ln(citN+1)
Delta × CN	0.209***	0.351***	0.069***	0.154***	0.111***	0.220***	0.006***	0.113***
	[0.020]	[0.030]	[0.006]	[0.015]	[0.008]	[0.014]	[0.001]	[0.003]
Delta × CN × Family Ownership	-0.137***	-0.207***						
	[0.021]	[0.032]						
Delta × CN × CEO History			-0.019**	-0.055***				
			[0.008]	[0.019]				
Delta × CN × Governance					-0.061***	-0.128***		
					[0.010]	[0.016]		
Delta × CN × SEI							0.116***	0.220***
							[0.008]	[0.016]
Country × Industry × Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Obs	1,185,885	1,185,885	1,219,611	1,219,611	1,140,406	1,140,406	2,962,194	2,962,194
Adj R2	0.378	0.399	0.413	0.422	0.441	0.456	0.383	0.399

This table shows how CEO incentives differentially affect US firms' technology transfer to China versus other countries across firms (columns (1) to (6)) and industries (columns (7) and (8)). The unit of observation is a firm-country-year. *Delta* measures CEO incentives and is defined as the dollar change in equity portfolio value for a 1% increase in stock price. CN is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. An interaction term of ln(TotalPay) and CN is included in all models. In columns (1) and (2), the binary variable *Family Ownership* indicates firms that have above 5% of their shares owned by the family of the firm's founder and 0 otherwise. In columns (3) and (4), the binary variable *CEO History* equals 1 if the CEO has been employed by the firm (irrespective of the position) for above median length and 0 otherwise. In columns (5) and (6), the binary variable *Governance* equals 1 if the G index for the corporate governance of the firms is equal to or below 5 (bottom decile) and 0 otherwise. Gompers, Ishii, and Metrick (2003) call this cut-off the "democracy" portfolio. In columns (7) and (8), we compare the effect in China's strategic emerging industries to that in the other industries. The binary variable SEI equals 1 for industries belonging to China's strategic emerging sectors. The outcome variables are two duplicate patenting measures – log (citation-weighted) number of patents in the corresponding country-year with priority traced back to the respective firm. Robust standard errors double clustered at the country level and the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 5: CEO Horizon: Fixed-Term CEO Contracts

	(1)	(2)	(3)	(4)
Dep. Var.	Technology Transfer			
	ln(N+1)	ln(citN+1)	ln(N+1)	ln(citN+1)
CEO Contractual Horizon × CN	-0.004***	-0.023***	-0.034***	-0.112***
	[0.001]	[0.003]	[0.009]	[0.019]
CEO Contractual Horizon measure	Continuous		Above Median (above 3 years)	
Country × Industry × Year FE	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES
Obs	193,450	193,450	193,450	193,450
Adj R2	0.4	0.399	0.4	0.399

The table repeats our main analysis, using information on fixed-term CEO contracts as a measure for CEO incentives. In particular, we use the information from Cziraki and Groen-Xu (2020) on CEO employment contracts with a fixed employment duration (including data on the length of the contract). The unit of observation is a firm-country-year. CEO Contractual Horizon is a measure of CEO contractual horizon. Columns (1) and (2) use a continuous measure of the number of years remaining in the CEO's employment contract. Columns (3) and (4) use a dummy variable that is 1 if the remaining employment duration is above the median (which is 3 years). CN is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. An interaction term of ln(TotalPay) and CN is included in all models. Columns (1) and (3) resemble column (5) of Table 2, Panel A. Columns (2) and (4) resemble column (6) of Table 2, Panel A. Robust standard errors double clustered at the country level and the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 6: The Effect of CEO Incentives on Technology Transfer – Dynamics

Panel A: Technology Transfer

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	Technology Transfer: ln(N+1)					
Delta × CN	0.011***	0.057***	0.076***	0.086***	0.063***	0.026***
	[0.002]	[0.004]	[0.005]	[0.005]	[0.004]	[0.002]
Sample	1993-1996	1997-2000	2001-2004	2005-2008	2009-2012	2013-2016
Country × Industry × Year FE	YES	YES	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES	YES	YES
Obs	416,465	491,071	477,931	525,162	536,842	514,723
Adj R2	0.394	0.409	0.4	0.374	0.356	0.295

Panel B: Technology Transfer (citation-weighted)

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	Technology Transfer: ln(citN+1)					
Delta × CN	0.057***	0.107***	0.151***	0.161***	0.116***	0.043***
	[0.006]	[0.008]	[0.010]	[0.009]	[0.009]	[0.004]
Sample	1993-1996	1997-2000	2001-2004	2005-2008	2009-2012	2013-2016
Country × Industry × Year FE	YES	YES	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES	YES	YES
Obs	416,465	491,071	477,931	525,162	536,842	514,723
Adj R2	0.402	0.413	0.414	0.387	0.363	0.29

This table shows how CEO incentives differentially affect US firms' technology transfer to China versus other countries over time. The sample is divided into 6 periods, each covering 4 years. The unit of observation is a firm-country-year. *Delta* measures CEO incentives and is defined as the dollar change in equity portfolio value for a 1% increase in stock price. CN is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. An interaction term of ln(TotalPay) and CN is included in all models. In Panels A and B, the outcome variables are two duplicate patenting measures – log (citation-weighted) number of patents in the corresponding country-year with priority traced back to the respective firm. Robust standard errors double clustered at the country level and the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 7: The Effect of CEO Incentives on Cross-Border Partnerships

	(1)	(2)	(3)
Dep. Var.	Dummy Variable for ...		
	Joint Venture	Strategic Alliance	Tech-related Partnership
Delta × CN	0.005***	0.006***	0.001***
	[0.000]	[0.001]	[0.000]
Delta × BRIC	0.001	0.002	0.000
	[0.001]	[0.002]	[0.000]
Dep. Var. Mean	0.001	0.002	0.001
Country × Industry × Year FE	YES	YES	YES
Firm × Year FE	YES	YES	YES
Obs	2,962,194	2,962,194	2,962,194
Adj R2	0.05	0.029	0.01

This table shows how CEO incentives affect cross-border partnerships formed between US firms and China versus US firms and other countries. The unit of observation is a firm-country-year. *Delta* measures CEO incentives and is defined as the dollar change in equity portfolio value for a 1% increase in stock price. *CN* is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. *BRIC* is an indicator variable for other BRIC countries, and equals 1 when the destination country is Brazil, Russia, or India. An interaction term of ln(TotalPay) and CN is included in all models. The outcome variables are dummy variables indicating the formation of a new partnership between the respective firm and country in the corresponding year. Columns (1) and (2) examine cross-border joint ventures and strategic alliances. Column (3) examines technology-oriented partnerships. Robust standard errors double clustered at the country level and the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 8: The Effect of CEO Incentives on Future Technological Outcomes
Technology Sourcing by Foreign Countries

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	Foreign Patent Citations: ln(N+1)					
	Application			Grant		
Delta × CN	0.036***	0.050***	0.066***	0.033***	0.046***	0.058***
	[0.005]	[0.005]	[0.007]	[0.004]	[0.005]	[0.006]
Delta × BRIC	0.013	0.018	0.026	0.009	0.015	0.021
	[0.012]	[0.016]	[0.018]	[0.011]	[0.014]	[0.017]
Future Years	1	3	5	1	3	5
Country × Industry × Year FE	YES	YES	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES	YES	YES
Obs	1,761,125	1,761,125	1,761,125	1,761,125	1,761,125	1,761,125
Adj R2	0.517	0.532	0.543	0.493	0.507	0.516

This table shows how CEO incentives affect future technology sourcing by China versus other countries. The unit of observation is a firm-country-year. *Delta* measures CEO incentives and is defined as the dollar change in equity portfolio value for a 1% increase in stock price. *CN* is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. *BRIC* is an indicator variable for other BRIC countries, and equals 1 when the destination country is Brazil, Russia, or India. An interaction term of ln(TotalPay) and CN is included in all models. The outcome variables are the log number of patent applications/granted patents in the respective country that cite the corresponding US firm's patents in future years (1, 3, 5 years). Robust standard errors double clustered at the country level and the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 9: The Effect of CEO Incentives on Future Technological Outcomes
International Inventor Migration

	(1)	(2)	(3)	(4)
Dep. Var.	Migrated Inventors from US firms: ln(N+1)			
	equal-weighted		value-weighted	
Delta × CN	0.017***	0.027***	0.018***	0.036***
	[0.002]	[0.003]	[0.002]	[0.004]
Delta × BRIC	0.008	0.012	0.007	0.012
	[0.007]	[0.011]	[0.007]	[0.011]
Future Years	1-5 years	6-10 years	1-5 years	6-10 years
Country × Industry × Year FE	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES
Obs	2,962,194	2,962,194	2,962,194	2,962,194
Adj R2	0.073	0.083	0.017	0.026

This table shows how CEO incentives affect inventor migration from US firms to China versus other countries. The unit of observation is a firm-country-year. *Delta* measures CEO incentives and is defined as the dollar change in equity portfolio value for a 1% increase in stock price. CN is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. $BRIC$ is an indicator variable for other BRIC countries, and equals 1 when the destination country is Brazil, Russia, or India. An interaction term of ln(TotalPay) and CN is included in all models. The outcome variable is the log number of inventors migrating from a US firm to another country in future years (1-5 years or 6-10 years). Columns (1) and (2) equal weight all the migrating inventors, while columns (3) and (4) value weight the inventors based on their pre-migration patenting productivity. Robust standard errors double clustered at the country level and the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 10: The Effect of CEO Incentives on Future Technological Outcomes
Exposure to Foreign Competition in Patenting

	(1)	(2)	(3)	(4)
Dep. Var.	Share of Foreign Country's Patents in US Firms' Area of Expertise			
	IPC 3 digit level		IPC 4 digit level	
Delta × CN	0.175***	0.264***	0.148***	0.261***
	[0.011]	[0.012]	[0.012]	[0.012]
Delta × BRIC	-0.005	-0.002	-0.003	0.001
	[0.011]	[0.014]	[0.010]	[0.013]
Future Years	1-5 years	6-10 years	1-5 years	6-10 years
Dep. Var. Mean	0.414	0.382	0.408	0.376
Country × Industry × Year FE	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES
Obs	2,962,194	2,962,194	2,962,194	2,962,194
Adj R2	0.644	0.604	0.62	0.583

This table shows how CEO incentives affect US firms' exposure to competition from China versus other countries in patenting. The unit of observation is a firm-country-year. *Delta* measures CEO incentives and is defined as the dollar change in equity portfolio value for a 1% increase in stock price. CN is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. $BRIC$ is an indicator variable for other BRIC countries, and equals 1 when the destination country is Brazil, Russia, or India. An interaction term of ln(TotalPay) and CN is included in all models. The outcome variable is the share of a foreign (non-US) country's patents in a US firm's area of expertise in future years (1-5 years or 6-10 years). Columns (1) and (2) (Columns (3) and (4)) define area and calculate the share at the IPC 3-digit (4-digit) level. IPC stands for international patent classification. Robust standard errors double clustered at the country level and the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 11: Technological Interactions with China and Future Sales Growth

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.			Sales Growth			
𝟙 (Past JV with CN)	-0.025***	-0.017***				
	[0.006]	[0.006]				
𝟙 (Past duplicate patenting in CN)			-0.023***	-0.014***		
			[0.004]	[0.004]		
Share of past duplicate patenting in CN					-0.092***	-0.050***
					[0.018]	[0.016]
Control	NO	YES	NO	YES	NO	YES
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Obs	42,007	36,277	42,007	36,277	42,007	36,277
Adj R2	0.088	0.12	0.089	0.12	0.088	0.119

This table shows how past interactions with China in the technology space affect a firm's future sales growth. The unit of observation is a firm-year. In columns (1) and (2) the variable of interest is a dummy that equals 1 if a firm opened a new joint venture in China in the past 10 years. In columns (3) and (4) the variable of interest is a dummy that equals 1 if a firm has duplicate patenting activities in China in the past 10 years. In columns (5) and (6) the variable of interest is a ratio that captures the share of a firm's cumulative duplicate patenting activities in China out of total cumulative duplicate patenting activities in all foreign countries in the past 10 years. Columns (2), (4), and (6) include controls for lagged firm-characteristics. The outcome variable is a firm's yearly sales growth. Robust standard errors clustered at the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

For Online Publication:

Appendix to "Did Western CEO Incentives Contribute to China's Technological Rise?"

A Additional Information on the Quid Pro Quo Policy

The Aircraft Industry as a Case Study for the Quid Pro Quo Policy. A noteworthy case study of the QPQP is the aircraft industry, which is dominated by Boeing and Airbus. Initially, only Airbus was manufacturing aircraft in China through JVs with local companies. In response, Chinese aircraft purchases were heavily tilted towards Airbus. In 2015 Boeing agreed to open an aircraft production facility in China that would be operated with a local JV partner. As part of this agreement, Boeing would for the first time ever build a factory outside the United States. Moreover, three state-owned airlines and the leasing subsidiary of a state-owned bank placed an order worth $38 billion, covering 300 new planes. Crucially, the JV partner of Boeing is the state-owned aerospace company Comac, which has a mandate to build a plane "C919" with the intention to compete with aircraft produced by Boeing and Airbus in the long run. Thus, in this case it is public knowledge that in exchange for market access Boeing is transferring technology to a Chinese company that intends to one day compete with Boeing.[23]

This deal was signed in September 2015, around the end of the tenure of James McNerney at Boeing (James McNerney stepped down as CEO of Boeing in July 2015 and as Chairman in March 2016). The signing took place at a visit of Boeing's facilities in Everett, Washington, by Chinese leader Xi Jinping, which was part of an official state visit. Based on our reading of news reports, most negotiations for this transaction likely occurred under the tenure of

[23]Vox (2015): "How China is Playing Boeing Against Airbus to Build its Own Airplane Industry," September 24, https://www.vox.com/2015/9/24/9389767/boeing-china-deal (accessed June 20, 2022).

McNerney as CEO. In particular, official visits by head of states usually require long and detailed preparations and negotiations about, for instance, diplomatic protocol and official talking points. Therefore, a visit by the Chinese leader to Boeing will likely have been carefully planned and all contracts to be signed at the event will likely have been negotiated well in advance. The presence of Xi Jinping at the signing of this technology transfer for market access agreement also highlights that the QPQP has the support of the highest level of the Chinese Communist Party and the Chinese government.

Boeing also has very high technology transfer to China, when considering our outcome variable of duplicate patenting. In addition, just before the end of his tenure at Boeing, the delta of McNerney's executive compensation increased by 0.8 of a standard deviation. McNerney also was a long-time General Electric (GE) employee, who immediately left the company after losing the race to succeed Jack Welch as CEO of GE. Moreover, in December 2022 the first delivery of a C919 to an airline (China Eastern Airlines Corp.) took place. Consequently, China's efforts to catch up with Western companies in the aircraft industry seem to be starting to bear fruit.[24]

Examples from the Gas Turbine Industry and the High-Speed Rail Industry. In 2001 China's National Development and Reform Commission laid out a strategy to acquire advanced gas turbine technology in exchange for market access. As part of this strategy Chinese firms cooperated with leading foreign firms in this business, including Siemens, General Electric, and Mitsubishi. In 2016, gas turbine technology was included as a key focus area in the "13th Five-Year Plan for Science and Technology Innovation." In 2018 Siemens signed an agreement with a Chinese state-owned enterprise, in which according to Chinese media "Siemens stated that this cooperation will take advantage of Siemens' leading position in gas turbine technology to support China's goal of independent research and development and manufacturing of heavy-duty gas turbines." The same media report wonders whether

[24]Bloomberg (2022): "China Delivers First Homegrown Plane to Take On Boeing, Airbus," December 9, bloomberg.com/news/articles/2022-12-09/china-delivers-first-jet-aimed-at-rivaling-boeing-and-airbus (accessed January 9, 2023).

this agreement will "do for China's heavy-duty gas turbine manufacturing industry what cooperation in high-speed rail did in that field." China considers itself as having captured an international lead in high-speed rail technology through "digestion, absorption, and re-innovation" of technology from Germany as well as Japan, including through partnerships with, again, Siemens. Chinese firms therefore "define today's global high-speed rail technologies" and "standards." Their journey to this technological leadership was aided by the Chinese government and the QPQP.[25]

Other Examples for the QPQP and Market Access Barriers. European Union Chamber of Commerce in China and Roland Berger (2021) contains a large number of examples and case studies on how China makes it difficult for foreign companies to do business in China, with many of these practices being part of the QPQP to force foreign MNCs to engage in technology transfer to China. The report, for instance, contains a case study of indirect barriers to foreign financial institutions with "licensing requirements that only allow a financial institution to apply for approval in one province at a time, with a lengthy process that can take up to a year". The same report also mentions that environmental regulations are more strongly enforced for foreign companies and that government officials sometimes intentionally misinterpret rules and regulations.

For a case study of Chinese technology transfer and technology theft practices in the crop seeds industry, see Hvistendahl (2020). For a discussion of several examples of technology transfer to China in the semiconductor, see chapter 44 of Miller (2022). The example of General Electric (GE), a company known for its focus on short-term financial performance under its former CEO Jack Welch, is discussed towards the end of the introduction of the paper. Moreover, among the companies with the largest number of JVs in China are several companies run by former GE executives, including firms such as Pfizer, Honeywell, and TRW.

[25]The information in this paragraph, including the quotes, is from Foundation for Defense of Democracies (2020): "Made in Germany, Co-opted by China," October 14, fdd.org/analysis/2020/10/14/made-in-germany-co-opted-by-china (accessed February 2, 2023).

Even companies that have agreed to technology transfer to China and are in the good graces of the CCP can fall out of favor if they are deemed to be too successful in mastering the Chinese market, by, for instance, gaining a "too large" market share. Such companies can become the target of a media campaign or regulatory pressure that reduces the momentum of a company's business activities in China, as Tesla has experienced, for example.[26]

Foreign Criticism of the Quid Pro Quo Policy. Foreign business executives are usually hesitant to openly criticize China's QPQP, the associated practices of forced technology transfer and barriers to market access, or the Chinese theft of foreign intellectual property. A rare exception to this was the criticism by Jürgen Hambrecht, the CEO of the German chemicals company BASF, who in 2010 brought up the issue of forced technology transfer directly to the Chinese premier Wen Jiabao during an official state visit of German chancellor Angela Merkel to China.[27] Somewhat ironically, Martin Brudermüller, the CEO of BASF in 2022, stated that BASF had never experienced any loss of intellectual property in China, thereby underlining how rare the public critique of his predecessor was.[28]

Made in China 2025. Illustrative of the "non-acknowledgement policy" around the QPQP is a related Chinese policy where this approach–at least initially–was not followed: the "Made in China 2025" policy, which was launched in 2015. The aim of this industrial policy is for China to become less reliant on foreign suppliers of high-tech products and services, and to eventually leapfrog them. The ambition of this policy plan, together with the detailed information provided (down to the level of individual industries and even companies), was initially not hidden from foreign parties, instead there was even an English language logo for this industrial policy. Following a backlash from the US, Europe, and elsewhere against this policy, the slogan "Made in China 2025" and China's ambition through this policy have

[26]Frankfurter Allgemeine Zeitung (2021): "Teslas China-Schock: Brennende Autos, Tote Polizisten," June 11, faz.net/aktuell/wirtschaft/digitec/tesla-in-china-brennende-autos-und-tote-nach-unfaellen-17383000.html?premium (accessed June 25, 2022).

[27]Financial Times (2010): "German Industrialists Attack China," July 18, ft.com/content/e57a722a-928f-11df-9142-00144feab49a (accessed June 5, 2021).

[28]The Economist (2022): "BASF's Plan to Wean Itself Off Cheap Russian Gas Comes with Pitfalls," May 26, economist.com/business/2022/05/26/basfs-plan-to-wean-itself-off-cheap-russian-gas-comes-with-pitfalls (accessed June 25, 2022).

later been de-emphasized in official communications and speeches, while the actual policy has remained unchanged.[29]

Is Forced Technology Transfer Unique to China? A question that might arise is whether such a QPQP is unique to China or whether other countries have been successful with similar policies. We are not aware of another country that has been able to successfully implement a similar policy.[30] There are likely two reasons for this. One factor is the sheer size of the Chinese economy and its high growth rates. Other countries lack the "market power" to extract similarly favorable terms from foreign MNCs, because their economies are too small and foreign MNCs might simply skip them if there is an onerous QPQP.[31] A second factor is that successfully implementing a QPQP requires not only a grand vision, but also consistent and competent long-term implementation, for which the continuity in Chinese policymaking and the state capacity of the Chinese government and the CCP are likely to be beneficial. Other developing and emerging countries might lack the ability of China to successfully implement a similar technology transfer policy (Pillsbury, 2015; Doshi, 2021; Shambaugh, 2021).

B Data Sources

ExecuComp. ExecuComp provides details of US executive compensation, including CEO compensation for S&P 1500 firms from 1993 to the present. Using this dataset, we construct measures to capture CEO incentives.

Compustat. We use Compustat to construct firm-level control variables such as size, leverage, and profitability.

[29] PBS (2019): "Made in China 2025: The Industrial Plan that China Doesn't Want Anyone Talking About," May 7, pbs.org/wgbh/frontline/article/made-in-china-2025-the-industrial-plan-that-china-doesnt-want-anyone-talking-about (accessed June 25, 2022).

[30] The closest policy we can find is the expropriation of German intellectual property by the United States during and after World War I (Moser and Voena, 2012; Pillsbury, 2015). However, this more resembles the Chinese theft of foreign intellectual property (which is not the focus of this paper) than the QPQP.

[31] For an article that argues that Vietnam lacks the power to impose technology transfer policies on foreign firms in the way China does, see: The Economist (2022): "Vietnam is Emerging as a Winner from the Era of Deglobalisation," September 22, economist.com/asia/2022/09/22/vietnam-is-emerging-as-a-winner-from-the-era-of-deglobalisation (accessed October 16, 2022).

SDC Platinum. SDC Platinum covers partnerships formed between two or more entities. We collect information on cross-border JVs and SAs. We also look at the nature of each relationship to identify technology-oriented relationships.

PATSTAT Global. PATSTAT Global is a worldwide patent database that provides detailed bibliographical information on over 100 million patent applications in more than 100 patent offices. We match the assignees in this dataset to US public firms and construct measures of technology transfer from these firms to other countries. We also measure international technology sourcing using this dataset.

USPTO PatentsView. United States Patent and Trademark Office (USPTO) PatentsView provides detailed information on patents issued by USPTO and their associated inventors. Leveraging this dataset, we first compute inventor migration to China and other countries from US public firms. We use data on each patent's international patent classification (which can be considered the industry classification of patents) to compute a firm's and a country's R&D specialization, which we then use to calculate a firm's exposure to innovation competition by a country.

C Global Evidence

C.1 Data and Measurement

For the global analysis, we use data from BoardEx, which, unlike ExecuComp, has international coverage. To compare the US with other technology origination countries, we construct an origination country $\times$ destination country $\times$ year panel. The outcome variable captures time-varying country pairwise technology transfer. The transfer origination countries cover the US and developed European countries with available CEO compensation data in BoardEx. The destination countries include all countries with significant patent offices. The sample is from 1999 to 2016, since BoardEx data starts from 1999. CEO incentives are measured at the country-year level by using the average value among public firms in that country.

C.2 Empirical Strategy

We supplement the firm-country level analysis with a country-pair level analysis, which follows a similar regression equation, except that the unit of observation varies at the country-pair level:

$$Y_{c1,c2,t} = \boldsymbol{\gamma_{c1,t}} + \boldsymbol{\alpha_{c2,t}} + \beta Delta_{c1,t} \times CN_{c2} + \varepsilon_{c1,c2,t} \tag{4}$$

The interaction term, $Delta_{c1,t} \times CN_{c2}$, links the varying levels of CEO incentives in technology origination countries to the amount of technology they transfer to China. We include country by year fixed effects in the regression. We use dyadic standard errors to account for correlations between pairs that share one country.

C.3 Results

Fernandes, Ferreira, Matos, and Murphy (2013) document that among all the developed countries, the US has the highest equity-linked CEO compensation, reaching 40% in 2006. Since such equity incentives tend to vest in the short term, we predict that the US transfers more technology to China compared with other rich, technologically advanced countries. In Figure 4, we detect a positive correlation between a country's average CEO equity incentives and the amount of technology transfer from this country to China.[32] In both Figure 4a and Figure 4b, the US is located in the upper right corner, indicating that the US provides the highest equity incentives to its CEOs and engages the most in technology transfer to China.

Table A.9 provides regression evidence. The empirical specification follows Equation 4. The dependent variable is the percentage share of duplicate patenting in each destination country with priority traced back to a developed country out of all duplicate patenting worldwide that can be traced back to this developed country. In columns (1) and (2), we calculate the median equity pay share of each country. In columns (3) and (4), we directly use the statistics reported in Table 1 of Fernandes, Ferreira, Matos, and Murphy (2013).

[32] We use the share of equity-linked pay out of total CEO pay, instead of delta, as a measure of equity incentives. This is because we have an international sample. Equity pay share can be consistently measured, but we lack data to calculate delta in some countries.

Across all specifications, we observe a positive and significant coefficient for the interaction term between CEO equity incentives and China. This means that China, relative to other countries, receives a larger share of technology transfer from a developed country where CEOs receive more high-powered equity incentives. Such global level evidence is helpful in explaining why the US seems to be affected the most by China's technological rise.

D Appendix Tables

Table A.1: Duplicate Patenting and Technology Sourcing by Foreign Countries

Panel A: Including All Destination Countries

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	Citations to a Patent Family from a Destination Country					
	𝟙 (citation)			ln (N+1)		
𝟙 (Duplicate Patenting) × 𝟙 (Post)	0.197***	0.202***	0.113***	0.206***	0.209***	0.143**
	[0.045]	[0.046]	[0.042]	[0.058]	[0.057]	[0.058]
Cited Family × Destination Country	YES	YES	YES	YES	YES	YES
Citing Year	YES	-	-	YES	-	-
Destination Country × Citing Year	NO	YES	YES	NO	YES	YES
Cited Family × Citing Year	NO	NO	YES	NO	NO	YES
Obs	7,070,042	7,069,959	6,900,814	7,070,042	7,069,959	6,900,814
Adj R2	0.139	0.143	0.167	0.252	0.256	0.278

Panel B: Including BRIC as Destination Countries

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	Citations to a Patent Family from a Destination Country					
	𝟙 (citation)			ln (N+1)		
𝟙 (Duplicate Patenting) × 𝟙 (Post)	0.086***	0.079***	0.026***	0.074***	0.069***	0.029***
	[0.002]	[0.002]	[0.009]	[0.002]	[0.002]	[0.008]
Cited Family × Destination Country	YES	YES	YES	YES	YES	YES
Citing Year	YES	-	-	YES	-	-
Destination Country × Citing Year	NO	YES	NO	NO	YES	NO
Cited Family × Citing Year	NO	NO	YES	NO	NO	YES
Obs	365,638	365,638	70,843	365,638	365,638	70,843
Adj R2	0.043	0.049	0.02	0.075	0.079	0.055

This table shows that technology sourcing is facilitated by duplicate patenting by comparing citations to the same patent family from destination countries with and without duplicate patenting (or with earlier and later duplicate patenting) of the respective technology. The unit of observation is a patent family-(destination) country-(citing) year. The sample contains a random 10% of all patent families with a family size above 5, i.e., with duplicate patenting in at least 4 countries. Panel A includes all destination countries, while Panel B includes only BRIC countries as the destination countries. 𝟙 (Duplicate Patenting) is a dummy that equals 1 if a patent family has a duplicate patent filed in the respective destination country, and 0 otherwise. 𝟙 (Post) is a dummy that equals 1 after duplicate patenting, and 0 otherwise. The outcome variables capture the probability and amount of citations to a patent family from a destination country. In columns (1) to (3), the outcome variable is a dummy that equals one if at least 1 patent filed by the destination country cites the respective patent family. In columns (4) to (6), the outcome variable is the log number of patents that are filed by the destination country and cite the respective patent family. Robust standard errors double clustered at the country level and the patent family level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table A.2: Validation – Duplicate Patenting as a Proxy for Technology Transfer

	(1)	(2)	(3)	(4)
Dep. Var.	Technology Transfer			
	ln(N+1)	ln(citN+1)	ln(N+1)	ln(citN+1)
Delta × CN × ProcessShare1	0.154***	0.421***		
	[0.058]	[0.102]		
Delta × CN × ProcessShare2			0.245***	0.621***
			[0.072]	[0.118]
Country × Industry × Year FE	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES
Obs	2,650,995	2,650,995	2,650,995	2,650,995
Adj R2	0.386	0.404	0.386	0.403

This table shows how CEO incentives differentially affect US firms' technology transfer for process versus product innovation. *ProcessShare*1 is the share of process innovation in any industry defined by 2-digit SIC code, using all claims in patent applications. *ProcessShare*2 is the share of process innovation in any industry defined by 2-digit SIC code, using only independent claims in patent applications. The unit of observation is a firm-country-year. *Delta* measures CEO incentives and is defined as the dollar change in equity portfolio value for a 1% increase in stock price. *CN* is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. An interaction term of ln(TotalPay) and CN is included in all models. The outcome variables are two duplicate patenting measures – log (citation-weighted) number of patents in the corresponding country-year with priority traced back to the respective firm. Robust standard errors double clustered at the country level and the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table A.3: Poisson Regression

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	Technology Transfer					
	N	citN	N	citN	N	citN
Delta × CN	0.028**	0.029***	0.028*	0.028***	0.058***	0.051***
	[0.014]	[0.010]	[0.014]	[0.010]	[0.013]	[0.013]
Control	-		Total Pay		Firm Characteristics	
Country × Year FE	YES	YES	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES	YES	YES
Obs	749,249	740,989	749,249	740,989	729,210	722,506

This table shows how CEO incentives affect US firms' technology transfer to China versus other countries, using a Poisson regression. The unit of observation is a firm-country-year. *Delta* measures CEO incentives and is defined as the dollar change in equity portfolio value for a 1% increase in stock price. *CN* is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. The outcome variables are two duplicate patenting measures – the (citation-weighted) count of the number of patents in the corresponding country-year with priority traced back to the respective firm. Robust standard errors double clustered at the country level and the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table A.4: The Effect of CEO Incentives on Technology Transfer – Controls

Panel A: Add Firm Characteristics

	(1)	(2)
	Technology Transfer	
Dep. Var.	ln(N+1)	ln(citN+1)
Delta × CN	0.055***	0.106***
	[0.003]	[0.006]
Firm Characteristics	YES	YES
Country × Industry × Year FE	YES	YES
Firm × Year FE	YES	YES
Obs	2,659,463	2,659,463
Adj R2	0.379	0.396

Panel B: Add Country Characteristics

	(1)	(2)
	Technology Transfer	
Dep. Var.	ln(N+1)	ln(citN+1)
Delta × CN	0.036***	0.066***
	[0.006]	[0.013]
Country Characteristics	YES	YES
Country × Industry × Year FE	YES	YES
Firm × Year FE	YES	YES
Obs	2,922,508	2,922,508
Adj R2	0.386	0.403

This table shows how CEO incentives affect US firms' technology transfer to China versus other countries by adding in more control variables. The unit of observation is a firm-country-year. Panel A adds interactions between firm characteristics (size, profitability, leverage, Tobin's q, capex, R&D intensity) and China as control variables. Note, that we always control for the log level of CEO pay. Panel B adds interactions between country characteristics (ln(GDP per capita), GDP per capita growth, ln(population), population growth) and China as control variables. *Delta* measures CEO incentives and is defined as the dollar change in equity portfolio value for a 1% increase in stock price. *CN* is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. An interaction term of ln(TotalPay) and CN is included in all models. The outcome variables are two duplicate patenting measures – log (citation-weighted) number of patents in the corresponding country-year with priority traced back to the respective firm. Robust standard errors double clustered at the country level and the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table A.5: Alternative CEO Incentive Measures: Scaled Wealth-Performance Sensitivity

Panel A: Technology Transfer and Cross-Border Partnerships

	(1)	(2)	(3)	(4)	(5)
	Technology Transfer		Dummy Variable for ...		
Dep. Var.	ln(N+1)	ln(citN+1)	Joint Venture	Strategic Alliance	Tech-related Partnership
WPS × CN	0.071***	0.134***	0.003***	0.004***	0.001**
	[0.006]	[0.012]	[0.000]	[0.001]	[0.000]
WPS × BRIC	-0.001	-0.002	0.000	0.001	0.000
	[0.003]	[0.006]	[0.000]	[0.001]	[0.000]
Country × Industry × Year FE	YES	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES	YES
Obs	2,954,529	2,954,529	2,954,529	2,954,529	2,954,529
Adj R2	0.382	0.398	0.049	0.029	0.01

Panel B: Future Technological Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Technology Sourcing			Inventor Migration		Exposure to Foreign	
Dep. Var.	Application			ln(N+1)	ln(N+1)	Competition in Patenting	
WPS × CN	0.034***	0.045***	0.058***	0.017***	0.026***	0.146***	0.278***
	[0.005]	[0.007]	[0.008]	[0.004]	[0.006]	[0.011]	[0.013]
WPS × BRIC	0.003	0.004	0.003	0.003	0.004	-0.005*	-0.006
	[0.003]	[0.004]	[0.004]	[0.003]	[0.005]	[0.003]	[0.004]
Future Years	1	3	5	1-5 years	6-10 years	1-5 years	6-10 years
Country × Industry × Year FE	YES	YES	YES	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES	YES	YES	YES
Obs	1,637,682	1,637,682	1,637,682	2,954,529	2,954,529	2,954,529	2,954,529
Adj R2	0.518	0.533	0.544	0.073	0.082	0.644	0.604

The table repeats our main analysis, using scaled wealth-performance sensitivity (Edmans, Gabaix, and Landier, 2009) as a measure for CEO incentives. Panel A examines the effect of CEO incentives on technology transfer and cross-border partnerships, while Panel B examines future technological outcomes. The unit of observation is a firm-country-year. WPS is the dollar change in CEO wealth for a 100 percentage point change in firm value, divided by annual flow compensation. CN is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. $BRIC$ is an indicator variable for other BRIC countries, and equals 1 when the destination country is Brazil, Russia, or India. An interaction term of ln(TotalPay) and CN is included in all models. Columns (1) and (2) of Panel A resemble columns (1) and (2) of Table 2, Panel B. Columns (3) to (5) of Panel A resemble columns (1) to (3) of Table 7. Columns (1) to (3) of Panel B resemble columns (1) to (3) of Table 8. Columns (4) and (5) of Panel B resemble columns (1) and (2) of Table 9. Columns (6) and (7) of Panel B resemble columns (1) and (2) of Table 10. Robust standard errors double clustered at the country level and the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table A.6: Alternative CEO Incentive Measures: Share of Equity-linked Pay

Panel A: Technology Transfer and Cross-Border Partnerships

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	Technology Transfer		Dummy Variable for ...		
	ln(N+1)	ln(citN+1)	Joint Venture	Strategic Alliance	Tech-related Partnership
EquityPayShare × CN	0.278***	0.541***	0.013***	0.005***	0.003***
	[0.011]	[0.024]	[0.001]	[0.001]	[0.000]
EquityPayShare × BRIC	0.051	0.107	0.003***	0.002	0.000
	[0.041]	[0.091]	[0.001]	[0.002]	[0.001]
Country × Industry × Year FE	YES	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES	YES
Obs	2,931,023	2,931,023	2,931,023	2,931,023	2,931,023
Adj R2	0.38	0.398	0.049	0.029	0.011

Panel B: Future Technological Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dep. Var.	Technology Sourcing			Inventor Migration		Exposure to Foreign	
	Application			ln(N+1)	ln(N+1)	Competition in Patenting	
EquityPayShare × CN	0.182***	0.241***	0.292***	0.029***	0.033***	1.037***	1.053***
	[0.023]	[0.025]	[0.025]	[0.002]	[0.003]	[0.048]	[0.047]
EquityPayShare × BRIC	0.029	0.044	0.053	0.015	0.021	-0.02	0.002
	[0.049]	[0.056]	[0.061]	[0.013]	[0.018]	[0.047]	[0.053]
Future Years	1	3	5	1-5 years	6-10 years	1-5 years	6-10 years
Country × Industry × Year FE	YES	YES	YES	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES	YES	YES	YES
Obs	1,618,994	1,618,994	1,618,994	2,931,023	2,931,023	2,931,023	2,931,023
Adj R2	0.517	0.533	0.543	0.07	0.079	0.643	0.603

The table repeats our main analysis, using share of equity linked pay as a measure for CEO incentives. Panel A examines the effect of CEO incentives on technology transfer and cross-border partnerships, while Panel B examines future technological outcomes. The unit of observation is a firm-country-year. $EquityPayShare$ is the share of equity-linked pay out of total CEO annual compensation. CN is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. $BRIC$ is an indicator variable for other BRIC countries, and equals 1 when the destination country is Brazil, Russia, or India. An interaction term of ln(TotalPay) and CN is included in all models. Columns (1) and (2) of Panel A resemble columns (1) and (2) of Table 2, Panel B. Columns (3) to (5) of Panel A resemble columns (1) to (3) of Table 7. Columns (1) to (3) of Panel B resemble columns (1) to (3) of Table 8. Columns (4) and (5) of Panel B resemble columns (1) and (2) of Table 9. Columns (6) and (7) of Panel B resemble columns (1) and (2) of Table 10. Robust standard errors double clustered at the country level and the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table A.7: Alternative CEO Incentive Measures: Equity Portfolio Delta in Thousands of Dollars

Panel A: Technology Transfer and Cross-Border Partnerships

	(1)	(2)	(3)	(4)	(5)
	Technology Transfer		Dummy Variable for ...		
Dep. Var.	ln(N+1)	ln(citN+1)	Joint Venture	Strategic Alliance	Tech-related Partnership
Delta × CN	0.037***	0.072***	0.003***	0.004***	0.001***
	[0.002]	[0.005]	[0.000]	[0.000]	[0.000]
Delta × BRIC	0.011	0.023	0.001	0.001	0.000
	[0.008]	[0.017]	[0.000]	[0.001]	[0.000]
Country × Industry × Year FE	YES	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES	YES
Obs	2,962,194	2,962,194	2,962,194	2,962,194	2,962,194
Adj R2	0.382	0.398	0.05	0.029	0.01

Panel B: Future Technological Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Technology Sourcing			Inventor Migration		Exposure to Foreign	
Dep. Var.	Application			ln(N+1)	ln(citN+1)	Competition in Patenting	
Delta × CN	0.018***	0.026***	0.034***	0.011***	0.017***	0.112***	0.170***
	[0.003]	[0.003]	[0.004]	[0.001]	[0.002]	[0.007]	[0.008]
Delta × BRIC	0.008	0.011	0.016	0.005	0.008	-0.003	-0.001
	[0.008]	[0.009]	[0.012]	[0.005]	[0.007]	[0.007]	[0.009]
Future Years	1	3	5	1-5 years	6-10 years	1-5 years	6-10 years
Country × Industry × Year FE	YES	YES	YES	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES	YES	YES	YES
Obs	1,639,945	1,639,945	1,639,945	2,962,194	2,962,194	2,962,194	2,962,194
Adj R2	0.518	0.533	0.544	0.073	0.083	0.644	0.604

The table repeats our main analysis, using equity portfolio delta values (in thousand $) instead of the standardized delta as a measure of CEO incentives. Panel A examines the effect of CEO incentives on technology transfer and cross-border partnerships, while Panel B examines future technological outcomes. The unit of observation is a firm-country-year. *Delta* measures CEO incentives and is defined as the dollar change in equity portfolio value for a 1% increase in stock price. The original value is divided by 1,000 for easier interpretation of the coefficient. CN is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. $BRIC$ is an indicator variable for other BRIC countries, and equals 1 when the destination country is Brazil, Russia, or India. An interaction term of ln(TotalPay) and CN is included in all models. Columns (1) and (2) of Panel A resemble columns (1) and (2) of Table 2, Panel B. Columns (3) to (5) of Panel A resemble columns (1) to (3) of Table 7. Columns (1) to (3) of Panel B resemble columns (1) to (3) of Table 8. Columns (4) and (5) of Panel B resemble columns (1) and (2) of Table 9. Columns (6) and (7) of Panel B resemble columns (1) and (2) of Table 10. Robust standard errors double clustered at the country level and the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table A.8: The Effect of CEO Incentives on Technology Transfer

Panel A: Alternative Samples

	(1)	(2)	(3)	(4)
Dep. Var.	Technology Transfer			
	ln(N+1)	ln(citN+1)	ln(N+1)	ln(citN+1)
Delta × CN	0.048***	0.089***	0.055***	0.107***
	[0.004]	[0.008]	[0.004]	[0.009]
Sample	Excluding Small		Excluding Europe	
Country × Industry × Year FE	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES
Obs	1,920,192	1,920,192	1,623,120	1,623,120
Adj R2	0.462	0.479	0.401	0.416

Panel B: Alternative Industry Definitions

	(1)	(2)	(3)	(4)
Dep. Var.	Technology Transfer			
	ln(N+1)	ln(citN+1)	ln(N+1)	ln(citN+1)
Delta × CN	0.051***	0.102***	0.052***	0.104***
	[0.003]	[0.007]	[0.004]	[0.007]
Industry Definition	2-digit SIC		4-digit SIC	
Country × Industry × Year FE	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES
Obs	3,033,150	3,033,150	2,887,442	2,887,442
Adj R2	0.38	0.394	0.409	0.42

This table shows how CEO incentives affect US firms' technology transfer to China versus other countries using alternative samples (Panel A) and alternative industry definitions (Panel B). In Panel A, columns (1) and (2) exclude firms that have a total average asset value below 1 billion USD during the sample period. Columns (3) and (4) exclude European countries from the sample. In Panel B, industry in columns (1) and (2) is defined by 2-digit SIC code. The unit of observation is a firm-country-year. Industry in columns (3) and (4) is defined by 4-digit SIC code. The unit of observation is a firm-country-year. *Delta* measures CEO incentives and is defined as the dollar change in equity portfolio value for a 1% increase in stock price. CN is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. An interaction term of ln(TotalPay) and CN is included in all models. The outcome variables are two duplicate patenting measures – log (citation-weighted) number of patents in the corresponding country-year with priority traced back to the respective firm. Robust standard errors double clustered at the country level and the firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table A.9: Global Evidence on CEO Incentives and Technology Transfer

Country-pair Level Analysis

	(1)	(2)	(3)	(4)
Dep. Var.	Technology Transfer (% of all destination countries)			
	Application	Grant	Application	Grant
EquityPayShare × CN	6.514***	5.482***	9.205***	12.194***
	[0.814]	[0.857]	[2.808]	[2.753]
EquityPayShare × BRIC	-0.463	-0.717	-2.252	-2.073
	[0.400]	[0.418]	[1.384]	[1.420]
Data Source	BoardEx		Fernandes et al (2012)	
Dep. Var. Mean	1.097	1.014	1.174	1.151
Origination Country × Year FE	YES	YES	YES	YES
Destination Country × Year FE	YES	YES	YES	YES
Obs	15,470	15,470	10,433	10,433
Adj R2	0.685	0.67	0.807	0.769

This table shows country-pair level analysis of how CEO incentives in developed European countries and the US affect these countries' technology transfer to China versus other countries. The unit of observation is a country-pair-year. *EquityPayShare* measures the percentage share of equity-linked pay in total CEO compensation. Columns (1) and (2) rely on BoardEx data to calculate the median *EquityPayShare* of each country. Columns (3) and (4) use the equity pay share statistics in Table 1 of Fernandes, Ferreira, Matos, and Murphy (2013). *CN* is an indicator variable for China, and equals 1 when the destination country is China and 0 otherwise. *BRIC* is an indicator variable for other BRIC countries, and equals 1 when the destination country is Brazil, Russia, or India. The outcome variable is the percentage share of duplicate patenting (applications/granted patents) in each destination country with priority traced back to the respective developed country out of all duplicate patenting worldwide that can be traced back to this developed country. Robust standard errors double clustered at the origination country level and the destination country level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.