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 novel 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. The evidence is 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.

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 is at the center of conflicts between China and Western countries. 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. In particular, foreign firms are often required to establish joint ventures in China to facilitate such technology transfer. Globally competitive Chinese firms have over time emerged in many technology-intensive sectors, such as renewable energy, high-speed trains, and turbines.[1] Many business executives, policymakers, and academics attribute China's rising technological output to its quid pro quo policy. The US Congress has held multiple hearings regarding (forced) technology transfer, accusing China of breaching intellectual property rights.

However, are there any Western-driven factors that may have contributed to China's technological rise? This paper shifts the focus to foreign multinationals and examines frictions within these firms that may affect their responses to China's quid pro quo policy. A key friction modern 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 ever-intensifying US-China technology conflict, we ask how this trend, and more specifically, high powered incentive contracts given to CEOs, affect technology transfer to China – an important determinant of not only firm-level outcomes but also national and even global welfare.

To answer the above question, we build a novel firm-country panel describing the technological and investment relationships that US firms form with over 70 countries. We leverage

[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).

detailed patenting information from PATSTAT Global and USPTO to create measures of technological interactions. First, we rely on 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 of using this measure is that all three major technology transfer channels, trade, FDI and licensing, would result in duplicate patenting (Keller, 2004). So although duplicate patenting itself may not directly measure technology transfer, its changes would track changes in technology transfer, and can therefore be considered as a proxy. Second, to assess long-term consequences in an innovation context, we construct three novel measures, all varying at the firm-country 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.

We investigate S&P 1500 firms from 1993 to 2016 and measure CEO incentives using portfolio delta, which equals the dollar change in equity portfolio value for 1% increase in stock price. Higher delta is associated with stronger equity incentives. Since equity incentives tend to vest in the short term – often no more than three years – while the cost of technology transfer only manifests in the long run, high equity incentives can shift the CEO's trade-off in favor of exchanging technology for short-term market access. This would predict a positive relationship between CEO equity incentives and technology transfer to China.

Consistent with the above prediction, we find that US firms managed by CEOs with stronger equity incentives transfer more technology to China. The magnitude of the effect is large: a one standard deviation increase in delta translates into 10% more technology transfer to China. Furthermore, we detect little influence of CEO incentives on technology transfers to other large developing countries or to other Asian countries. To facilitate the transfer of technology, firms form partnerships with Chinese local businesses. If the CEO has a one standard deviation higher equity incentives, the firm is three times more likely to establish joint ventures and strategic alliances, including technology-oriented ones, in 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. Developing China's market likely requires extra effort. At the same time, technology transfer may be inevitable during the expansion into China, especially if the firm sets up production facilities there. Then the relationships we observe 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. 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.

We use cross-sectional tests to distinguish between the "effort" and "myopia" interpretations. First, we find that a more long-term oriented shareholder base mitigates the effects of high equity incentives on technology transfer to China, suggesting a potential conflict of interest between long-term investors and the CEO, which points towards the myopia interpretation. Second, analyst coverage amplifies the effect of high equity incentives. Since analysts impose short-term pressure on firm performance, this is again consistent with the myopia interpretation. Under the effort interpretation, institutional ownership and analyst coverage should not matter, at least not unambiguously in the direction observed in our cross-sectional tests. In addition, the relationship between high equity incentives and technology transfer to China is weaker if the CEO is a long-term investor in the firm and if the firm is not financially constrained and therefore under no short term pressure to boost its sales or profits. Albeit less direct, these tests also provide support for the myopia interpretation.

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 losing 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. In the data, CEOs transfer even more technology to China in SEIs, providing additional evidence for the myopia interpretation.

What are the long-term consequences? 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 cast doubt on our technology transfer measure as well as the myopia interpretation of the effects of high equity incentives. Evidence on negative long-run implications, on the contrary, would alleviate the concern that duplicate patenting captures the strength of IPR protection. Moreover, it further would invalidate the effort interpretation, which predicts better long-term outcomes for the firm when CEOs increase their effort provision in 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.

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 high-powered CEO incentives and its technology transfer to China. 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.

Our paper has important policy implications, since it might be in the interest of Western firms and policy-makers to limit the technology transfer to China, especially the part driven by high-powered CEO incentives. One solution is to lengthen CEOs' horizons, by, for example, substantially extending the vesting period of equity. Other potential approaches include giving more voting rights to long-term shareholders, as in France (Bourveau, Brochet, and Garel, 2019), or adding labor representatives to corporate boards, as in Germany. Such labor presentation can lead to more long-term oriented decision making (Jäger, Schoefer, and Heining, 2021). Last, (Western) policy-makers could set up governmental agencies with powers to approve or veto corporate alliances or joint ventures between firms from their home countries and Chinese firms. Such an approach might be easier to implement than letting governmental agencies monitor technology transfer directly. At the same time, this approach targets one of the key mechanisms through which technology transfer from Western firms to China takes place.

Related Literature. Our research contributes to four lines of work. First, the paper adds to the literature on CEO compensation. A number of papers document a positive relationship between stock and option holdings and accounting irregularities (see Cheng and Warfield (2005) and Bergstresser and Philippon (2006), among others). Edmans, Fang, and Lewellen

(2017) construct a direct measure of CEO short-term incentives – the quantity of equity scheduled to vest in a given period – and link this to changes in real investment, especially in R&D. Gonzalez-Uribe and Groen-Xu (2017) compute the CEO contract time horizon and study its impact on corporate innovation.[2] This paper moves away from the typical US firm-level setting and analyzes the extensive technological and investment relationships US firms have with other countries. We exploit cross-country and cross-firm variations for identification and add to this literature by documenting an important real effect of CEO incentives – technology transfer to China and the implications for Western firms' long-term competitive advantages in R&D.

Second, a burgeoning literature on technology transfer and diffusion in a global setting has emerged. Prior work has documented the role of foreign direct investment (FDI) (Aitken and Harrison, 1999; Javorcik, 2004; Keller and Yeaple, 2009), intellectual property rights (Branstetter, Fisman, and Foley, 2006; Cockburn, Lanjouw, and Schankerman, 2016), financial development (Comin and Nanda, 2019), geography (Comin, Dmitriev, and Rossi-Hansberg, 2012; Hovhannisyan and Keller, 2019), and legal institutions (Bian, Meier, and Xu, 2020) in cross-border technology transfer and diffusion. These factors all vary at the country level and typically do not depend on firm-level decisions or corporate policies. In contrast, this paper takes the perspective of knowledge-exporting firms and documents that their decisions on technology transfer depend on CEO incentives. This paper also differs by utilizing granular data to compile a detailed firm-country panel for its analysis. It uncovers an important, firm-driven micro-channel behind global technology transfer.

This paper also contributes to the literature on China's growth and its technological catch-up. Song, Storesletten, and Zilibotti (2011) build a growth model highlighting the role of productive entrepreneurial firms and reallocation. Holmes, McGrattan, and Prescott (2015) assess the impact of China's quid pro quo policy on China's growth and global innovation using a multi-country dynamic general equilibrium model. Leveraging the Chinese

[2]For a survey of the literature on CEO compensation, see Edmans, Gabaix, and Jenter (2017).

automobile industry as a laboratory, Bai, Barwick, Cao, and Li (2020) document the role of FDI via quid pro quo in facilitating knowledge spillover to developing countries. Our paper deviates by adding firm-specific factors in technology-exporting countries into the discussion, which helps paint a more complete picture of China's growth and technology catch-up.

Last, a nascent literature studies the interaction between the US and China in innovation (Hombert and Matray, 2018; Bena and Simintzi, 2019; Hoberg, Li, and Phillips, 2019). These papers focus on how the rise of China affects US firms' innovation, while our research question is in the opposite direction. We document how US corporations foster future Chinese competitors in technological innovation.

2 Data and Variable Measurement

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

2.1 Data Sources

ExecuComp. ExecuComp provides details of US executive compensation, including CEO compensation for S&P 1500 firms from 1992 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.

BoardEx. Compared with ExecuComp, BoardEx has global coverage. To compare the US with other developed countries, we use BoardEx to construct measures on each country's average CEO incentives.

SDC Platinum. SDC Platinum covers partnerships formed between two or more entities.

We collect information on cross-border joint ventures and strategic alliances. 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. 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. Combined with information on each US firm's R&D specialization, we also calculate the firm's exposure to foreign competition in patenting.

2.2 Measurement: CEO Incentives

CEO incentives, varying at the firm-year level, are measured using CEO equity portfolio delta. This measure 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 only 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.[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

[3] It takes time for China to digest, adapt, and advance foreign technology. In the case of high-speed trains, it took China more than ten years to compete with Western firms and start exporting its high-speed trains. 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 (accessed April 5, 2021).

results. Nevertheless, we rerun all the analyses using raw values (in thousand $) to ensure the robustness of our results (see Table A.2). Importantly, in robustness checks, we also use alternative measures, including CEO compensation mix (Harris and Bromiley, 2007; Larcker, Richardson, and Tuna, 2007) and scaled wealth-performance sensitivity (Edmans, Gabaix, and Landier, 2009).

2.3 Measurement: Technology Transfer and Partnerships

Technology Transfer. We measure technology transfer using information on patent priority rights. A priority right is triggered by the first filing of a patent application. It allows the claimant to 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 relying on patent priority rights to trace technology transfer has been used by Lanjouw and Mody (1996), Eaton and Kortum (1999), and Dechezlepretre, Glachant, Hascic, Johnstone, and Meniere (2011). The fact that firm i patents its existing technology in country c ("duplicate patenting") indicates a transfer, because patenting provides the exclusive right to commercially exploit the technology in the country where the patent is filed.

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 as a proxy.

To further validate the measure, we examine the number of S&P 1500 firms that invest or patent in China over time. Figure 1 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 joint ventures, strategic alliances, and any technology-driven relationships (Figure 1a) or when we restrict to technology-driven relationships only (Figure 1b).

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

Cross-Border Partnerships. To explore the potential channels through which technology transfer takes place in practice, we construct dummy variables indicating different types of partnerships that are formed between firm i and country c at year t. We focus on joint ventures, strategic alliances, and technology-oriented partnerships.[4]

2.4 Measurement: Future Technological Outcomes

To assess the long-term consequences in an international and R&D context, we construct three novel measures based on granular patenting data, all varying at the firm-country level.

Technology Sourcing by Foreign Countries. To compute this measure, we 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' location from USPTO PatentsView, we count the number of inventors who were af-

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

filiated with firm i and move from US to country c in each year. After moving, we double check that 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.[5]

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 as $\alpha_{i,ipc,t}$. In the end, 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 expertise. Equivalently, this measure captures firm-specific technology catch-up or competition pressure in patenting from each country.

2.5 Global Evidence

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. More specifically, the transfer origination countries cover 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.

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

2.6 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 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 the means of other firm characteristics, profitability has a value of 0.124, Capex (capital expenditure to total assets ratio) has a value of 0.054, and R&D intensity (R&D expense to total asset ratio) has a value 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 quite 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 other countries 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-digits level.

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

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

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 in the regression. 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, 2021). 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 firm 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 a main setting to study all outcome variables, including technology transfer, cross-border partnerships, and future technological outcomes. We then 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:

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

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.

4 Results

4.1 Technology Transfer

We start by analyzing the effect of CEO incentives on technology transfer to China. Using the specification in Equation 2, columns (1) and (2) of Panel A, Table 2 report OLS regression results of 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. For example, the Chinese government gradually lifted trade barriers in the retail sector after joining the WTO, and as a result, US firms conducted more business in China and transferred more technology to China. At the same time, it could be that CEOs in the retail sector happen to receive more high-powered and short-term incentives on average. 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 (except for the regressions that use a global sample of executive compensation).

Across all specifications, we observe a larger effect when the dependent variable is the citation-weighted number of patents compared with 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 quid pro quo policy and foreign firms' heterogeneous responses to this policy.

4.1.1 Measurement: Validation of Outcome Variable

A measurement concern is that duplicate patenting captures 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 the concern that duplicate patenting is exclusively about commercialization in China is justified, then 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. For data availability reasons the share of process innovation for each firm is defined at the 2-digit SIC code level. In Table 3, we report results from this test. In columns (1) and (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 point estimate, 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 additional validation for our measure.

4.1.2 Robustness

A. Firm-level Controls. One may argue that other firm-level characteristics such as R&D intensity or capital expenditure 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. To evaluate these arguments, we include in the regression an extended list of interaction terms between firm-level observables (size, profitability, leverage, Tobin's q, capex, R&D intensity) and the indicator for China. The results are tabulated in Panel A of Table 4. We find that adding these controls barely changes the significance level or the economic magnitude of the effect of CEO portfolio delta, suggesting that most firm characteristics are orthogonal to CEO equity incentives in determining firms' technology transfer policy. At the same time, the high stability of our estimation after adding in different controls suggests that the bias from omitted variables is probably limited (Oster, 2019).

B. Country-level Controls. 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. If true, our estimates of technology transfer to China may be mostly driven by China's vast market potential, rather than its special quid pro quo policy. In response, we add to the regression interaction terms between CEO equity portfolio delta and macroeconomic variables that indicate either the size or the growth of the destination market (ln(GDP per capita), GDP per capita growth, ln(population), and population growth). Panel B of Table 4 reports the results. After controlling for these country-level characteristics, the coefficient on $Delta \times CN$ remains highly significant and the magnitude is reduced by only one third. We conclude that these country-level factors alone cannot explain the large amount of technology transfer to China; the main effect is still driven by firms' differential responses to China's unique quid pro quo policy.

Another way of interpreting the results is that without China's unique quid pro quo policy, the same US firm with high CEO equity incentives would curtail technology transfer to China by two-thirds. One may consider the two thirds as "excess" transfer that is not driven by market fundamentals. It seems the Chinese government is able to leverage the country's vast market potential to demand more technology transfer than firms would do absent the quid pro quo policy.

C. Alternative Samples. One concern might be that our results are driven by firm size being correlated with CEO incentives and technology transfer to China in a way that is not accounted for by our various fixed effects and control variables. To address this concern, we exclude firms with less than 1 billion USD during the sample period from the analysis. The results in models 1 and 2 of Panel A of Table A.1 document that our results are robust to this concern. Another concern might be that within the European Union firms can file for patent protection with national patent offices and the European Patent Office (EPO). If the substitution pattern between the EPO and national patent offices was unchanged over time, it would be accounted for by our fixed effects. But if there are changes over time in duplicate patenting for Europe being achieved through the European Patent Office versus national European patent offices, than one might be worried whether changes in duplicate patenting in Europe might affect the "control group" in a way that could drive our results. We address this concern by dropping all European countries from our sample and the results remain unchanged (columns (3) and (4) of Table A.1).

Next, we show that our results are robust to alternative industry definitions. In the baseline specification, we measure industry at the 3-digit SIC level. Measuring industry at the 2-digit SIC level has the advantage that each industry group will have a larger number of firms, making it less likely that industry fixed effects are driven by outliers. Measuring industry at the 4-digit SIC level has the advantage that the firms within an industry group are more comparable to each other. The results in Panel B of Table A.1 show that the results are robust to 2-digit SIC level (columns (1) and (2)) and 4-digit (columns (3) and (4)) SIC level industry definitions.

4.1.3 Cross-Sectional Heterogeneity: Effort vs. Myopia Interpretation

There are two potential interpretations for why CEOs with high equity incentives establish more partnerships with China and 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 on behalf of executives, firms' could give their CEOs high equity incentives to induce them to exert effort. At the same time, technology transfer may be inevitable during the expansion to China, especially if the firm sets up production facilities there. Then the relationships we observe are consistent with the effort-inducing property of high equity incentives and providing such incentives could 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. 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 large government procurement market or lean on state-owned enterprises to redirect their purchases to particular Western multinationals. Such actions by the Chinese government can quickly boost a Western multinational's sales and profits.

We use cross-sectional tests to distinguish between the "effort" and "myopia" interpretation, including four tests with variation at the firm-level and one test with variation at the industry-level. The cross-sectional variations we exploit point to different predictions under the effort and myopia interpretation.

A. Institutional Ownership. We first examine institutional ownership. Institutional investors typically have long investment horizons, they monitor the CEO's actions, and their presence may mitigate the effects of CEO short-termism (Aghion, Van Reenen, and Zingales, 2013). Under the myopia interpretation, the presence of more long-term investors should lead to less technology transfer by firms managed by CEOs with high equity incentives. In contrast, under the effort interpretation a more long-term orientated sharebase should induce CEOs with high equity incentives to transfer even more technology to China. We extract institutional ownership data from the Thomson Reuters 13F database and sort firms into two groups based on their institutional ownership percentage. Columns (1) and (2) of Table 5 present our findings with a triple-difference empirical design, in which the binary variable $InstOwnership$ indicates firms assigned to the high institutional ownership group. The estimated coefficient on the triple interaction term $Delta \times CN \times InstOwnership$ is negative and significant, suggesting that CEOs become less responsive to their equity incentives if their employers have a higher level of institutional ownership. This finding is consistent with the myopia interpretation.

B. Analyst Coverage. The second dimension of cross-sectional heterogeneity we investigate is analyst coverage. Higher analyst coverage suggests more short-term capital market pressure and under the myopia interpretation it should affect CEOs' trade-off between the short-term benefits of accessing the vast Chinese market and the long-term costs of transferring technology to China. In contrast, analyst coverage does not affect the predictions of the effort interpretation regarding technology transfer to China. We obtain data on analyst coverage from IBES. We sort firms into two groups based on the number of analysts following them. Columns (3) and (4) of Table 5 present our findings, again with a triple-difference design, in which the binary variable $AnalystCoverage$ indicates firms with above-median analyst coverage. Consistent with our prediction, the positive coefficient on the triple interaction term $Delta \times CN \times AnalystCoverage$ implies that CEOs are even more responsive to high equity incentives when firms are subject to higher short-term capital market pressure due to greater analyst coverage.

C. CEO Ownership. Third, we investigate whether CEOs are long-term investors of the firms they manage. For the effort interpretation, a CEO with high equity incentives should transfer even more technology to China if she is also a long-term investor in the firm. For the myopia interpretation, a CEO with high equity incentives should transfer less technology to China given that she is a long-term investor in the firm and therefore cares about its long term value. We obtain information on CEO ownership data from Execucomp. We create the dummy variable *CEO_Ownership*, which equals one if the CEO owns more than 5% of the firm and zero otherwise. Columns (5) and (6) of Table 5 present our findings, using a triple-difference design with *CEO_Ownership* interacted with $Delta \times CN$. The negative point estimate for the tripple interaction term is in line with the myopia interpretation.

D. Financial Constraints. Fourth, we consider the effect of financial constraints. For financially constrained firms, myopic behavior might be in the interest of shareholders–at least relative to non-financially constrained firms (Hackbarth, Rivera, and Wong, 2018). Consequently, in case of the myopia interpretation the effect of high CEO equity incentives on technology transfer to China might be exacerbated for financially constrained firms. For instance, a firm that is operating in China and that is financially constrained might agree to more technology transfer, if the Chinese government eases market access in the short-run. For the effort interpretation, there is no clear prediction how it could interact with a firm's financial constraints. We create a binary variable $FinancialConstraints$, which equals one for firms that are subject to financial constraints. We define financially constrained firms as those that are in the top decile of the Whited-Wu index of financial constraints (Whited and Wu, 2006). In columns (7) and (8) of Table 5 we present the results from a triple-difference design with $FinancialConstraints$ interacted with $Delta \times CN$. The positive point estimate for the tripple interaction term supports the myopia interpretation.

E. China's Strategic Emerging Industries. We now exploit 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 quid pro quo policy. 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 losing technology to China–especially in industries prioritized by the Chinese government since Chinese efforts to catch up with Western firms will likely be particularly intense. On the contrary, 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. Moreover, for SEIs the Chinese government might be especially willing to reward (or punish) Western firms with favored access to the government procurement market or by directly instructing state-owned enterprises to buy from particular Western firms, to 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.[6] We then map these industries to 3-digit SIC codes. The dummy variable SEI indicates firms that specialize in these strategic emerging industries. Columns (1) and (2) of Table 6 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 SEI industries where China's quid pro quo policy tends to be even more demanding. 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.

Taken together, these firm- and industry-level cross-sectional tests support the myopia interpretation. Moreover, alternative stories must explain (1) why high CEO equity incentives are associated with a greater amount of technology transfer to China than to other countries, and (2) why this relationship is more pronounced in those firm- and industry-subsamples for which the myopia interpretation applies.

4.1.4 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 7, we divide our sample period from 1993 to 2016 into six equal sub-periods of

[6] Based on Kenderdine (2017) and documents from the US-China Business Council, the strategic emerging industries include biotechnology, energy saving equipment, new generation information technology, new materials, new energy vehicles, advanced manufacturing, high technology services, and digital creative industries.

four years. Panel A reports the result 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.

We interpret the dynamics as follows. Initially, the Chinese did not have much market power to extract much technology in exchange for market access. In the middle two time periods (2000s), the market power of the Chinese government increased substantially. At this point, however, Western firms had not yet experienced many scenarios where they face long-run negative consequences of nurturing their future Chinese competitors. Accordingly, Western firms were not (yet) forcefully responding to the technological threat from China. The technology transfer by CEOs to China therefore peaked during this sample period. In more recent years, Western awareness of the downsides of "too much" technology transfer to China surged, weakening the effect of CEO equity incentives on technology transfer to China.

The dynamics reveal important insights about the interactions between Western firms and the Chinese government, and at the same time raise the bar for alternative explanations. Alternative stories not only have to explain our main result and the cross-sectional heterogeneities across firms and industries, but also the dynamics of the main effect.

4.2 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. In particular, 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 joint ventures, strategic alliances, or technology-driven relationships between the respective US firm and China in any given year. Table 8 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 incentive are more likely to form joint ventures in China than in other countries. We move to strategic alliances 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 joint ventures or strategic alliances, including technology-related relationships, with China. These organizational vehicles facilitate the transfer of valuable technology from US firms to their Chinese partners.

4.3 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, policy makers, and the stakeholder 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 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 for the 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. Utilizing international patent citation records, we first study future technology sourcing by China versus technology sourcing by other (BRIC) countries. Table 9 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 turn to 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.

Second, we find that these US firms lose important R&D human capital to China in the long run. To provide evidence, we first 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 10, 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 next five or ten years. 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.

With Chinese firms sourcing more knowledge and poaching R&D talents from certain US firms, we expect these 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 therefore 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 11. 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.

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.

4.4 Other CEO Incentive Measures

4.4.1 Scaled Wealth-Performance Sensitivity

We rerun our main analysis using scaled wealth-performance sensitivity (WPS) as a measure for CEO incentives (Edmans, Gabaix, and Landier, 2009). WPS captures the dollar change in CEO wealth for a 100 percentage point change in firm value, divided by annual flow compensation. One major empirical advantage of this incentive measure is that it is independent of firm size, and therefore comparable across firms and over time. We standardize this measure so that it has a mean of 0 and a standard deviation of 1 to facilitate comparison with the results from the baseline specifications. Table 12 reports the estimation results using WPS instead of equity portfolio delta in the main regressions. Across all outcome variables, we observe positive coefficients on $WPS \times CN$ and these coefficients are highly significant. More importantly, the economic size of the effect remains similar. A one standard deviation increase in WPS leads to a similar amount of increase in technology transfer to China, cross-border partnerships formed with China, and exposure to patenting competition from China as a one standard deviation increase in equity delta.

4.4.2 Equity Pay Share

We also repeat our main analysis using CEO compensation mix. In particular, we calculate the share of equity-linked pay out of total CEO compensation in each year. We denote this variable as $EquityPayShare$. The mean value of $EquityPayShare$ using our S&P 1500 sample from 1993 to 2016 is around 40%, which is very close to the number reported in Fernandes, Ferreira, Matos, and Murphy (2013) for US firms.[7] Table 13 reports the estimation results using this alternative measure. The coefficient on $EquityPayShare \times CN$ remains positive and highly significant across all outcome variables, suggesting that firms with a higher share of equity-linked CEO pay transfer more technology to China and subsequently experience large, negative consequences in R&D related outcomes.

4.5 Global Evidence

To establish external validity, we also provide global evidence at the country-pair level. 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. Consistent with this prediction, in Figure 2, we detect a positive correlation between a country's average CEO equity incentives and the amount of technology transfer from this country to China.[8] In both Figure 2a and Figure 2b, the US is located in the upper right corner, indicating that the US provides the highest equity incentives to its CEOs, and at the same time, engages the most in technology transfer to China.

Table 14 provides corresponding statistical evidence. Unlike previous regressions that utilize a firm-country panel, the empirical specification here uses a country-pair panel and follows Equation 4. We focus on CEO incentives in developed European countries and the US. 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 rely on BoardEx data to calculate the median equity pay share of each country. In columns

[7] Fernandes, Ferreira, Matos, and Murphy (2013) rely on 2006 fiscal year CEO pay data extracted from the ExecuComp database, and the stock and option component is 39% on average.

[8] 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.

(3) and (4), we directly use the statistics reported in Table 1 of Fernandes, Ferreira, Matos, and Murphy (2013). 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.

5 Policy Implications

China is in fierce technological competition with rich, developed countries. Our findings that CEO incentives affect the amount of technology transfer to China by Western firms therefore have significant policy implications. Western firms might lose their competitive advantage if they transfer too much technology to China, resulting in declining wages and employment for these firms. The demise of these firms can have negative externalities on their home countries through, for instance, lower tax revenues, or a reduction in aggregate demand (Mian and Sufi, 2014).

Consequently, it might be in the interest of Western firms and policy-makers to limit technology transfer to China, especially the part driven by high-powered CEO incentives. A direct approach is that either firms or governmental agencies make CEO compensation, at least for technology oriented firms, more long-term oriented. Substantially extending the vesting period of equity is one option. Other potential approaches include giving more voting rights to long-term shareholders, as in France (Bourveau, Brochet, and Garel, 2019), or adding labor representatives to corporate boards, as is the case in Germany. Such labor presentation can lead to more long-term oriented decision making (Jäger, Schoefer, and Heining, 2021).

Finally, policy-makers in developed countries could extend the powers of national security oriented bodies such as the Committee on Foreign Investment in the United States, 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 government agency for a joint venture or corporate alliance 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 joint venture, to veto it based on national interests. Such an approval or veto mechanism does not directly target technology transfer to China, but it is easier to implement than asking a firm to seek approval for each technology that it wants to share with China. Moreover, since joint ventures and corporate alliances are a key mechanism for how technology transfer to China takes place, restricting this mechanism should also limit the technology transfer to China.[9]

6 Conclusion

This paper studies the role of CEO incentives in shaping firms' strategy 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 quid pro quo policy, managers of 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. Leveraging micro data on the global network of patents, we construct novel measures of the technological interactions between US public firms and over 70 countries, including China. Our comprehensive firm-country panel also allows for a difference-in-differences design with an extensive set of fixed effects to control for firm-specific and industry-country-specific shocks.

We find that CEOs with high-powered incentive contracts engage more in forming cross-border partnerships with China and transferring technology to China compared with other

[9]While the above policy options can help address the problem of myopic CEOs transferring too much technology to China, they can have other, unintended consequences. Therefore, one should exert caution in implementing these policies without a comprehensive evaluation of their impact.

large, developing countries. This effect is more pronounced among firms with lower institutional ownership and higher analyst coverage. 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 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 micro channel behind China's growth and technological rise.

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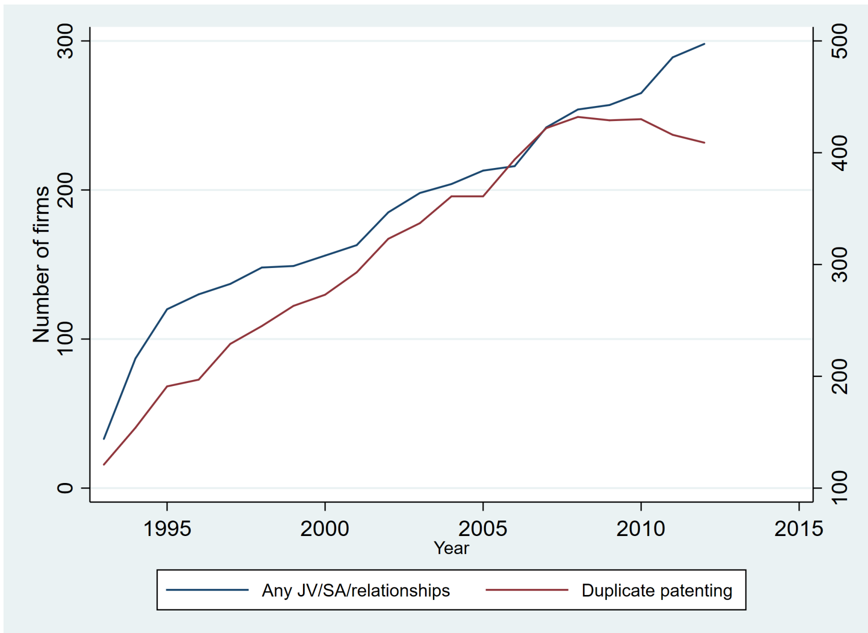
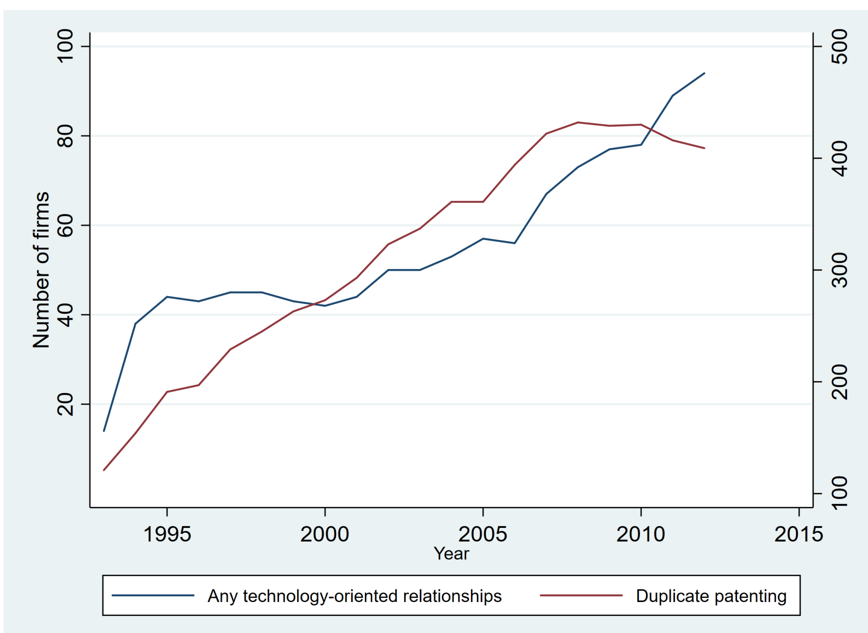
Figure 1: Correlation between Cross-Border Partnerships and Duplicate Patenting



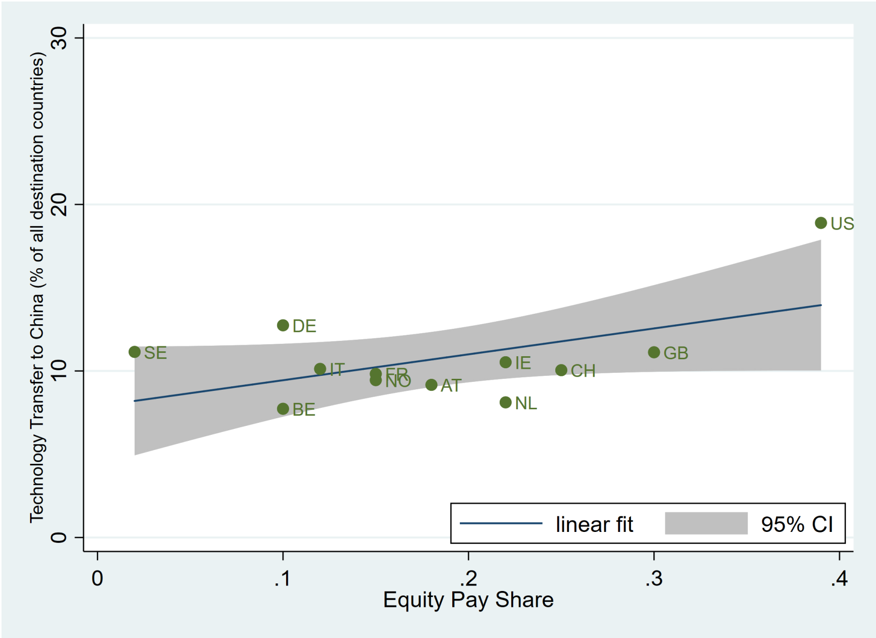
(a) All Relationships



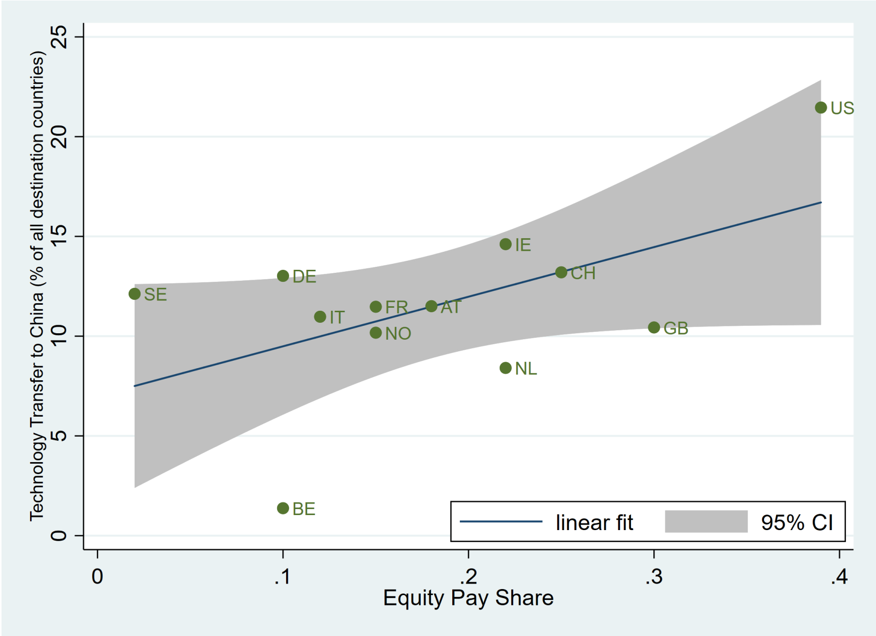
(b) Technology-oriented Relationships

Figure 1 plots the number of S&P 1500 firms that invest (left y-axis) or patent (right y-axis) in China over time. Figure 1a includes all cross-border partnerships including joint ventures, strategic alliances, and any technology-driven relationships. Figure 1b includes only technology-driven relationships.

Figure 2: Global Evidence – Technology Transfer to China vs. Equity Pay Share



(a) Patent Counts



(b) Citation Weighted Patent Counts

Figure 2 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 alliances)	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 one when the destination country is China and zero otherwise. *BRIC* (*Asian*) is an indicator variable for other BRIC (Asian) countries, and equals one when the destination country is Brazil, Russia, India (or in Asia). An interaction term of ln(TotalPay) and CN is included in all models of 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 and firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 3: Measurement: Validation of Patent Priority as a Proxy for Technology Transfer

	(1)	(2)	(3)	(4)
	Technology Transfer			
Dep. Var.	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. $ProcessShare1$ is the share of process innovation in any industry defined by 2-digit SIC code, using all claims in patent applications. $ProcessShare2$ 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 one when the destination country is China and zero 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 and 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 – Add 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 one when the destination country is China and zero 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 and firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 5: The Effect of CEO Incentives on Technology Transfer – Heterogeneity Across Firms

	(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	0.075***	0.152***	0.038***	0.065***	0.076***	0.144***	0.057***	0.110***
	[0.006]	[0.011]	[0.006]	[0.014]	[0.006]	[0.011]	[0.005]	[0.010]
Delta × CN × InstOwnership	-0.035***	-0.081***						
	[0.007]	[0.015]						
Delta × CN × AnalystCoverage			0.016*	0.043**				
			[0.009]	[0.018]				
Delta × CN × CEO_Ownership					-0.026***	-0.047***		
					[0.007]	[0.012]		
Delta × CN × FinancialConstraints							0.053**	0.106**
							[0.023]	[0.050]
Country × Industry × Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Firm × Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Obs	2,670,632	2,670,632	2,621,941	2,621,941	2,962,194	2,962,194	2,724,360	2,724,360
Adj R2	0.385	0.4	0.391	0.405	0.382	0.399	0.381	0.397

This table shows how CEO incentives differentially affect US firms' technology transfer to China versus other countries across firms. 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 one when the destination country is China and zero otherwise. In columns (1) to (4), the binary variables *InstOwnership* and *AnalystCoverage* separately indicate firms assigned to the high-institutional-ownership and high-analyst-coverage group (above median). In columns (5) and (6), the binary variable *CEO_Ownership* equals one if the CEO owns more than 5% of the firm and zero otherwise. In columns (7) and (8), the binary variable *FinancialConstraints* equals to one for firms that are subject to financial constraints (top decile in terms of the Whited-Wu index). 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 and 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 – Heterogeneity Across Industries

China's Strategic Emerging Industries

	(1)	(2)
	Technology Transfer	
Dep. Var.	ln(N+1)	ln(citN+1)
Delta × CN	0.006***	0.013***
	[0.001]	[0.003]
Delta × CN × SEI	0.116***	0.220***
	[0.008]	[0.016]
Country × Industry × Year FE	YES	YES
Firm × Year FE	YES	YES
Obs	2,962,194	2,962,194
Adj R2	0.383	0.399

This table shows how CEO incentives differentially affect US firms' technology transfer to China versus other countries across industries. We compare the effect in China's strategic emerging industries to that in the other industries. The binary variable SEI equals one for industries belonging to strategic emerging sectors of China. 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 one when the destination country is China and zero 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 and 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 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 one when the destination country is China and zero otherwise. An interaction term of ln(TotalPay) and CN is included in all models. In Panel 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 and 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 Cross-Border Partnerships

	(1)	(2)	(3)
	Dummy Variable for ...		
Dep. Var.	Joint Venture	Strategic Alliances	Tech-related Partnerships
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 one when the destination country is China and zero otherwise. $BRIC$ is an indicator variable for other BRIC countries, and equals one 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 different types of partnerships that are formed 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 and 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

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 one when the destination country is China and zero otherwise. $BRIC$ is an indicator variable for other BRIC countries, and equals one 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 applied/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 and 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
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 one when the destination country is China and zero otherwise. $BRIC$ is an indicator variable for other BRIC countries, and equals one 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 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 and firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 11: 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 one when the destination country is China and zero otherwise. $BRIC$ is an indicator variable for other BRIC countries, and equals one 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 and firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 12: 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 Alliances	Tech-related Partnerships
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(citN+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 one when the destination country is China and zero otherwise. $BRIC$ is an indicator variable for other BRIC countries, and equals one 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 Panel B, Table 2. Columns (3) to (5) of Panel A resemble columns (1) to (3) of Table 8. Columns (1) to (3) of Panel B resemble columns (1) to (3) of Table 9. Columns (4) and (5) of Panel B resemble columns (1) and (2) of Table 10. Columns (6) and (7) of Panel B resemble columns (1) and (2) of Table 11. Robust standard errors double clustered at the country and firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 13: Alternative CEO Incentive Measures: Share of Equity-linked Pay

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 Alliances	Tech-related Partnerships
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)
	Technology Sourcing			Inventor Migration		Exposure to Foreign	
Dep. Var.	Application			ln(N+1)	ln(citN+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 one when the destination country is China and zero otherwise. $BRIC$ is an indicator variable for other BRIC countries, and equals one 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 Panel B, Table 2. Columns (3) to (5) of Panel A resemble columns (1) to (3) of Table 8. Columns (1) to (3) of Panel B resemble columns (1) to (3) of Table 9. Columns (4) and (5) of Panel B resemble columns (1) and (2) of Table 10. Columns (6) and (7) of Panel B resemble columns (1) and (2) of Table 11. Robust standard errors double clustered at the country and firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 14: Global Evidence on CEO Incentives and Technology Transfer
Country-pair Level Analysis

	(1)	(2)	(3)	(4)
	Technology Transfer (% of all destination countries)			
Dep. Var.	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 one when the destination country is China and zero otherwise. $BRIC$ is an indicator variable for other BRIC countries, and equals one 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 and destination country 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?"

Table A.1: The Effect of CEO Incentives on Cross-Border Partnerships

Panel A: Alternative Samples

	(1)	(2)	(3)	(4)
	Technology Transfer			
Dep. Var.	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)
	Technology Transfer			
Dep. Var.	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 one when the destination country is China and zero 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 country and firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table A.2: 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 Alliances	Tech-related Partnerships
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 one when the destination country is China and zero otherwise. *BRIC* is an indicator variable for other BRIC countries, and equals one 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 Panel B, Table 2. Columns (3) to (5) of Panel A resemble columns (1) to (3) of Table 8. Columns (1) to (3) of Panel B resemble columns (1) to (3) of Table 9. Columns (4) and (5) of Panel B resemble columns (1) and (2) of Table 10. Columns (6) and (7) of Panel B resemble columns (1) and (2) of Table 11. Robust standard errors double clustered at country and firm level are denoted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.