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Optimal Ownership and Firm Performance: An Analysis of China's FDI Liberalization

Abstract

Seminal theories of the firm posit that firm ownership is allocated to minimize contractual inefficiencies. Yet, it remains unclear how much the optimal ownership choice affects firm performance in practice. This paper provides a first quantification of the gains from optimal ownership within multinational firms, by exploiting a major liberalization of China's policy restrictions on foreign ownership. The liberalization allowed previously restricted firms to become fully foreign owned. We find that these reoptimized ownership choices raise firm output by 40% and productivity by 7.5% on average. An extended property-rights theory of the multinational firm rationalizes these effects and their heterogeneity.

JEL-Codes: D230, F210, F230, L220, L230.

Keywords: multinational firms, ownership, integration, firm performance, property-rights theory, China.

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1 Introduction

Seminal theories of the firm agree that the optimal choice of firm ownership is crucial for efficiency in production. This is the case in transaction-cost economics (Williamson, 1975, 1985), in the property-rights approach (Grossman and Hart, 1986; Hart and Moore, 1990), and in other prominent theories of the firm (see Gibbons, 2005). In these theories, contractual frictions and relationship-specificity give rise to inefficiencies in production, and firms allocate ownership rights in order to minimize these inefficiencies. The fundamental question of firm ownership and integration, which dates back to the seminal work of Coase (1937), has also been studied extensively in an international context to understand the boundaries of multinational firms (Antràs, 2003).

Yet, one key question has remained open: "How do the organizational decisions of multinational firms shape firm-level performance?" (Antràs, 2015, p. 261). What is missing in the literature is direct empirical evidence on the efficiency-enhancing effects of optimal ownership and a quantification of how much it matters in practice. The key challenge for such a quantification exercise lies in identifying plausibly exogenous variation in ownership. Ideally, one would like to identify a firm that experiences an exogenous change from non-optimal to optimal ownership. But such a change is hardly ever observable in a market economy, where ownership can freely adjust.

In this paper, we overcome this identification challenge by exploiting a major liberalization of policy restrictions on foreign ownership in China. Historically, foreign direct investment (FDI) into China was severely restricted and firms producing certain products faced explicit upper bounds on foreign ownership shares. However, a substantial part of these FDI restrictions was abolished in 2002, as a consequence of China's WTO accession. The FDI liberalization allowed foreign multinational enterprises (MNEs) to reoptimize their ownership shares in Chinese firms. This setting provides us with the unique opportunity to quantify the performance gains of a change from the restricted to the (revealed) optimal allocation of ownership rights. Exploiting the FDI liberalization in a quasi-experimental design, we find that reoptimized ownership had significant positive effects on firm performance. We further demonstrate that these effects and their heterogeneity can be rationalized by contractual frictions according to the property-rights theory (PRT) of the MNE.

We obtain these results by combining panel data on Chinese manufacturing firms with information on the FDI policy from official sources. To precisely identify the firms affected by the FDI liberalization, we provide a novel *product-level* mapping of the policy to firms. To achieve this, we develop a text-based matching algorithm, which associates detailed but non-standardized product descriptions in our firm data with similarly detailed product descriptions in the policy documents. This algorithm, combined with extensive manual checks and corrections, yields a precise and high-quality assignment of the FDI policy to firms. The matched data highlight the importance of the FDI policy and the liberalization: 14.7% of all firms in our data set were subject to FDI restrictions

in 2001 and this number dropped by almost two thirds to 5.5% in 2002.

In the first part of our empirical analysis, we investigate the direct effect of the major FDI liberalization in 2002 on foreign ownership. We do so by focusing on the set of firms that faced FDI restrictions prior to 2002. Within this set, we compare firms for which FDI was liberalized to a control group of firms that remained restricted in a difference-in-differences (DiD) specification. To account for the selection of liberalized products by the Chinese government, we combine the DiD model with an inverse probability weighting (IPW) approach, which ensures that firms in the control group do not differ from the liberalized firms in terms of pre-reform observables. The estimation results confirm that the FDI liberalization had the expected positive effect on foreign ownership shares, and in particular, it significantly increased the probability that a Chinese firm became fully foreign owned. By a revealed preference argument, these additional foreign acquisitions reflect changes from restricted to optimal ownership.

In the second, main part of the empirical analysis, we analyze the consequences of these reoptimized ownership decisions for firm performance. This exercise faces the major challenge of identifying the effect of moving to optimal ownership, which we are interested in, from the selection effect inherent to foreign acquisitions. To address this challenge, we develop a novel identification strategy, relying on a control group of similar firms which experienced an increase in foreign ownership unrelated to the FDI policy. To be precise, we specify a DiD model for firm performance that defines the 'treated' firms as those for which an FDI restriction was abolished in 2002 and which subsequently became fully foreign owned. These firms are compared to a control group of firms active in the same industries, which also became fully foreign owned over the same years, but which were unregulated, i.e., not subject to the FDI policy in any observed year. We combine the DiD model with IPW, as before, to account for the government's selection of liberalized products. Importantly, our product-level measure of the FDI policy allows us to identify the performance effects within firms while controlling for unobservable shocks at the level of narrowly defined (4-digit) industries. Furthermore, we control at the product level for the contemporaneous reductions in tariffs and trade policy uncertainty associated with China's WTO accession.

Our main estimation results show that the reoptimization of ownership gave rise to substantial gains in firm performance. The liberalized firms adopting full foreign ownership experienced output gains of 40% and productivity gains of 7.5% on average. The performance effects are rather stable over time and robust to various alterations in the empirical implementation.

How did reoptimized ownership improve firm performance? In search for indicative evidence on the underlying mechanism, we proceed by investigating the effects on other firm outcomes. We do not find any evidence that reoptimized ownership increased either financial health, product innovation, exporting or importing behavior. We draw two conclusions from these insignificant results. First, our empirical strategy successfully controls for the benefits of foreign (vs. domes-

tic) ownership, which has typically been associated with these outcomes. Second, it seems highly unlikely that either one of the possible explanations based on foreign owners alleviating financial constraints, providing access to export markets, or facilitating imports can fully explain the identified effects on output. Instead, they seem to be driven by hard-to-observe changes inside firms, such as enhanced technology transfers or improvements in the provision of non-contractible inputs.

To rationalize the performance gains and obtain guidance on the underlying mechanism, we set up a model based on the PRT of the MNE. In the model, a foreign MNE and a Chinese manufacturer both contribute relationship-specific inputs to a joint production process in China. We emphasize that this framework may describe either vertical or horizontal FDI. In either case, contracts are incomplete, so both parties face a hold-up problem and hence underinvest into the inputs. The MNE chooses its *continuous* ownership share in the manufacturer and it does so to minimize these inefficiencies. Into this framework, we introduce the Chinese FDI policy as an upper bound on the foreign ownership share, which aggravates the inefficiencies. FDI liberalization then induces a restructuring process towards optimal, higher foreign ownership shares in the constrained firms. The model predicts that this reoptimized ownership choice generates efficiency gains, which boost firm output. Crucially, the output gains arise only in headquarter-intensive industries, where the inputs provided by the foreign firm are relatively more important. In a model extension featuring partial contractibility of inputs, we obtain the additional prediction that the performance gains should be greater in industries relying more heavily on contract-intensive inputs.

We take these theoretical predictions to the data and find evidence on effect heterogeneity in line with the PRT: The output gains tend to be stronger in industries that are more intensive in capital or skilled labor, two standard proxies for headquarter intensity. We also find that firms in more contract-intensive industries gained more from the liberalization of ownership restrictions. These findings support the hypothesis that the optimal ownership choice improves firm performance by reducing contractual inefficiencies.

We contribute to the literature investigating the organization of multinational firms, pioneered by Antràs (2003), Antràs and Helpman (2004), and Grossman and Helpman (2002, 2003). Our theoretical analysis builds on the PRT model by Antràs (2003), introducing partial contractibility as in Acemoglu et al. (2007) and Antràs and Helpman (2008). We allow for continuous ownership shares to account for international joint ventures (JVs), akin to Bircan (2014) and Eppinger and Kukharskyy (2021). Our treatment of policy restrictions on foreign ownership has antecedents in Asiedu and Esfahani (2001) and Cui (2011). Empirical research in this literature has predominantly focused on testing theoretical predictions regarding the factors that shape the choice of integration vs. outsourcing and mostly found patterns consistent with the PRT (Antràs and Yeaple,

2014).[1] A major gap in this literature is the lack of evidence on the consequences (rather than the determinants) of MNEs' organizational choices (Antràs, 2015). We fill this void and provide a first quantification of the performance gains from optimal integration decisions in MNEs.

A related literature in organizational economics has empirically investigated vertical integration and its consequences (see Lafontaine and Slade, 2007, and Bresnahan and Levin, 2013, for reviews). While the main outcomes of interest in this literature are foreclosure and prices, a few industry-specific case studies have examined the effects of integration on measures of performance.[2] In an innovative paper on the U.S. airline industry, Forbes and Lederman (2010) construct an instrument for integration decisions using cross-sectional variation in long-run weather conditions within the airlines' networks. They find a positive impact of integration on flight-specific performance measures. Moving beyond industry-specific analysis, the closely related paper by Atalay et al. (2019) examines the role of firm boundaries for domestic shipments within and across U.S. firms. Their analysis suggests that integration can significantly boost (domestic) trade. Our contribution is unique in exploiting policy restrictions on ownership, which allow us to identify the performance effects of firms moving *from restricted to optimal* ownership over time. To the best of our knowledge, this is the first paper to study the performance effects of integration in many industries and in an international context.

Our work is also related to a strand of the FDI literature estimating the effects of foreign acquisitions on firm-level outcomes. In this literature, the combination of DiD models with firm fixed effects and matching or IPW based on the propensity score has emerged as the best practice for estimating treatment effects.[3] Several studies have identified positive effects of foreign acquisitions on firm performance, though some papers find no significant gains (e.g. Wang and Wang, 2015, for China). We build on the methodology from this literature but emphasize that our contribution is substantially different in terms of its core objective, empirical setup, and main insights. While the existing literature has aimed at identifying differences associated with the 'foreignness' of the owner, our goal instead is to estimate the effects of organizational restructuring from a restricted towards the optimal allocation of ownership rights. While we do exploit policy restrictions on FDI, our empirical design allows us to explicitly control for the various benefits of foreign own-

[1] Several papers in this literature have analyzed U.S. industry-level data on intra-firm trade, e.g.: Antràs (2003, 2015), Yeaple (2006), and Nunn and Trefler (2008). Firm-level studies on the organization of global sourcing have typically focused on firms' headquarters in developed countries: Tomiura (2007) for Japan, Corcos et al. (2013), Defever and Toubal (2013), and Berlingieri et al. (2020) for France, Federico (2010) for Italy, Kohler and Smolka (2011, 2021) for Spain, and Alfaro et al. (2019) for the U.S. Feenstra and Hanson (2005) and Fernandes and Tang (2012) use highly disaggregate (though not firm-level) customs data from China to analyze ownership and control over input purchases in Chinese processing trade.

[2] Two notable early contributions highlighting efficiency gains are Chipty (2001) on the TV industry and Hortaçsu and Syverson (2007) on the ready-mixed concrete industry, both in the U.S.

[3] See e.g. Arnold and Javorcik (2009), Chen (2011), Girma and Görg (2007), Girma et al. (2015), Guadalupe et al. (2012), Jiang et al. (2018), Koch and Smolka (2019), and Wang and Wang (2015).

ership (by the choice of the control group), so we can clearly identify the performance gains from reoptimized ownership decisions.

Finally, our paper advances the literature assessing China's policy restrictions on FDI. We are aware of three studies which have previously considered the economic implications of the Chinese FDI policy reform of 2002, though with different objectives than our paper: Sheng and Yang (2016) show that the liberalization increased product variety in Chinese exports; Lu et al. (2017) examine possible spillovers from FDI induced by the liberalization; and Brandt et al. (2017) control for the FDI liberalization in their analysis of tariff reductions. A common feature in this literature is that the FDI policy was matched to firms at the *industry* level. We make progress by developing a more precise, *product-specific* matching of the FDI policy to firms, which allows for identifying the effects of the liberalization within narrowly defined industries. To our knowledge, we are also the first to exploit information on equity requirements, which impose specific upper bounds on foreign ownership shares. We show that the FDI liberalization directly caused more firms to become fully foreign owned and these ownership changes induced substantial performance gains.

2 Policy background and data

2.1 China's FDI liberalization

China held tight regulations on FDI until the mid-1990s. In 1995, the first 'Catalogue for the Guidance of Foreign Investment Industries' (henceforth referred to as the Catalogue) was published as a guideline for regulations on FDI. In the Catalogue, products are sorted into three categories: 'restricted', 'encouraged', and 'prohibited', with FDI into all other products not included in the Catalogue being 'permitted'.[4] Different rules and restrictions apply to products in different categories. Stringent restrictions on foreign ownership structures are imposed on firms producing 'restricted' products and no FDI is allowed in 'prohibited' products. For products in the 'encouraged' category, foreign investors enjoy preferential treatment such as reduced tax rates.

Equity requirements are one particular type of restrictions that directly constrain foreign ownership structures. They can take the form of a *Sino-Foreign joint venture* requirement or a *majority Chinese ownership* requirement. Under the *Sino-Foreign joint venture* requirement, a foreign investor has to find a Chinese partner and form a JV to operate in China. Hence, this regulation excludes full foreign ownership, corresponding to a foreign equity share of 100%. Under the *majority Chinese ownership* requirement, a foreign investor can only own 50% or less of the firm's

[4]FDI restrictions were prevalent across the manufacturing sector. We provide examples of regulated products in Online Appendix A.1 and show the cross-sectoral distribution in Online Appendix A.2.

equity.[5] Hence, it precludes majority foreign ownership (and full ownership by implication).

In 2002, China experienced a major FDI liberalization as a direct consequence of China's accession to the WTO in 2001.[6] China abolished any restrictions on foreign investment related to international trade in order to comply with the Agreement on Trade-Related Investment Measures (TRIMs). Moreover, China accepted additional obligations that substantially exceed the standard WTO rules (Qin, 2007). They extended China's commitments to liberalizing FDI by granting national treatment to foreign-owned firms and abolishing equity restrictions on particular products.[7] To fulfill these obligations, China undertook a regulatory reform in 2002, which involved a substantial revision of the Catalogue.

Figure 1 illustrates the major FDI liberalization in 2002 after China's WTO accession. It depicts the share of firms in our data that are subject to the FDI policy in each year over the period of 1998–2007 (see Sections 2.2 and 2.3 for the matching procedure and details on the firm data). The major FDI liberalization is clearly visible. In 2002, the share of firms for which FDI was restricted dropped by two thirds from 14.5% to 4.5%. A relevant share of firms also dropped an explicit JV or majority requirement.[8] At the same time, the share of firms producing products for which FDI is 'encouraged' increased. Variation across all other years is largely driven by compositional changes. While there was another minor FDI liberalization effective in 2005, this change affected very few products and can hardly be discerned from the figure. In the subsequent analysis, we hence focus on the major reform in 2002.

FDI restrictions in general and the 2002 liberalization in particular affected firms across many different sectors in Chinese manufacturing. The cross-sectoral distribution, shown in Online Appendix A.2, reveals that particularly in manufacturing of paper, chemicals, and non-ferrous metal products many firms were affected.

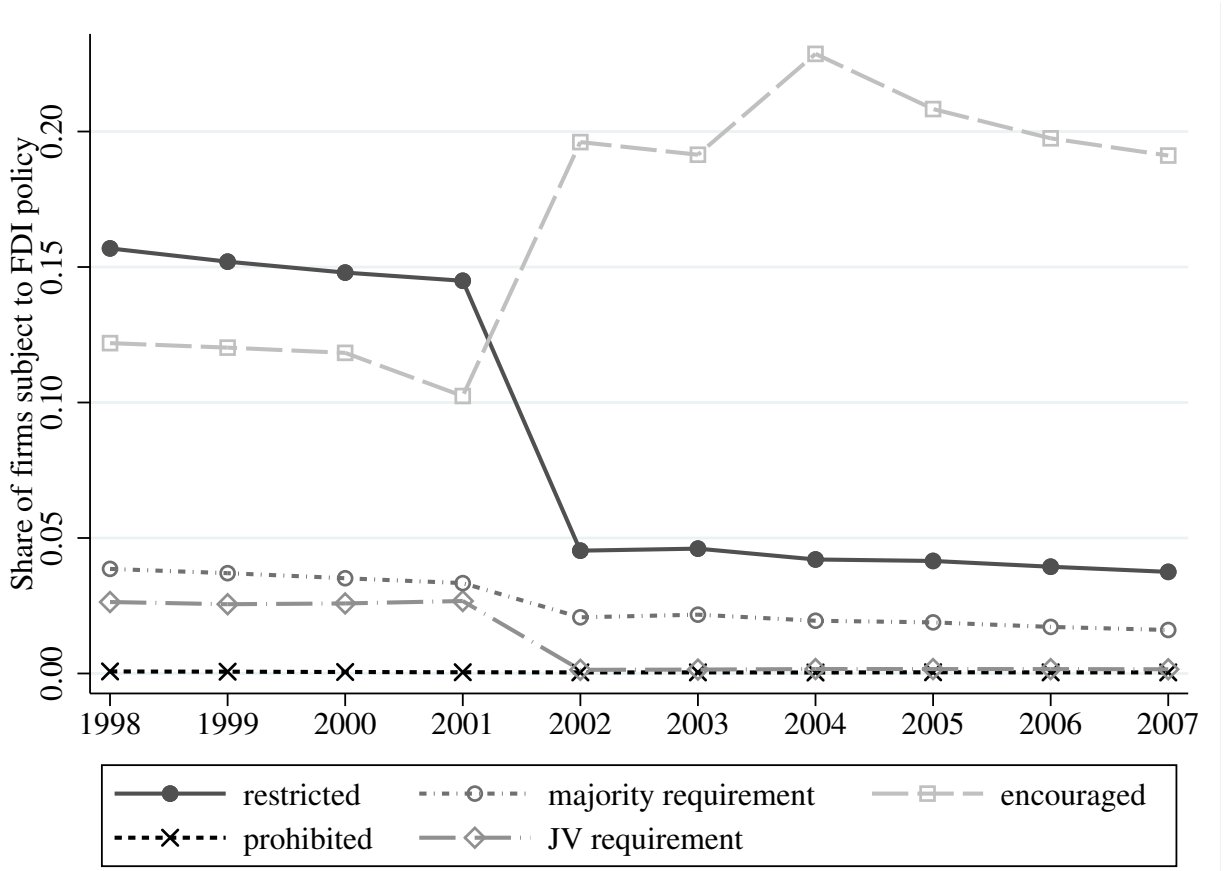
[5] In some cases, the requirement is that Chinese parties shall hold a higher equity share than any foreign party in the JV, which is known as a *relative majority Chinese ownership* requirement.

[6] The Catalogue was revised in 1997, 2002, 2004, and 2007 and thereby became more liberal over time. We code the policy changes by their effective dates. The 2002 revision was implemented on April 1, 2002, so we code it as effective in 2002. The 2004 revision was implemented on January 1, 2005, but its scope was very limited (see below). The 2007 revision was also minor and implemented on December 1, 2007, so it did not affect our period of analysis (1998–2007).

[7] For example, Article 207 of the "Report of the Working Party on the Accession of China" states explicitly: "With respect to the manufacture of motor vehicle engines, the representative of China also confirmed that China agreed to remove the 50 percent foreign equity limit for joint-ventures upon accession." This article was incorporated into the accession protocol.

[8] Taking into account general restrictions (restricted or prohibited) and specific equity requirements (JV or majority), the share of firms facing *any* FDI restrictions dropped from 14.7% to 5.5%.

Figure 1: FDI liberalization in Chinese manufacturing, 1998–2007



The figure shows the shares of firms subject to different FDI policies. Source: Authors' computations based on the 'Catalogue for the Guidance of Foreign Investment Industries' (various issues).

2.2 Product-level matching of the FDI policy to firms

From the information provided in the Catalogue, we identify Chinese firms subject to the FDI policy. We achieve this by developing a novel product-level matching of the FDI policy to firms. More specifically, we apply a natural language processing (NLP) algorithm to match the product descriptions from the FDI Catalogue to textual descriptions of products in our firm data (see Section 2.3). A similar matching approach has been adopted by Imbert et al. (2022) to associate the products made by Chinese firms with 6-digit Harmonized System (HS) product codes. We build on their algorithm, train it using a larger training corpus, and then apply the algorithm to match the FDI policy to firms at the product level. Finally, we conduct extensive manual checks and corrections to achieve precise, high-quality matches. Details are provided in Online Appendix A.1.

We consider our product-level FDI policy measures a substantial advancement in the literature studying China's FDI policy along two key dimensions. First, and most importantly, matching the

FDI policy to firms at the product level substantially improves the precision of measuring the FDI policy. The literature has previously relied on matching the product descriptions from the Catalogue to firms at the level of industries according to the Chinese Industry Classification (CIC) (see e.g. Brandt et al., 2017; Lu et al., 2017; Sheng and Yang, 2016). Our more precise measure allows us to assess the impact of the FDI liberalization on foreign ownership and on the performance of foreign-owned firms *within* narrow 4-digit CIC industries, while controlling for (unobservable) industry-specific shocks. Second, in addition to the general FDI policy categories, we exploit information on specific foreign equity requirements (JV or majority), which have not previously been exploited. Since equity requirements exist also in products for which FDI is generally 'encouraged,' and since these requirements are immediately relevant for foreign ownership, incorporating them into the analysis is an important improvement.

To illustrate the benefits of our product-specific matching, we provide in Online Appendix A.2 a comparison of our FDI policy variables to the aforementioned industry-specific measures. Five facts emerge. First, our product-specific coding assigns the FDI policy categories to fewer firms (around 7% vs. 15% for the industry-specific measures). Second, correlations between our measure and the industry-specific ones are positive but low, around 0.3 for the 'restricted' FDI policy. This is due to the fact that firms producing regulated products are active in a variety of different industries, but also there are many firms not producing regulated products within the industries that the previous literature has coded as regulated. Third, these cross-sectional discrepancies translate into large differences in the assignment of the FDI liberalization in 2002. E.g. in the transport equipment sector, industry-specific coding of the FDI policy vastly overstates the scope of the FDI liberalization, which in practice only affected firms producing very specific auto components. Fourth, our product-level matching is essential to identifying and differentiating liberalized firms in many different manufacturing sectors (defined at the 2-digit CIC level). We find that liberalized firms and those for which FDI remained restricted after the reform coexist in all except one sector, while the industry-specific policy variables would identify firms in very few sectors as liberalized, with liberalized and still restricted firms coexisting in even fewer sectors. The product-level FDI policy matching is thus crucial for identifying the effects of the liberalization from sectoral shocks. Fifth, consistency checks using our firm-level data reveal that our product-specific FDI policy measure is more in line with observed foreign ownership patterns, in the sense that we see much fewer violations of the policy (e.g. full foreign ownership in the 'prohibited' FDI category) compared to the industry-specific measures. We interpret these patterns as evidence of the high quality and precision of our product-level matching approach.

2.3 Firm data

To investigate foreign ownership and firm performance in China, we use data from the Chinese Annual Surveys of Industrial Production (ASIP), conducted by the National Bureau of Statistics of China (NBSC). This is the most comprehensive survey data set available for industrial firms in China, accounting for over 90% of industrial output and over 70% of industrial employment in 2004 (Brandt et al., 2012). It forms the basis for major statistics published in China Statistical Yearbooks and has been widely used in economic research (e.g. by Hsieh and Klenow, 2009, and Brandt et al., 2017). The data set covers all state-owned enterprises (SOEs) and all other firms with total sales exceeding 5 million RMB (around US$ 620,000 at the running exchange rate in 2005) in the industrial sector (including manufacturing, mining, and utilities). It is a panel for the period of 1998–2007, covering several years before and after the major FDI policy reform in 2002. For our purpose, we limit the analysis to manufacturing firms, resulting in a sample of close to half a million firms (on average around 180,000 firms per year). We follow Cai and Liu (2009) in taking necessary steps to clean the data. Some firms changed their official ID over the sample period, hence we follow Brandt et al. (2012) to track each firm over time using their ID, name, industry, address, and other information.

From the ASIP, we collect detailed firm-level production and balance-sheet information (gross output, value added, employment, wage bill, fixed assets, material input purchases, etc.). Most importantly, the data contain information on the firms' ownership structures. Our measure of foreign ownership is the share of foreign investors, including investors from Hong Kong, Macao, or Taiwan (to which the FDI restrictions apply), in the firm's paid-in capital. This variable has the important advantage that it allows us to observe the precise degree of foreign ownership instead of just binary information on the foreign ownership status.

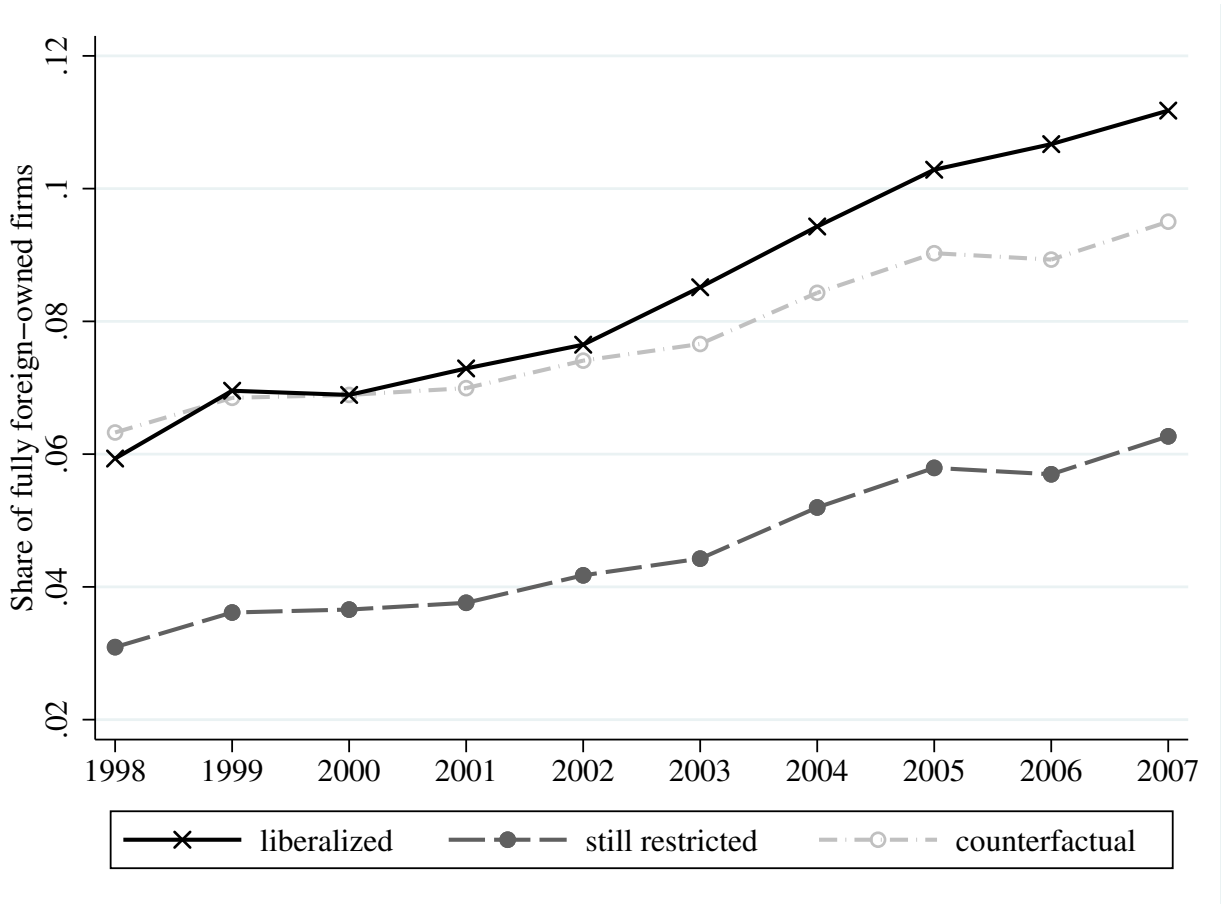
To obtain a measure of total factor productivity (TFP) from the ASIP, we construct a chain-linked Törnqvist index à la Caves et al. (1982) and Aw et al. (2001), using labor, capital, and materials as inputs. We compute the firm-level real capital stock by applying the perpetual inventory method to our firm panel. Throughout the analysis, output is deflated by industry-specific output deflators and material inputs are deflated by the industry-specific input deflators, both provided by Brandt et al. (2012). The wage bill is deflated by the consumer price index for China from the World Bank's World Development Indicators.

3 FDI liberalization and foreign ownership

3.1 A look at the raw data

Figure 2 depicts the shares of fully foreign-owned firms among firms for which FDI was liberalized (solid line) vs. still restricted (dashed line) after 2001. Both of these groups faced FDI restrictions before the reform, i.e., FDI was either entirely prohibited, restricted, or subject to equity requirements for at least one of the products they produced in 2001. For liberalized firms, any such restrictions were abolished in 2002, while they persisted for firms labeled as 'still restricted'.

Figure 2: Prevalence of full foreign ownership among liberalized vs. restricted firms, 1998–2007



The figure shows the shares of fully foreign-owned firms per year among all firms facing some FDI restrictions (prohibited, restricted, or equity requirements) in 2001, distinguished between those for which FDI restrictions were liberalized in 2002 (12,220 firms; 83,450 observations) vs. those for which FDI remained still restricted (7,499 firms; 49,484 observations). The 'counterfactual' line is parallel to the one for still restricted firms, shifted up by the difference between both groups in 2000. Source: Authors' computations based on the FDI Catalogue (various issues) and ASIP firm data.

The figure shows that the prevalence of full foreign ownership was generally low in the pre-reform years, but slightly higher among the firms for which FDI would subsequently be liberalized. There is an upward trend for both groups, as more firms become fully foreign owned over time. While the trends seem to evolve in parallel during 1998–2001, full foreign ownership increased more steeply among liberalized firms after the FDI policy reform of 2002. This pattern is visualized by adding the dashed-and-dotted line. It represents the counterfactual evolution of full foreign ownership among the still restricted firms, shifted up by the observed difference to liberalized firms in 2000. The divergence between the liberalized firms and this counterfactual after 2002 is an indication that FDI liberalization promoted full foreign ownership. Next we test this hypothesis.

3.2 Empirical strategy

How did FDI liberalization affect foreign ownership? We examine this question by specifying the following difference-in-differences (DiD) model for foreign ownership FO_{it} in firm i and year t:

$$FO_{it} = \gamma\ liberalized_i \times after_t + \sum_s \phi_s\ \mathbf{T}_i\ \times YEAR_s + \delta_i + \delta_{Jt} + \epsilon_{it}. \tag{1}$$

We consider the following measures of foreign ownership FO_{it} as alternative dependent variables: the continuous *FO share* and dummy variables indicating either *full FO*, *majority FO*, or *FO share* $\geq$25%. The latter constitutes the legal threshold required for obtaining the status of a foreign-invested enterprise in China.

We estimate equation (1) in the sample of firms that initially faced some FDI restriction (prohibited, restricted, or equity requirements) in 2001. The key indicator variable $liberalized_i$ distinguishes firms for which all FDI restrictions were abolished in 2002 (coded as one) from those firms for which FDI remained restricted (coded as zero). The dummy variable $after_t$ is equal to zero until 2001 and equal to one after 2001. The key interaction effect to be estimated is γ.

Since China's WTO accession predates the FDI liberalization by just one year, it is paramount to control for effects of the ensuing trade policy changes on foreign ownership. Fortunately, the matching between Chinese firms' products and 6-digit HS codes provided by Imbert et al. (2022) allows us to control for these contemporaneous changes very precisely. To control for reductions in Chinese import tariffs, we exploit information on initial tariff levels (specifically applied tariffs in 1998, at the beginning of our sample), which have been found to be good predictors of subsequent tariff reductions, and which are historically determined and hence plausibly exogenous (Amiti and Konings, 2007; Brandt et al., 2017; Liu and Qiu, 2016).

While tariffs on Chinese exports to its major trading partners had already been low before 2001, it is well understood that the WTO accession substantially reduced the uncertainty associated with

trade policy for Chinese exports to the U.S. (Feng et al., 2017; Handley and Limão, 2017; Liu and Ma, 2020; Pierce and Schott, 2016). We measure trade policy uncertainty (TPU) as the gap between the worst-case (or 'column 2') tariffs and most favored nation (or 'normal trade relations') tariffs in 1996, following Pierce and Schott (2016). Tariffs and TPU are measured at the 6-digit HS product level, which we match to the firms' main products produced in 2001 using the correspondence by Imbert et al. (2022). Thereby we obtain firm-specific measures of initial tariffs and TPU in the pre-reform period, summarized by the vector $\mathbf{T}_i$. We include flexible interaction terms of $\mathbf{T}_i$ with year dummies $YEAR_t$ to control for their time-varying effects.

We further control for initial conditions and time-invariant firm heterogeneity via firm fixed effects δ_i and for aggregate shocks by 2-digit sector J via sector-year fixed effects δ_{Jt}. These fixed effects also absorb the direct effects of $liberalized_i$ and $after_t$. ϵ_{it} denotes the error term.

The identification of γ in equation (1) may be threatened by the selectivity of FDI liberalization. Though the set of restricted products was historically determined in the 1990s, and even though the FDI liberalization was mandated by the WTO accession, Chinese policy makers arguably maintained some discretion about which products to liberalize in 2002. The resulting bias might go either way. On the one hand, an upward bias in γ may arise if there was positive selectivity of the FDI liberalization in the sense that FDI restrictions were relaxed for products produced by firms that were more prone to becoming fully foreign owned (once allowed). On the other hand, γ may be downward biased if the Chinese government deliberately maintained FDI restrictions on products that were more likely targets of foreign acquisitions, e.g. for political economy reasons related to infant industries, critical infrastructure, or labor market performance. To address this selection problem, we combine the DiD model with an inverse probability weighting (IPW) approach.

The aim of the IPW approach is to make the distributions of liberalized and non-liberalized firms more comparable in terms of observables and thereby also in terms of unobservables before the reform. If the government selected liberalized products based on observable characteristics, this approach can identify the effect of the FDI liberalization and resolve the selection problem.[9] Specifically, we estimate equation (1) while reweighting observations for the still restricted firms in the control group by $\hat{p}/(1-\hat{p})$, where $\hat{p}$ is the estimated propensity score (predicted treatment probability), to obtain the average treatment effect on the treated (ATT).[10]

The propensity score is obtained from a logit regression of the liberalization dummy on the following firm characteristics in 2000: *output*, *employment*, and the *wage* per employee (all in logs); *FO share* and *age*; the *export share* in total sales and the *import share* in firms' total input

[9]Matching and reweighting methods based on the propensity score (Rosenbaum and Rubin, 1983; DiNardo et al., 1996; Hirano et al., 2003; Abadie, 2005) are well-established in the literature estimating treatment effects in quasi-experimental settings, including in the FDI literature.

[10]Throughout the analysis, we exclude the few observations off the common support and winsorize $\hat{p}$ at the 99th percentile (similar to Guadalupe et al., 2012) to reduce the impact of outliers.

purchases, which we compute after matching Chinese customs micro data to the ASIP. This selection of covariates is motivated by known considerations of the Chinese government in relaxing the FDI restrictions, such as avoiding adverse labor market effects, promoting exports, and protecting infant industries (see the discussion in Lu et al., 2017). It further includes determinants of foreign acquisitions that have been established in the literature (Arnold and Javorcik, 2009; Guadalupe et al., 2012; Wang and Wang, 2015). Importantly, the propensity score model also includes 2-digit sector J fixed effects. Thus, we identify the effects from liberalized vs. still restricted firms within the same sector, a feature enabled by our product-level matching of the FDI policy.

3.3 Estimation results

Table 1 summarizes the results. We find the expected positive effect of FDI liberalization on foreign ownership, as measured by the continuous foreign ownership share in column (1). This effect is both economically and statistically significant. The point estimate equals 1.3 percentage points, which amounts to 11.4% relative to the average foreign ownership share in this sample of restricted firms in 2001 (indicated at the bottom of the table).

Table 1: Direct effect of FDI liberalization on foreign ownership

	(1)	(2)	(3)	(4)
	FO share	*Full FO*	*Majority FO*	*FO share* $\geq$25%
liberalized $\times$ *after*	0.0134^b	0.0237^a	0.0156	0.00375
	(0.00580)	(0.00813)	(0.0100)	(0.00839)
Mean of dependent variable in 2001	0.1177	0.0614	0.1125	0.1673
Mean relative effect size	11.4%	38.6%	13.9%	2.2%

The table reports estimates of equation (1). The measure of foreign ownership FO used as a dependent variable is indicated in the header for each column. The number of observations is 94,817. Standard errors clustered by firm are reported in parentheses. a indicates 1% significance and b indicates 5% significance.

Columns (2)–(4) reveal that this effect is driven by firms moving to full foreign ownership. FDI liberalization increased firms' probability of being fully foreign owned by 2.4 percentage points, corresponding to a substantial relative effect of 38.6%. The estimated effects on firms reaching the foreign ownership thresholds of 50% or 25% are smaller and not statistically significant. These estimates suggest that FDI liberalization substantially increased foreign ownership in Chinese firms, in particular by enabling more full foreign acquisitions.

In robustness checks, we reexamine the effect of FDI liberalization on full foreign ownership after adding two further sets of control variables. First, to ensure we identify the effects of relaxed

FDI restrictions rather than benefits associated with the 'encouraged' FDI policy, we control for interaction effects between year dummies and a dummy variable indicating products for which FDI was newly encouraged in 2002, a change which may coincide with relaxed FDI restrictions for some firms. Second, to control more rigorously for unobserved confounding shocks, we include industry-year fixed effects at the level of detailed 4-digit CIC codes. The results reported in Online Appendix B.1 strongly confirm the positive effect of dropping FDI restrictions on full foreign ownership. We also experiment with alternative, industry-level measures of the FDI policy from the literature. We find that these measures do not serve to identify the effects, highlighting the benefit of our product-level measure, which exploits within-industry variation in the liberalization.

4 Ownership restructuring and firm performance

4.1 Identification strategy

We now turn to our empirical analysis of the paper's main question: How does the optimal allocation of ownership rights affect firm performance? To speak to this question, we exploit the changes in ownership enabled by the major reform of China's FDI policy in 2002. As shown in the previous section, FDI liberalization significantly increased the probability of Chinese firms becoming fully foreign owned. Thus we focus on liberalized firms moving to full foreign ownership after the reform, which constitute our treatment group. We seek to identify the treatment effects of these particular ownership changes—moving from restricted ownership to the freely chosen and thus (by a revealed preference argument) optimal ownership.

This exercise requires an estimate of the unobserved counterfactual: how performance among the treated firms would have evolved in the absence of treatment. To estimate this counterfactual, we follow a large empirical literature in relying on the performance of a comparable control group in estimating a difference-in-differences (DiD) model.

Identification in this setting faces a formidable challenge: non-random selection of firms by foreign investors makes the search for a comparable control group very difficult. It is a well-known fact that foreign investors engage in 'cherry picking' by acquiring the firms with the most favorable growth prospects (see e.g. Blonigen et al., 2014). This concern is ameliorated by the fact that we consider movements to 100% foreign ownership; yet, selectivity might also apply to the intensity of integration.

To resolve this challenge, we propose a novel identification strategy: We compare fully foreign-acquired firms treated by the FDI liberalization to a control group of similar fully foreign-acquired firms, which are not directly affected by the FDI policy. More specifically, we focus on the sample of firms which are never in full foreign ownership over the observed pre-reform years 1998–2001,

but which become fully foreign owned after 2001. In this sample, we identify the treated firms, for which all FDI restrictions were abolished in 2002, and compare them to firms that are active in the same sectors but were never subject to any FDI policy during the sample period. Firms in this control group produce similar products, are equally selected by foreign investors, and are undergoing very similar ownership changes as the treated firms. The key difference is that these firms did not face any FDI restrictions and changed ownership for idiosyncratic reasons. Our strategy can thus eliminate the selectivity concern and serve to identify the causal effect of reoptimized ownership.

The DiD model explaining the performance Y_{it} of firm i in year t is specified as follows:

$$Y_{it} = \beta \, \textit{treated}_i \times \textit{after}_t + \sum_s \boldsymbol{\tau}_s \, \mathbf{T}_i \times \textit{YEAR}_s + \alpha_i + \alpha_{jt} + \varepsilon_{it}, \tag{2}$$

where the main outcome variables Y_{it} of interest are $\ln$ *output* and $\ln$ *TFP*. The treatment group indicator $\textit{treated}_i$ identifies liberalized firms moving to full foreign ownership after 2001; it is zero for unregulated firms also moving to full foreign ownership after 2001.[11] The dummy variable $\textit{after}_t$ is equal to zero until 2001 and equal to one after 2001. β is the DiD estimator. If the change from restricted to optimal ownership boosts firm performance, we should see $\beta > 0$.

The performance effects are identified from the time variation within firms and within narrowly defined industries by conditioning on fixed effects by firm α_i and by 4-digit industry-year α_{jt}. The firm fixed effects control for initial conditions, including the FDI policy, ownership structure, location, and unobservables such as physical productivity. Industry-year fixed effects absorb any aggregate or industry-specific shocks, and they also control for trade policy changes induced by the WTO accession that affected firms' inputs. On the output side, we control in a precise and flexible manner for the effects of reduced tariffs and trade policy uncertainty (summarized by $\mathbf{T}_i$) at the firm level, by interacting year dummies $\textit{YEAR}_t$ with initial values of $\mathbf{T}_i$, measured at the level of 6-digit HS products and matched to firms' products (as described in Section 3.2).

A remaining challenge to identification is related to selectivity of the FDI policy. As discussed in Section 3.2, there may be selection of the products for which FDI was liberalized by the Chinese government within the scope of its commitments related to the WTO accession. This selectivity may be correlated (positively or negatively) with firm performance, giving rise to bias in our estimate of β. To address this concern, we combine our DiD model with an IPW approach. The underlying assumption of selection on lagged observables seems plausible in this setting, since the FDI restrictions had been determined in the 1990s and the FDI liberalization of 2002 then applied to the vast majority of all restricted firms in Chinese manufacturing (see Figure 1). To implement

[11] The $\textit{treated}_i$ variable is essentially an indicator of FDI liberalization, defined by the removal of all FDI restrictions (prohibited, restricted, or equity requirements) on the products the firm produced in 2001. We introduce the new variable to clearly distinguish this dummy, which is zero for unregulated firms, from the $\textit{liberalized}_i$ dummy in Section 3, which is zero for still restricted firms.

the IPW approach, we follow the same steps as in Section 3.2: We estimate the propensity scores from a logit regression of the treatment dummy on the previously identified set of pre-reform covariates in 2000 as well as 2-digit sector dummies and reweigh control group observations in the regression to estimate the ATT. Online Appendix B.2 reports our logit estimates of the model used to obtain these propensity scores, and it shows that any conditional mean differences in these initial covariates are eliminated after reweighting firms in this way.

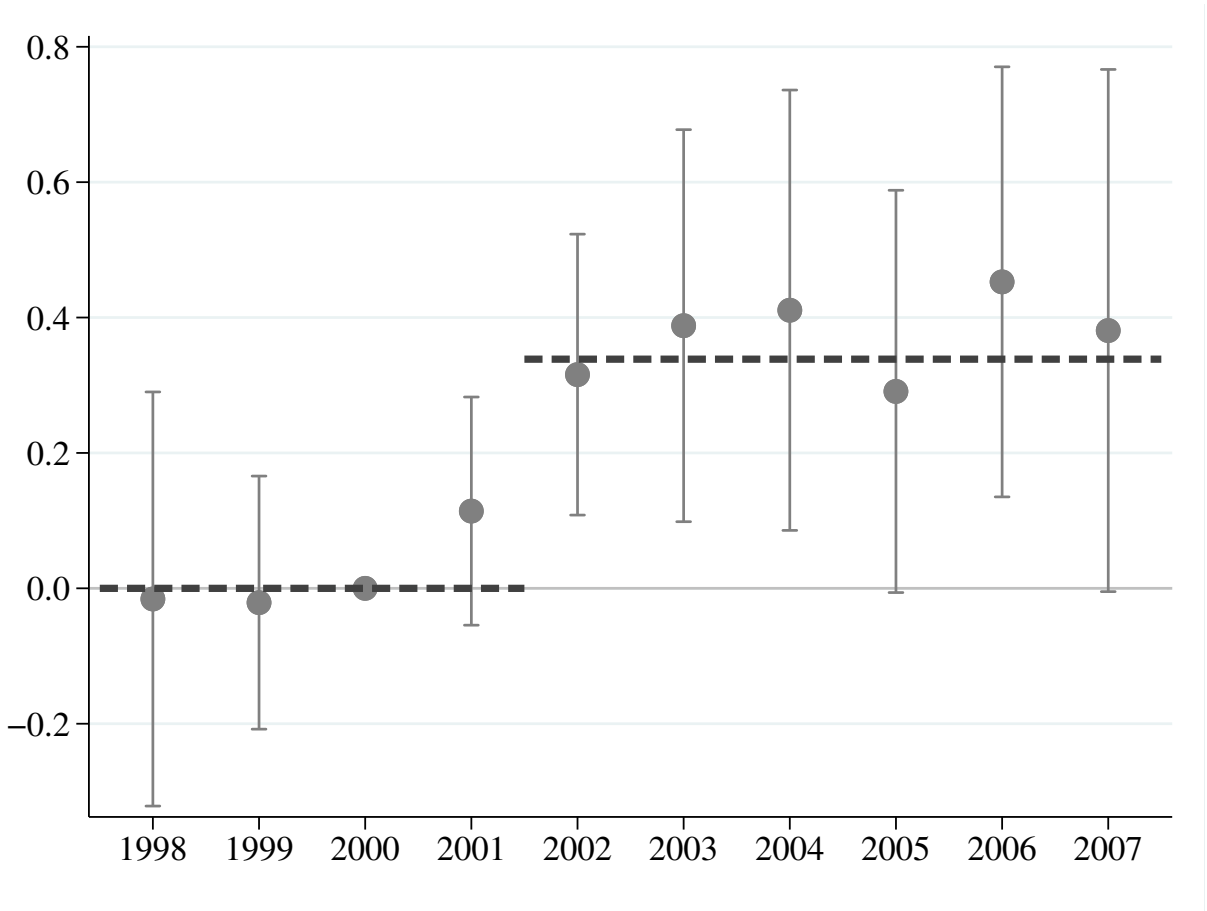
Before proceeding to the results, we briefly discuss our choice of identification strategy compared to an alternative, two-stage approach. In light of our results regarding the impact of FDI liberalization on foreign ownership in Section 3, one may attempt to exploit the reform as an instrumental variable (IV) for increased foreign ownership. Specifically, one might regress firm performance on foreign ownership and use the FDI liberalization as an IV for foreign ownership in the first stage. Such an approach may seem appealing, but in our view, it would risk confounding the effect of interest with the benefits of foreign ownership. Recall that our goal is to identify the effect of *reoptimized* ownership, i.e., the change from the restricted to the (revealed) optimal allocation of ownership rights. However, the treated firms are at the same time also subject to increased *foreign* (vs. domestic) ownership, which is known to benefit firms in multiple ways even in the absence of any lifting of policy restrictions (see Section 4.4 for a discussion). An IV estimate would thus identify a local average treatment effect that may be considered the combined effect of both *reoptimized* ownership and *foreign* ownership (compared to the counterfactual of no ownership change at all). By using other firms that also become fully foreign owned as a control group, our DiD approach is specifically geared towards controlling for the benefits of foreign acquisitions and isolates the impact of the change from restricted to optimal ownership.

4.2 Main estimation results

Figure 3 illustrates the estimated effect of reoptimized ownership on firm output. The dashed line indicates our baseline estimate of β in the DiD specification (2) distinguishing two periods (before vs. after the reform), while the dots show estimates from a more flexible specification interacting $treated_i$ with year dummies. We find that the change from restricted to optimal ownership caused economically and statistically significant gains in firm performance. The estimate of the ATT is $\hat{\beta} = 0.339$, suggesting that reoptimizing ownership boosted firm output by 40.4% on average. This effect is quite stable over the post-liberalization period.

The estimates from the flexible specification illustrated in Figure 3 allow us to compare pre-treatment trends in firm performance across the treatment and control groups. While the identifying assumption of parallel (counterfactual) trends is fundamentally untestable, we follow standard practice in the DiD literature to examine whether parallel trends hold before treatment. It is re-

Figure 3: Effects of reoptimized ownership on firm performance



The figure shows the estimated ATT of reoptimized ownership on $\ln$ *output*. The dashed line represents our baseline estimate of β in specification (2). The dots represent point estimates of annual interaction effects from a more flexible specification of equation (2), interacting $treated_i$ with year dummies. The spikes indicate 95% confidence intervals, based on standard errors clustered by firm.

assuring that we find no evidence of significant differences in the evolution of firm output in the pre-treatment period, with annual interaction effects very close to zero for 1998 and 1999, respectively, compared to the base year 2000. The estimate in 2001 is also not significantly different from 2000, though it is greater in magnitude. This points to the possibility of an anticipation effect in 2001, which might arise due to China's accession to the WTO being concluded in late 2001. Thus, some firms might already have started preparing for (or benefiting from the prospect of) future foreign acquisitions towards the end of 2001. For this reason, we choose 2000 as a base year, and we further omit the year 2001 in a robustness check discussed in Section 4.3.

Table 2 summarizes our DiD estimates of how the reoptimization of ownership enabled by the FDI reform affected firm performance and other outcomes. Column (1) reports the average output

gains illustrated in Figure 3. Besides this sizable effect on output, we also identify a positive effect on TFP, which is estimated at 7.5% (with a p-value of 0.067) in column (2). The subsequent columns show that effects on input measures, capital K and labor L, and also on the wage per employee w are all positive but not statistically significant. This combined evidence suggests that the change from restricted to optimal ownership increased firms' efficiency, generating substantially more output from only slightly more inputs. Column (6) reports the effect on profitability (profits Π over *sales*). This effect is small at 3% and marginally insignificant (with a p-value of 0.102). We interpret this as weak evidence that the efficiency gains benefited both workers and firm owners.

Table 2: Effects of reoptimized ownership on firm outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
	$\ln$ *output*	$\ln$ *TFP*	$\ln K$	$\ln L$	$\ln w$	Π/ *sales*
treated $\times$ *after*	0.339^a	0.0719^c	0.0324	0.0599	0.0589	0.0306
	(0.119)	(0.0392)	(0.105)	(0.0884)	(0.0586)	(0.0187)
Observations	9,671	8,811	9,624	9,671	9,671	9,671
R^2	0.898	0.677	0.937	0.904	0.758	0.512

The table reports estimates of β in equation (2) for alternative dependent variables, indicated in the header. Standard errors clustered by firm are reported in parentheses. a indicates 1% significance and c indicates 10% significance.

4.3 Robustness checks

In this section, we carefully examine the robustness of our main result on the performance gains from reoptimized ownership. We begin by focusing on a possible violation of the crucial parallel trends assumption. Rambachan and Roth (2023) argue that classical methods of DiD inference require parallel trends to hold exactly, which may be a strong assumption in practice. They suggest a partial identification approach allowing for violations in parallel trends based on observed deviations from exactly parallel trends in the pre-treatment period. In our empirical setting, we are mainly concerned about differential shocks to the treated vs. control group, rather than diverging trends across both groups, hence we focus on bounding the relative magnitudes of the deviations. Applying this approach, we find that the output gains identified in our main analysis remain significant at the 5% level once we allow for deviations from parallel trends after treatment up to the maximum deviation that is observed during the pre-treatment period ($\bar{M} = 1$ in their notation, which is considered a "natural benchmark" by Rambachan and Roth, 2023, p. 9).

We discuss a set of further important robustness checks, the results of which are shown in Online Appendix B.3. First, we vary our approach of matching the FDI policy to firms. In our

preferred approach, we consider all product-level matches with a similarity score of at least 0.8 and then implement extensive manual checks and corrections, which are also applied to matches with a lower score. This approach minimizes the risk of false positive matches (type I errors), but there remains a risk of false negatives (type II errors), i.e., we might be missing some firms that were in practice affected by the policy. In two robustness checks, we hence lower the cutoff for selecting matches to 0.7 and 0.6, respectively. In this way, we substantially reduce the risk of type II errors, by selecting a large share of all potential matches suggested by our algorithm (see Online Appendix A.1 for the distribution of similarity scores), but we commit more type I errors. The results from using these alternative matching criteria confirm the significant output gains from reoptimized ownership. For lower cutoffs of the similarity score the point estimates of the performance effects are slightly smaller, in line with greater measurement error and more false positive assignments of treatment compared to our preferred approach.

As discussed above, Figure 3 indicates the possibility of an anticipation effect in 2001, which may arise if firms started preparing for full foreign acquisitions as soon as they learned about the imminent FDI reform in 2001. As a simple robustness check, we omit the year 2001 from the regression and find slightly larger performance effects, as expected. Furthermore, if firms anticipated the FDI liberalization, this might also have affected their product choices and hence our assignment of treatment in 2001. To address this possibility, we conduct a robustness check in which we assign the FDI policy to firms based on their products in 2000 and estimate the effect relative to the period 1999–2000. The resulting estimate is positive and significant, but plausibly smaller than our baseline result, as it includes the (weaker) anticipation effect.

Since we assign the treatment exclusively based on pre-reform product information, some firms may be able to become foreign owned because they switch to producing unregulated products, rather than due to the liberalization of their previously produced products. As we condition the DiD regression on firm-year observations (in the post-reform period) in which the treated firms continued to produce the liberalized products, the estimate strongly confirms our main result.

One may also wonder about the relevance of increased foreign ownership vs. new foreign acquisitions. For firms with initially non-zero foreign ownership, it seems more likely that a relationship with the same foreign owner existed already before the reform and we can be more assured that the identified effect corresponds to a reoptimized ownership choice. Restricting attention to firms with a positive *FO share* in the pre-reform years (around half of the estimation sample), the performance gains are confirmed, though they are slightly smaller and statistical significance is weaker in this reduced sample.

We have focused on full foreign acquisitions in the main analysis, yet the FDI policy includes some more specific ownership thresholds (equity requirements) and firms crossing these thresholds may similarly be considered as treated. To examine this question, we use a modified treatment vari-

able, which identifies a firm as treated if it crosses a foreign ownership threshold after this threshold was abolished by the FDI liberalization (while maintaining the 100% threshold for firms subject to general restrictions and for the control group). The result exploiting these equity thresholds is almost identical to our baseline estimate.

We also conduct extensive robustness checks with respect to the covariates included in our propensity score estimation to account for other factors possibly correlated with the FDI liberalization. We briefly discuss the results of two of these variations of the IPW approach. First, we incorporate a large set of additional firm-level covariates observed in 2000 into the logit model: $\ln$ *TFP*, the equity share owned by the state or collectives, a Herfindahl index of dispersion in ownership shares (computed across all non-foreign ownership categories reported in the ASIP data), the *liquidity ratio* (defined as $(\textit{current assets} - \textit{current liabilities})/\textit{ total assets}$) and the *leverage ratio* (defined as $\textit{total liabilities}/\textit{total assets}$) as measures of financial conditions, as well as initial tariffs and trade policy uncertainty $\mathbf{T}_i$. Second, we include in addition to this large set also $\ln$ *output* in 1999 to account for differences in pre-treatment performance dynamics. The estimates for the output effect from these specifications are of a similar magnitude as in our main analysis.

Finally, since the paper manufacturing sector (CIC code 22) is dominated by liberalized firms (see Online Appendix A.2 for the cross-sectoral distribution), it may be difficult to find sufficiently many firms in the control group that are comparable to these firms. We thus exclude the paper manufacturing sector in the final robustness check, which likewise confirms the substantial output gains from reoptimized ownership.

4.4 Discussion of possible explanations

The performance effects of reoptimized ownership identified above call for an explanation. Which changes inside the firms during the restructuring process may rationalize the large output gains? A closely related question is whether increased *foreign* ownership may contribute to explaining the identified performance gains. This section pursues two goals: First, we demonstrate that the performance gains cannot be attributed to foreign (vs. domestic) ownership. Second, we discuss possible explanations for how reoptimized ownership may have boosted firm performance.

We begin by discussing how increased foreign ownership can be expected to affect firm performance and examine whether we see any evidence of such effects driving our results. Notably, the treated firms in our setup are characterized by moving to full foreign ownership, but the same applies to firms in the control group by our research design. One might still wonder whether the foreign acquisitions had any *differential* effects across treatment and control groups and thereby confound our results. To assess this possibility, we examine a range of other outcome variables, which have been identified in the literature as typically affected by foreign acquisitions. This exer-

cise can be thought of as a search for a 'smoking gun' indicating the relevance of certain benefits of foreign ownership. The estimates may also be informative more broadly about the changes taking place inside the firm during the ownership restructuring process, as discussed below.

The FDI literature has identified at least four sets of benefits associated with foreign ownership that may improve firm performance: improved financial conditions, technology transfers, access to export markets, and imported inputs. First, MNEs can alleviate financial constraints of their subsidiaries, e.g. by providing access to internal capital markets (Desai et al., 2004; Alfaro and Chen, 2012; Eppinger and Smolka, 2022), and this is highly relevant for Chinese firms (Poncet et al., 2010; Manova et al., 2015; Wang and Wang, 2015). Second, after full acquisitions, foreign owners may increase transfers of intangibles to their subsidiaries, e.g. in the form of a better technology to produce improved or new products. Such transfers of intangibles play a prominent role in several analyses of firm boundaries and FDI (e.g. Atalay et al., 2014; Bolatto et al., 2023; Jiang et al., 2018; Kukharskyy, 2020). Third, foreign acquisitions can come with improved access to export markets via the foreign parent's distribution network, which fosters innovation and performance (Guadalupe et al., 2012; Kohler and Smolka, 2021). Fourth, foreign-owned firms import more inputs and use them more efficiently than domestically owned firms (Halpern et al., 2015).

In Table 3, we consider alternative outcomes that are associated with these four channels. First, we test whether ownership restructuring improved financial conditions, by considering two standard indicators of financial health as alternative dependent variables in equation (2): the *liquidity ratio* and the *leverage ratio* (defined in Section 4.3). Columns (1) and (2) show small and insignificant point estimates for both of these measures. Second, to assess the role of technology transfers, we examine a measure of product innovation available in the ASIP: the share of new products in total sales.[12] The insignificant, negative estimate in column (3) provides no evidence for the role of product innovation. Third, we consider the effect on the *export share* as a broad measure of export market access. Again, we find no significant effect in column (4). Fourth, to examine the role of imported intermediate inputs, we consider effects on the *import share* as an outcome. Column (5) shows that importing did not become relatively more important due to ownership restructuring. We further explore the rich customs data and find a large positive point estimate for the effect on the import value of capital goods ($\ln$ *capital imports*). This estimate, reported in column (6), is however not statistically significant either, as it is confined to the subsample of firms with positive imports of capital goods both before and after the liberalization.

We draw two main conclusions from the insignificant results presented in Table 3. The first is that changes from restricted to optimal ownership did not have a notable effect on any of the outcomes typically associated with the benefits of foreign ownership, to the extent that we observe useful proxies for these outcomes. Thus, differential effects of foreign acquisitions are very un-

[12] Other measures of innovation are unfortunately not available in our data for the relevant period.

Table 3: Effects of reoptimized ownership on other firm outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
	Liquidity ratio	*Leverage ratio*	*Sales share new products*	*Export share*	*Import share*	ln *capital imports*
treated × *after*	0.00768	-0.0272	-0.0158	0.0144	0.00150	0.323
	(0.0393)	(0.0449)	(0.0256)	(0.0310)	(0.0281)	(0.293)
Observations	9,671	9,671	8,714	9,668	9,671	1,835
R^2	0.682	0.724	0.764	0.867	0.787	0.894

The table reports estimates of β in equation (2) for alternative dependent variables, indicated in the header. Standard errors clustered by firm are reported in parentheses.

likely to be responsible for the large gains in firm performance. This is in line with expectations, as our identification strategy is designed to control for changes that are due to foreign ownership. We acknowledge that these insignificant results do not allow for drawing strong conclusions, as we merely cannot reject the hypothesis of no effect and measurement is imperfect, in particular for innovation. Our second takeaway from this analysis is that the dominating explanation for the performance gains is likely to be driven by other, potentially unobservable changes taking place inside the liberalized firms. We proceed by briefly discussing possible mechanisms, which are not easily discerned from observable outcomes, and devote Section 5 to explicitly developing one explanation based on the canonical PRT of the MNE.

We consider four explanations for the performance effects related to financial constraints, technology transfers, excludability, and non-contractible investments. First, ownership restructuring may have relaxed the financial constraints of Chinese firms, despite the estimated null effects for liquidity and leverage ratios, if financing via equity or internal credit is not reflected in these measures. Intuitively, if the financial channel is at work, we would expect stronger effects in financially dependent industries. Second, technology transfers may be crucial but are unfortunately unobservable in our data. If technology transfers play an important role, we would expect stronger effects in industries more intensive in research and development (R&D). We will return to these hypotheses in Section 5.2. Third, we consider the role of excludability of headquarter inputs. Suppose the foreign firm cannot exclude that the inputs it contributes to the production process may be misused by the Chinese manufacturer to its own benefit. If full ownership gives the foreign firm full control over the activities of its Chinese subsidiary and eliminates this risk, we would expect that the liberalization-induced full acquisitions result in greater provision of such headquarter inputs and boost firm performance. Finally, we offer an explanation based on the PRT in Section 5: Essentially, if contractual frictions matter even inside the firm, obtaining property rights through

ownership will improve the foreign firm's incentives to invest into non-contractible headquarter inputs. Obviously, all four explanations are linked, as the excludability and PRT mechanisms both relate to contractual frictions, and in both cases ownership may induce co-financing or technology transfers. Thus, these explanations are hard to distinguish empirically given the available data.

5 A Property-Rights Theory Explanation

5.1 Theoretical model

We adapt the PRT of the MNE by Antràs (2003) to the Chinese context by allowing for partial ownership in Sino-foreign JVs and incorporating policy restrictions on foreign ownership. Here, we focus on the key assumptions and insights, relegating all details to Online Appendix C.

We consider the relationship between a foreign firm F and a manufacturer M in China. M produces a differentiated good x, which may be an intermediate input, shipped to firm F in a *vertical FDI* relationship, or a final good in case of a *horizontal FDI* relationship. We assume iso-elastic (derived) demand for x and a Cobb-Douglas technology combining headquarter services h provided by F and components m provided by M. A key assumption is that all investments into h and m are fully relationship-specific, as they need to be customized to the production process, and non-contractible because they cannot be verified by a court. Only after investments are sunk, F and M bargain over the surplus from the relationship. These assumptions imply a two-sided hold-up problem. F anticipates this when initially choosing the ownership share $s \in [0, 1]$ in M, where a higher s raises F's outside option in ex-post bargaining. The resulting optimal s increases in headquarter intensity η, reflecting a greater importance of F's non-contractible investments.

We introduce the Chinese FDI restrictions as an upper bound on s and show that, naturally, FDI liberalization induces an ownership restructuring process among previously constrained firms, which increase their foreign ownership shares s. Our main theoretical result is that this reorganization increases firm output, but only if headquarter intensity is high: $\eta > 0.5$. Intuitively, the increase in s induced by FDI liberalization ameliorates F's underinvestment into h, while it aggravates M's underinvestment into m. For a high η, the first effect dominates and the efficiency gains from the optimal allocation of ownership rights materialize in the form of higher firm output.

In a model extension, we allow for partial contractibility μ following Acemoglu et al. (2007) and Antràs and Helpman (2008). The analysis confirms our main prediction on output gains and adds further insights regarding the expected heterogeneity of this effect. Though the complexity of the extended model prevents us from providing a tractable proof of how the effect depends on μ, we obtain a clear and intuitive picture from numerical simulations, illustrated in Online Appendix D.3: The positive output effect (conditional on $\eta > 0.5$) is predicted to be stronger

if production involves a greater share μ of non-contractible inputs. To sum up, the PRT model predicts that liberalizing ownership restrictions should have beneficial effects on firm performance, in particular if headquarter inputs are important and if inputs are non-contractible.

5.2 Heterogeneous performance effects of reoptimized ownership

As an empirical test of the PRT model, we examine the heterogeneity of the performance effects from reoptimized ownership. We implement this test by adding to our main specification (2) triple interaction terms of $treated_i \times after_t$ with different variables suggested by theory (along with all relevant two-way interactions).

The PRT model predicts positive effects of optimal ownership restructuring on output only for production processes characterized by a high headquarter intensity. Thus, we include triple interaction terms with standard proxies of headquarter intensity used in the literature, namely capital intensity and skill intensity (Antràs, 2003; Yeaple, 2006). This approach builds on the premise that the foreign owner is more likely to contribute relationship-specific investments in capital or human capital relative to raw labor.[13] To ensure that our proxies of headquarter intensity are exogenous, we use data on U.S. industries in 1990 from the NBER CES database.[14] For both proxies of η, we construct dummies for 'high' (i.e., above-median) values and augment equation (2) by the triple interaction term: $treated_i \times after_t \times high\ headquarter\ intensity_j$.

We have further formulated the hypothesis that the performance effects should be greater in industries that heavily rely on non-contractible inputs. To test this hypothesis, we examine the triple interaction term $treated_i \times after_t \times high\ contract\ intensity_j$, where the latter variable is a dummy variable indicating above-median contract intensity from Nunn (2007).

Table 4 reports the estimation results from these triple interaction models. Columns (1)–(3) include the triple interaction terms one by one (along with the relevant two-way interaction terms, which are not reported to save space). We obtain positive point estimates for the triple interaction effects, as predicted, but these are not statistically significant. In column (4), we include all interaction terms in a single specification, which delivers stronger evidence in favor of our theoretical predictions: We find large positive estimates for all three triple interaction effects, which are statistically significant in two cases. The results suggest that the performance effects of optimal

[13] This assumption is highly plausible also in the Chinese context. For instance, Bai et al. (2004) document that 'equipment installation' and 'staff training' are among the tasks typically done by the foreign partners in Sino-foreign JVs. Huang (2008) stresses the importance of foreign owners in providing access to capital for Chinese firms. Björkman and Lu (1999) document that MNEs send expatriate managers and engineers to their Chinese subsidiaries.

[14] Specifically, we compute *capital intensity* as the capital stock divided by total payroll and *skill intensity* as the payroll share of non-production workers, both measured at the level of 4-digit SIC industries in the U.S. in 1990, and matched to Chinese firms via 4-digit CIC codes. We use 1990 data rather than contemporaneous values, since they better reflect the technology used in Chinese industries in the early 2000s.

ownership restructuring are concentrated in industries characterized by a high skill intensity and a high contract intensity.

Table 4: Heterogeneous performance effects of reoptimized ownership

	(1)	(2)	(3)	(4)	(5)
treated × *after*	0.276^c	0.139	0.0712	-0.679^c	-0.478
	(0.161)	(0.166)	(0.229)	(0.384)	(0.374)
treated × *after* × *high capital intensity*	0.121			0.533	0.655^c
	(0.242)			(0.350)	(0.345)
treated × *after* × *high skill intensity*		0.290		0.640^b	0.675^b
		(0.218)		(0.319)	(0.317)
treated × *after* × *high contract intensity*			0.407	0.487^c	0.359
			(0.260)	(0.258)	(0.260)
treated × *after* × *financial dependence*					1.516
					(1.001)
treated × *after* × *R&D intensity*					-8.967
					(6.940)
Observations	9,310	9,310	9,310	9,310	9,284

The table reports estimates of β in equation (2) with $\ln$ *output* as the dependent variable and the displayed triple interaction terms added. All relevant two-way interaction terms are also included but not reported. Standard errors clustered by firm are reported in parentheses. b indicates 5% significance and c indicates 10% significance.

These regressions are geared towards testing our explanation of the performance gains based on the PRT. Yet, there may be other plausible mechanisms rationalizing these gains, as discussed in Section 4.4. Two alternative explanations are related to (i) ownership restructuring alleviating financial constraints in the Chinese firms or (ii) technology transfers making these firms more productive. We aim to test and partly control for these alternative mechanisms by adding further triple interaction terms to the specification, in analogy to the contracting-based covariates. To test whether performance gains were greater in firms that are highly dependent on external finance, we consider the measure of financial dependence suggested by Rajan and Zingales (1998) and computed by Kroszner et al. (2007) from U.S. firms over the 1980s and 1990s. To test whether performance gains were greater in more high-tech, research-intensity industries, where technology transfers would seem to be particularly valuable, we consider R&D intensity (also taken from Kroszner et al., 2007). The estimates reported in the final column of Table 4 do not lend support to these alternative hypotheses, but they do confirm the positive triple interaction effects predicted by our imperfect contracting model (significant for capital and skill intensity).

Overall, the empirical findings from this heterogeneity analysis support the predictions of our model: Ownership restructuring was particularly beneficial for firms in which the provision of

typical headquarter inputs is more important and where contractual frictions are more severe. We interpret these results through the lens of the PRT: By moving from restricted to optimal ownership after the FDI liberalization, the treated firms grew and became more efficient because their foreign owners were willing to increase their contributions of non-contractible headquarter inputs. Notably, this interpretation is also consistent with the estimated increase in TFP (in Table 2), reflecting more efficient input provision, and the large point estimate for the effect on capital imports (in Table 3). Still, we acknowledge that these analyses only provide suggestive evidence in favor of one model, but cannot serve to discriminate between alternative explanations.

6 Conclusions

In this paper, we provide a first quantification of the gains in firm performance that can be achieved by the optimal allocation of ownership rights within multinational firms. We exploit the major liberalization of China's policy restrictions on foreign ownership to show that the reoptimized ownership choices led to firm-level output growth by 40% and significant productivity gains. By comparing fully foreign-acquired firms for which FDI was liberalized to other fully foreign-acquired firms that were unaffected by the policy, our difference-in-differences approach identifies the gains from optimal ownership restructuring. We also show that heterogeneity in the performance effects can be rationalized by an extended property-rights theory of the multinational firm. Our results demonstrate that optimal ownership matters substantially for firm performance in practice.

These findings suggest that policy makers should carefully consider the efficiency costs of policies distorting ownership decisions. Restrictions on foreign ownership remain prevalent around the world, including in industrialized countries (see OECD, 2019). As a case in point, the U.S. even tightened and extended its FDI reviews by the Committee on Foreign Investment in the United States (CFIUS) in 2018. Also within countries, various domestic policies may prevent optimal firm ownership, such as restrictions on mergers and acquisitions or state ownership.[15] This paper provides evidence for large firm-level gains from alleviating ownership restrictions, suggesting that contractual frictions and distorted ownership may play a relevant role in explaining misallocation and aggregate productivity (Hsieh and Klenow, 2009).[16] Notably, these gains may be magnified in the aggregate through firm entry, exit, and reallocation. Quantifying the aggregate welfare effects of allowing for optimal ownership thus remains an important task for future research.

[15] Lafontaine and Slade (2007) stress that profit-maximizing integration decisions are typically found to be optimal also from a consumer's perspective. For evidence on the inferior performance of state-owned enterprises, see Dollar and Wei (2007) and Berkowitz et al. (2017).

[16] In related work, Boehm (2022) finds that a reduction in contract enforcement costs to the level of the U.S. would bring per-capita income gains of more than 1.5% to most countries.

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Online Appendix *(not for publication)*

Optimal Ownership and Firm Performance:
An Analysis of China's FDI Liberalization

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February 20, 2024

A Data Appendix: Chinese FDI policy

A.1 Product-level matching

The ASIP firm data set does not contain a systematic classification of products, as discussed by Imbert et al. (2022), but it contains textual descriptions of up to three main products per firm. These product descriptions are highly specific, but they are not standardized. Similar products may be described by different firms using different wording and the same firm may use different wording in different years. For example, a firm may report 'Washer' in one year and 'Washing equipment' in another year, while another firm reports 'Manufacture of washing machine' for the same product.

Importantly, the FDI policy is also product-specific: within each broadly-defined sector, the FDI Catalogue describes the specific products that are subject to one of the three policy categories: 'restricted', 'encouraged', or 'prohibited' FDI. FDI in products not mentioned in the Catalogue is by implication 'permitted'. In addition, the FDI Catalogue specifies which products are subject to equity requirements (JV or majority requirements). For example, in the sector 'conventional machinery manufacturing', the 2002 version of the Catalogue specifies that FDI is restricted in 'production of containers' and 'manufacturing of small and medium plain bearing'. In the FDI Catalogue of 1997, FDI in firms producing 'auto and motorcycle engines' is restricted and additionally requires majority shareholding by a Chinese partner. In the Catalogue of 2002, the FDI restriction in this product category is dropped, as is the equity requirement, and instead FDI into 'auto and motorcycle engines' is even encouraged. This is one example of a liberalized product. In Table A.1, we offer several further examples extracted and translated from the FDI Catalogue of 2002.

To match the FDI policy to firms, we develop a natural language processing (NLP) algorithm associating products produced by manufacturing firms with products listed in the FDI Catalogue. The algorithm systematically compares the textual product descriptions provided by firms in the ASIP data set with those in the Catalogue. Our matching procedure closely follows Imbert et al.

(2022). First, we clean the textual product descriptions in both data sets by applying a tokenizer ('jieba'), which groups Chinese characters into words. A list of stop words are used to filter out common words or particles. In this process, we transform a list of characters into a sequence of identified words. Next, we apply the powerful neural net developed by Google ('WORD2VEC') to represent every contiguous sequence of words in a vector space. To train the neural net, we use the word embeddings provided by Song et al. (2018) and trained on the Tencent AI Lab corpus and project the word sequence onto the vector space.[1] This representation allows us to compute the similarity between any sequence of words. More specifically, we construct a normalized similarity score between 0 and 1 from the average of the distance metric between all combinations of contiguous word sequences taken from (i) the product descriptions by firms in the ASIP data and (ii) the product descriptions in the FDI Catalogue. Note that the Catalogue groups products into broadly defined sectors (22 manufacturing sectors), so we restrict the search and matching within each broad sector, which increases the matching speed and precision. The resulting matches may be non-unique, so we match the policy to firms based on the product with the highest similarity score.

After these procedures, we end up with an FDI policy associated with the products reported by firms in the ASIP data. Each match is associated with a similarity score indicating the match quality. Taking the 2002 cross-section of the ASIP data for example, out of around 142,000 firm observations, about 107,000 firms' main products could be matched to the 2002 FDI Catalogue, with an average matching similarity score of 0.693 and a median score of 0.715. Figure A.1 illustrates the distribution of the similarity score. For our baseline analysis, we assign the FDI policy to firms only for matches with a similarity score above 0.8 or for lower scores in case implied by our manual checks and corrections (described below). We choose this relatively high threshold of 0.8 to be conservative and minimize the risk of false assignment of the FDI policy to firms. Subsequently, we also conduct robustness checks using lower thresholds of 0.7 or 0.6. We consider the match quality at a similarity score of 0.8 to be relatively high based on manual checks and inspection. For example, the product 'glass fiber reinforced plastic fishing and cruising boats', listed as a product for which is encouraged in the FDI Catalogue of 2002, is matched to 'rowing boats and cruising boats' in the ASIP data, at a similarity score of 0.802. Table A.2 lists several further examples of matches with different matching similarity scores for the FDI Catalogue of 2002.

[1]The training corpus provides a large collection of common contexts and word associations in order to best represent semantic similarity. The corpus we rely on is based on the Tencent AI Lab Embedding Corpora for Chinese and English Words and Phrases. Compared with the Wikipedia word embedding corpus that has been widely used (see Li et al., 2018), the Tencent AI Lab corpus has a much larger dictionary and word coverage. The word embedding algorithm developed by Song et al. (2018) relies on directional skip-gram (DSG), with consideration of not only the word co-occurrence patterns, but also their relative positions modeled by a special direction vector.

The examples of matched products suggested by the algorithm, listed in Table A.2, show that we achieve very good matches at high similarity scores, but they also illustrate the need for quality checks. The top three examples illustrate that matches with similarity scores above 0.9 are typically close to perfect and correctly assigned. Also those product descriptions with matching scores between 0.8 and 0.9 are very similar, but there are some cases in this range for which the matches are not sufficiently precise and need to be manually corrected. For example, firms that are producing 'auto components' are generally matched to the 'encouraged' FDI policy in 'Manufacturing of key automobile components'. However, this category represents a collection of very specific components only some of which were indeed subject to the policy. The detailed description of this product category is 'Manufacturing of key automobile components: brake assembly, driving bridge assembly, transmission gear, diesel engine oil pump, diesel engine turbine supercharger, diesel engine external exhaust control device, filters, constant speed gimbal, shock absorber, gauge panel, special high intensity fixtures.' The table shows that the product 'car seats and other accessories' reported by a firm is matched to this category with a similarity score of 0.8031. Since car seats and accessories do not show up in the detailed list, this match is incorrect and needs to be revised. Furthermore, in a few cases, the policy is place-based: a product for which FDI is 'restricted' in the Eastern provinces is 'permitted' in Western provinces.

Thus, in order to achieve a very precise and high-quality matching of the FDI policy to firms, we conduct extensive manual checks of the matches in a final step and manually correct individual cases if necessary. This is an important step, as illustrated by the example discussed in the previous paragraph. In the case of car seats or other auto components not mentioned in the detailed list of 'Manufacturing of key automobile components' encouraged in the Catalogue of 2002, we correct the policy assignment and code them as 'permitted' FDI instead. For a policy change pertinent to location, we use firms' location information to correct it. We manually check all product-level matches with a similarity score above 0.8 and then apply the resulting correction procedures to all products, including those that share the same part of the product string and have been matched with similarity scores below 0.8. Since the equity requirements in the FDI Catalogue are similarly product specific, our matching procedure also serves to identify firms subject to these specific restrictions on foreign ownership shares.

Table A.1: Examples from the FDI Catalogue of 2002

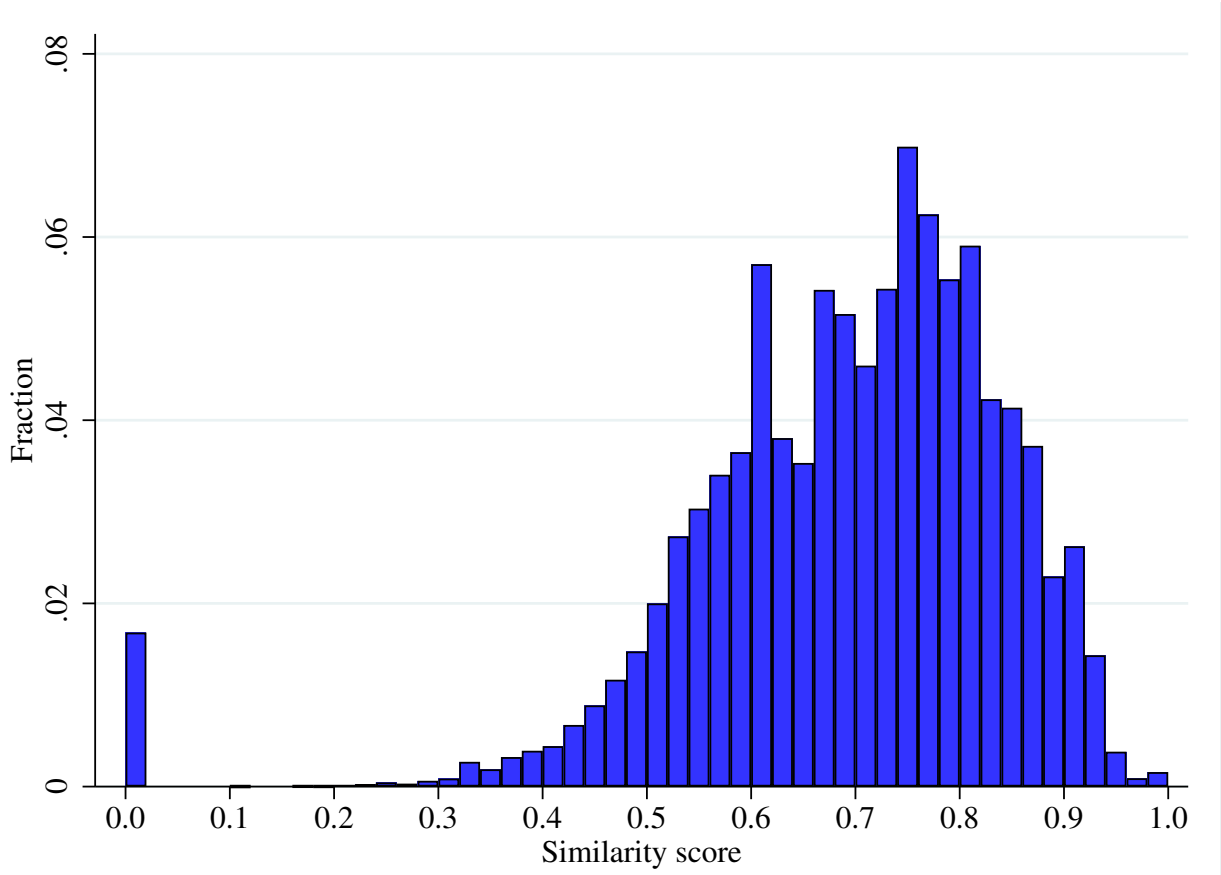
鼓励	**Encouraged**
（十八）交通运输设备制造业	**(18) Transportation equipment manufacturing.**
1) 汽车、摩托车整车制造	1) Manufacturing of automobiles and motor cycles.
2) 汽车、摩托车发动机制造	2) Manufacturing of automobiles and motor cycles' engines.
3) 汽车关键零部件制造：制动器总成、驱动桥总成、变速器、柴油机燃油泵、柴油机涡轮增压器、柴油车机外排放控制装置、滤清器（三滤）、等速万向节、减震器、组合仪表、专用高强度紧固件	3) Manufacturing of key automobile components: brake assembly, driving bridge assembly, transmission gear, diesel engine oil pump, diesel engine turbine supercharger, diesel engine external exhaust control device, filters, constant speed gimbal, shock absorber, gauge panel, special high intensity fixtures.
限制	**Restricted**
（三）纺织业	**(3) Textile**
1) 毛纺、棉纺	1) Wool and cotton textile.
2) 丝	2) Silk.
（七）医药制造业	**(7) Medication manufacturing.**
1) 氯霉素、青霉素 G、洁霉素、庆大霉素、双氢链霉素、丁胺卡那霉素、盐酸四环素、土霉素、麦迪霉素、柱晶白霉素、环丙氟哌酸、氟哌酸、氟嗪酸生产	1) Production of chloromycetin, penicillium G, lincomycinum, gentamycin, dihydrostreptomycin, amikacin, chlorhydric acid cyclomycin, terramycin, medemycin, kitasamycin, ciprofloxacin hydrochloride, norfloxacin, fluoroacid.
（十二）专用设备制造业	**(12) Special equipment manufacturing.**
1) 中低档 B 型超声显像仪制造	1) Manufacturing of low or medium B type ultrasonoscope.
禁止	**Prohibited**
（五）其他制造业	**(5) Other manufacturing.**
1) 象牙雕刻	1) Ivory carving.
2) 虎骨加工	2) Tiger bone processing.

Table A.2: Examples of product-level matches based on the FDI Catalogue of 2002

Similarity score	**Product name in ASIP**	**Product name in FDI Catalogue**	**Evaluation**
0.980	woolen textile	woolen textile, cotton textile	Good Match
0.955	phosphate fertilizer, compound fertilizer	Biofertilizer, Highly concentrated fertilizer (Potassium fertilizer, Phosphate fertilizer), Production of compound fertilizer	Good Match
0.901	Pepsi-Cola brand carbonated beverage	Production of foreign brand carbonated beverages	Good Match
0.851	Concentrated feed	Development and production of bio-based feed and protein feed	Good Match
0.804	Dairy beverages	Development and production of fruit and vegetable beverages, protein beverages, tea beverages, and coffee beverages	Good Match
0.803	Environmentally friendly paint	Production of high-performance coatings	Good Match
0.803	Car seats and other accessories	Manufacturing of key automobile components: brake assembly, driving bridge assembly, transmission gear, diesel engine oil pump, diesel engine turbine supercharger, diesel engine external exhaust control device, filters, constant speed gimbal, shock absorber, gauge panel, special high intensity fixtures	Manual correction
0.751	Plastic products	Production of engineering plastics and plastic alloys	Manual correction
0.606	PVC shoes, leather shoes	New techniques for leather finishing and dressing	Manual correction

Note: The table reports examples of matches between products reported by firms in the ASIP data and products reported in the FDI Catalogue effective in 2002, as suggested by our matching algorithm and sorted by the similarity score computed by the algorithm. The final column indicates our evaluation of the matching result: good matches result in assignment of the policy, low quality matches were revised manually for similarity scores ≥ 0.8 or coded as 'permited' for similarity scores < 0.8.

Figure A.1: Distribution of matching similarity score for 2002



The figure shows the distribution of similarity scores from the matching procedure for the year 2002 across 142,852 observations matched by the algorithm (before the manual checks and cleaning procedure).

A.2 Comparison of product-level vs. industry-level FDI policy

This Appendix compares our firm-product-specific FDI policy classification to industry-level measures previously used in the literature. We summarize the key differences in five facts.

First, our product-specific coding on average assigns fewer firms to the FDI policy categories. Table A.3 provides summary statistics. In our ten-year panel, we identify on average around 7.1% of firms for which FDI was restricted and a very small group of firms for which FDI was entirely prohibited (0.0005%). The industry-level measures provided by Brandt et al. (2017) and Sheng and Yang (2016) imply much higher shares of around 13.1–13.2% firms with restricted and 1.5% with prohibited FDI. The latter paper also identifies industries with encouraged FDI, which host 32.6% of our firm-year observations, compared to 17.9% for our product-level assignment of this policy category. These patterns are in line with expectations, as our coding identifies more narrowly defined products and is thus more precise.

Second, there is substantial non-overlap between our product-level measure of FDI policy and industry-level assignments. In particular, it is clearly not the case that only firms active in the industries coded as 'restricted' in previous work produce restricted products. Instead, such firms exist in a variety of different industries. Table A.4 provides correlation coefficients across alternative measures of the FDI policy. The correlation coefficients of our product-level policy assignment vs. the industry-specific measures are 0.29–0.35 for the restricted category and around 0.05–0.13 for prohibited FDI. In the case of the 'encouraged' FDI the correlation is 0.27.

Third, these cross-sectional discrepancies translate into large differences in the coding of firms for which FDI was liberalized, in the sense of lifting restrictions on FDI, in 2002. Among those firms coded as 'liberalized' in 2001 by our FDI policy measure, only around one third (4,317 out of 12,220) would also be identified as liberalized by the Brandt et al. (2017) industry-level FDI policy measure. Instead, an additional 9,331 firms would be assigned by their approach to liberalized industries, although they do not produce liberalized products according to our firm-product-level classification. This group even includes 1,065 firms identified by our approach as still restricted after 2002.

Fourth, our product-level matching is essential to identifying and differentiating liberalized firms in many manufacturing sectors, broadly defined at the 2-digit CIC level. Figure A.2(a) illustrates the distribution of liberalized firms across 2-digit sectors in 2001 for the different policy measures. It is evident that the product-level match identifies liberalized firms in many different sectors (29 out of 30 2-digit CIC codes), while they are confined to nine or 16 sectors, respectively, according to the industry-specific measures. Large discrepancies across different FDI policy measures are visible e.g. in the 'Paper,' 'Pharmaceuticals,' and 'Transport Equipment' sectors. The first two sectors are examples in which industry-specific measures fail to capture all liberalized firms as identified by our product-specific matching. In the transport equipment sector, industry-specific coding of the FDI policy instead overstates the scope of the liberalization, which in practice only affected firms producing very specific auto components (see the discussion at the end of Appendix A.1).

Expanding on this fourth point, a further issue with industry-specific FDI policy measures arises once we also consider firms coded as 'still restricted' after 2001. To illustrate this issue, Figure A.2(a) depicts the shares of liberalized firms among initially restricted firms: For our product-level policy matching, these shares are between zero and 100% in 29 out of 30 sectors, implying that liberalized and still restricted firms coexist. By contrast, the industry-level measures would mostly assign the liberalization to all firms in a given sector, with liberalized and still restricted firms coexisting in only five or nine sectors, respectively, according to these measures. These facts illustrate that the product-level FDI policy match is essential in identifying the effects of the liberalization if one wants to control for macroeconomic shocks at the sectoral level by sector-year

fixed effects.

Fifth, our product-specific assignment of the FDI policy to firms is more in line with observed foreign ownership patterns. Note that in principle we should see very little foreign ownership among firms for which FDI is coded as prohibited. Table A.5 summarizes violations of this policy. For firms with a prohibited FDI policy according to our classification, only 5.3% have a foreign ownership share of 25% or more and only 1.1% are fully foreign owned, compared to much higher shares in the full panel of all firms, namely 19.5% for $\geq$25% foreign ownership and 11.1% for full foreign ownership. By contrast, the industry-specific measures by Brandt et al. (2017) and Sheng and Yang (2016) reveal many more violations of the prohibited FDI policy, coding 17.8–20.0% of all firm-year observations with prohibited FDI as foreign owned by at least 25% and 9.1–9.5% of observations in prohibited FDI industries as fully foreign owned, only slightly below the shares in the overall population.

A similar consistency check for firms facing foreign equity requirements (not used in the previous literature) confirms that the shares of majority foreign owned firms are much lower in this subpopulation compared to the full sample, as we would expect. We interpret these patterns as evidence of the high quality and precision of our product-level FDI policy assignment.

Table A.3: Summary statistics for alternative FDI policy measures

Variable	Mean	Std. dev.	Min.	Max.	Observations
Restricted FDI (product)	0.071	0.256	0	1	1,815,205
Restricted FDI (Sheng & Yang, 2016)	0.132	0.338	0	1	1,815,205
Restricted FDI (Brandt et al., 2017)	0.133	0.339	0	1	1,813,271
Prohibited FDI (product)	0.000	0.022	0	1	1,815,205
Prohibited FDI (Brandt et al., 2017)	0.015	0.122	0	1	1,813,271
Prohibited FDI (Sheng & Yang, 2016)	0.015	0.123	0	1	1,815,205
Restricted or prohibited FDI (product)	0.071	0.257	0	1	1,815,205
Restricted or prohibited FDI (Brandt et al., 2017)	0.144	0.351	0	1	1,813,271
Restricted or prohibited FDI (Sheng & Yang, 2016)	0.147	0.354	0	1	1,815,205
Encouraged FDI (product)	0.179	0.383	0	1	1,815,205
Encouraged FDI (Sheng & Yang, 2016)	0.326	0.469	0	1	1,815,205

The table reports summary statistics of alternative measures of the FDI policy.

Table A.4: Correlations across alternative FDI policy measures

	Restricted FDI			Prohibited FDI			Restricted or prohibited FDI			Encouraged FDI	
	Product	SY2016	BVBWZ2017	Product	BVBWZ2017	SY2016	Product	BVBWZ2017	SY2016	Product	SY2016
Restricted (product)	1.000										
Restricted (SY2016)	0.294	1.000									
Restricted (BVBWZ2017)	0.355	0.758	1.000								
Prohibited (product)	-0.006	-0.006	-0.000	1.000							
Prohibited (BVBWZ2017)	0.035	-0.048	0.045	0.053	1.000						
Prohibited (SY2016)	0.034	-0.049	0.044	0.134	0.800	1.000					
Restricted or prohibited (product)	0.996	0.292	0.354	0.078	0.039	0.045	1.000				
Restricted or prohibited (BVBWZ2017)	0.335	0.720	0.954	0.013	0.303	0.233	0.335	1.000			
Restricted or prohibited (SY2016)	0.292	0.938	0.739	0.041	0.230	0.300	0.295	0.768	1.000		
Encouraged (product)	-0.129	0.019	0.009	-0.010	0.046	0.043	-0.129	0.028	0.032	1.000	
Encouraged (SY2016)	-0.134	0.042	0.047	0.007	-0.065	-0.058	-0.133	0.030	0.020	0.273	1.000

The table reports correlations across alternative measures of the FDI policy. BVBWZ2017 indicates Brandt et al. (2017) and SY2016 indicates Sheng and Yang (2016).

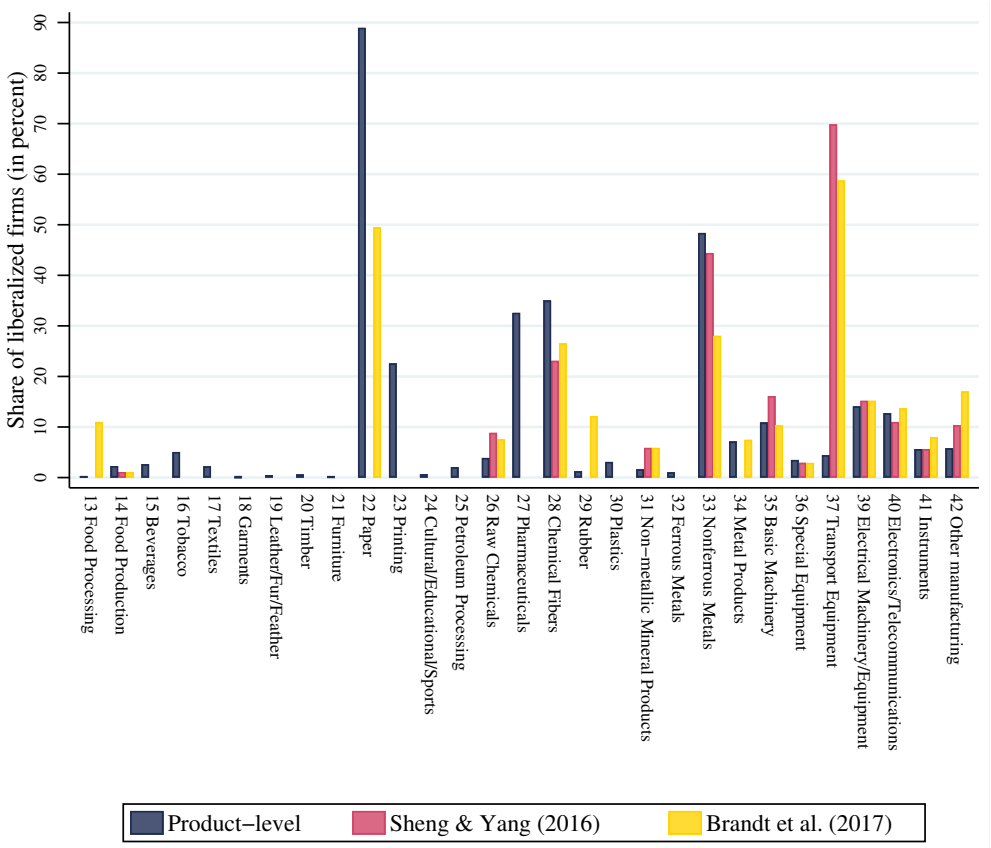
Table A.5: Violations of the prohibited FDI policy across alternative measures

	Product-level		Brandt et al. (2017)		Sheng & Yang (2016)	
Variable	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
FO share > 0	0.055	0.229	0.220	0.414	0.195	0.397
FO share $\geq 25\%$	0.053	0.224	0.200	0.400	0.179	0.383
Full foreign ownership	0.012	0.108	0.096	0.294	0.091	0.287
FO share	0.033	0.149	0.149	0.320	0.135	0.310
Observations	849		27,574		27,669	

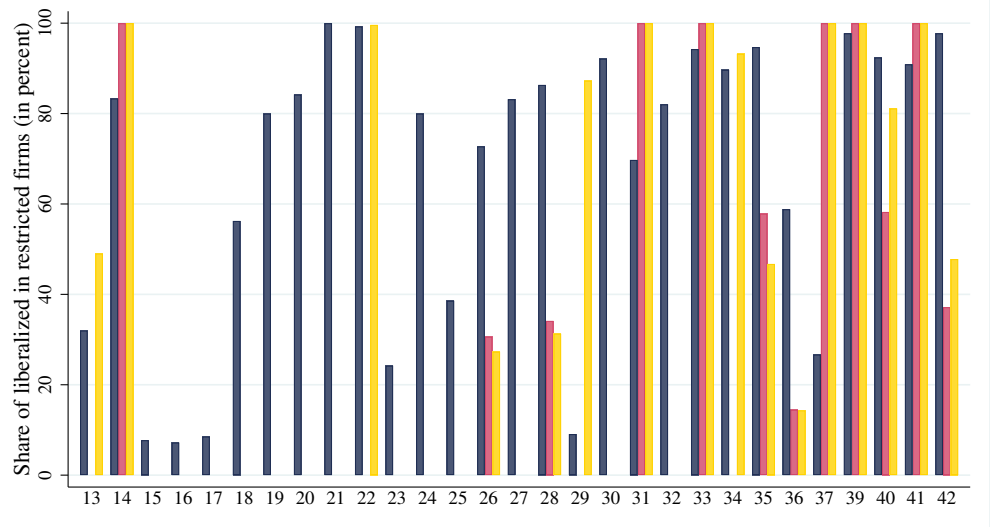
The table reports summary statistics of different foreign ownership dummy variables among firms that are assigned the prohibited FDI category by alternative measures of the FDI policy, documenting violations of this policy.

Figure A.2: Cross-sectoral distribution of liberalized firms, 2001

(a) Shares of liberalized firms among all firms by sector



(b) Shares of liberalized firms among initially restricted firms by sector



The figures illustrate shares of liberalized firms by 2-digit CIC sector in 2001, according to different FDI policy measures. Shares are computed relative to all firms by sector in Figure A.2(a) and relative to initially restricted firms by sector in Figure A.2(b).

B Empirical Appendix: Additional results

B.1 Robustness checks for effect of FDI liberalization on foreign ownership

Table B.1: Robustness checks for effect of FDI liberalization on foreign ownership

	(1)	(2)	(3)	(4)
	Baseline	+ control newly encouraged	+ 4-digit industry × year FE	+ newly encouraged & 4-dig. ind. × year FE
liberalized × *after*	0.0237^a	0.0311^b	0.0261^b	0.0367^b
	(0.00813)	(0.0126)	(0.0103)	(0.0162)
Observations	94,817	93,454	94,154	92,782
R^2	0.848	0.850	0.865	0.867

The table provides robustness checks for the direct effect of the FDI liberalization on foreign ownership based on estimates of equation (1) in the paper with added control variables. The dependent variable is the *full FO* dummy. The sample includes liberalized vs. still restricted firms. In column (1), we replicate the estimate from the second column of Table 1. In column (2), we add interaction effects of year dummies with a dummy variable indicating firms for which the FDI policy 'encouraged' was newly introduced in 2002. In column (3), we augment the main specification with 4-digit industry × year fixed effects. In column (4), we combine both. Standard errors clustered by firm are reported in parentheses. a indicates 1% significance and b indicates 5% significance.

Table B.2: Effect of FDI liberalization on foreign ownership for alternative FDI policy measures

	(1)	(2)	(3)	(4)	(5)	(6)
	Unweighted		IPW with sector FE		IPW without sector FE	
	BVBWZ2017	SY2016	BVBWZ2017	SY2016	BVBWZ2017	SY2016
liberalized × *after*	-0.0247^{c}	-0.0145	-0.0395^{b}	-0.0429^{b}	-0.0661^{a}	-0.0490^{b}
	(0.0131)	(0.0144)	(0.0189)	(0.0181)	(0.0241)	(0.0191)
Observations	64,410	46,895	17,114	7,739	49,093	35,300
R^2	0.738	0.720	0.795	0.728	0.727	0.699

The table reports estimates of equation (1) in the paper for alternative, industry-specific measures of the FDI policy. The dependent variable is the *full FO* dummy. The sample includes liberalized vs. still restricted firms. BVBWZ2017 indicates Brandt et al. (2017) and SY2016 indicates Sheng and Yang (2016). Columns (1) and (2) show unweighted regressions, columns (3) and (4) apply IPW as in our main analysis, and columns (5) and (6) implement the IPW approach without 2-digit sector fixed effects, since for the industry-specific policy measures liberalized and still restricted firms coexist only in few sectors. Standard errors clustered by firm are reported in parentheses. a indicates 1% significance, b indicates 5% significance, and c indicates 10% significance.

B.2 Inverse probability weighting

Table B.3: Logit estimation of the propensity score and reweighted estimation

	(1)	(2)
	Propensity score estimation	Reweighted regression
ln *output*	0.0321^a	-0.00551
	(0.0107)	(0.0292)
FO share	-0.0788^b	0.0111
	(0.0308)	(0.0914)
Firm age	0.000568	0.00112
	(0.000880)	(0.00266)
$\ln L$	0.00984	0.0287
	(0.0131)	(0.0358)
$\ln w$	-0.00642	0.000206
	(0.0140)	(0.0427)
Export share	-0.0914^a	-0.00723
	(0.0259)	(0.0669)
Import share	0.180^a	-0.00286
	(0.0332)	(0.0988)
Observations	1,182	1,178
Pseudo R^2	0.430	0.099
χ^2	224.0	22.85

The table reports average marginal effects from logit regressions predicting treatment in the main analysis of firm performance. The dependent variable is the *treated*$_i$ dummy (as defined in Section 4.1). Covariates are measured at the firm level in 2000 and predict treatment after 2001. 2-digit sector fixed effects are included but not reported. Column (1) reports the regression that predicts the propensity score used for the IPW in the main analysis (in Table 2). Column (2) reports the same regression reweighted by the estimated propensity score, which excludes four firms outside the common support. It shows that conditional differences in these covariates are insignificant after reweighting. Robust standard errors are reported in parentheses. a indicates 1% significance, b indicates 5% significance, and c indicates 10% significance.

B.3 Robustness checks for performance effects of reoptimized ownership

Table B.4: Robustness checks concerning the performance gains from reoptimized ownership

	(1)	(2)	(3)	(4)	(5)
	Product match score ≥ 0.7	Product match score ≥ 0.6	Omitting 2001	Effects relative to 2000	Liberalized products
treated $\times$ *after*	0.296^a	0.272^b	0.386^a	0.252^b	0.347^a
	(0.111)	(0.113)	(0.141)	(0.124)	(0.119)
Observations	8,165	7,539	8,586	10,926	9,434
Firms	997	925	1,174	1,325	1,176
R^2	0.901	0.900	0.896	0.903	0.901

	(6)	(7)	(8)	(9)	(10)
	Initial *FO share*> 0	Equity thresholds	IPW: Adding covariates	IPW: Adding output in 1999	Exclude paper sector
treated $\times$ *after*	0.264^c	0.342^a	0.326^a	0.309^c	0.279^b
	(0.150)	(0.118)	(0.126)	(0.158)	(0.132)
Observations	4,729	9,710	9,001	6,837	9,033
Firms	581	1,182	1,092	807	1,103
R^2	0.923	0.897	0.899	0.907	0.903

The table reports estimates of β in equation (2) in the paper with $\ln$ *output* as the dependent variable and modifications indicated in the header for each panel. See the text in Section 4.3 for details on these modifications. Standard errors clustered by firm are reported in parentheses. a indicates 1% significance, b indicates 5% significance, and c indicates 10% significance.

C Theory Appendix: PRT model

C.1 Model setup

We adapt the PRT of the MNE by Antràs (2003) to the Chinese context by allowing for partial ownership in Sino-foreign JVs and incorporating policy restrictions on foreign ownership. Proofs are provided in Appendix D.

Consider the production process of a differentiated good x, commissioned by a foreign firm F and implemented by a manufacturer M in China. Firms face iso-elastic demand for their variety of x, implying a price: $p = A\, x^{\alpha-1}$, where $1/(1-\alpha)$, with $\alpha \in (0,1)$, is the constant elasticity of substitution between varieties and A is an industry-specific demand shifter. Notably, this modeling approach is agnostic about the purpose of (and the source of demand for) good x, which may be an intermediate input shipped to firm F in a *vertical FDI* relationship, or it may be a final good sold to consumers in China or third countries in a *horizontal FDI* relationship.[2]

Good x is produced by M in China using the following Cobb-Douglas technology:

$$x = \left(\frac{h}{\eta}\right)^{\eta} \left(\frac{m}{1-\eta}\right)^{1-\eta}, \tag{C.1}$$

where h denotes headquarter services provided by the foreign firm F and m denotes intermediate inputs provided by the Chinese manufacturer M. The headquarter intensity is denoted by $\eta \in (0,1)$. An important assumption is that the two parties' investments into the inputs h and m are fully relationship-specific because they need to be customized to this production process, and these investments are non-contractible because they cannot be verified by a third party (e.g. a court of law).[3] These inputs are produced one-to-one from labor at marginal costs c_h and c_m, respectively.

The timing of the model is as follows. In the first stage, F offers to many potential manufacturers a contract specifying the ownership share $s \in [0,1]$ and a transfer payment, which is accepted by one manufacturer M. In the second stage, both parties non-cooperatively choose their input investments. The fact that these investments are non-contractible and relationship-specific leads to lock in and a two-sided hold-up problem with underinvestments into both h and m (under any organizational form s). In the third stage, F and M share the surplus from the relationship according to the generalized Nash bargaining solution, with F's bargaining power denoted by $\beta \in (0,1)$. Finally, the good is produced and sold, and revenues are shared as agreed.

The key assumption in this setup is that by choosing a higher s, the firm F improves its own

[2] In case of the vertical FDI interpretation, the demand function can be thought of as derived demand resulting from demand for a final good produced with the input x, as in Antràs (2003).

[3] We will consider partial contractibility in Section C.3. For a PRT model featuring both partial contractibility and partial relationship specificity, see Eppinger and Kukharskyy (2021).

bargaining position, while diminishing that of M. Formally, we assume that, if bargaining breaks down, F can produce and sell a fraction $\delta(s) \in [0,1)$ of x, with $\delta'(s) > 0$ and $\delta(0) = 0$; similarly, M can then produce and sell a fraction $\lambda(s) \in [0,1)$ of x, with $\lambda'(s) < 0$ and $\lambda(1) = 0$. Intuitively, each party has residual property rights over a share of the assets, which allows them to generate some revenues. However, we impose $\lambda(s) + \delta(s) < 1$, so there will always be an overall efficiency loss if the relationship breaks up. This modeling of continuous ownership shares generalizes the approach by Antràs (2003), which is nested in our framework for the restricted choice set $s \in \{0,1\}$ and $\lambda(s) = 0$. [4]

C.2 Equilibrium and theoretical predictions

We solve the model by backward induction. Our assumptions imply that in the final, bargaining stage firm F obtains a revenue share equal to

$$\beta_F(s) \equiv \beta + (1-\beta)\delta(s)^\alpha - \beta\lambda(s)^\alpha, \tag{C.2}$$

which is uniquely determined by the chosen ownership structure s and exogenous parameters, and is strictly increasing in s.

In the second stage, anticipating the hold-up problem that arises in bargaining, both firms underinvest into the inputs in the second stage. These input choices result in the following, suboptimal output level:

$$x^* = A^{\frac{1}{1-\alpha}} \alpha^{\frac{1}{1-\alpha}} \left(\frac{\beta_F(s)}{c_h}\right)^{\frac{\eta}{1-\alpha}} \left(\frac{1-\beta_F(s)}{c_m}\right)^{\frac{1-\eta}{1-\alpha}}. \tag{C.3}$$

In the first stage, F chooses the optimal ownership share s^* as

$$s^* = \Lambda^{-1}(\beta_F - \beta), \qquad s^* \in [0,1], \tag{C.4}$$

$$\text{where} \quad \beta_F^* = \frac{\eta(\alpha\eta + 1 - \alpha) - \sqrt{\eta(1-\eta)(1-\alpha\eta)(\alpha\eta + 1 - \alpha)}}{2\eta - 1} \tag{C.5}$$

and $\Lambda(s) \equiv (1-\beta)\delta(s)^\alpha - \beta\lambda(s)^\alpha$. Equation (C.4) describes a unique and strictly increasing mapping of s^* to the optimal revenue share (C.5), which is the same expression as in Antràs and

[4] Our symmetric notion of outside options seems particularly appropriate if M produces a final good for the local market in a horizontal FDI relationship. It is also in accordance with Chinese JV laws, which stipulate that both profits during operation and the remaining assets in case of dissolution are to be divided in proportion to the parties' shares in the JV's registered capital; see Article 4 in MofCom (2001a) and Article 94 in MofCom (2001b). Bai et al. (2004) find a very high correlation between the equity share of the foreign partner and its voting share in a JV. Anecdotal evidence on the dissolution of Sino-foreign JVs suggests that foreign firms have in practice been paid out in proportion to their equity share; see e.g. the cases of Danone, discussed by The Economist (2007), or Volvo (2018).

Helpman (2004). Rather than restricting the ownership decision to a dichotomous choice between zero or full integration, as is standard in the literature, we proceed with the general case and allow F to choose any ownership share in the unit interval.

In choosing s^*, F trades off underinvestments into h and m, which vary systematically with η:

Lemma 1 (Headquarter intensity)**.** *The optimal ownership share s^* increases (weakly) in headquarter intensity η.*
Proof. *See Appendix D.1.*

This result reflects the key intuition of the PRT (Grossman and Hart, 1986): The party contributing the more important non-contractible investments should optimally be assigned (more) ownership rights. Thus, a higher headquarter intensity η, associated with a greater importance of F's input in the joint production process, implies a higher optimal ownership share s^*. Consequently, firms choose arm's length contracting ($s^* = 0$) in industries with a low η, they organize in JVs ($0 < s^* < 1$) in the intermediate range of η, where s^* is strictly increasing in η, and full integration ($s^* = 1$) is optimal for high values of η.

We introduce the Chinese FDI policy as an upper bound $\bar{s}$ on the ownership share of the foreign firm F in its Chinese manufacturer M. This upper bound varies from zero, in case FDI is entirely prohibited, to just below one, in case the foreign firm is required to have at least a Chinese minority partner in a JV. It follows from Lemma 1 that constrained firm pairs will be those active in headquarter-intensive industries. By contrast, in industries with a low headquarter intensity such an upper bound is less likely to be binding because low ownership shares are preferable on efficiency grounds.

The direct effect of FDI liberalization (abolishing $\bar{s}$) on ownership is straightforward:

Lemma 2 (Optimal ownership restructuring)**.** *Abolishing foreign ownership restrictions leads to an increase in foreign ownership among previously constrained firm pairs.*

This result follows directly from profit-maximizing behavior. Since firms choose their ownership form to maximize profits, a policy reform that abolishes a binding upper bound $\bar{s} < s^*$ will induce the constrained firm pairs to increase their foreign ownership shares towards the optimal s^*. Lemma 2 predicts the increased foreign ownership due to liberalization that we see in the data.

The consequences of reoptimized ownership are summarized in our key theoretical prediction:

Proposition 1 (Firm performance)**.** *Optimal ownership restructuring after liberalizing ownership restrictions increases output in firms characterized by a high headquarter intensity $\eta > 0.5$.*
Proof. *See Appendix D.2.*

Intuitively, the policy-enabled increase in ownership s induces previously constrained firm pairs to adjust their input quantities and output level towards the optimum. This ownership change

ameliorates F's underinvestment into headquarter services h, while it aggravates M's underinvestment into intermediate inputs m. As a result, output will increase among the previously constrained firms if headquarter services h are more important in production (compared to m), or formally, if η exceeds the threshold $\hat{\eta} = 0.5$. The reasons is that, among these firms, the aggravated underinvestment by the Chinese manufacturer is more than compensated for by the improved investment incentives of the foreign firm. Thus, the efficiency gains from an optimal allocation of ownership rights materialize in the form of higher output, as shown in our empirical main analysis, but this effect is predicted to be positive only in headquarter-intensive industries.

C.3 Partial contractibility

Imperfect contractibility is key to our theoretical predictions above, yet there is no parameter governing the degree of contractual incompleteness because we have assumed zero contractibility of input investments. To examine the role of varying contractual frictions, we allow for partial contractibility in a model extension following Acemoglu et al. (2007) and Antràs and Helpman (2008). Specifically, we now assume that each input consists of a continuum of activities indexed by n:

$$m = \exp\left[\int_0^1 \ln m(n)\mathrm{d}n\right], \qquad h = \exp\left[\int_0^1 \ln h(n)\mathrm{d}n\right].$$

Of these inputs, only those in the range $[0, \mu]$ are contractible, with $\mu \in (0, 1)$. The remaining activities, in the range $(\mu, 1]$, are assumed to be non-verifiable and thus not contractible.[5]

The timing of the model remains unchanged, but the contract in the first stage of the game now includes the investments into contractible inputs. Thus, only investments into the non-contractible range of activities for both h and m are chosen non-cooperatively and remain subject to the hold-up problem in ex-post bargaining.

We follow Antràs and Helpman (2008) to derive the optimal choices of contractible and non-contractible investments and thereby obtain an expression for equilibrium output generalizing equation (C.3) (see Appendix D.3). To examine how increased ownership s after liberalizing ownership restrictions affects firm output conditional on η and μ, we implement similar comparative statics as in our baseline model. The analysis confirms our main result from Proposition 1: The output effects of reoptimized ownership are positive for any $\eta > \hat{\eta} = 0.5$. Unfortunately, the complexity of the resulting derivative prevents us from providing a tractable proof of how the effect of reoptimized ownership depends on contractibility μ. Yet, we obtain a clear and intuitive picture from numerical simulations, illustrated in Appendix D.3: The positive output effect (conditional on $\eta > 0.5$) is predicted to be stronger for a lower contractibility of inputs, or put differently,

[5] We do not introduce distinct parameters for the contractibility of the different inputs since we cannot distinguish the two empirically.

if the share of non-contractible inputs is greater. Intuitively, the model predicts that liberalizing the ownership restriction should have more beneficial effects on firm performance if headquarter inputs are more important and if many of these inputs are non-contractible.

D Theory Appendix: Proofs

D.1 Optimal ownership share and proof of Lemma 1

In the first stage of the game, the firm chooses the ownership share s^* that maximizes total operating profits:

$$\max_{s^*} \Pi = \alpha^{\frac{\alpha}{1-\alpha}} A^{\frac{1}{1-\alpha}} \Psi(\beta_F(s^*)), \tag{D.1}$$

$$\text{where} \quad \Psi(\beta_F(s^*)) \equiv \left(\frac{\beta_F(s^*)}{c_h}\right)^{\frac{\alpha\eta}{1-\alpha}} \left(\frac{1-\beta_F(s^*)}{c_m}\right)^{\frac{\alpha(1-\eta)}{1-\alpha}} \times \Big(1 - \alpha\eta\beta_F(s^*) - \alpha(1-\eta)\left[1-\beta_F(s^*)\right]\Big), \tag{D.2}$$

and $\beta_F(s^*)$ is given by equation (4).

Setting the partial derivative of $\Psi(\cdot)$ in equation (D.2) with respect to β_F to zero and simplifying yields:

$$\begin{aligned} 0 &= \left(\beta_F c_h^{-1}\right)^{\frac{\alpha\eta}{1-\alpha}} \left(\left[1-\beta_F\right] c_m^{-1}\right)^{\frac{\alpha(1-\eta)}{1-\alpha}} \times \Lambda, \\ \text{with} \quad \Lambda &\equiv (2\eta-1)\,\beta_F^2 + 2\eta\,(\alpha - \alpha\eta - 1)\,\beta_F - \eta\,(\alpha - \alpha\eta - 1)\,. \end{aligned}$$

The first two factors in this expression are non-negative for any $\beta_F \in (0,1)$ and $c_m, c_h > 0$, so we can concentrate on the term Λ. Setting $\Lambda = 0$ and solving the quadratic form delivers the optimal revenue share β_F^* given in equation (7). Finally, s^* in equation (6) is obtained by rearranging equation (4).

The optimal revenue share β_F^* is weakly increasing in headquarter intensity η, as

$$\frac{\partial \beta_F^*}{\partial \eta} = \frac{\left[2\alpha\eta(1-\eta) - 1 + 2\sqrt{\eta(1-\eta)(1-\alpha\eta)(\alpha\eta+1-\alpha)}\right]\left[2\alpha\eta(\eta-1) - (1-\alpha)\right]}{2(2\eta-1)^2\sqrt{\eta(1-\eta)(1-\alpha\eta)(\alpha\eta+1-\alpha)}}$$

is non-negative. This can be seen by noting that for α approaching 1 and η approaching 0.5 each of the two terms in square brackets approaches its supremum, which is negative in each case, so both terms are negative for all admissible parameter values. The denominator is non-negative. Thus, the entire expression is non-negative. It follows from the strictly monotonic relationship between s^* and β_F^* that an increase in η, raising β_F^*, implies a higher s^*. This completes the proof of Lemma 1.

D.2 Proof of Proposition 1

Taking the partial derivative of x^* from equation (5) yields:

$$\frac{\partial x^*}{\partial \beta_F(s)} = x^* \left[\frac{\eta - \beta_F(s)}{(1-\alpha)\beta_F(s)\left[1-\beta_F(s)\right]} \right],$$

which is positive if and only if $\eta > \beta_F(s)$. This is true for any headquarter intensity of $\eta > \hat{\eta} = 0.5$, as is easily verified using equation (7), replicated here for convenience:

$$\beta_F^* = \frac{\eta(\alpha\eta + 1 - \alpha) - \sqrt{\eta(1-\eta)(1-\alpha\eta)(\alpha\eta+1-\alpha)}}{2\eta - 1}.$$

β_F^* is strictly increasing in η, as shown in the proof of Lemma 1 (see Appendix D.1). For the limiting cases of $\eta = 1$ and $\eta = 0$, we obtain $\beta_F^*|_{\eta\to 1} = 1$ and $\beta_F^*|_{\eta\to 0} = 0$. The nominator of β_F^* is strictly positive, while the denominator switches sign from negative to positive at $\eta = 0.5$, where the expression is not defined. Thus, there exists a unique threshold $\hat{\eta} = 0.5$, with $\partial x^*/(\partial \beta_F(s)) < 0$ if $\eta < 0.5$, but $\partial x^*/(\partial \beta_F(s)) > 0$ if $\eta > 0.5$. Hence, an increase in $\beta_F(s)$ (due to an increase from $\bar{s}$ to s^*) raises output if $\eta > \hat{\eta} = 0.5$. This completes the proof of Proposition 1.

D.3 Model extension with partial contractibility

In this Appendix, we provide details on the model extension in Section C.3 and offer simulation results.

The optimal input choices are equivalent to equations (4) and (7) in Antràs and Helpman (2008). The optimal investment choices for non-contractible inputs are:

$$\begin{aligned} m(n)^{1-\alpha\omega} &= \alpha A^{1-\alpha}\eta^{-\alpha\eta}(1-\eta)^{-\alpha(1-\eta)} \times \left[\left(\frac{\beta\eta}{c_h} \right)^{\alpha\omega_h} \left(\frac{(1-\beta)(1-\eta)}{c_m} \right)^{1-\alpha\omega_h} \right] \\ &\times \left[\exp\left(\alpha\eta \int_0^\mu \ln h(n)\mathrm{d}n + \alpha(1-\eta)\int_0^\mu \ln m(n)\mathrm{d}n \right) \right] = m_n^{1-\alpha\omega}, \quad \text{for } n \in (\mu, 1], \\ h(n)^{1-\alpha\omega} &= \alpha A^{1-\alpha}\eta^{-\alpha\eta}(1-\eta)^{-\alpha(1-\eta)} \times \left[\left(\frac{\beta\eta}{c_h} \right)^{1-\alpha\omega_m} \left(\frac{(1-\beta)(1-\eta)}{c_m} \right)^{\alpha\omega_m} \right] \\ &\times \left[\exp\left(\alpha\eta \int_0^\mu \ln h(n)\mathrm{d}n + \alpha(1-\eta)\int_0^\mu \ln m(n)\mathrm{d}n \right) \right] = h_n^{1-\alpha\omega}, \quad \text{for } n \in (\mu, 1]. \end{aligned}$$

Investments into contractible inputs are:

$$m(n) = \left(\frac{1-\alpha\left(\beta\omega_h + (1-\beta)\omega_m\right)}{1-\alpha\omega}\right)^{\frac{1-\alpha\omega}{1-\alpha}} \times \left(\frac{\eta}{c_h}\right)^{\frac{\alpha\mu\eta}{1-\alpha}} \left(\frac{1-\eta}{c_m}\right)^{1+\frac{\alpha\mu(1-\eta)}{1-\alpha}}$$
$$\times \left[\alpha A^{1-\alpha}\eta^{-\alpha\eta}(1-\eta)^{-\alpha(1-\eta)}\left(\frac{\beta\eta}{c_h}\right)^{\alpha\omega_h}\left(\frac{(1-\beta)(1-\eta)}{c_m}\right)^{\alpha\omega_m}\right]^{\frac{1}{1-\alpha}} = m_c, \quad \text{for } n \in [0,\mu].$$
$$h(n) = \left(\frac{1-\alpha\left(\beta\omega_h + (1-\beta)\omega_m\right)}{1-\alpha\omega}\right)^{\frac{1-\alpha\omega}{1-\alpha}} \times \left(\frac{\eta}{c_h}\right)^{1+\frac{\alpha\mu\eta}{1-\alpha}} \left(\frac{1-\eta}{c_m}\right)^{\frac{\alpha\mu(1-\eta)}{1-\alpha}}$$
$$\times \left[\alpha A^{1-\alpha}\eta^{-\alpha\eta}(1-\eta)^{-\alpha(1-\eta)}\left(\frac{\beta\eta}{c_h}\right)^{\alpha\omega_h}\left(\frac{(1-\beta)(1-\eta)}{c_m}\right)^{\alpha\omega_m}\right]^{\frac{1}{1-\alpha}} = h_c, \quad \text{for } n \in [0,\mu].$$

In these equations, we use the definitions $\omega_h \equiv \eta(1-\mu)$, $\omega_m \equiv (1-\eta)(1-\mu)$, and $\omega \equiv \omega_h + \omega_m$.

Substituting all four input choices into the production function:

$$x^*_\mu = \eta^{-\eta}(1-\eta)^{-(1-\eta)} h_c^{\eta\mu} h_n^{\eta(1-\mu)} m_c^{\mu(1-\eta)} m_n^{(1-\mu)(1-\eta)},$$

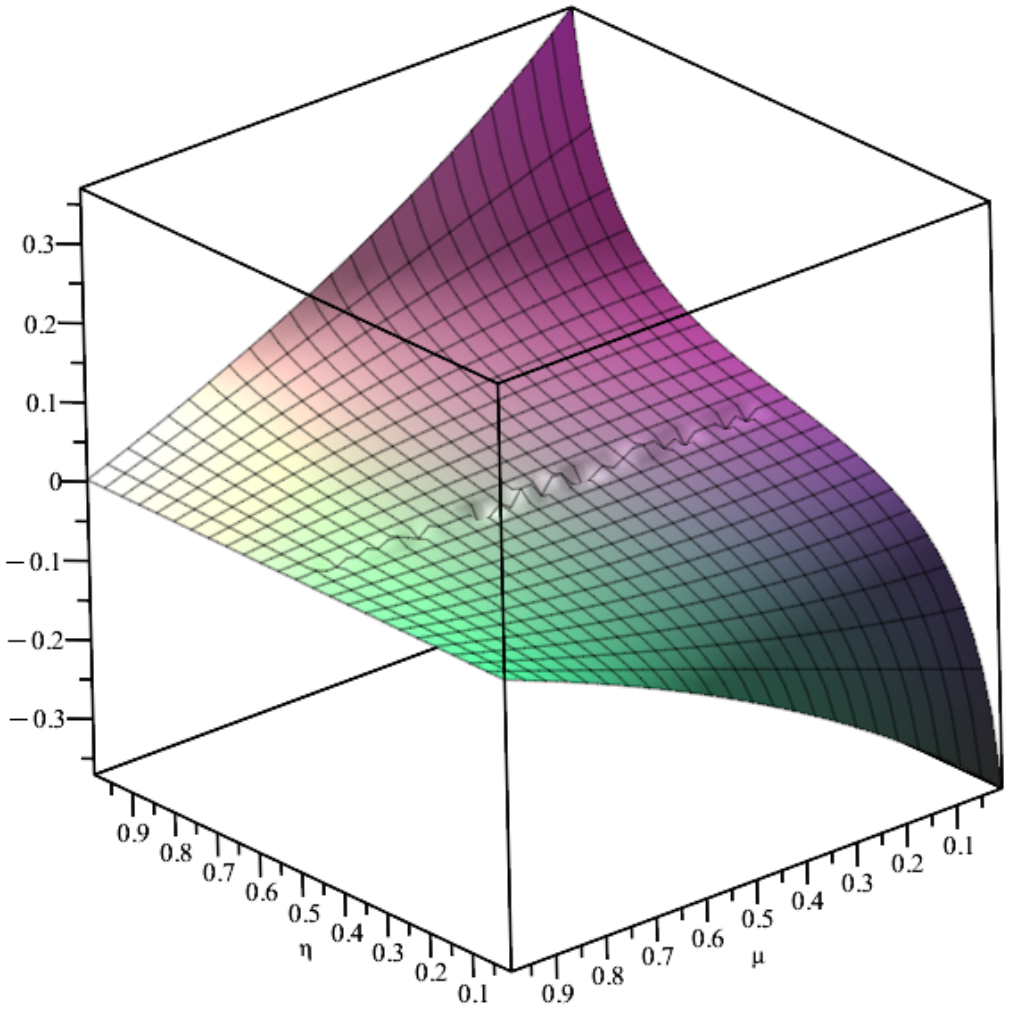
we obtain an expression for optimal output depending only on $\beta_F(s)$ and exogenous parameters.

The optimal revenue share of the firm becomes:

$$\beta^*_{F,\mu} = \frac{\eta(1-\mu)[1-\alpha(1-\eta)(1-\mu)] - \sqrt{\eta(1-\eta)(1-\mu)^2[1-\alpha\eta(1-\mu)][1-\alpha(1-\eta)(1-\mu)]}}{(2\eta-1)(1-\mu)}.$$

To examine how increased ownership s after liberalizing ownership restrictions affects firm output, we exploit the monotonicity of $\beta_F(s)$ in s and conduct the same comparative statics as in our baseline model. Specifically, we compute $\partial x^*_\mu/(\partial\beta_F(s))$ and examine how this derivative, evaluated at $\beta^*_{F,\mu}$, depends on η and μ. The analysis confirms that the output effects of reoptimized ownership are positive for any $\eta > \hat{\eta} = 0.5$, as in the baseline model. Furthermore, we find that conditional on being positive ($\eta > 0.5$), the effects are stronger for a lower contractibility μ. Figure D.1 illustrates these results for the case of $A = c_h = c_m = 1$ and $\alpha = 0.5$. Further simulations demonstrate that our conclusions hold independent of these parameter values.

Figure D.1: Predicted effect of increased ownership on output $\partial x^*_\mu/(\partial \beta_F)$ depending on η and μ



The figure shows the partial derivative $\partial x^*_\mu/(\partial \beta_F)$ evaluated at $A = c_h = c_m = 1$, $\alpha = 0.5$, and the full range of admissible values of $\eta \in (0, 1)$ and $\mu \in (0, 1)$. At $\eta = 0.5$, the simulations are non-smooth since $\beta^*_{F,\mu}$ is not defined. $\partial x^*_\mu/(\partial \beta_F)$ is positive and increasing in μ for any $\eta > 0.5$.