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1 Real Options Framework

This section presents the option-exercise structure behind the four hypotheses and the unsigned stayer implication, and determines the sign of the comparative statics that generate the two selection hypotheses, H1a and H2a. We build on the standard entry-exit-under-uncertainty results of Dixit (1989) and Dixit and Pindyck (1994). Our own contribution is the mapping from firm resources to these parameters and the treatment of financing capacity as a constraint on exercising the entry option (Boyle and Guthrie, 2003). We therefore state the results and derive only the comparative statics specific to our mapping. As in the text, the two populations are treated separately: prior suppliers choose between staying and exiting, and prior non-suppliers between entering and staying out.

Setup. A firm's relationship with the target yields an operating profit flow

$$\pi_t = D_t m(s_t) - c,$$

where $D_t \geq 0$ is target demand, $m(s_t)$ is the per-unit margin permitted under regulatory stringency s_t (with $m'(s_t) < 0$), and c is operating cost. The state variables D_t and s_t are common drivers as they move the value of the relationship for every firm alike. Let V denote the common, state-driven present value of an active supply relationship with the target, not including the option value of exit or entry. For potential entrants, let v_i denote the largely unobserved firm-specific component of the value of entering, so the value of entry is $V + v_i$. Firms differ in two observed resources: (1) outside options o , which set the salvage value $R(o)$ of redeployed capacity ($R' > 0$), and (2) financial flexibility f , the capacity to fund an irreversible commitment and bear its downside. Relationship-specific (switching) costs are κ . The state variables evolve stochastically with volatility σ , and the two-sided movement of s_t is what gives the options value. We attach the firm-specific term v_i to the entry value alone because that is where it does work. On the exit margin, both the sorting and the post-exit outcome are anchored by the salvage value $R(o)$, so a firm-specific continuation term would not change H1a or H1b. A new entrant, by contrast, has no redeployment anchor, and its outcome turns on the realized value of the new relationship.

Option-exercise rules. The trigger structure below is a standard result from the entry-exit-under-uncertainty literature, which we take as given (Dixit, 1989; McDonald and Siegel, 1986; Dixit and Pindyck, 1994). Under irreversibility and two-sided uncertainty, exercise is governed by triggers separated from break-even by an option premium $\Omega(\sigma) > 0$ that increases in σ :

- Exit (prior supplier): $V \leq R(o) - \Omega_X(\sigma)$;
- Stay (prior supplier): $V > R(o) - \Omega_X(\sigma)$;
- Enter (non-supplier): $V + v_i \geq K + \Omega_E(\sigma)$ and $f \geq \tilde{f}(K)$;
- Stay out (non-supplier): otherwise,

where K is the sunk cost of entry. The stay region for a prior supplier is the band of inaction above the exit trigger, whose width increases in κ and σ (Dixit, 1989, on hysteresis). The premia Ω_X and Ω_E place the triggers a margin away from break-even; this is the formal counterpart of the option raising the bar that a move must clear.

Response choice or selection hypotheses (comparative statics)

1. Exit sorts on outside options (H1a). The exit trigger $R(o) - \Omega_X$ rises with o . Holding the state fixed, $\partial \Pr(\text{exit})/\partial o > 0$. A prior supplier with larger o crosses the exit trigger at a less adverse state and is more likely to exit than to stay. Financial flexibility does not enter $R(o)$ and so does not move the exit margin.
2. Entry sorts on financial flexibility (H2a). Entry requires both $V + v_i \geq K + \Omega_E$ and the funding constraint $f \geq \tilde{f}(K)$. Because V is driven by common states and v_i is largely unobserved, the observable firm-level margin among outsiders is the funding constraint: $\partial \Pr(\text{enter})/\partial f > 0$. Empirically, we proxy f inversely with the debt ratio. Outside options govern $R(o)$, which is irrelevant to a firm building a new relationship, and so do not move the entry margin; level attributes (below) do not relax the funding constraint and so do not move it either.

Outcome hypotheses and the stayer implication (selection and state-dependence)

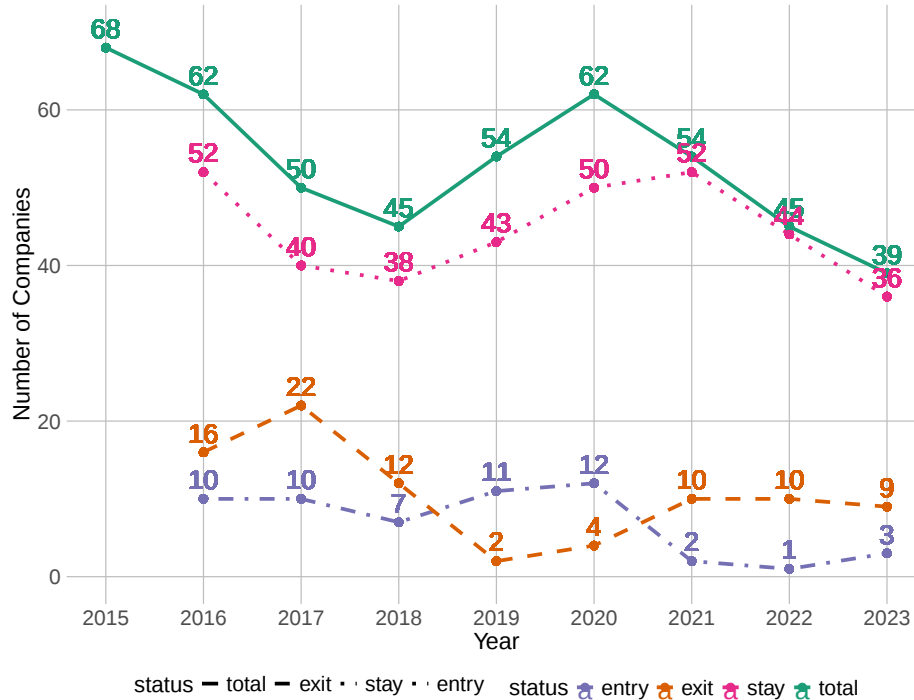
1. Exiters should not systematically underperform peer firms in profitability (H1b). A prior supplier exits only when $R(o) \geq V + \Omega_X$, so redeployment beats continuation by at least the option premium. This alone does not imply that exiters outperform their peers. But exit is sorted on outside options (H1a), so observed exiters are drawn from firms with high $R(o)$, whose post-exit performance should reflect successful redeployment rather than loss. The rare low- $R(o)$ exiter, pushed out only by a severe fall in V , is the exception.
2. Stayers mothball; their activity is state-dependent, their peer-relative profitability unsigned (the stayer implication). Firms with small o have a low exit trigger and lie inside the band of inaction or hysteresis, so they hold rather than exit. Their target-related activity is driven by the state variables. It rises and falls with target demand D_t and the permitted margin $m(s_t)$. Its realized value is bounded below by $R(o) - \Omega_X$ in absolute terms, since a firm facing worse would have exited. But $R(o)$ for a low- o firm need not exceed the peer return, so the peer-relative profitability comparison is indeterminate and left unsigned.
3. Entrants outperform peer firms in profitability (H2b). Among firms that can fund entry, entry is taken only when the firm-specific expected value of entering is sufficiently high. The outperformance comes from selection on v_i , not from financial flexibility itself. A marginal entrant earns only a normal return; the gain belongs to the intramarginal entrants whose expected surplus is high.

Resources that do not sort (null effect on choices). Let an observed attribute such as research intensity or brand raise the flow uniformly, $\pi_t \rightarrow \pi_t + a$ with a common across states. Then V , $R(o)$, and the stay-out value each rise by the same discounted amount, leaving the trigger differences in the exercise rules unchanged. Such an attribute moves both sides of each comparison together and so cancels from it. Hence, it predicts neither exit nor entry. It shifts the level of performance and is carried as a control in the outcome equation. This is why measured productivity-like resources are predicted to be null in the choice models. Insofar as they raise the value of all options together, they do not change which option a firm selects. This does not rule out selection into entry on v_i , the largely unobserved firm-specific value of entering, which affects the expected surplus from the entry option specifically and therefore can generate entrant outperformance.

2 Background: US Sanction Measures on Huawei and Responses of American Suppliers

American Supplier Responses. For each year, we classified each American firm’s status (exit, stay, or new entry) relative to its previous year’s status in Huawei’s supply chain. We computed the annual total number of American suppliers as the prior-year total minus current-year exits plus new entrants. Figure 1 presents these four series. The total number of US suppliers was 68 in 2015, dropped to 45 in 2018, rose to 62 in 2020, and fell to 39 in 2023. Turnover among American suppliers is high. There were many exits and entrants both before and after sanctions, with more new entrants in 2019–2020, but more exits than entrants in other years. Each year, the firms that remained outnumbered both exits and entrants.

Figure 1: US Suppliers to Huawei: Total, Exit, Stay, and Entry Over Time (All Industries)



Note: Exit, stay, and entry are missing for 2015 because tracking begins in 2015, and 2014 values are unavailable.

Response Groups. Because the export-side restrictions directly relevant to suppliers took effect in 2020, our empirical analysis focuses on firm responses during the 2020–2023 period and includes three relevant groups: (1) Stayer-post-2020, firms that supplied Huawei before 2018 (before the imposition of any sanction measures) and continued to supply throughout the four years from 2020; (2) Exiter-post-2020, firms that supplied before 2018 but stayed for only part of the post-2020 window;¹ (3) Entrant-post-2020, firms with no prior supply relationship with Huawei that began supplying for the first time during 2020–2023.² Figures 2, 3, and 4 illustrate each firm’s supply chain timeline, respectively.

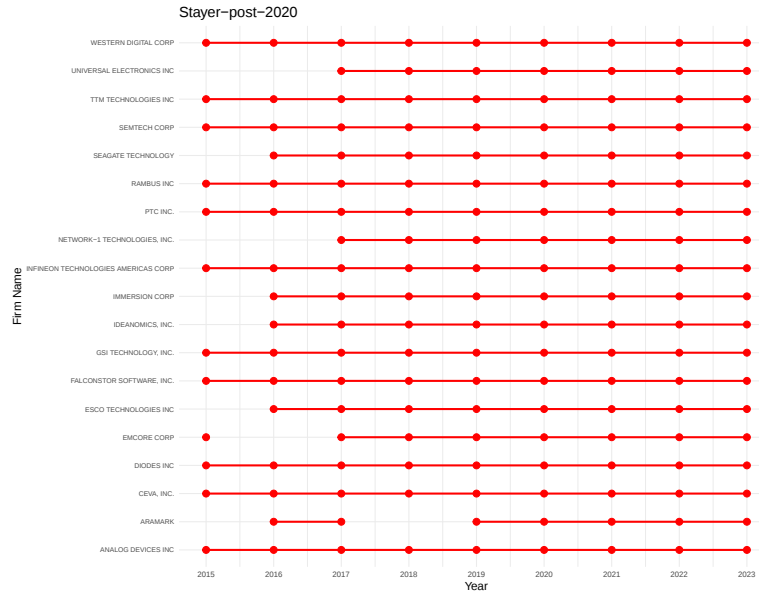
¹Firms that exited prior to 2018 or during 2018–2019 are excluded from this response group.

²The annual entry counts in Figure 1 are gross, counting any firm that supplies in a given year but not the prior year, so they include re-entries by former suppliers (e.g., Harmonic, 2022; Silicon Laboratories and Knowles, 2023; Cirrus Logic, 2023). In empirical analysis, we distinguish first-time entry from re-entry, and Entrant-post-2020 includes only first-time entrants.

Table 1: Timeline of US Sanctions against Huawei

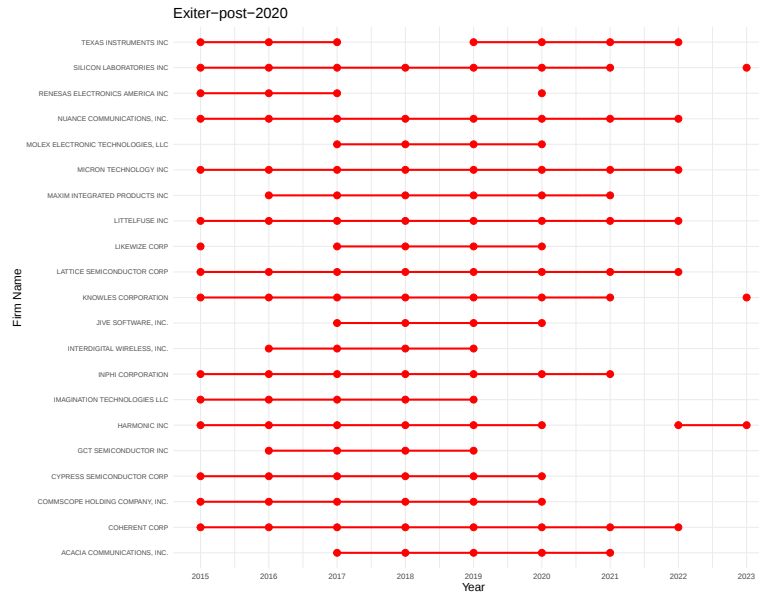
Date	Document	Agency	Actions	Reason	Note
12/12/2017	Legislation: National Defense Authorization Act for Fiscal Year 2018 (NDAA 2018, Public Law 115-91), Section 1656	115th US Congress	prohibiting the Department of Defense (DOD) from using or procuring telecommunications equipment provided by Huawei (or its subsidiaries or affiliates)	risks to DOD's missions related to nuclear deterrence and homeland defense	Effective date: one year after the date of the enactment of the Act
08/13/2018	Legislation: John S. McCain National Defense Authorization Act for Fiscal Year 2019 (NDAA 2019, Public Law 115-232), Section 889	115th US Congress	prohibiting the federal government from using or procuring telecommunications equipment provided by Huawei (or its subsidiaries or affiliates)	national security risks to US communications networks	Effective date: one year after the date of the enactment of the Act. Used to justify restrictions imposed by the FCC (85FR 230) and the DOD, GSA, and NASA (85 FR 42665)
05/16/2019	Final rule: Addition of Entities to the Entity List (84 FR 22961, Doc: 2019-10616) under Export Administration Regulations (EAR)	Bureau of Industry and Security (BIS), Department of Commerce	imposing a licensing requirement on the export, reexport, or transfer of US goods, software, and technology to Huawei and 68 of its non-US affiliates	involved in activities contrary to US national security or foreign policy interests	Nine follow-up final rules by BIS: (1) 5/20/2019-8/19/2019: adding a temporary general license allowing certain transactions with Huawei and its 68 non-US affiliates (84 FR 23468); (2) 8/19/2019: adding 46 additional non-US affiliates of Huawei to the Entity List (84 FR 43493; 84 FR 43487); (3) 8/19/2019-11/18/2019: extending temporary general license to Huawei and its 68 non-US affiliates plus 46 additional non-US affiliates (84 FR 43487); (4) 11/18/2019-2/16/2020: extending temporary general license to Huawei and its 114 non-US affiliates (84 FR 64018) (5) 2/13/2020-4/1/2020: extending temporary general license to Huawei and its 114 non-US affiliates (85 FR 8722) (6) 3/10/2020-5/15/2020: extending temporary general license to Huawei and its 114 non-US affiliates (85 FR 14416) (7) 5/15/2020-8/13/2020: extending temporary general license to Huawei and its 114 non-US affiliates (85 FR 29610) (8) 5/15/2020: interim final rule (foreign-produced direct product rule) (85 FR 29849) (9) 8/17/2020: adding 38 additional non-US affiliates of Huawei to the Entity List; replacing the temporary general license for Huawei and its non-US affiliates with a more limited permanent authorization; imposing a license requirement on foreign-produced items using controlled US technology and software (85 FR 51596)
11/12/2020	Executive Order (13959, 85 FR 73185): Addressing the Threat From Securities Investments That Finance Communist Chinese Military Companies	President Donald Trump	prohibiting US investors from purchasing or investing in securities of companies labeled as "Communist Chinese military companies," including Huawei.	mitigating the threat to the national security, foreign policy, and economy of the US	Effective date: 1/11/2021 (investment); 11/11/2021 (divestment). Follow-up Executive Orders: (1) 1/13/2021 (13974 by Trump, 86 FR 4875): amending EO 13959 with reinforced restrictions; (2) 6/3/2021 (14032 by Biden, 86 FR 30145): superseding EO 13959 with broadened restrictions

Figure 2: Firm Group: Stayer-post-2020



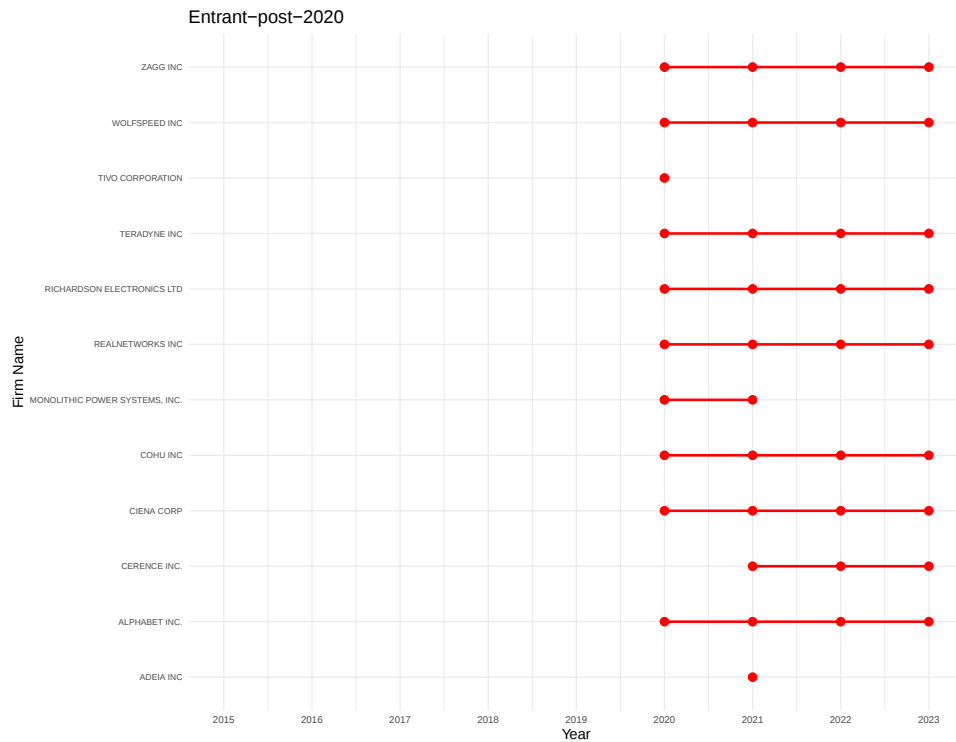
Note: This figure shows the supply chain histories of US suppliers that supplied Huawei between 2015 and 2017 and continue supplying for all years after 2020. The figure reflects the full set of firms in this group. The estimation sample is smaller due to data availability.

Figure 3: Firm Group: Exiter-post-2020



Note: This figure shows the supply chain histories of US suppliers that supplied Huawei between 2015 and 2017 but did not continue supplying for all years after 2020. These firms are classified as Exiter-post-2020. The figure reflects the full set of firms in this group. The estimation sample is smaller due to data availability.

Figure 4: Firm Group: Entrant-post-2020



Note: This figure shows the supply chain histories of US suppliers that began supplying Huawei in 2020 or later. The figure reflects the full set of firms in this group. The estimation sample is smaller due to data availability.

3 Export-side Measures

Export-side Measures. The direct constraint on American suppliers began on May 16, 2019, when BIS added Huawei and 68 of its non-US affiliates to the Entity List under the Export Administration Regulations (EAR),³ for activities contrary to US national security or foreign policy interests. The listing imposed a licensing requirement on American suppliers regarding their export, reexport, or transfer of US goods, software, and technology to Huawei and its listed affiliates, under a license review policy that BIS describes as ‘most commonly’ a presumption of denial.⁴

On its face, the listing imposed a direct constraint on Huawei’s American suppliers. However, the May 16, 2019 rule was followed by nine subsequent rules that alternately loosened or tightened it. On the one

³The EAR, which temporarily operated under the International Emergency Economic Powers Act (IEEPA) during 2001-2018, derived its permanent statutory authority from the ECRA. The Export Control Reform Act of 2018 (ECRA) modernized and codified the legal authority for US export controls. The ECRA itself did not impose Huawei-specific restrictions but established the statutory basis on which the BIS later imposed export-side measures.

⁴See (1) 15 C.F.R. pt. 744, supp. no. 4 (Entity List), specifying, for many listed entities, a license review policy of “presumption of denial” for items subject to the EAR; (2) BIS, Entity List FAQs, noting that the license review policy is “most commonly” a presumption of denial, available at <https://www.bis.gov/media/documents/entity-list-faqs.pdf>; (3) H. Comm. on Foreign Affairs, 90-Day Review Report on the Bureau of Industry and Security (Dec. 7, 2023), recommending that “presumption of denial” mean a license “will be denied in essentially every instance” <https://foreignaffairs.house.gov/news/press-releases/mccaul-releases-90-day-review-report-commerce-department-s-bis>.

hand, between May 20, 2019 and May 15, 2020, BIS repeatedly issued or extended six temporary general licenses (TGLs), which authorized otherwise restricted transactions with Huawei and its listed non-US affiliates for limited periods, each typically lasting two to three months. On the other hand, BIS expanded Huawei’s affiliate list from 68 to 114 on August 19, 2019, and then to 152 on August 17, 2020. On that later date, the temporary general license lapsed and was replaced by a narrower permanent authorization, and the foreign direct product rule took effect, requiring a license for foreign-produced items made with controlled US technology and software.

The substantial leeway of 2019–2020 thus gave way in 2020 to an operationally binding regime, after broad TGL coverage lapsed. We therefore treat 2020 as the onset of treatment. This timing choice relies on observable features of the regulatory environment including the broad TGL regime and its lapse. We do not observe firm-level license applications or approvals. Our data record whether a firm appears in Huawei’s supply chain in a given year, not whether that relationship operated under a specific license, a temporary general license, or another authorization. We therefore treat licensing as part of the regulatory environment that kept supply possible under the restrictions, not as a firm-level mechanism we can directly measure.

These export-side rules are also notable for how they were issued. The Entity List designation of Huawei, and the revisions that followed it, were promulgated under a statutory exemption that narrowed the procedural channels through which firms could shape the rule. Section 1762 of the Export Control Reform Act exempts Entity List actions from the core requirements of the Administrative Procedure Act, including prior notice of proposed rulemaking, the opportunity for public participation, and any delay in the effective date.⁵ Because the Entity List actions bypassed notice-and-comment, affected suppliers had no formal procedural channel through which to contest or reshape the designation itself. Other political channels remained open in principle, but they shaped the broader policy environment rather than the Entity List licensing decisions that directly bound suppliers. We return to the consequences of this procedural insulation for supplier lobbying when we analyze firms’ response choices below.

4 Descriptive Statistics, Diagnostics, and Robustness Checks

Table 2: Summary Statistics (Exit vs. Stay Probit Sample)

Variable	Observations	Mean	Std. Dev.	Min	Max
Exiters (1 = exiter, 0 = stayer)	30	0.467	0.507	0.000	1.000
Log(Number of Customers in Huawei’s Industry)	30	1.308	0.954	0.000	3.258
R&D Spending / Sales	30	0.161	0.132	0.000	0.452
Advertisement Spending / Sales	30	0.002	0.004	0.000	0.014
Debt Ratio	30	0.437	0.188	0.081	0.805
Log(Lobbying Expenditures)	30	4.271	6.279	0.000	16.111

Note: Summary statistics for the estimation sample of the full Exit vs. Stay probit model (Model 6 of Table 2 in the main text). The sample includes only stayers and exiter firms.

⁵The relevant Federal Register notices for Huawei-related Entity List actions state: “Pursuant to section 1762 of ECRA, this action is exempt from the Administrative Procedure Act (5 U.S.C. 553) requirements for notice of proposed rulemaking, opportunity for public participation, and delay in effective date.” Because the exemption removes the notice-and-comment requirement, BIS also determined that no Regulatory Flexibility Act analysis was required: “Because a notice of proposed rulemaking and an opportunity for public comment are not required to be given for this rule by 5 U.S.C. 553, or by any other law, the analytical requirements of the Regulatory Flexibility Act, 5 U.S.C. 601, et seq., are not applicable. Accordingly, no regulatory flexibility analysis is required, and none has been prepared.” See 84 Fed. Reg. 22961 (May 21, 2019), Docket No. 2019-10616. Substantially similar language appears in the subsequent Entity List modifications and TGL extensions.

Table 3: Summary Statistics (Entry vs. Peer Probit Sample)

Variable	Observations	Mean	Std. Dev.	Min	Max
Entrant (1 = entrant, 0 = peer)	223	0.045	0.207	0.000	1.000
Debt Ratio	223	0.535	0.271	0.065	1.525
Log(Number of Customers in Huawei's Industry)	223	0.862	1.104	0.000	5.004
R&D Spending / Sales	223	0.188	0.761	0.000	10.929
Advertisement Spending / Sales	223	0.039	0.084	0.000	0.632
Log(Lobbying Expenditures)	223	6.097	6.957	0.000	18.366

Note: Summary statistics for the estimation sample of the full Entry vs. Never-Supplier Peers probit model (Model 6 of Table 3 in the main text). The sample consists of entrants and their non-entrant FactSet 2010–2017 industry peers.

Table 4: Summary Statistics (Doubly Robust DiD Estimation Sample)

Variable	Observations	Mean	Std. Dev.	Min	Max
Return on Assets (ROA)	4,116	0.061	0.207	-2.535	0.908
Log(Operating Revenue)	4,194	6.914	2.296	0.000	13.319
Log(Operating Expenses)	4,194	6.822	2.079	0.955	13.263
Log(Number of Customers in Huawei's Industry)	4,116	0.814	1.026	0.000	4.997
R&D Spending / Sales	4,116	0.908	11.126	0.000	268.393
Advertisement Spending / Sales	4,116	0.019	0.054	0.000	0.625
Log(Total Assets)	4,116	7.138	2.216	0.589	13.382
Debt Ratio	4,116	0.510	0.265	0.017	2.686
Log(Lobbying Expenditures)	4,116	3.580	5.920	0.000	17.053

Note: Summary statistics based on the pooled models in the main text. ROA and the covariates are computed from the pooled ROA model sample (4,116 firm-year observations). Log(Operating Revenue) and Log(Operating Expenses) come from the pooled revenue and expenses model samples (4,194 observations each). Advertising intensity is reported as a raw ratio (advertising expenditures / sales).

Table 5: Peer Group Robustness of ROA Effects: Overall ATT

	Pooled	Stayers	Exiters	Entrants
Panel A. FactSet 2017 peers				
ATT (ROA)	-0.0076 (0.0134)	-0.0207 (0.0204)	-0.0064 (0.0153)	0.0410*** (0.0148)
Observations	3243	3052	3019	2988
Panel B. FactSet 2010-2017 & Orbis peers				
ATT (ROA)	0.0034 (0.0127)	-0.0073 (0.0193)	-0.0057 (0.0153)	0.0499*** (0.0141)
Observations	4467	4276	4247	4212

Notes: Each cell reports the doubly robust DiD estimate for peer-relative ROA. 'FactSet 2017 peers' draws peer firms from FactSet's supply chain competitor groups from 2017. 'FactSet 2010–2017 & Orbis peers' combines FactSet competitor groups from 2010–2017 with Orbis competitor peers in 2017. The treatment year is 2020, except for exiters, where estimates come from a staggered design with treatment timing equal to each firm's year of exit. Standard errors in parentheses. ** $p < 0.05$, *** $p < 0.01$

Table 6: Pre-Trend Tests for Pooled and Separate Doubly-robust DiD Models

	ROA	Revenue	Expenses
Panel A. Pooled Models			
χ^2 statistic	0.5464	3.6938	6.2204
p-value	0.9688	0.4490	0.1833
Panel B. Separate Models			
Stayer-post-2020			
χ^2 statistic	0.5689	5.2725	10.7412
p-value	0.9665	0.2605	0.0296
Exiter-post-2020			
χ^2 statistic	3.1471	2.2273	2.3666
p-value	0.5335	0.6940	0.6687
Entrant-post-2020			
χ^2 statistic	2.1741	4.1967	24.2504
p-value	0.7038	0.3800	0.0001

Notes: This table reports the pre-trend tests after estimating [Callaway and Sant'Anna \(2021\)](#) difference-in-differences models. The null hypothesis is that all pre-treatment dynamic effects equal zero. For the Exiter-post-2020 group, we assess pre-trends using a pooled specification that treats these firms as treated in 2020. Recent work in applied DiD notes that cohort-specific pretrend tests in staggered settings often over-reject and produce unstable results when each treatment cohort size is small and treatment timing is uneven ([Roth, 2022](#)). We thus evaluate pre-trends using a pooled specification for the staggered DiD. In our Exiter-post-2020 group, no firm exits Huawei before 2020, so defining a common pseudo-treatment date in 2020 does not misclassify any actual treatment status in the true pre-treatment period.

Table 7: Pre-treatment Placebo Tests for ROA

	Pooled	Stayer	Entrant	Exiter
S = 1 (onset 2019)	-0.0040 (0.0089)	-0.0040 (0.0193)	-0.0099 (0.0111)	0.0061 (0.0081)
S = 2 (onset 2018)	-0.0037 (0.0176)	-0.0119 (0.0350)	0.0087 (0.0138)	0.0013 (0.0270)
S = 3 (onset 2017)	-0.0004 (0.0146)	-0.0035 (0.0157)	-0.0050 (0.0243)	0.0072 (0.0309)

Notes: Following [Liu, Wang and Xu \(2024\)](#), the placebo test assigns a fake common onset before the true 2020 treatment to test whether the effect is approximately zero. S is the number of pre-treatment years treated as fake post-periods. All specifications use the same 2015-2019 window. S = 1 dates the fake onset at 2019 (placebo period 2019; baseline 2018), S = 2 at 2018 (placebo periods 2018-2019; baseline 2017), and S = 3 at 2017 (placebo periods 2017-2019; baseline 2016). Each cell reports the overall ATT (simple aggregation) over the fake post periods via [Callaway and Sant’Anna \(2021\)](#), using the same covariates as the main specification. Peer firms are the never-treated FactSet 2010-17 peer. A near-zero, insignificant estimate across S = 1, 2, 3 indicates the placebo is robust to the number of placebo periods. Years 2020-2023 are excluded because under an earlier fake onset, they would fall after the true 2020 treatment and contaminate the comparison. The exiter group is estimated with a non-staggered design that assigns the common fake onset for comparability. Re-estimating the exiter group with the staggered design leaves the main-text estimates unchanged, because each cohort’s baseline is its own exit year minus one (2020/2021/2022), and 2019 is a pre-treatment period there. Standard errors in parentheses. ** $p < 0.05$, *** $p < 0.01$.

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