Not in My Backyard

Portfolio Allocation under Water Scarcity*

Thalassa de Waal†

August 14, 2026

Abstract Investors typically overweight domestic equities, reflecting a persistent home bias. This paper studies a setting in which domestic holdings carry more risk than foreign holdings do, giving rise to a not-in-my-backyard effect in portfolio choice that could attenuate or even reverse this home bias. I formalize a model in which investors tilt away from firms that contribute to resource constraints in the economies to which they are most exposed, and I examine this empirically in the context of water: a critical, geographically constrained input whose scarcity varies across firms and locations. Domestic ownership is lower for firms contributing to water scarcity at headquarters, a pattern that does not hold for foreign ownership and is therefore difficult to reconcile with uniform risk pricing. A one-standard-deviation increase in local water scarcity is associated with a 14.5 to 45.4 percent decline in portfolio share relative to the mean domestic position, and the asymmetry is stable over long horizons, inconsistent with a short-lived informational frictions explanation. The results are consistent with portfolio allocations shifting away from firms that contribute most to binding local constraints as resource scarcity intensifies.

Keywords: home bias, portfolio choice, institutional investors, resource constraints, physical risk

JEL classifications: G11, G15, G23, G40, Q25.

*I thank Abe de Jong, Herman de Jong, Amaury de Vicq, Zheng Zhang, and participants at the 2026 Financial Management Association European Conference, and the 2026 International Symposium on Climate, Finance and Sustainability for their helpful comments and suggestions.

†University of Groningen, Groningen, The Netherlands, t.de.waal@rug.nl

1. Introduction

Standard international portfolio theory implies that investors should diversify globally and allocate capital according to firms' exposure to systematic risk factors. Yet investors tend to overweight domestic equities, exhibiting a persistent home bias (French and Poterba, 1991; Karolyi and Stulz, 2003; Lewis, 1999). A large literature explains this as individually rational: informational frictions (Chaieb, Errunza, and Lu, 2024; Van Nieuwerburgh and Veldkamp, 2009), familiarity (Chan, Covrig, and Ng, 2005), and local monitoring advantages (Dasgupta, Huynh, and Xia, 2023) can all reduce the risk investors face in domestic holdings specifically.

This paper considers the opposite possibility: that investors face *increased* risk in domestic holdings. Domestic investors, due to their home bias, typically hold more of their domestic firms than other investors do, leading to holdings concentrated in a shared location. When firms operating in the same location share a common, physically limited resource, one firm's depletion of it can threaten the production capabilities and thus economic performance of every other firm drawing on that resource. With domestic investors holding more of these firms, their portfolios are more exposed to the risk of resource depletion in that location than foreign investors' portfolios are.

This risk exposure gives rise to a not-in-my-backyard incentive, the central subject of this paper: reducing capital to the firm contributing to the local resource depletion can protect the value of an investor's other holdings dependent on that same local resource. Less capital allocated reduces resources withdrawn, and less withdrawal reduces depletion. This yields the paper's central empirical prediction: domestic ownership should be lower in firms that contribute to local resource depletion, an effect that can attenuate or even reverse the home bias as depletion worsens.

I test this not-in-my-backyard effect in the context of water, a production input particularly well suited to this purpose. Water is geographically constrained, imperfectly substitutable, and jointly used across firms within local economies, meaning that intensive use by some firms can weigh on the value of others sharing the same resource. Firms differ substantially in water use, and local water availability varies continuously from abundance to scarcity, generating cross-sectional variation in the degree to which firms contribute to local resource depletion. Water scarcity is also economically consequential: reductions in water availability have been shown to lower output and economic growth (Zaveri, Damania, and Engle, 2023), with projected GDP losses of up to 8 percent in high-income countries and 10 to 15 percent in lower-income countries by 2050 (Global Commission on the Economics of Water, 2024). These constraints are becoming more binding over time, with global water demand projected to exceed supply by 56 percent as early as 2030 (Strong, Kuzma, Vionnet, and Reig, 2020), as population growth raises demand and climate change reduces freshwater supply (Global Commission on the Economics of Water, 2024; Zaveri et al., 2023). These trends have attracted policy attention and calls to reallocate capital away from water-intensive activities (Food and Agricultural Organization of the United Nations, 2022; World Bank Group, 2016), underscoring the relevance of understanding how investors respond to water constraints in practice.

Using a global panel of institutional ownership, firm-level water use data, and NASA satellite-derived local water availability measures, I find strong support for the not-in-my-backyard effect. Domestic ownership is lower for firms that contribute more to local water scarcity, a pattern not present in foreign ownership. At the level of individual investor portfolios, portfolio shares allocated to domestic firms decline with local water availability at a firm's headquarters: a one-standard-deviation change in local water levels is associated with a 14.5 to 45.4 percent change in portfolio share relative to the mean domestic position. Isolating a firm's own contribution to scarcity, rather than its exposure to local conditions alone, provides a more direct test of the mechanism, and produces a comparable decline that holds both cross-sectionally and within investor-firm pairs over time as that firm's own conditions change. The domestic-foreign investor asymmetry is difficult to reconcile with uniform risk pricing, and is instead consistent with differential exposure to local conditions as the relevant mechanism.

The reduction in domestic ownership reflects both a decline in portfolio share and exclusion from the portfolio entirely, consistent with tilting and divesting rather than engagement, two classes of governance mechanisms that can occur alongside each other (McCahery, Sautner, and Starks, 2016). The domestic-foreign difference is itself concentrated among non-US investors specifically. The pattern is stable across every horizon tested, up to fifteen years, and is difficult to reconcile with a transitory shock, which should attenuate at longer horizons, or an informational advantage, which should narrow the domestic-foreign gap as conditions become publicly observable over time.

This paper contributes to the literature on the home bias and its response to risk. A first strand of literature documents that the home bias persists even when domestic firms are exposed to economically relevant risks, including carbon transition risk (Boermans and Galema, 2025; Bolton, Eskildsen, and Kacperczyk, 2024). Where the home bias persists despite transition risk, this may be because transition risk does not fall disproportionately on domestic investors: it is typically borne at the firm level, not at any of the firm's locations in particular. Similarly for the physical risk component: emissions' externalities are global and diffuse, leaving the domestic economy no more exposed than any other. Financing these emissions through overallocation therefore does not expose domestic investors' own other holdings to elevated risk, transition or physical, so the not-in-my-backyard incentive does not arise here. Water is the reverse case: overwithdrawal depletes a physical resource shared only among firms at a single location, so financing a firm's water use through overallocation directly exposes an investor's own other holdings there, precisely the condition that does give rise to the not-in-my-backyard effect.

A second strand of literature identifies conditions under which investors do rebalance away from domestic firms. These conditions are location-specific circumstances: regulatory enforcement actions (Dasgupta et al., 2023), natural disasters (Alok, Kumar, and Wermers, 2020), adverse

ESG events (Gerasimova and Rohrer, 2023), and pollution (Huynh, Li, and Xia, 2025). This rebalancing reflects the salience these circumstances generate among local investors, or, for pollution specifically, an investor's own personal experience with it. Tilting away from water scarcity requires neither salience nor personal experience: it is a financial consideration on the investor's part, not a psychological one. Overallocating to a firm that contributes to local water scarcity threatens the value of an investor's other holdings at that same location, giving rise to the not-in-my-backyard incentive.

Together, these two strands leave a gap this paper fills: how the home bias responds to a risk that is physical rather than transition-based and local rather than global and diffuse, one investors respond to for financial rather than psychological reasons. The investor response this paper studies is forward-looking too, anticipating risk before it materializes, in line with the literature on climate risk more broadly, which studies whether investors price conditions anticipated in the future, including sea-level rise (Bernstein, Gustafson, and Lewis, 2019), drought trends (Hong, Li, and Xu, 2019) and broader climate risk (Painter, 2020). None of the literatures reviewed above studies a physical, local risk arising from the growing scarcity of a resource critical to production, one to which investors respond in anticipation. Section 2 formalizes how such a resource factors into production, how its scarcity can threaten other firms' value, and how this gives rise to a not-in-my-backyard incentive for domestic investors.

The remainder of the paper is organized as follows. Section 2 presents the conceptual framework, section 3 describes the data and variable construction, and section 4 presents the empirical results. Section 5 concludes.

2. Conceptual Framework

Section 1 proposes that domestic investors face a distinct not-in-my-backyard incentive to tilt away from firms that contribute to local water scarcity, since such firms impose costs to which domestic investors are more exposed than foreign investors. This risk is physical rather than transition-based: it arises from the state of a shared local reserve, rather than from regulatory, litigation, or reputational responses borne at the firm level. This section formalizes the argument in three steps: Section 2.1 shows how local water availability enters firm production. Section 2.2 shows how a firm's water use can reduce the value of other firms sharing the same local reserve. Section 2.3 shows how this externality shapes investor portfolio choice. Together these steps yield two predictions that organize the empirical tests in Section 4.

2.1. Water Availability and Firm Production

Consider a set of firms that draw water from shared local reserves. Each firm a_i is associated with one or more locations ℓ, a headquarters location and, where applicable, one or more other locations at which it operates, and at each location ℓ there is a shared freshwater reserve $W_{\ell,t}$ on which every firm present at ℓ draws. Alongside water, firm a_i employs productive capital $K_{a_i,t}$. Production follows a Leontief production function, in which inputs cannot substitute for one another (Leontief, 1941):

$$P_{a_i,t} \;=\; \min(\alpha\, K_{a_i,t},\;\; \beta\, WU_{a_i,t})\,, \tag{1}$$

where $WU_{a_i,t} \geq 0$ is total water use and $1/\beta$ is the water requirement per unit of output.[1] When water is the binding input, production falls below the level installed capital would otherwise permit; when capital binds, additional water access goes unused. Each location's reserve evolves as

$$W_{\ell,t+1} = W_{\ell,t} - \sum_{i:\, \ell \in L(a_i)} WU_{a_i,\ell,t} + R_{\ell,t}, \tag{2}$$

where $R_{\ell,t}$ is natural recharge and the summation adds up the water withdrawn by every firm operating at ℓ, that is, every firm a_i for which ℓ belongs to its location set $L(a_i)$. Because $W_{\ell,t+1}$ is determined by the aggregate withdrawals of every firm at ℓ, each firm's water use reduces the reserve available to every other firm at that location in the following period. This need not reduce every other firm's production immediately: output falls only once water becomes the binding input in Equation (1). But each unit withdrawn lowers the reserve that determines whether and when that threshold is reached, tightening the constraint that other firms sharing the location eventually face. Provencher and Burt (1993) model this same reserve dynamic for firms extracting groundwater from a shared aquifer, using an aggregate stock equation of the same form as Equation (2).

The empirical analysis in Section 3 examines firm-level water use and local water availability separately, since each captures a distinct source of variation, and also constructs a combined water stress measure as their interaction. This is because a firm's contribution to local scarcity depends jointly on how much water it withdraws and on how close the local reserve already is to the point at which it binds production: heavy water use at a location with abundant reserves contributes little to scarcity, while modest use at a location already under stress can contribute substantially.

[1] The Leontief specification is appropriate because the water requirement per unit of output is set by the physical production process rather than by relative input prices: processes such as irrigated agriculture, semiconductor fabrication, textile dyeing, and brewing exhibit near-fixed water-to-output ratios that cannot be reduced in the short run by substituting other inputs. Labor is omitted for parsimony and would not affect any result, since the mechanism operates through the capital-to-water-use channel. The model also abstracts from firms' ability to invest in water efficiency over time; because such investment would attenuate water use independently of the mechanism studied here, the empirical estimates should be read as a lower bound on its strength.

2.2. The Externality on Other Firms' Value

Water can thus act as a binding constraint on a firm's production. What matters for firm value, and in turn for investor portfolio choice, is the cost of that constraint. Let $\text{Cost}_{a_i}(W_{\ell,t+1})$ denote the present value of the reduction in firm a_i's future cash flows attributable to the water reserve at location ℓ. Whether a binding constraint operates by reducing output directly or by raising the cost of securing water is immaterial to the mechanism: either channel lowers future cash flows and, through discounting, the present value of the firm. $\text{Cost}_{a_i}(W_{\ell,t+1})$ is accordingly strictly decreasing in $W_{\ell,t+1}$ when water binds firm a_i's production, and flat otherwise: a firm whose water access already exceeds what its installed capital could use bears no cost from a marginal reduction in the reserve. Foregone production is not merely a modeling abstraction: reductions in water availability have been shown to lower economic output and growth (Zaveri et al., 2023), with the Global Commission on the Economics of Water (Global Commission on the Economics of Water, 2024) projecting substantial GDP losses under continued water stress. $\text{Cost}_{a_i}(\cdot)$ is intended to capture exactly this real economic channel at the firm level.

A firm's water use imposes two kinds of cost on the commons it shares. The *direct* cost falls on the firm itself: by withdrawing from the shared reserve, a firm lowers its own future water availability and the cash flows this generates. The *indirect* cost falls on every other firm operating at the same location, whose future production is constrained by the same reduction in $W_{\ell,t+1}$. Formally, the total cost of a_1's water use at location ℓ is

$$\text{TotalCost}_{a_1,\ell}(WU_{a_1,\ell,t}) = \underbrace{\text{Cost}_{a_1}(W_{\ell,t+1})}_{\text{direct}} + \underbrace{\sum_{j \in N_\ell \setminus \{1\}} \text{Cost}_{a_j}(W_{\ell,t+1})}_{\text{indirect}}, \tag{3}$$

where N_ℓ denotes the set of firms operating at ℓ, and $N_\ell \setminus \{1\}$ every firm at ℓ other than a_1 itself. Firm a_1's profit-maximizing choice of water use accounts for the direct cost, since that cost is borne by a_1 itself, but not for the indirect cost, since the reduced cash flows of other firms do not enter a_1's objective function. As a result, the marginal social cost of a_1's water use strictly exceeds the marginal private cost it internalizes whenever at least one other firm sharing a location with a_1 is itself water-constrained (Lemma 1 in Appendix A). Provencher and Burt (1993) derive this same divergence between private and social marginal cost for firms extracting groundwater from a shared aquifer. This gap means firm a_1 withdraws more than is collectively efficient, the standard commons inefficiency (Gordon, 1954; Hardin, 1968), with the resulting distortion growing in the number of firms sharing the commons. Appendix B documents a direct illustration: Taiwan's 2021 drought forced government water rationing that threatened production at TSMC, whose chip fabrication is highly water-intensive, alongside every other firm drawing on the same reserve.

2.3. Investor Portfolio Choice

Investor I holds a portfolio that may include not only firm a_1 but also other firms operating at the same locations as a_1. Heavier withdrawal by a_1 tightens the reserve, raising the likelihood that water becomes the binding constraint for other firms sharing that reserve. Future cash flows, and hence value, then decline for any firm at that location for which water is, or becomes, the binding constraint. This includes any firm at that location in which I holds a position. Investor I therefore faces a tradeoff in choosing how much capital Inv_{a_1} to allocate to a_1: reducing Inv_{a_1} lowers a_1's capital stock and, through Equation (1), its production and water use, easing the constraint a_1 imposes on the reserves at each of its locations and protecting the value of I's other holdings there. This protection is not free: capital withdrawn from a_1 forgoes whatever expected return a_1 would otherwise have offered, an opportunity cost $c(\Delta Inv_{a_1}) > 0$ that increases in the size of the reduction. Investor I reduces Inv_{a_1} only when the value protected elsewhere in the portfolio exceeds this forgone return.

Investor I's net payoff from a marginal reduction in Inv_{a_1} is

$$\Delta\Pi_I \;=\; -\,c(\Delta Inv_{a_1}) \;+\; \sum_{\ell \in L(a_1)} \theta_I^{\ell} \cdot \Delta\,\mathrm{TotalCost}_{a_1,\ell}, \tag{4}$$

where $\mathrm{TotalCost}_{a_1,\ell}$ is the aggregate loss in value, and hence in investor returns, that a_1's water use imposes on firms operating at location ℓ (Equation (3), Appendix A). $\Delta\,\mathrm{TotalCost}_{a_1,\ell} > 0$ is the reduction in this loss achieved by reducing Inv_{a_1}. $\theta_I^{\ell} \geq 0$ captures the extent to which I's portfolio is financially exposed to economic conditions at ℓ. Because investors are known to overweight their home markets (French and Poterba, 1991; Lewis, 1999), their holdings, and hence their exposure to conditions in any given location, are concentrated at home. θ_I^{ℓ} is therefore largest when ℓ is I's home market, and lower elsewhere.

Investor I reduces Inv_{a_1} whenever

$$c(\Delta Inv_{a_1}) \;<\; \sum_{\ell \in L(a_1)} \theta_I^{\ell} \cdot \mathrm{TotalCost}_{a_1,\ell}(WU_{a_1,t}). \tag{5}$$

Equation (5) is the central object of the model: an investor is more likely to tilt away from a_1 the higher its exposure θ_I^{ℓ} to the locations where a_1 operates, and the larger the cost a_1's water use imposes there. This delivers the paper's central predictions, formalized as Proposition 1 in Appendix A:

Prediction 1 (Domestic tilt). For a firm a_1 contributing to water scarcity at its headquarters, domestic investors, whose exposure θ_I^{ℓ} to the headquarters location is higher per the home bias evidence above, are more likely to satisfy Equation (5) than foreign investors, and therefore tilt away from a_1 to a greater degree, all else equal.

Prediction 2 (No symmetric foreign tilt). For foreign investors, whose home market is by definition never a_1's headquarters, exposure θ_I^ℓ to the headquarters location is correspondingly low, so the decision rule in Equation (5) is less likely to be satisfied there than for domestic investors. Foreign holdings should therefore show little association with scarcity at headquarters, in contrast to domestic holdings.

This structural feature, headquarters location is always home to domestic investors and never home to foreign investors, offers a clean setting in which to separate exposure-driven tilting from uniform risk pricing, which would instead predict a symmetric response across both investor groups.

The model treats θ_I^ℓ as a reduced-form measure of financial exposure to location ℓ, without defining its precise source: portfolio overlap through other holdings is the most direct channel, but correlated exposure through non-portfolio wealth, such as local business interests, real estate, or other undiversifiable claims on the local economy, would enter Equation (4) in the same way and generate the same predictions. What the model requires is only that an investor's home market is informative about θ_I^ℓ on average, consistent with the home bias evidence already discussed.

3. Data

Quarterly institutional ownership data are obtained from FactSet Ownership, and define the universe of holdings studied in this paper. I construct a measure of each firm's contribution to local water scarcity, drawing on firm water use, firm locations, and local water availability. Annual corporate water use data are obtained from S&P Global Trucost Environmental. Firm headquarters and asset locations are obtained from S&P Global Trucost Physical Risk; asset locations represent physical facilities and serve as a proxy for production locations. Local water conditions are obtained from satellite data from NASA's GRACE missions and matched to firm locations. Stock price and accounting data are obtained from CRSP and Compustat. The sample begins in 2012, the first year for which local water availability data are available, and ends at year-end 2024, the most recent quarter of institutional ownership data available.

3.1. Institutional ownership

FactSet Ownership reports holdings of institutional investors with discretion over their assets, including banks, investment advisors, hedge funds, mutual funds, pension funds, and insurance companies. Holdings are collected from regulatory filings, including 13F filings in the United States and comparable disclosure regimes elsewhere, as well as annual reports, stock exchange announcements, and other corporate and industry disclosures.

The analysis draws on two related samples, one for each level of the empirical strategy. The firm-level sample measures aggregate institutional ownership at the firm level, using the metrics of Ferreira and Matos (2008), and comprises 6,553 unique non-financial firms across 42 countries and regions. The institution-level sample instead measures the holdings of individual institutions, revealing exact investor-firm linkages, and comprises 29.8 million holdings of 3,458 unique firms, held across 277,421 portfolios of 10,909 unique institutions. The smaller firm count in the institution-level sample reflects the additional data cleaning, following Ferreira and Matos (2008), required to construct individual portfolio holdings, beyond what the firm-level sample's aggregate ownership measure requires. Section 4 shows the paper's main results are robust within the subset of firms common to both samples.

3.1.1. Firm-Level Institutional Ownership

The firm-level sample reports quarterly equity holdings for publicly listed firms headquartered in developed and emerging markets included in the MSCI ACWI, as well as Luxembourg. *Institutional ownership* is defined as the share of a firm's market capitalization held by institutional investors; *domestic institutional ownership* denotes the share held by investors domiciled in the country of listing, while *foreign institutional ownership* refers to the share held by investors domiciled elsewhere.

The sample spans 42 countries and regions, with the largest shares listed in the United States and Japan; Appendix Table C.1 reports the full country distribution for both the firm-level and institution-level samples. Institutional ownership varies substantially across countries, as shown in Figure C.1. Domestic investors hold a dominant share of equity in the United States, Great Britain, Sweden, Poland, and India; in the remaining countries, foreign ownership predominates, with foreign investors accounting for nearly all holdings in Ireland. Because investor composition varies by country, I include country fixed effects to isolate the differential responses of domestic and foreign investors from country-level characteristics.

3.1.2. Institution-Level Portfolio Holdings

The sample of institutional equity holdings is constructed from FactSet's Ownership database, which covers three underlying categories: 13F filings, mutual fund holdings, and stakes-based data. The stakes-based data is compiled from annual reports and transaction announcements across countries, supplemented by 10-K, 13D, and 13G filings for U.S. securities; SEDAR filings for Canadian securities; and RNS announcements and share registers for UK securities. Combining these sources yields broader coverage of institutional ownership than any single source provides alone, particularly outside the United States. For holdings reported in multiple sources, I follow Ferreira and Matos (2008): for U.S. securities, the 13F report is used; for non-U.S. securities, the larger of the 13F and mutual fund positions is used. Stakes-based data is used only for holdings not captured by either the 13F or mutual fund sources.

The sample period runs from 2012 through 2024, consistent with the firm-level sample described above. Holdings are restricted to equity, preferred equity, and American Depositary Receipts with available price and market capitalization data, and are aggregated to the quarterly management-entity level.[2] Gaps in quarterly coverage of up to seven quarters are filled by rolling forward an institution's most recently observed portfolio. Following Bolton et al. (2024), I further exclude portfolios with fewer than ten holdings, with exclusively domestic or exclusively foreign holdings (classified relative to the institution's home country), or with more than 50% of assets under management concentrated in a single security, since such portfolios are unlikely to reflect diversified institutional investment behavior. The resulting sample, prior to matching with water and control variable data, consists of 64.4 million holdings of 28,113 unique firms across 284,313 portfolios, held by 10,994 unique institutions.

These holdings are matched to institution type and country classifications provided by FactSet. Internet Appendix Table IA.1 lists the full range of institution types and their mapping to the broader investor categories (broker, private banking, hedge fund, investment advisor, long-term investor, government, and other) used throughout the paper, and Internet Appendix Table IA.3 lists the corresponding country and region classifications. Internet Appendix Table IA.2 reports the distribution of institution types in the final matched sample, and Internet Appendix Table IA.4 reports the distribution across countries both before and after merging with water and control variable data

From this 64.4-million-holding sample, I construct three variables capturing the intensive margin of institutional ownership. For each institution-quarter, I compute the share of portfolio assets under management allocated to each firm held, summing to 100% across the institution's holdings. I refer to this measure as *portfolio share*, and take its natural logarithm to reduce the influence of skewness in portfolio weights. I decompose this measure into *dom. portfolio share* and *for. portfolio share*, the shares allocated to domestic and foreign holdings respectively (log-transformed in the same way), where domestic/foreign status is defined relative to the institution's home country as described above. These three variables serve as the main dependent variables in the intensive-margin analysis.

To capture the extensive margin, I follow the approach of Koijen and Yogo (2019), as implemented in Bolton et al. (2024), and define, for each institution, an investment universe consisting of all stocks held at any point over the preceding twelve quarters. Within this universe, *own* is an indicator variable equal to 1 if the institution holds the stock in the current quarter, and 0 if the stock is included in the institution's investment universe but is no longer held. This variable

[2] Aggregation is performed at the management-entity level rather than the ultimate-parent level, since the manager is the relevant decision-maker for portfolio allocation.

serves as the main dependent variable in the extensive-margin analysis. Because this construction requires twelve quarters of trailing data, the sample used for extensive-margin analysis begins in 2015.

Matching to firm-level water use, water availability, and control variable data, described in the next sections, restricts the full sample described above. The final institution-level sample consists of 29.8 million holdings of 3,458 unique firms across 277,421 portfolios, held by 10,909 unique institutions.

3.2. Firm-level water use

I obtain annual firm-level water use data from S&P Global Trucost Environmental. *Direct water use* captures water consumed in the firm's own operations. *Total water use* includes direct consumption and upstream supply chain consumption. *Indirect water use* is computed as the difference between total and direct use to isolate supply chain water consumption. For the average firm, indirect water use accounts for 88.9 percent of total water use. All three measures are reported in cubic meters and log-transformed for analysis. To account for the lag between fiscal quarter-end and publication of annual reports, all water use variables are lagged by six months.

3.3. Local water availability

I measure local water conditions at firm locations using monthly anomalies in terrestrial water storage from NASA's Gravity Recovery and Climate Experiment (GRACE) mission and its successor, GRACE Follow-On. GRACE and GRACE-FO measure changes in Earth's gravitational field at 1° × 1° spatial resolution, which reflect changes in total terrestrial water mass including surface water in rivers, lakes, and reservoirs as well as subsurface water in aquifers and soil moisture. The water level anomalies used throughout the analysis are expressed as deviations in meters from each location's average water level over 2005–2010. Raw NASA GRACE data extend back to 2002, and this longer series is used separately to construct longer lags and rolling-window measures in Section 4. The anomaly itself, however, is only available once the 2005–2010 baseline window closes: 2011 is the first year for which it can be computed at all, and 2012 is accordingly the first full calendar year of anomaly data, which sets the start of the main sample.[3] Over the period 2002–2024, the data cover 31,183 terrestrial gridpoints across 235 months of observations, resulting in 7,328,005 location-month observations. Coverage is interrupted by a 12-month gap during the 2017–2018 transition from GRACE to GRACE-FO, with scattered additional missing months listed in the appendix. Figure 1 illustrates the spatial distribution of water storage anomalies at three points across the sample period.

[3]The exact release date of this anomaly product is not independently confirmed; 2012 is used as a conservative first full year of availability.

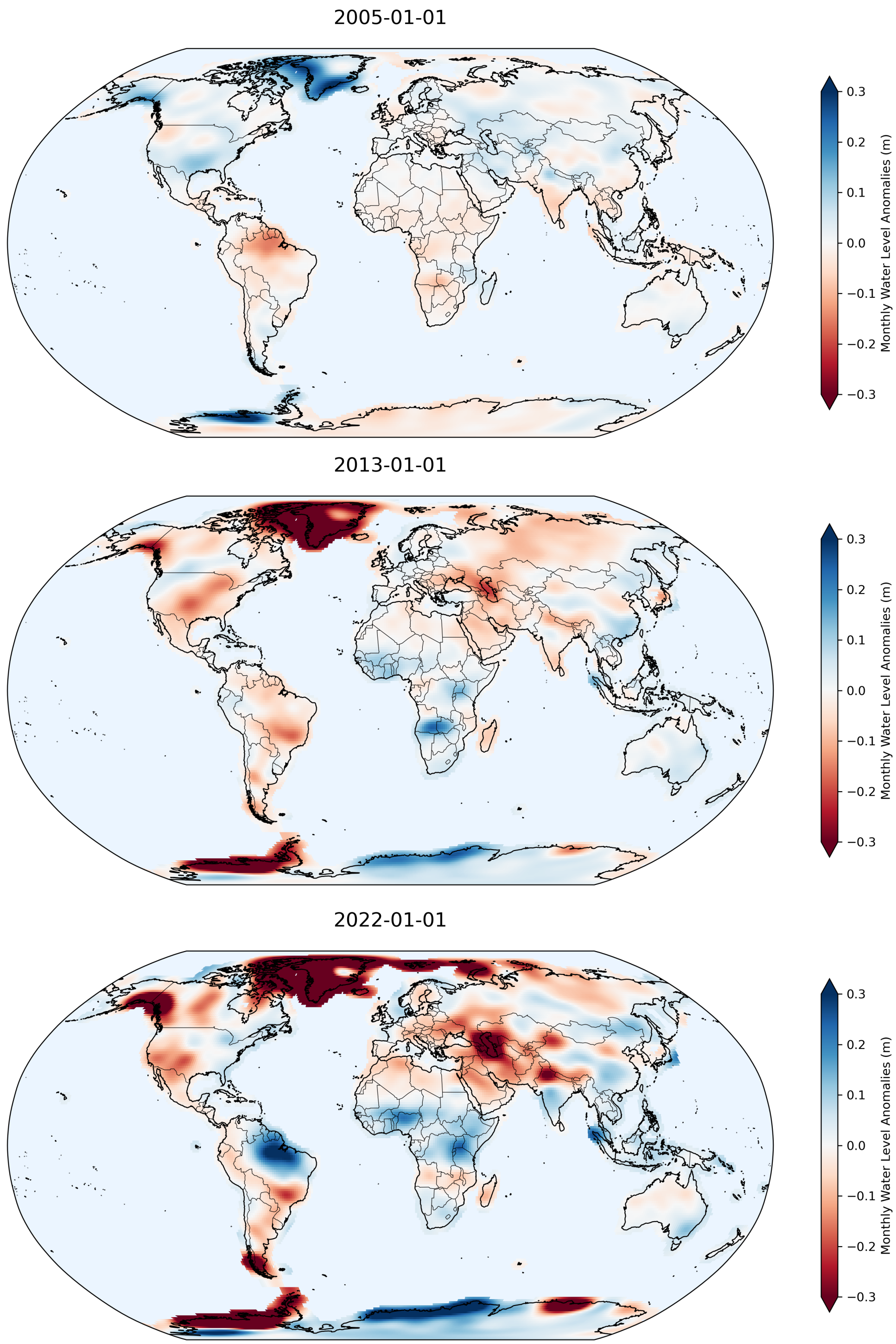

Figure 1: NASA GRACE(-FO) Terrestrial Water Storage Anomalies

These maps show seasonally adjusted Terrestrial Water Storage Anomalies from NASA's GRACE and GRACE-FO missions, expressed as monthly deviations from the 2005–2010 location-specific mean. The color scale spans the interquartile range (25th–75th percentile). Blue denotes increases in water storage; red denotes decreases.

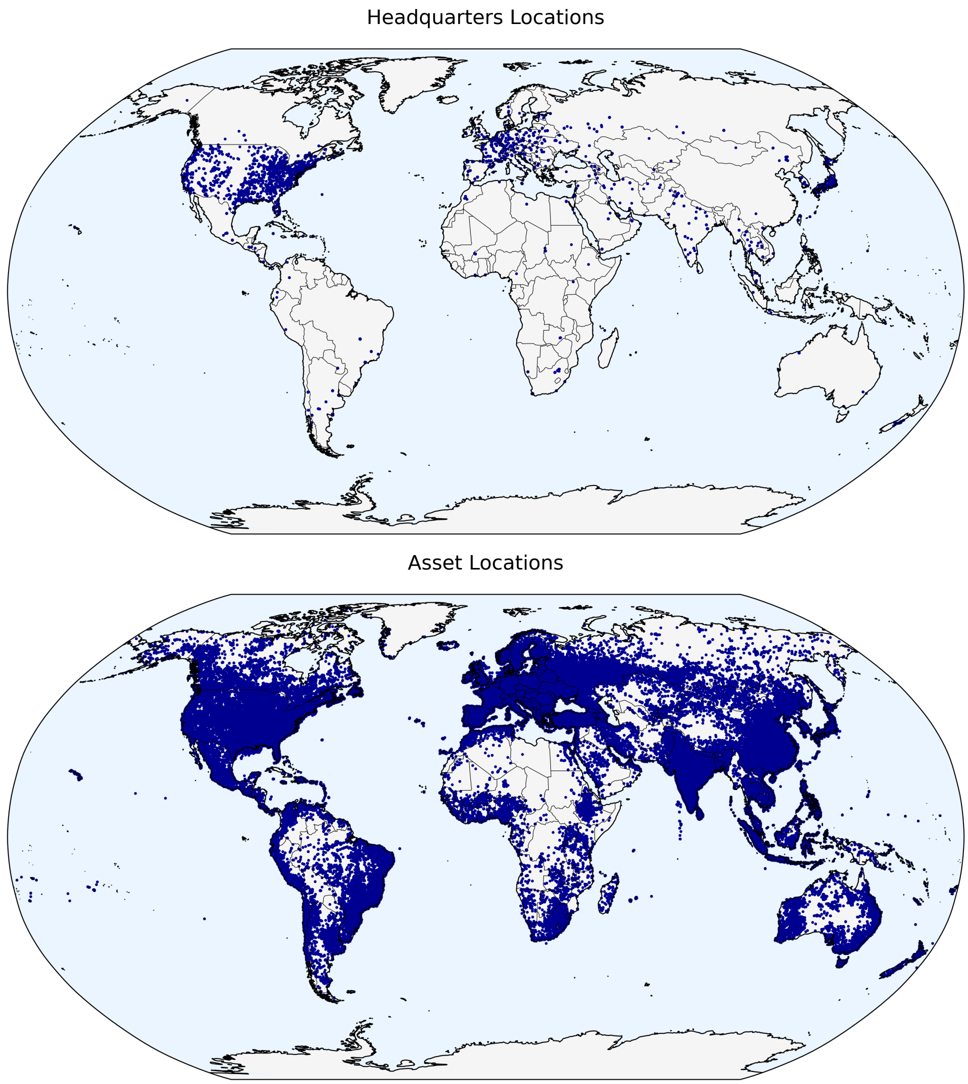

Figure 2: Trucost Headquarters and Asset Locations

GRACE data are well-suited for measuring firm-level exposure to water constraints. While traditional drought indices such as the Palmer Drought Severity Index (PDSI), the United States Drought Monitor (USDM), and the Standardized Precipitation and Evapotranspiration Index (SPEI) remain valuable for understanding agricultural drought, they measure primarily soil moisture. Although GRACE correlates with these traditional drought measures (Zhao, Geruo, Velicogna, and Kimball, 2017), it includes all terrestrial water sources, thus providing a more complete picture of water availability for industrial production.

Firm locations are obtained from S&P Global Trucost Physical Risk. The data report latitude and longitude coordinates for 849,905 asset locations, serving as a proxy for production locations. Together with 32,089 headquarters, the sample comprises 881,994 unique firm locations. I employ nearest-neighbor matching to identify the closest NASA gridpoint to each firm location by minimizing the distance between location and gridpoint coordinates. Haversine distances are used rather than Euclidean distance to account for Earth's curvature. Water level data are lagged by two months to account for the 40–60 day publication delay in satellite observations.

Figure 2 displays the geographic distribution of headquarters and asset locations respectively, illustrating that headquarters are substantially more geographically clustered than production facilities. Many asset locations are situated outside the country of the firm's headquarters, and thus outside the local economy to which domestic investors are disproportionately exposed. By comparing domestic investor holdings relative to water availability changes at a firm's headquarters and at its production locations, I can isolate the role of constraint location, holding the firm constant.

I aggregate local water availability data to the firm, constructing three firm-level measures for each month: the equally weighted average water anomaly across all firm locations combining both headquarters and assets, the equally weighted average across asset locations only, and the value at the headquarters location only. This disaggregation allows me to test whether water availability changes at headquarters and at production locations are differentially associated with investor allocations.

3.4. Water stress

As discussed in Section 2.1, firm-level water use and local water levels do not, on their own, measure a firm's contribution to local water constraints. A water-intensive firm may contribute little to water constraints if it operates in an area with abundant availability, while a firm with modest water use in a low-availability region may contribute substantially to binding constraints. A comprehensive measure therefore combines both water use and local water levels to capture the degree to which a firm exacerbates local water constraints.

I construct this index using direct water use, the volume of water consumed in the firm's own operations, rather than total water use, which includes upstream supply chain consumption. Total water use cannot be reliably matched to local water levels for this purpose, because local water levels are identified by the firm's own locations, not those of its suppliers, which may operate in regions with different water conditions; including upstream use would therefore introduce measurement noise. Total water use remains useful elsewhere in this paper as a control for a firm's water-intensive scale, a purpose that does not require location matching (Section 4.1).

For firm i in quarter t, I standardize direct water use and changes in local water levels within each quarter, across firms, and define the water stress index as

$$\text{WaterStress}_{i,t} = z(WU_{i,t}) - z(\Delta W_{i,t}), \tag{6}$$

where $z(\cdot)$ denotes the cross-sectional standardization of a variable within quarter t, $WU_{i,t}$ is direct water use, and $\Delta W_{i,t}$ is the change in local water levels, computed separately for headquarters and asset locations. The index rises with higher water use, with a decline in water levels, or with both, and falls with the reverse. This water stress index builds on the water stress measure I develop with coauthors in a concurrent working paper (Alves, De Waal, Hagens, Ten Bosch, and Van Dijk, 2025), adapted here as a standardized difference rather than an interaction term.

3.5. Control variables

The sample of firms includes only those with listed common equities and excludes investment vehicles, funds, trusts, and other financial firms. For these firms, I collect stock price and accounting data to construct control variables. Stock prices are obtained from CRSP for U.S. firms and from Compustat Global and Compustat North America for non-U.S. firms. Quarterly accounting data are obtained from Compustat Global and Compustat North America.

Stock price data are used to construct three variables. *Volatility* is the standard deviation of monthly returns in U.S. dollars over the preceding 12 months, excluding the most recent month; *Momentum* is the cumulative return over the preceding 12 months, excluding the most recent month, requiring at least nine months of available returns; and *Beta* is the market beta calculated over the past 24 months. The risk-free rate is proxied by the one-month Treasury bill rate from the Kenneth French website.

Accounting data are used to construct five variables. *Firm size* is the natural logarithm of market capitalization in millions of dollars; *Investments/assets* is the ratio of capital expenditure changes to total assets; *Leverage* is the ratio of total debt to total assets; *Book-to-market* is the ratio of book value of equity to market value of equity; and *Return on equity* is the ratio of net income to the market value of equity. Following Fama and French (1992), I assume a conservative six-month delay between the fiscal period end and the public availability of quarterly accounting information.

3.6. Summary statistics

Table 1 reports summary statistics for the variables used in the regressions. Panel A documents institutional ownership patterns. The average firm has 41 percent institutional ownership (median 28 percent), with domestic investors holding the majority. The substantial cross-sectional variation in both the level and composition of institutional ownership provides the primary variation for identifying investor responses. Panel B presents water use, water availability, and water stress measures. Water levels in regression tables refer to anomalies in terrestrial water storage, serving as a measure of local water availability. Firms in the sample average 43.5 billion liters of annual water use. Local water availability, on average, shows modest declines, but the distribution exhibits a pronounced

Table 1: Firm-Level Summary Statistics

This table reports summary statistics for the variables used in the firm-level regressions. **Panel A** reports statistics on quarterly firm-level institutional holdings from FactSet Ownership. *Institutional Ownership*, and *Domestic* and *Foreign Institutional Ownership* report total, domestic and foreign institutional ownership as a percentage of market capitalization. **Panel B** reports yearly firm-level measures on water use, monthly aggregated measures of changes in local water levels, and the constructed water stress metric. *Ln. Total, Direct,* and *Indirect Water Use* are the natural logarithms of total, direct and indirect water use in m^3. Δ *Water Levels Total* represents changes in local water availability, measured as an equal-weighted average of seasonally-adjusted water level anomalies at the firm's headquarters and global assets. Δ *Water Level HQ* and Δ *Water Levels Assets* then represent such water level anomalies at the firm's headquarters and global assets respectively. *Water Stress Total*, *Water Stress HQ*, and *Water Stress Assets* report the standardized difference between Ln. Direct Water Use and Water Levels Total, Water Levels HQ, and Water Levels Assets respectively. **Panel C** reports the control variables, constructed using data from Compustat and CRSP. *Ln. Firm Size* is the natural logarithm of market capitalization in $ millions; *Investments/Assets* is the ratio of change in capital expenditures to total assets; *Leverage* is the ratio of total debt to total assets; *Book-to-Market* is the ratio of book value of equity to market value of equity; *Return on Equity* is the ratio of net income to market value of equity; *Volatility*; is the standard deviation of monthly stock returns over the preceding 12 months, excluding t-1 *Beta*; is the market beta calculated over the past 24 months; *Momentum* is the cumulative stock return over the preceding 12 months, excluding t-1. All control variables (except *Ln. Firm Size*) are winsorized at 1.0%

Variable	obs	mean	sd	min	p25	median	p75	max
Panel A: Institutional Holdings								
Inst. Ownership	234,155	40.759	33.080	0.000	12.650	28.312	71.954	100.000
Domestic Inst. Ownership	234,155	30.555	33.711	0.000	2.691	10.542	63.578	99.895
Foreign Inst. Ownership	234,155	10.204	10.372	0.000	2.880	7.510	14.180	100.000
Panel B: Water Variables								
Ln. Total Water Use	139,090	17.588	2.421	2.974	16.222	17.708	19.126	25.027
Ln. Direct Water Use	138,981	14.419	3.024	-0.947	12.637	14.395	16.086	25.016
Ln. Indirect Water Use	139,090	17.332	2.281	2.954	16.077	17.524	18.803	24.733
Δ Water Levels Total	208,503	-0.000	0.060	-0.725	-0.027	0.001	0.031	0.329
Δ Water Levels HQ	208,502	-0.001	0.061	-0.680	-0.029	0.000	0.033	0.335
Δ Water Levels Assets	40,809	-0.003	0.066	-1.411	-0.022	0.001	0.025	0.255
Water Stress Total	103,973	-0.011	1.404	-5.681	-0.920	-0.043	0.833	11.762
Water Stress HQ	103,973	-0.004	1.421	-5.585	-0.923	-0.048	0.835	11.845
Water Stress Assets	20,116	0.779	1.389	-5.895	-0.079	0.719	1.629	16.546
Panel C: Control Variables								
Ln. Size	231,840	7.181	1.648	1.610	6.132	7.118	8.251	13.554
Investments/Assets	221,542	0.012	0.013	-0.000	0.003	0.008	0.015	0.075
Leverage	223,880	0.229	0.188	0.000	0.065	0.206	0.344	0.838
Book-to-Market	223,140	0.885	0.928	0.012	0.314	0.619	1.108	5.746
Return on Equity	223,807	0.013	0.048	-0.205	0.000	0.009	0.024	0.218
Volatility	228,773	0.114	0.068	0.032	0.068	0.095	0.138	0.412
Beta	228,614	1.170	0.824	-0.676	0.632	1.083	1.595	4.057
Momentum	229,349	0.130	0.517	-0.754	-0.169	0.053	0.306	2.574

Table 2: Investor-Level Summary Statistics

This table reports summary statistics for the variables used in the institution-level regressions. **Panel A** reports statistics on quarterly portfolio holdings from FactSet Ownership. *Inclusion* is an indicator equal to one if a firm in the investor's investment universe is included in their portfolio in a given quarter, and zero otherwise. *Portfolio Share*, *Dom. Portfolio Share*, and *For. Portfolio Share* report the proportion of assets under management allocated to an individual stock, overall and by domestic and foreign stocks. *Ln. Portfolio Share* is the natural logarithm of *Portfolio Share*. *Holdings*, *Dom. Holdings*, and *For. Holdings* report the average number of stocks per portfolio, overall and by domestic and foreign firms. *Assets Under Management* represent the value of quarterly holdings, expressed in million U.S. dollars. Definitions for water and control variables in **panel B** and **panel C** are provided in table 1.

Variable	obs	mean	sd	min	p25	median	p75	max
Panel A: Institutional Holdings								
Inclusion	36,946,498	0.681	0.466	0.000	0.000	1.000	1.000	1.000
Portfolio Share (%)	29,776,056	0.548	1.586	0.000	0.006	0.050	0.346	49.995
Dom. Portfolio Share (%)	16,372,240	0.739	1.901	0.000	0.014	0.099	0.583	49.995
For. Portfolio Share (%)	13,403,816	0.314	1.036	0.000	0.003	0.021	0.148	49.780
Ln. Portfolio Share	29,776,056	-3.225	2.875	-17.307	-5.109	-3.001	-1.061	3.912
Ln. Dom. Portfolio Share	16,372,240	-2.598	2.737	-17.307	-4.305	-2.313	-0.539	3.912
Ln. For. Portfolio Share	13,403,816	-3.991	2.855	-17.190	-5.921	-3.862	-1.910	3.908
Holdings	277,421	234.676	535.111	10.000	36.000	73.000	181.000	10,692
Dom. Holdings	277,421	119.512	240.137	1.000	18.000	43.000	98.000	3,224
For. Holdings	277,421	115.164	408.779	1.000	3.000	12.000	52.000	9,591
Assets under Management	277,421	4,138	42,751	0.013	57.630	185.619	873.660	4,367,326
Panel B: Water Variables								
Ln. Total Water Use	22,255,296	18.916	2.090	3.112	17.668	18.940	20.348	25.027
Ln. Direct Water Use	22,203,245	15.405	2.762	-1.406	13.700	15.267	16.877	25.016
Ln. Indirect Water Use	22,255,296	18.665	2.003	3.084	17.487	18.699	20.031	24.733
Δ Water Levels Total	25,274,613	0.002	0.065	-0.784	-0.037	0.003	0.045	0.311
Δ Water Levels HQ	25,274,613	0.003	0.068	-0.784	-0.040	0.004	0.049	0.311
Δ Water Levels Assets	6,679,094	-0.007	0.069	-1.040	-0.036	-0.003	0.029	0.269
Water Stress Total	17,947,209	0.33	1.32	-5.56	-0.54	0.31	1.19	12.00
Water Stress HQ	17,947,209	0.32	1.32	-5.46	-0.55	0.29	1.19	11.91
Water Stress Assets	5,299,287	1.08	1.33	-5.28	0.26	1.04	1.82	8.71
Panel C: Control Variables								
Ln. Size	29,747,647	8.615	1.566	1.615	7.537	8.565	9.674	13.556
Investments/Assets	29,267,599	0.011	0.011	-0.000	0.004	0.008	0.015	0.069
Leverage	29,338,298	0.272	0.174	0.000	0.147	0.260	0.376	0.917
Book-to-Market	29,357,368	1.272	1.304	0.010	0.422	0.856	1.609	6.856
Return on Equity	29,377,327	0.043	0.071	-0.241	0.007	0.025	0.065	0.271
Volatility	29,701,747	0.090	0.050	0.033	0.058	0.078	0.105	0.431
Beta	29,689,333	1.083	0.641	-0.696	0.676	1.029	1.410	3.982
Momentum	29,714,098	0.153	0.388	-0.753	-0.071	0.106	0.309	2.460

left skew: with large declines more severe than large increases. This asymmetry indicates that firms may operate under potentially severe local water availability constraints. The water stress variable, defined as the standardized difference between direct water use and changes in water availability, captures the degree to which firms contribute to binding local resource constraints. The variation across firms in both water use and local water availability creates substantial cross-sectional variation in firms' contribution to local constraints. Panel C reports control variables constructed from standard sources. All control variables except firm size are winsorized at the 1.0 percent level.

Table 2 reports summary statistics for the institution-level sample. Panel A documents portfolio-level holdings patterns. The average institution allocates 0.55% of assets under management to a given holding (median 0.05%), with a highly right-skewed distribution reflecting the fact that most portfolios hold many small positions alongside a small number of larger ones. Domestic holdings account for a larger share of portfolio assets on average than foreign holdings (0.74% versus 0.31%), consistent with the home bias documented in the firm-level sample. The typical institution holds 73 stocks (mean 235), split between 43 domestic and 12 foreign holdings at the median, indicating that domestic exposure is achieved through a larger number of positions as well as larger individual stakes. Assets under management are highly skewed across institutions, ranging from small managers to the largest global asset managers, with a median of $186 million and a mean of $4.1 billion. Panels B and C report water and control variables, respectively, constructed as described in Table 1.

3.7. Aggregate evidence

Before turning to the paper's central prediction about *which* investors are associated with water scarcity at *which* locations, I test whether institutional ownership is associated with water scarcity at all. Table 3 regresses aggregate institutional ownership on each of the three firm-level water scarcity measures introduced in Section 3: direct water use, which captures the volume of water a firm withdraws at their locations; changes in water levels, which captures fluctuations in water levels as a proxy for water availability at their locations; and the water stress index, which combines the two to capture a firm's water use relative to local availability. All three measures are aggregated across a firm's headquarters and asset locations, rather than evaluated at the locations separately, since the purpose of this table is to establish that ownership is associated with water scarcity in the aggregate, prior to testing the location-specific mechanism the theory describes.

Table 3 shows that all three measures are significantly associated with institutional ownership, with signs consistent with investors treating water scarcity as a material risk. The water stress index, which combines water use and water levels into a single measure of a firm's water use relative to local availability, is negatively associated with ownership (columns 1–2): firms contributing more heavily to local scarcity are held less by institutional investors. Changes in water levels are positively associated with ownership (columns 3–4): as water becomes more abundant, ownership rises, and

Table 3: Water Scarcity Measures and Aggregate Ownership

This table reports the results of regressions of aggregate institutional ownership on *Water Stress Total* (columns 1–2), Δ*Water Levels Total* (columns 3–4), and *Ln. Direct Water Use* (columns 5–6), with all measures aggregated to the firm-level. Variable definitions are provided in Table 1. All regressions include country×quarter/year fixed effects, with even-numbered models additionally including industry×quarter/year fixed effects. Standard errors are double-clustered at the firm and quarter/year level. Robust t-statistics are presented in parentheses. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Institutional Ownership	(1)	(2)	(3)	(4)	(5)	(6)
Water Stress Total	-0.8946***	-0.7466***				
	(-4.0544)	(-3.2587)				
Δ Water Levels Total			7.8812**	7.9738**		
			(2.2553)	(2.3523)		
Ln. Direct Water Use					-0.6425***	-0.4994***
					(-4.7137)	(-3.3587)
Ln. Total Water Use	1.0034***	1.9359***			1.4468***	2.2674***
	(5.1058)	(8.1032)			(6.3699)	(8.2098)
Ln. Size	1.6986***	1.4337***	3.3228***	3.8495***	1.5007***	1.2387***
	(6.4548)	(5.1104)	(18.6620)	(21.7181)	(5.8385)	(4.6038)
Investments/Assets	-42.3414**	32.0824	-27.0655*	45.7364***	-44.6444**	24.0994
	(-2.2080)	(1.6115)	(-1.7840)	(3.0494)	(-2.4751)	(1.2927)
Leverage	-0.4932	2.5758*	3.6779***	7.5945***	-0.5116	2.4909*
	(-0.3602)	(1.8256)	(2.9141)	(6.0534)	(-0.3852)	(1.8422)
Book-to-Market	0.3341	0.4565	1.5070***	2.3391***	0.3520	0.4672
	(1.1691)	(1.5788)	(6.3713)	(9.7700)	(1.2058)	(1.6002)
Return on Equity	4.7905*	0.0537	5.5124**	1.4011	4.5777*	0.0268
	(1.7640)	(0.0195)	(2.1788)	(0.5677)	(1.7069)	(0.0099)
Volatility	-62.7301***	-61.2239***	-79.5971***	-80.4183***	-64.3565***	-63.6064***
	(-13.9133)	(-13.7739)	(-21.8098)	(-21.8151)	(-15.3320)	(-15.0800)
Beta	2.0961***	1.2772***	2.7403***	2.0811***	1.9554***	1.2011***
	(5.4465)	(3.5875)	(9.0385)	(7.5211)	(6.3331)	(4.1133)
Momentum	2.8775***	2.8637***	3.9318***	4.0568***	2.8100***	2.7350***
	(7.3464)	(7.2041)	(9.8957)	(9.7839)	(8.2684)	(7.7213)
Constant	20.0341***	5.0977	21.7919***	16.3742***	22.5478***	7.6158**
	(6.0767)	(1.4008)	(13.7186)	(10.3569)	(7.9591)	(2.3277)
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes
Observations	99,933	99,898	168,400	168,384	131,716	131,663
R-squared	0.7516	0.7722	0.6971	0.7174	0.7505	0.7711

by implication, ownership falls as water becomes scarcer. Direct water use is negatively associated with ownership (columns 5–6), in line with institutional investors reducing holdings in firms using more water. The theory isolates direct water use for this test, as a firm depletes the reserve at a given location through the water it withdraws there, and this is what direct water use captures. The water stress and direct water use regressions both control for total water use, which includes water used across a firm's supply chain, amounting to 88.9%. Total water use is a scale control, not a competing measure of the mechanism. It varies with a firm's water footprint, but not with what that footprint does to any single location's reserve, since there is no reason to assume supply chain water is drawn from the same location as the firm's own water. I control for it because larger firms use more water and are also more heavily held by institutional investors for reasons unrelated to water.

These results establish that the association between water scarcity and institutional ownership holds in the aggregate data, across three distinct ways of measuring scarcity. They do not, however, test the mechanism proposed in Section 2, which predicts that the associations established above should be concentrated among investors with greater financial exposure to the location where scarcity arises, and should be substantially weaker for investors with less exposure. Testing this prediction requires separating institutional ownership by investor domicile and evaluating water conditions separately at different firm locations, depending on whether they are in the investor's country of domicile or not, since θ_I^ℓ in Equation (5) varies with ℓ specifically, not with a composite measure that pools locations together. Section 4 undertakes these tests directly, decomposing the aggregate patterns documented here by investor origin and by firm location.

4. Results

This section tests the paper's central prediction: institutional ownership is associated with a firm's contribution to local water scarcity, and this association is stronger for investors more exposed to the affected location. Section 4.1 documents this pattern in firm-level data and tests its persistence over time. Section 4.2 uses investor-level data to test whether investors reduce their exposure to a given firm or exit it entirely, and how this differs for firms domiciled inside and outside the United States. Both sections test the prediction using each of the three water measures from Section 3, in the same order: water levels, water stress, and water use.

4.1. Firm-level results

Regressions of institutional ownership on changes in water levels show that domestic ownership is associated with local conditions at a firm's headquarters, while foreign ownership, with lower exposure to those same conditions, is not. Water stress ties this association to a firm's own *contribution* to local conditions, rather than to the conditions alone, providing a stricter test of Equation (3), and the geographic asymmetry holds. Water use alone, evaluated independent of local water levels, isolates the effect of water use absent an indication of scarcity. Without scarcity, water need not be a binding constraint on production (Equation (1)), so the decision rule (Equation (5)) predicts no domestic tilt, and none is found.

Table 4 reports regressions of domestic and foreign institutional ownership on changes in water levels at headquarters and asset locations. The results are asymmetric, consistent with Predictions 1 and 2. At headquarters, domestic ownership is associated with water level changes: a one-standard-deviation increase corresponds to a 0.56 to 0.60 percentage point increase in domestic ownership, or

Table 4: Δ Water Levels and Institutional Ownership by Investor Origin

This table reports the results of regressions of domestic (columns 1–4) and foreign (columns 5–8) institutional ownership on Δ Water Levels HQ (Panel A) and Δ Water Levels Assets (Panel B), each lagged by two months to account for a 40–60 day reporting lag. *Fall* and *Rise* capture increases and decreases in water levels respectively. Other variable definitions are provided in Table 1. All regressions include a constant, the same accounting controls as in Table 3, and country×quarter/year fixed effects, with even-numbered models additionally including industry×quarter/year fixed effects. Standard errors are double-clustered at the firm and quarter/year level. Robust t-statistics are presented in parentheses. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Panel A: Headquarters

	Domestic				Foreign			
Institutional Ownership	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Water Levels HQ	9.2507***	9.8743***			1.5149	1.7118		
	(2.9190)	(3.2056)			(1.0386)	(1.1446)		
Δ Water Levels HQ - Fall			11.7860***	12.8196***			2.7928	4.0448
			(3.1631)	(3.5198)			(1.0469)	(1.4938)
Δ Water Levels HQ - Rise			5.9917	6.0373			-0.1278	-1.3276
			(1.2609)	(1.2997)			(-0.0513)	(-0.5276)
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes		Yes
Observations	168,400	168,384	168,400	168,384	168,400	168,384	168,400	168,384
R-squared	0.7750	0.7870	0.7750	0.7870	0.3659	0.3990	0.3659	0.3991

Panel B: Asset Locations

	Domestic				Foreign			
Institutional Ownership	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Water Levels Assets	2.9048	2.9112			5.1330**	3.9024		
	(0.7600)	(0.8820)			(2.1986)	(1.6056)		
Δ Water Levels Assets - Fall			-0.2976	-0.5925			6.6566***	5.2395**
			(-0.0826)	(-0.1855)			(2.7989)	(2.1057)
Δ Water Levels Assets - Rise			15.0424	16.9618*			-0.6417	-1.4597
			(1.5170)	(1.7240)			(-0.0797)	(-0.1779)
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes		Yes
Observations	29,578	29,145	29,578	29,145	29,578	29,145	29,578	29,145
R-squared	0.8064	0.8248	0.8066	0.8250	0.3899	0.4414	0.3901	0.4416

1.85 to 1.97 percent relative to the mean domestic holding. Decomposing the change into declines and increases shows this association is driven entirely by declines: a one-meter fall in water levels is associated with an 11.79 to 12.82 percentage point reduction in domestic ownership, while a rise shows no significant association. Foreign ownership shows no association with water level changes at headquarters in either direction. This asymmetry is consistent with θ_I^ℓ in Equation (5) being highest when ℓ is an investor's home country, which, for a domestic holding, is where the firm is headquartered. It is also consistent with $\text{Cost}_{a_i}(W_{\ell,t+1})$ in Equation (3) being strictly decreasing only once water binds, so that declining levels, not rising ones, generate a response.

The pattern reverses at asset locations. Domestic ownership shows no consistent association with water level changes there, while a one-standard-deviation decline in water levels is associated with a 0.26 to 0.34 percentage point reduction in foreign ownership, or 2.52 to 3.32 percent relative

Table 5: Water Stress and Institutional Ownership by Investor Origin

This table reports the results of the regressions of domestic (columns 1–4) and foreign (columns 5–8) institutional ownership on *Water Stress*. Variable definitions are provided in Table 1. All regressions include a constant, Ln. Total Water Use, and additionally the same accounting controls as in Table 3. They also include country×quarter/year fixed effects, with even-numbered models additionally including industry×quarter/year fixed effects. Standard errors are double-clustered at the firm and quarter/year level. Robust t-statistics are presented in parentheses. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

	Domestic				Foreign			
Institutional Ownership	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Water Stress HQ	-0.6156***	-0.5475***			-0.3604***	-0.3665***		
	(-3.2499)	(-2.8199)			(-3.0862)	(-2.9418)		
Water Stress Assets			-0.2283	-0.2104			-0.9294***	-0.8568**
			(-0.7838)	(-0.7711)			(-3.0237)	(-2.5910)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes		Yes
Observations	99,934	99,899	18,226	17,911	99,934	99,899	18,226	17,911
R-squared	0.8379	0.8482	0.8930	0.9085	0.3949	0.4429	0.5007	0.5713

to the mean foreign holding, concentrated again in declines rather than increases. This reversal is consistent with each investor group's exposure being concentrated at the location within its own economic sphere: headquarters for domestic investors, and, plausibly, asset locations that more often coincide with a foreign investor's home market. This last point is not tested directly here.

Table 5 reports regressions of domestic and foreign institutional ownership on water stress. Water stress is constructed as the standardized difference between a firm's own water use and water levels at its location, a firm-specific proxy for its contribution to the depletion of the shared reserve $W_{\ell,t+1}$ in Equation (2). Where water levels capture exposure to local conditions, water stress isolates a firm's own contribution to them. At headquarters, a one-standard-deviation increase in water stress is associated with a 0.78 to 0.87 percentage point decrease in domestic ownership, larger than the 0.51 to 0.52 percentage point decrease found for foreign ownership. At asset locations, the pattern reverses: foreign ownership falls by 1.19 to 1.29 percentage points for a one-standard-deviation increase in water stress, while domestic ownership shows no significant association. The dominant asymmetry, domestic ownership associated with headquarters stress and foreign ownership with asset location stress, matches the pattern found for water levels. Foreign ownership's smaller but significant association with headquarters stress is consistent with exposure θ_I^{ℓ} in Equation (5) being lower, but not necessarily zero, away from an investor's home market. All regressions include total water use as a control; the reasoning, and its relation to direct water use, the input to the water stress index, is discussed alongside the water use results below.

Table 6 reports regressions of domestic and foreign institutional ownership on water use. Direct water use is the theoretically relevant measure: it depletes the shared reserve $W_{\ell,t+1}$ in Equation (2). Indirect water use, by contrast, is consumed by suppliers who may operate anywhere in the world,

Table 6: Water Use and Institutional Ownership by Investor Origin

This table reports the results of the regressions of domestic (columns 1–4) and foreign (columns 5–8) institutional ownership on *Ln. Direct Water Use*. Variable definitions are provided in Table 1. All regressions include a constant, the same accounting controls as in Table 3, and country×quarter/year fixed effects, with even-numbered models additionally including industry×quarter/year fixed effects. Standard errors are double-clustered at the firm and quarter/year level. Robust t-statistics are presented in parentheses. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

	Domestic				Foreign			
Institutional Ownership	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln. Direct Water Use	-0.2075**	0.0700	-0.3427***	-0.1517	-0.2280***	-0.2548***	-0.2746***	-0.3206***
	(-2.4651)	(0.7018)	(-3.1731)	(-1.2664)	(-3.9119)	(-3.6162)	(-3.6113)	(-3.8657)
Ln. Indirect Water Use	1.0966***	1.6127***			0.3413***	0.4291***		
	(7.2515)	(7.6581)			(3.6902)	(3.5923)		
Ln. Total Water Use			1.0077***	1.6633***			0.3221***	0.4563***
			(5.4587)	(7.3455)			(2.8288)	(3.4721)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes		Yes
Observations	124,045	123,996	124,045	123,996	124,045	123,996	124,045	123,996
R-squared	0.8407	0.8504	0.8398	0.8502	0.3927	0.4407	0.3920	0.4406

and is unlikely to be drawn from the same reserve. Direct water use alone is confounded with firm scale: larger firms use more water and are more heavily held by institutional investors for reasons unrelated to water. In addition to the accounting controls included throughout, I address this by controlling for indirect and, separately, total water use, both proxies for a firm's water-intensive scale that do not require the location match direct water use requires.

Controlling for scale in this way, direct water use is associated with lower ownership for foreign investors in every specification, ranging from a 0.69 to 0.97 percentage point decrease per one-standard-deviation increase in direct water use. For domestic investors, the association is significant in two of the four specifications, ranging from a 0.63 to 1.04 percentage point decrease; in the other two, the coefficient is smaller or positive and not significant. Indirect and total water use are themselves positively associated with ownership throughout, consistent with the scale confound they are included to address. There is no domestic tilt for direct water use. Under the Leontief production function in Equation (1), water binds production, and becomes costly, only when it is scarce relative to capital. Direct water use alone carries no information on whether this is the case. Water levels and water stress, unlike water use, capture information on local water availability directly, which is why only they reveal the domicile-specific asymmetry documented above.

Beyond the absence of a tilt, these coefficients, where significant, are negative for both domestic and foreign investors. This pattern is not itself predicted by Equation (5), which concerns exposure to a firm's contribution to local conditions rather than water use in isolation. One possibility is that water-intensive firms carry a baseline financial, reputational or regulatory risk considered independently of local scarcity. I explore whether water use, water levels and water stress are priced in global equity markets more broadly in ongoing joint work; this specific channel is not tested here.

4.1.1. Long-horizon persistence

The results above could reflect a transitory shock rather than a persistent structural relation, or an informational advantage on local water conditions that domestic investors capitalize on. I test both alternatives by re-estimating the water levels and water stress specifications using rolling averages of the underlying water level measures over horizons ranging from three months to fifteen years. A transitory shock interpretation predicts attenuation of the effect at longer horizons; an informational interpretation predicts the domestic-foreign asymmetry itself should narrow as any informational advantage dissipates. Neither pattern is present; both the effect itself and the geographical pattern persist.

Table 7 reports the results of regressions on water level changes at each horizon: Panel A for domestic ownership at headquarters, Panel B for foreign ownership at asset locations, the two associations central to Section 4.1. At headquarters, domestic ownership's association with declines in water levels is significant at every horizon, while its association with rises is insignificant at every horizon. Figure 3 plots this effect, in both raw and standardized terms: the raw coefficient on declines grows with the horizon, while the one-standard-deviation effect on the right axis is stable. That the decline-rise asymmetry holds at every horizon, not only in the primary specification, reinforces that the association reflects depletion of the reserve specifically, rather than a symmetric reward for abundance: $\mathrm{Cost}_{a_i}(W_{\ell,t+1})$ in Equation (3) is strictly decreasing in the reserve when water binds a firm's production, consistent with the significant response to declines, and flat otherwise, consistent with the null response to rises.

At asset locations, foreign ownership's association with declines is significant from three months through at least five years, and loses statistical significance at the 15-year horizon. Domestic ownership is significantly associated with rises in water levels at asset locations (Appendix C.2). Two features of the data are relevant to both patterns. First, unlike headquarters, which are always in the domestic investor's home country by construction, an asset location may or may not be, so exposure θ_I^ℓ can vary across a firm's asset locations for both domestic and foreign investors. The firm-level water level measure at asset locations averages across these locations, combining high- and low-exposure locations into a single coefficient. Second, a rise in water levels need not indicate that water has stopped binding a firm's production. If it remains binding even as it rises, $\mathrm{Cost}_{a_i}(W_{\ell,t+1})$ continues to fall, and a positive association with ownership, as found for domestic investors, is consistent with what the model would predict. Disaggregating asset locations by whether they coincide with a given investor's home country, for both domestic and foreign investors, is left for future work. Full results at every horizon are reported in Appendix C.2.

Table 8 reports the corresponding results for water stress, with the same panel structure: domestic ownership at headquarters, and foreign ownership at asset locations. Both associations remain significant at every horizon. Unlike water levels, the association at asset locations does not attenuate to insignificance at fifteen years. Full results are reported in Appendix C.3. Water use is

Table 7: Water Levels and Institutional Ownership by Investor Origin, Rolling Averages

This table reports the results of the regressions of domestic institutional ownership on Δ *Water Levels HQ* (Panel A) and foreign institutional ownership on Δ *Water Levels Assets* (Panel B), using different rolling averages. *Rise* and *Fall* capture increases and decreases in water levels respectively. Other variable definitions are provided in Table 1. All regressions include a constant, the same controls as in Table 3, and country×quarter/year fixed effects, with even-numbered models additionally including industry×quarter/year fixed effects. Standard errors are double-clustered at the firm and quarter/year level. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Panel A: Domestic Institutional Ownership – Headquarters								
Institutional Ownership	3 Months	3 Months	1 Year	1 Year	5 Years	5 Years	15 Years	15 Years
Δ Water Levels HQ - Fall	11.8045***	13.0696***	12.6653***	14.0076***	13.8011**	16.0905**	28.5686**	32.1912**
	(3.0109)	(3.4084)	(3.0055)	(3.4073)	(2.2044)	(2.6398)	(2.1857)	(2.5169)
Δ Water Levels HQ - Rise	6.7416	6.4359	6.1783	5.9940	10.0270	9.4144	16.4411	14.9267
	(1.3523)	(1.3195)	(1.1451)	(1.1359)	(1.3522)	(1.2971)	(0.9375)	(0.8683)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes		Yes
Observations	168,400	168,384	168,354	168,338	167,750	167,734	88,202	88,195
R-squared	0.7750	0.7870	0.7751	0.7871	0.7758	0.7879	0.7636	0.7747
Panel B: Foreign Institutional Ownership – Asset Locations								
Institutional Ownership	3 Months	3 Months	1 Year	1 Year	5 Years	5 Years	15 Years	15 Years
Δ Water Levels Assets - Fall	6.5973***	5.2559**	6.6989**	5.3613**	7.4665**	5.8388*	10.3683	7.6615
	(2.7225)	(2.0808)	(2.6885)	(2.0616)	(2.5863)	(1.8620)	(1.6671)	(1.1121)
Δ Water Levels Assets - Rise	-0.0508	-1.1609	0.0819	-1.2595	-3.1144	-4.0139	-7.8656	-7.9690
	(-0.0060)	(-0.1344)	(0.0088)	(-0.1317)	(-0.2429)	(-0.3067)	(-0.2771)	(-0.2754)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes		Yes
Observations	29,578	29,145	29,578	29,145	29,578	29,145	15,064	14,881
R-squared	0.3901	0.4416	0.3900	0.4416	0.3897	0.4414	0.4180	0.4684

not re-estimated at these horizons. Absent information on local water levels, water use alone does not determine $\text{Cost}_{a_i}(W_{\ell,t+1})$ in Equation (3), so the theory does not predict a domestic-foreign asymmetry in the association with water use at any horizon, consistent with the null asymmetry found in Section 4.1.

Together, these results are inconsistent with both alternatives considered above: persistence at longer horizons rules out a transitory shock, and the preserved domestic-foreign asymmetry rules out an informational advantage that should narrow as conditions become public. The observed persistence does follow directly from the model presented in Section 2. Equation (3) defines $\text{Cost}_{a_i}(W_{\ell,t+1})$ as the present value of future cash-flow reductions, depending on the reserve's future trajectory rather than a single period's realization. The measures used here, by contrast, are constructed from past, realized water level trajectories. The two are connected through Equation (2): because the reserve carries forward from one period to the next, net of withdrawal and recharge, a longer realized trajectory is a less noisy signal of the same depletion that will determine the reserve's future trajectory. Persistence at long horizons is therefore consistent with investors responding to this persistent signal, rather than to a transitory, single-period condition.

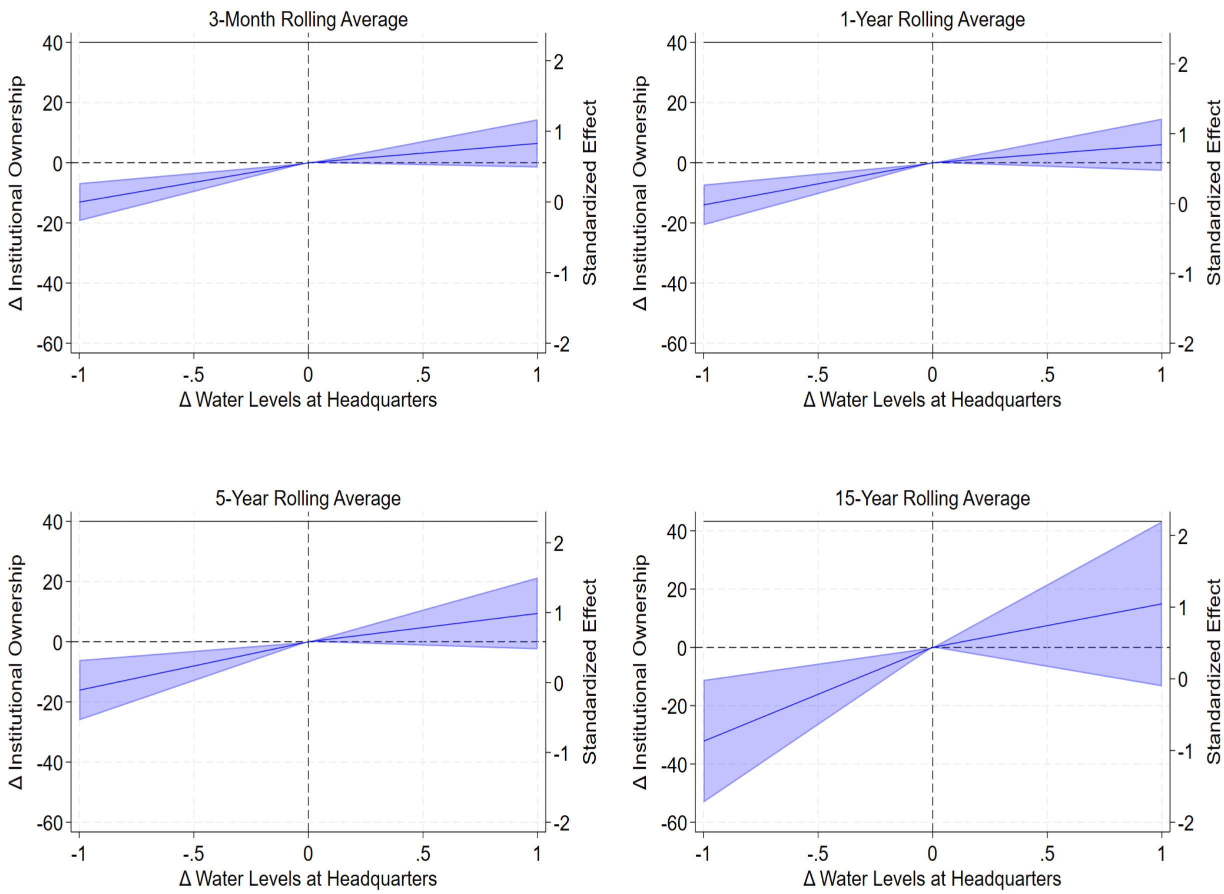

Figure 3: Δ Water Levels HQ and Domestic Institutional Ownership

This figure plots coefficients (with 90% confidence intervals) from regressions of domestic institutional ownership on changes in water levels at firm headquarters, using rolling averages over horizons ranging from three months to fifteen years. For each horizon, the left y-axis shows the change in institutional ownership associated with a one-unit change in water levels, separately for declines (left of the origin) and increases (right of the origin). The right y-axis reports the effect of a one-standard-deviation change in total water levels.

4.2. Investor-level results

Firm-level institutional ownership is the sum of many individual investors' portfolio choices. This section addresses two questions. First, the extent to which the pattern documented in Section 4.1 operates through the extensive margin, whether a firm is excluded from a portfolio entirely, or the intensive margin, whether the portfolio share allocated to a given firm changes. Second, per the decision rule in Equation (5), for which investors excluding or reducing a holding would be rational; I test whether the association differs for firms domiciled inside versus outside the United States. All regressions are weighted by an investor's assets under management, lagged one quarter, consistent with the implicit dollar-weighting of the firm-level ownership measures.

Table 8: Water Stress and Institutional Ownership by Investor Origin, Rolling Averages

This table reports the results of the regressions of domestic institutional ownership on Δ *Water Stress HQ* (Panel A) and foreign institutional ownership on Δ *Water Stress Assets* (Panel B), using different rolling averages. Variable definitions are provided in Table 1. All regressions include a constant, Ln. Total Water Use, and additionally the same accounting controls as in Table 3. They also include country×quarter/year fixed effects, with even-numbered models additionally including industry×quarter/year fixed effects. Standard errors are double-clustered at the firm and quarter/year level. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Panel A: Domestic Institutional Ownership – Headquarters								
Institutional Ownership	3 Months	3 Months	1 Year	1 Year	5 Years	5 Years	15 Years	15 Years
Water Stress HQ	-0.6194***	-0.5547***	-0.6058***	-0.5444***	-0.5548***	-0.4968**	-0.5235**	-0.5305**
	(-3.2381)	(-2.8234)	(-3.1466)	(-2.7461)	(-2.8298)	(-2.4567)	(-2.2930)	(-2.2706)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes		Yes
Observations	99,934	99,899	99,927	99,892	99,654	99,618	63,061	63,055
R-squared	0.8379	0.8482	0.8379	0.8482	0.8387	0.8490	0.8161	0.8272

Panel B: Foreign Institutional Ownership – Asset Locations								
Institutional Ownership	3 Months	3 Months	1 Year	1 Year	5 Years	5 Years	15 Years	15 Years
Water Stress Assets	-0.9343***	-0.8598**	-0.9267***	-0.8503**	-0.8913***	-0.8228**	-0.9939***	-0.9209***
	(-3.0327)	(-2.5895)	(-3.0228)	(-2.5720)	(-2.9567)	(-2.5692)	(-3.3193)	(-3.0843)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes		Yes
Observations	18,226	17,911	18,226	17,911	18,226	17,911	10,347	10,182
R-squared	0.5008	0.5714	0.5008	0.5713	0.5005	0.5712	0.5268	0.5955

4.2.1. Aggregate patterns

As in the firm-level analysis, I first establish that an association exists in the pooled investor-level data, before testing which investors it is concentrated among. This pooled test does not test Predictions 1 and 2, which concern domicile-specific exposure, but it does show whether the association operates through the extensive margin, the intensive margin, or both.

Table 9 reports regressions of the extensive and intensive margin on water levels. Inclusion, an indicator equal to one if a firm in an investor's investment universe is currently held, captures the extensive margin; portfolio share captures the intensive margin. Each fixed effect specification identifies the association from a different source of variation. The first includes quarter/year fixed effects, comparing across investors and firms within a quarter. The second adds institution-by-quarter/year fixed effects, a cross-sectional test comparing across firms within a given investor's portfolio in a given quarter. The third replaces quarter/year with institution-by-firm fixed effects, a time-series test comparing a given investor's holding of a given firm over time as that firm's water conditions change. All three specifications are used in every table that follows.

Both margins are positively associated with headquarters water levels in the first two specifications: as the water reserve levels fall, $\text{Cost}_{a_i}(W_{\ell,t+1})$ in Equation (3) rises, making the divestment

Table 9: Portfolio Inclusion, Portfolio Share, and Δ Water Levels

This table reports regressions of portfolio inclusion (Panel A) and portfolio share (Panel B) on Δ *Water Levels HQ* (columns 1–3) and Δ *Water Levels Assets* (columns 4–6), pooled across all investors. Variable definitions are provided in Table 2. All regressions include a constant, and the same accounting controls as in Table 3, and are weighted by assets under management, lagged one quarter. Columns (1) and (4) include quarter/year fixed effects; columns (2) and (5) additionally include institution-by-quarter/year fixed effects; columns (3) and (6) replace quarter/year with institution-by-firm fixed effects. Standard errors are double-clustered at the institution and quarter/year level. Robust t-statistics are presented in parentheses. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Panel A: Extensive Margin						
Portfolio Inclusion	(1)	(2)	(3)	(4)	(5)	(6)
Δ Water Levels HQ	0.1136***	0.1450***	0.0012			
	(6.249)	(6.993)	(0.0540)			
Δ Water Levels Assets				0.0156	0.0100	-0.0776*
				(0.8923)	(0.5061)	(-1.858)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Quarter/Year	Yes	Yes		Yes	Yes	
Institution x Quarter/Year		Yes	Yes		Yes	Yes
Institution x Firm			Yes			Yes
Observations	30,822,681	30,822,119	30,739,367	7,465,828	7,461,865	7,443,602
R^2	0.02493	0.18723	0.52833	0.03178	0.19844	0.53013
Panel B: Intensive Margin						
Portfolio Share	(1)	(2)	(3)	(4)	(5)	(6)
Δ Water Levels HQ	2.123***	2.032***	-0.2130			
	(4.430)	(4.690)	(-1.437)			
Δ Water Levels Assets				-0.4264	-0.3134	-0.0798
				(-0.8265)	(-0.6794)	(-0.5232)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Quarter/Year	Yes	Yes		Yes	Yes	
Institution x Quarter/Year		Yes	Yes		Yes	Yes
Institution x Firm			Yes			Yes
Observations	23,946,393	23,945,295	23,697,111	6,159,937	6,151,871	6,102,645
R^2	0.36846	0.45616	0.86676	0.41930	0.50855	0.88182

condition in Equation (5) more likely to be satisfied, so ownership should be lower where levels have fallen and higher where they have risen. Neither association is significant in the third specification. Neither margin is consistently associated with water levels at asset locations. Table 10 reports the corresponding results for water stress, which also controls for total water use as in Table 5, though its coefficient is not shown: headquarters water stress is negatively associated with both margins in the first two specifications, by similar reasoning: as the reserve falls, $\text{Cost}_{a_i}(W_{\ell,t+1})$ in Equation (3) rises, predicting lower ownership. Asset location water stress is negatively associated with portfolio share, though not inclusion, in the same two specifications. Neither construct is significant in the third specification. Table 11 reports the corresponding results for water use: direct water use is

Table 10: Portfolio Inclusion, Portfolio Share, and Water Stress

This table reports regressions of portfolio inclusion (Panel A) and portfolio share (Panel B) on *Water Stress HQ* (columns 1–3) and *Water Stress Assets* (columns 4–6), pooled across all investors. Variable definitions are provided in Table 2. All regressions include a constant, and the same accounting controls as in Table 3, and are weighted by assets under management, lagged one quarter. Columns (1) and (4) include quarter/year fixed effects; columns (2) and (5) additionally include institution-by-quarter/year fixed effects; columns (3) and (6) replace quarter/year with institution-by-firm fixed effects. Standard errors are double-clustered at the institution and quarter/year level. Robust t-statistics are presented in parentheses. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Panel A: Extensive Margin						
Portfolio Inclusion	(1)	(2)	(3)	(4)	(5)	(6)
Water Stress HQ	-0.0067***	-0.0099***	-0.0007			
	(-4.072)	(-5.846)	(-0.6059)			
Water Stress Assets				-0.0000	-0.0012	0.0015
				(-0.0073)	(-0.8136)	(0.9327)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Quarter/Year	Yes	Yes		Yes	Yes	
Institution x Quarter/Year		Yes	Yes		Yes	Yes
Institution x Firm			Yes			Yes
Observations	23,639,434	23,638,573	23,576,920	6,446,795	6,442,219	6,426,488
R^2	0.02686	0.19575	0.54892	0.02743	0.20559	0.53914
Panel B: Intensive Margin						
Portfolio Share	(1)	(2)	(3)	(4)	(5)	(6)
Water Stress HQ	-0.2107***	-0.2005***	-0.0024			
	(-7.965)	(-8.607)	(-0.2816)			
Water Stress Assets				-0.0994***	-0.0977***	0.0043
				(-3.943)	(-4.233)	(0.4021)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Quarter/Year	Yes	Yes		Yes	Yes	
Institution x Quarter/Year		Yes	Yes		Yes	Yes
Institution x Firm			Yes			Yes
Observations	17,365,917	17,362,513	17,187,720	5,048,949	5,038,497	4,997,722
R^2	0.36097	0.45783	0.87929	0.40539	0.50386	0.88866

negatively associated with both margins in every specification, including the third. Indirect and total water use, included as controls in the same way as at the firm level, are positively associated with both margins in most specifications. Every sign reported here matches the corresponding sign at the firm level, a first indication that the investor-level data is consistent with the pattern documented in Section 4.1.

That water use survives the third specification while water levels and water stress do not is consistent with the geographic asymmetry documented using the firm-level data: water use shows no domestic-foreign asymmetry at the firm level, while water levels and water stress do. Pooling domestic and foreign investors, whose responses to water levels and water stress may differ, can

Table 11: Portfolio Inclusion, Portfolio Share, and Water Use

This table reports regressions of portfolio inclusion (Panel A) and portfolio share (Panel B) on *Ln. Direct Water Use*, pooled across all investors. Variable definitions are provided in Table 2. All regressions include a constant, and the same accounting controls as in Table 3, and are weighted by assets under management, lagged one quarter. Columns (1) and (4) include quarter/year fixed effects; columns (2) and (5) additionally include institution-by-quarter/year fixed effects; columns (3) and (6) replace quarter/year with institution-by-firm fixed effects. Standard errors are double-clustered at the institution and quarter/year level. Robust t-statistics are presented in parentheses. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Panel A: Extensive Margin						
Portfolio Inclusion	(1)	(2)	(3)	(4)	(5)	(6)
Ln. Direct Water Use	-0.0008	-0.0022***	-0.0020***	-0.0009	-0.0030***	-0.0025***
	(-1.347)	(-3.352)	(-5.484)	(-1.003)	(-3.229)	(-4.847)
Ln. Indirect Water Use	0.0001	0.0025**	0.0053***			
	(0.1242)	(2.322)	(2.723)			
Ln. Total Water Use				0.0001	0.0033**	0.0039**
				(0.0873)	(2.267)	(2.431)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Quarter/Year	Yes	Yes		Yes	Yes	
Institution x Quarter/Year		Yes	Yes		Yes	Yes
Institution x Firm			Yes			Yes
Observations	28,753,989	28,752,939	28,703,451	28,753,989	28,752,939	28,703,451
R^2	0.02516	0.19481	0.53170	0.02516	0.19482	0.53169
Panel B: Intensive Margin						
Portfolio Share	(1)	(2)	(3)	(4)	(5)	(6)
Ln. Direct Water Use	-0.0690***	-0.0636***	-0.0054**	-0.1091***	-0.1030***	-0.0209***
	(-10.64)	(-10.96)	(-2.454)	(-16.36)	(-17.93)	(-8.258)
Ln. Indirect Water Use	0.1012***	0.1022***	0.1578***			
	(10.59)	(10.61)	(12.99)			
Ln. Total Water Use				0.1444***	0.1434***	0.1218***
				(12.59)	(12.81)	(11.15)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Quarter/Year	Yes	Yes		Yes	Yes	
Institution x Quarter/Year		Yes	Yes		Yes	Yes
Institution x Firm			Yes			Yes
Observations	21,480,382	21,476,050	21,314,618	21,480,382	21,476,050	21,314,618
R^2	0.34934	0.44952	0.87460	0.34981	0.44991	0.87451

attenuate an association that a domicile-specific test recovers. Section 4.2.2 tests this directly.

4.2.2. Geographical patterns

The previous section pooled all investors, but institutions domiciled in the United States account for 65 percent of institutions in the investor-level sample (Table C.1), so a pooled regression could reflect US investor behavior more than non-US behavior. This section separates US from non-US investors and tests whether their associations differ. I additionally split the sample by domestic and foreign status, not yet present in the pooled regressions. Each water measure is interacted with indicators for both, isolating four institutional investor groups: non-US domestic, non-US foreign, US domestic, and US foreign. Implied effects for each group, reported alongside the raw interaction coefficients in each table, are computed via the delta method, using the estimated coefficients' variance-covariance matrix to obtain the standard error of each linear combination.

Water Levels

Table 12 reports water levels interacted with foreign and US-domiciled status for portfolio share. At headquarters, non-US investors' domestic holdings show the largest implied effect of any group, and the only one significant in every specification: a one-standard-deviation decrease in headquarters water levels is associated with a 0.11 to 0.34 percentage point decrease in portfolio share in specifications (1) and (2), the cross-sectional comparison across firms within a given investor's portfolio, and a 0.15 percentage point decrease in specification (3), the time-series comparison within a given investor's holding of a given firm. Relative to the mean domestic position of 0.74 percent of assets under management, this is a 14.5 to 45.4 percent decrease in the cross-sectional comparison and a 19.6 percent decrease in the time-series comparison,[4] a substantial adjustment relative to a typical position that holds up whether measured across an investor's portfolio at a point in time or within a single holding over time. Non-US investors' foreign holdings show a smaller but still significant effect in the cross-sectional comparison, 7.6 to 8.0 percent in relative terms; non-US investors' domestic holdings are 1.9 to 4.9 times larger in specifications (1) and (2). Unlike non-US investors' domestic holdings, this effect is not significant in the time-series comparison. This pattern, a large domestic effect and a smaller but still positive foreign effect, is fully consistent with Predictions 1 and 2: θ_I^ℓ in Equation (5) is highest for domestic investors at a firm's home market, but is not necessarily zero for foreign investors there, and the relative magnitudes here match that ordering.

The pattern does not hold for US investors. US investors' foreign holdings show an effect of similar direction and magnitude to non-US investors' foreign holdings in the cross-sectional comparison, 0.83 in both specifications (1) and (2), consistent with the same exposure logic that holds for non-US investors; this effect is not significant in specification (3). The pattern found for domestic holdings among non-US investors is not present among US investors. Their domestic holdings show no association with headquarters water levels in specifications (1) and (2), and are instead significant and negative in specification (3). The absence of a positive association for the domestic holdings of US investors is explored further in the water stress discussion below, which more directly tests a firm's own contribution to local conditions rather than mere exposure to them.

At asset locations, no group shows a consistent association across specifications, in contrast to the significant foreign ownership association documented at the firm level in Section 4.1. Non-US

[4] Percentage changes are computed as $(\exp(\hat{\beta} \times \sigma) - 1) \times 100$, rather than the linear approximation $\hat{\beta} \times \sigma \times 100$, since the coefficients are large enough that the two diverge meaningfully.

Table 12: Portfolio Share and Δ Water Levels: Foreign and US Investor Status

This table reports regressions of portfolio share on Δ *Water Levels HQ* (columns 1–3), interacted with indicators for foreign and US-domiciled investor status, and on Δ *Water Levels Assets* (columns 4–6), interacted with the same indicators. Implied effects for each of the four investor groups, non-US domestic, non-US foreign, US domestic, and US foreign, are reported below the interaction terms. Variable definitions are provided in Table 2. All regressions include a constant, and the same accounting controls as in Table 3, and are weighted by assets under management, lagged one quarter. Columns (1) and (4) include quarter/year fixed effects; columns (2) and (5) additionally include institution-by-quarter/year fixed effects; columns (3) and (6) replace quarter/year with institution-by-firm fixed effects. Standard errors are double-clustered at the institution and quarter/year level. Robust t-statistics are presented in parentheses. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Ln. Portfolio Share	(1)	(2)	(3)	(4)	(5)	(6)
Δ Water Levels HQ	1.997**	5.501***	2.636***			
	(2.305)	(3.263)	(3.314)			
Foreign	-2.204***	-2.477***		-2.342***	-2.782***	
	(-14.14)	(-10.27)		(-13.75)	(-9.633)	
US Inv.	-0.6687***			-0.6672***		
	(-4.480)			(-4.404)		
Foreign × US Inv.	-0.3485	-0.1086		-0.3309	0.0463	
	(-1.037)	(-0.3027)		(-1.049)	(0.1233)	
Δ Water Levels HQ × Foreign	-0.9228	-4.368**	-2.537***			
	(-0.9732)	(-2.567)	(-3.171)			
Δ Water Levels HQ × US Inv.	-1.951**	-5.442***	-3.403***			
	(-2.289)	(-3.244)	(-3.938)			
Δ Water Levels HQ × Foreign × US Inv.	1.706*	5.146***	3.620***			
	(1.791)	(3.031)	(3.886)			
Δ Water Levels Assets				0.3188	1.966**	0.8703
				(0.5562)	(2.112)	(1.487)
Δ Water Levels Assets × Foreign				-0.7476	-2.425**	-0.6595
				(-0.9952)	(-2.442)	(-1.047)
Δ Water Levels Assets × US Inv.				0.4645	-1.172	-0.7877
				(0.8354)	(-1.263)	(-1.269)
Δ Water Levels Assets × Foreign × US Inv.				0.1594	1.789*	0.0852
				(0.2121)	(1.825)	(0.1191)
Implied effect by group						
Non-US, Domestic	1.9972**	5.5007***	2.6355***	0.3188	1.9657**	0.8703
	(2.31)	(3.26)	(3.31)	(0.56)	(2.11)	(1.49)
Non-US, Foreign	1.0744**	1.1323***	0.0988	-0.4288	-0.4591	0.2108
	(2.45)	(2.64)	(0.62)	(-1.18)	(-1.35)	(0.78)
US, Domestic	0.0458	0.0584	-0.7674***	0.7834***	0.7937***	0.0827
	(0.31)	(0.44)	(-2.87)	(3.59)	(3.74)	(0.37)
US, Foreign	0.8291***	0.8362***	0.3157	0.1952	0.1581	-0.4917**
	(5.58)	(5.10)	(1.46)	(0.58)	(0.54)	(-2.45)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Quarter/Year	Yes	Yes		Yes	Yes	
Institution x Quarter/Year		Yes	Yes		Yes	Yes
Institution x Firm			Yes			Yes
Observations	23,946,393	23,945,295	23,697,111	6,159,937	6,151,871	6,102,645
R^2	0.51919	0.59421	0.86682	0.56890	0.64694	0.88184

investors' domestic holdings are significant only in specification (5), 1.97. US investors' domestic holdings are significant in specifications (4) and (5), 0.78 to 0.79, but not in specification (6); US investors' foreign holdings are significant only in specification (6), -0.49. Unlike headquarters, which by construction is always a domestic investor's home country, asset locations can be anywhere in the world and are not by definition domestic or foreign to any specific investor. Theory therefore gives a much weaker prediction of which investor group should respond most strongly at asset locations, and the absence of a clean pattern here is consistent with that weaker prediction, not evidence against the mechanism confirmed at headquarters. θ_I^ℓ varies across a firm's individual asset locations, and the aggregate measure used here does not distinguish them. Disaggregating asset locations by whether they coincide with a given investor's home country, as discussed in Section 4.1, would provide a more precise test of this mechanism.

Table 13 reports the corresponding results for inclusion, and the domestic-foreign gap already documented for portfolio share appears here too, more pronounced. In specifications (1) and (2), non-US investors' domestic holdings coefficients are 6.7 to 7.7 times larger than those for non-US investors' foreign holdings, compared with 1.9 to 4.9 times for portfolio share. A one-standard-deviation decrease in headquarters water levels is associated with a 2.8 to 3.5 percentage point decrease in the probability of inclusion for non-US investors' domestic holdings, a 4.1 to 5.2 percent decrease relative to the mean inclusion rate of 68.1 percent, a meaningful adjustment; as with portfolio share, this holds in the cross-sectional comparison, though it does not hold in the time-series comparison of specification (3). The table also shows two further headquarters patterns. US investors' foreign holdings are significant across all three specifications, 0.5 to 0.6 percentage points, the only group and construct combination associated with headquarters water levels in both the cross-sectional and time-series comparison. US investors' domestic holdings are not significant in any specification; portfolio share showed the same null result in the cross-sectional comparison but reversed sign in the time-series comparison, a reversal inclusion does not show.

At asset locations, inclusion shows a similarly inconsistent pattern to portfolio share, though not an identical one. Non-US investors' domestic holdings are significant in specifications (4) and (6), 0.35 and 0.19, but not in specification (5); US investors' domestic and foreign holdings are each significant in one specification only, with mixed signs across the table. As with portfolio share, theory does not give a strong prediction of which investor group should respond most strongly at asset locations, where a firm's assets are not by definition domestic or foreign to any specific investor, and the results here do not support a clear interpretation.

Predictions 1 and 2 are supported by both margins, each strongest along a different dimension. Portfolio share is the more robust indicator of the non-US domestic effect at headquarters, holding in both the cross-sectional and time-series comparison, where inclusion holds only in the cross-sectional comparison. Inclusion, in turn, shows a sharper domestic-foreign asymmetry, and, unlike portfolio share, no reversal for US investors' domestic holdings in the time-series comparison. Read together, the two margins corroborate the same main finding from different angles.

Water Stress

Table 14 reports water stress interacted with foreign and US-domiciled status for portfolio share. Non-US investors' domestic holdings are significant in every specification, including specification

Table 13: Portfolio Inclusion and Δ Water Levels: Foreign and US Investor Status

This table reports regressions of portfolio inclusion on Δ*Water Levels HQ* (columns 1–3), interacted with indicators for foreign and US-domiciled investor status, and on Δ*Water Levels Assets* (columns 4–6), interacted with the same indicators. Implied effects for each of the four investor groups, non-US domestic, non-US foreign, US domestic, and US foreign, are reported below the interaction terms. Variable definitions are provided in Table 2. All regressions include a constant, and the same accounting controls as in Table 3, and are weighted by assets under management, lagged one quarter. Columns (1) and (4) include quarter/year fixed effects; columns (2) and (5) additionally include institution-by-quarter/year fixed effects; columns (3) and (6) replace quarter/year with institution-by-firm fixed effects. Standard errors are double-clustered at the institution and quarter/year level. Robust t-statistics are presented in parentheses. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Inclusion	(1)	(2)	(3)	(4)	(5)	(6)
Δ Water Levels HQ	0.5169***	0.4114***	0.1025			
	(6.182)	(5.551)	(1.164)			
Foreign	-0.0923***	-0.1157***		-0.0890***	-0.1014***	
	(-5.856)	(-9.265)		(-5.244)	(-10.67)	
US Inv.	0.0295			0.0129		
	(1.160)			(0.5731)		
Foreign × US Inv.	0.0168	-0.0134		0.0323	-0.0035	
	(0.8053)	(-0.6963)		(1.424)	(-0.1839)	
Δ Water Levels HQ × Foreign	-0.4496***	-0.3495***	-0.1156			
	(-5.242)	(-4.823)	(-1.265)			
Δ Water Levels HQ × US Inv.	-0.5225***	-0.4098***	-0.1513			
	(-6.217)	(-5.427)	(-1.538)			
Δ Water Levels HQ × Foreign × US Inv.	0.5469***	0.4424***	0.2336**			
	(6.204)	(5.845)	(2.131)			
Δ Water Levels Assets				0.3506***	0.0614	0.1877***
				(5.955)	(1.072)	(2.788)
Δ Water Levels Assets × Foreign				-0.3666***	-0.0806	-0.3368***
				(-5.522)	(-1.393)	(-3.930)
Δ Water Levels Assets × US Inv.				-0.3377***	-0.0308	-0.2825***
				(-5.446)	(-0.5034)	(-3.361)
Δ Water Levels Assets × Foreign × US Inv.				0.3970***	0.0781	0.4058***
				(3.975)	(0.8162)	(3.786)
Implied effect by group						
Non-US, Domestic	0.5169***	0.4114***	0.1025	0.3506***	0.0614	0.1877***
	(6.18)	(5.55)	(1.16)	(5.95)	(1.07)	(2.79)
Non-US, Foreign	0.0673***	0.0619***	-0.0131	-0.0160	-0.0192	-0.1491***
	(5.01)	(3.45)	(-0.48)	(-0.66)	(-0.76)	(-2.93)
US, Domestic	-0.0056	0.0016	-0.0487	0.0129	0.0306	-0.0949**
	(-0.35)	(0.12)	(-1.12)	(0.66)	(1.47)	(-2.27)
US, Foreign	0.0917***	0.0945***	0.0692***	0.0433	0.0281	-0.0258
	(6.05)	(6.47)	(3.31)	(0.82)	(0.52)	(-0.43)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Quarter/Year	Yes	Yes		Yes	Yes	
Institution x Quarter/Year		Yes	Yes		Yes	Yes
Institution x Firm			Yes			Yes
Observations	30,822,681	30,822,119	30,739,367	7,465,828	7,461,865	7,443,602
R^2	0.04335	0.21158	0.52836	0.04481	0.21461	0.53015

(3), the time-series comparison. A one-standard-deviation increase in headquarters water stress is associated with a 0.11 to 0.19 percentage point decrease in portfolio share. Relative to the mean domestic position of 0.74 percent of assets under management that amounts to a 15.3 to 25.9 percent decrease in relative terms. The persistence of the association across the cross-sectional and

Table 14: Portfolio Share and Water Stress: Foreign and US Investor Status

This table reports regressions of portfolio share on *Water Stress HQ* (columns 1–3), interacted with indicators for foreign and US-domiciled investor status, and on *Water Stress Assets* (columns 4–6), interacted with the same indicators. Implied effects for each of the four investor groups, non-US domestic, non-US foreign, US domestic, and US foreign, are reported below the interaction terms. Variable definitions are provided in Table 2. All regressions include a constant, and the same accounting controls as in Table 3, and are weighted by assets under management, lagged one quarter. Columns (1) and (4) include quarter/year fixed effects; columns (2) and (5) additionally include institution-by-quarter/year fixed effects; columns (3) and (6) replace quarter/year with institution-by-firm fixed effects. Standard errors are double-clustered at the institution and quarter/year level. Robust t-statistics are presented in parentheses. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Ln. Portfolio Share	(1)	(2)	(3)	(4)	(5)	(6)
Water Stress HQ	-0.1655***	-0.2269***	-0.1257***			
	(-4.695)	(-5.513)	(-4.589)			
Foreign	-2.145***	-2.413***		-2.367***	-2.843***	
	(-13.01)	(-9.116)		(-14.95)	(-9.317)	
US Inv.	-0.5018***			-0.6499***		
	(-2.894)			(-3.960)		
Foreign × US Inv.	-0.4935	-0.3079		-0.2970	0.0834	
	(-1.450)	(-0.8256)		(-0.9552)	(0.2146)	
Water Stress HQ × Foreign	0.0222	0.0801*	0.1279***			
	(0.5073)	(1.889)	(4.590)			
Water Stress HQ × US Inv.	0.1906***	0.2521***	0.1283***			
	(4.725)	(5.201)	(4.168)			
Water Stress HQ × Foreign × US Inv.	-0.1794***	-0.2372***	-0.1353***			
	(-3.313)	(-4.237)	(-4.304)			
Water Stress Assets				-0.0975**	-0.1073***	-0.0126
				(-2.126)	(-3.129)	(-0.5462)
Water Stress Assets × Foreign				0.0116	0.0256	-0.0057
				(0.2168)	(0.6793)	(-0.2928)
Water Stress Assets × US Inv.				0.0424	0.0503	0.0023
				(0.9137)	(1.409)	(0.0885)
Water Stress Assets × Foreign × US Inv.				-0.0813	-0.0944*	0.0476*
				(-1.274)	(-1.952)	(1.857)
Implied effect by group						
Non-US, Domestic	-0.1655***	-0.2269***	-0.1257***	-0.0975**	-0.1073***	-0.0126
	(-4.69)	(-5.51)	(-4.59)	(-2.13)	(-3.13)	(-0.55)
Non-US, Foreign	-0.1433***	-0.1469***	0.0023	-0.0859***	-0.0817***	-0.0183
	(-5.12)	(-5.92)	(0.23)	(-3.92)	(-4.35)	(-1.24)
US, Domestic	0.0251	0.0252	0.0026	-0.0551***	-0.0571***	-0.0103
	(1.48)	(1.41)	(0.22)	(-4.93)	(-5.34)	(-0.73)
US, Foreign	-0.1321***	-0.1320***	-0.0048	-0.1248***	-0.1258***	0.0315**
	(-6.43)	(-6.64)	(-0.43)	(-4.29)	(-4.70)	(2.34)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Quarter/Year	Yes	Yes		Yes	Yes	
Institution x Quarter/Year		Yes	Yes		Yes	Yes
Institution x Firm			Yes			Yes
Observations	17,365,917	17,362,513	17,187,720	5,048,949	5,038,497	4,997,722
R^2	0.52303	0.61027	0.87931	0.56346	0.65242	0.88868

time-series specifications is the clearest evidence in the paper that the association reflects a firm's own contribution to local conditions, not merely its exposure to them, as measured by water level changes.

Non-US investors' foreign holdings and US investors' foreign holdings both show a similar, smaller pattern in the cross-sectional comparison, specifications (1) and (2), consistent with a weaker but not absent exposure channel for foreign investors; neither holds in the time-series comparison. US investors' domestic holdings show no association with headquarters water stress in any specification. Both the aggregate domestic effect itself and the domestic-foreign split are therefore concentrated among non-US investors.

Returning to the decision rule in Equation (5), the absence of a domestic effect among US investors is consistent with the same rule that produces a positive effect elsewhere, provided the balance of costs and benefits of tilting and divestment differ by domicile. One candidate explanation is that, for US investors, the firms driving domestic water withdrawal are themselves large, high-return domestic holdings, raising $c(\Delta Inv_{a_1})$, the costs of changing investments, for the specific holding that would need to be reduced. Reducing or exiting this position means giving up the returns that firm currently generates within the portfolio; the value protected by doing so depends on $\theta_I^\ell \cdot \text{TotalCost}_{a_1,\ell}$ in Equation (3), the benefit to the investor's other holdings near location ℓ from a reduced draw on the shared reserve. If the returns given up by reducing the position in the water-intensive firm exceed the value protected in these other holdings, remaining invested is the financially rational choice, not a failure to respond to water risk. A related possibility, not incorporated into the model as specified, is that the cost of engaging with management directly is lower for US investors' domestic holdings than the cost of adjusting a position, making engagement rather than divestment or tilting the relevant margin.

At asset locations, non-US investors' domestic and foreign holdings are both significant in specifications (4) and (5), 0.08 to 0.10 percentage points, a much smaller domestic-foreign gap than at headquarters. For US investors, foreign holdings are significant and larger than domestic holdings in the same two specifications, the reverse of the non-US ordering.

Table 15 reports water stress interacted with foreign and US-domiciled status for inclusion. Non-US investors show a markedly clean domestic-foreign split. Domestic holdings are significantly negative in specifications (1) and (2), a one-standard-deviation increase in headquarters water stress associated with a 2.1 to 2.4 percentage point decrease in the probability of inclusion, 3.0 to 3.5 percent relative to the mean inclusion rate of 68.1 percent; foreign holdings show no association at all, statistically indistinguishable from zero in every specification. Unlike in the portfolio share regressions, the association does not hold in specification (3), the time-series specification.

A similar domestic-foreign split holds for US investors in specifications (1) and (2). US investors' domestic holdings are significantly negative in both specifications, 0.7 to 0.8 percentage points; US investors' foreign holdings are smaller and weaker, not significant in specification (1) and only

Table 15: Portfolio Inclusion and Water Stress: Foreign and US Investor Status

This table reports regressions of portfolio inclusion on *Water Stress HQ* (columns 1–3), interacted with indicators for foreign and US-domiciled investor status, and on *Water Stress Assets* (columns 4–6), interacted with the same indicators. Implied effects for each of the four investor groups, non-US domestic, non-US foreign, US domestic, and US foreign, are reported below the interaction terms. Variable definitions are provided in Table 2. All regressions include a constant, and the same accounting controls as in Table 3, and are weighted by assets under management, lagged one quarter. Columns (1) and (4) include quarter/year fixed effects; columns (2) and (5) additionally include institution-by-quarter/year fixed effects; columns (3) and (6) replace quarter/year with institution-by-firm fixed effects. Standard errors are double-clustered at the institution and quarter/year level. Robust t-statistics are presented in parentheses. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Inclusion	(1)	(2)	(3)	(4)	(5)	(6)
Water Stress HQ	-0.0178***	-0.0157***	-0.0061			
	(-4.605)	(-3.597)	(-1.622)			
Foreign	-0.0934***	-0.1106***		-0.1062***	-0.1006***	
	(-5.417)	(-8.448)		(-5.897)	(-11.09)	
US Inv.	0.0220			-0.0088		
	(0.8982)			(-0.3742)		
Ln. Total Water Use	0.0019*	0.0033***	0.0006	-0.0010	-0.0003	-0.0012
	(1.905)	(3.176)	(0.4681)	(-0.8321)	(-0.2349)	(-0.9912)
Foreign × US Inv.	0.0219	-0.0153		0.0513**	-0.0034	
	(0.9608)	(-0.7102)		(2.161)	(-0.1764)	
Water Stress HQ × Foreign	0.0176***	0.0153***	0.0049			
	(4.495)	(4.473)	(1.244)			
Water Stress HQ × US Inv.	0.0125**	0.0100*	0.0115**			
	(2.744)	(1.958)	(2.487)			
Water Stress HQ × Foreign × US Inv.	-0.0145**	-0.0137**	-0.0166***			
	(-2.685)	(-2.706)	(-3.312)			
Water Stress Assets				-0.0103***	-0.0009	-0.0039
				(-3.843)	(-0.3360)	(-1.004)
Water Stress Assets × Foreign				0.0116***	0.0020	0.0055
				(4.487)	(0.8184)	(1.335)
Water Stress Assets × US Inv.				0.0091***	-0.0021	0.0064
				(3.068)	(-0.7116)	(1.411)
Water Stress Assets × Foreign × US Inv.				-0.0084**	0.0021	-0.0073
				(-2.115)	(0.6278)	(-1.422)
Implied effect by group						
Non-US, Domestic	-0.0178***	-0.0157***	-0.0061	-0.0103***	-0.0009	-0.0039
	(-4.61)	(-3.60)	(-1.62)	(-3.84)	(-0.34)	(-1.00)
Non-US, Foreign	-0.0002	-0.0004	-0.0012	0.0013	0.0011	0.0016
	(-0.09)	(-0.14)	(-0.88)	(0.70)	(0.53)	(0.71)
US, Domestic	-0.0053***	-0.0057***	0.0054**	-0.0011	-0.0030***	0.0026
	(-2.96)	(-3.45)	(2.52)	(-1.33)	(-4.35)	(1.23)
US, Foreign	-0.0021	-0.0041*	-0.0063***	0.0020	0.0011	0.0007
	(-0.94)	(-1.95)	(-4.03)	(0.73)	(0.46)	(0.31)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Quarter/Year	Yes	Yes		Yes	Yes	
Institution x Quarter/Year		Yes	Yes		Yes	Yes
Institution x Firm			Yes			Yes
Observations	23,639,434	23,638,573	23,576,920	6,446,795	6,442,219	6,426,488
R^2	0.04356	0.21871	0.54900	0.03932	0.22052	0.53914

marginally significant in specification (2), 0.5 percentage points. Overall, the effect sizes are smaller than for non-US investors, consistent with non-US investors driving the overall result. Specification (3) reverses sign for US investors' domestic holdings, significant and positive, 0.7 percentage points, an increase in inclusion where the association is negative elsewhere.

At asset locations, non-US investors' domestic holdings are significant only in specification (4), 1.4 percentage points; US investors' domestic holdings are significant only in specification (5), 0.4 percentage points. No other group is significant at asset locations.

Water Use

Table 16 reports direct water use interacted with foreign and US-domiciled status for portfolio share. Non-US investors' domestic holdings are negatively associated with direct water use in five of six specifications, not significant only in specification (3). Non-US investors' foreign holdings show a very similar effect, also significant in the same five specifications; in no specification is the difference between the two groups significantly different from zero. There is no domestic-foreign split. This is in line with theory: the location-specific externality channel formalized in Equation (3), on which Predictions 1 and 2 rest, requires information on whether water binds a firm's production; water use alone does not provide this, so no domicile-specific asymmetry in this channel is predicted, and none is found.

US investors' foreign holdings show a qualitatively identical pattern, significant in the same five specifications and of similar magnitude to the non-US groups. US investors' domestic holdings are the one partial exception: consistently significant, with the correct sign, when controlling for total water use, specifications (4) through (6), but not when controlling for indirect water use, specifications (1) and (2), and smaller in magnitude than US investors' foreign holdings throughout. Across all four groups, none shows the domestic-dominant pattern found for water levels and water stress; this absence is itself the theoretically predicted result.

A statistically and economically significant association nonetheless exists, albeit independent of investor domicile. This could indicate transition risk, exposure to regulation, litigation, and reputational cost tied to a firm's water use, which typically operates at the firm level. The model in Section 2 does not capture this channel: it formalizes a physical risk channel instead, location-specific because it is tied to the state of a shared local reserve.

Table 17 reports direct water use interacted with foreign and US-domiciled status for inclusion. While the raw coefficients show a small statistical difference between non-US investors' domestic and foreign holdings, this resolves into null implied effects for both in specifications (1), (2), (4), and (5); the exception is specifications (3) and (6), the time-series comparison, where both groups are significantly negative, domestic roughly three times larger than foreign. These implied effects are the near-exact complement of the pattern found for portfolio share: strong where share is weak and weak where share is strong. Portfolio share's association appears to reflect a cross-sectional

Table 16: Portfolio Share and Water Use: Foreign and US Investor Status

This table reports regressions of portfolio share on *Ln. Direct Water Use*, interacted with indicators for foreign and US-domiciled investor status. Implied effects for each of the four investor groups, non-US domestic, non-US foreign, US domestic, and US foreign, are reported below the interaction terms. Variable definitions are provided in Table 2. All regressions include a constant, and the same accounting controls as in Table 3, and are weighted by assets under management, lagged one quarter. Columns (1) and (4) include quarter/year fixed effects; columns (2) and (5) additionally include institution-by-quarter/year fixed effects; columns (3) and (6) replace quarter/year with institution-by-firm fixed effects. Standard errors are double-clustered at the institution and quarter/year level. Robust t-statistics are presented in parentheses. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Ln. Portfolio Share	(1)	(2)	(3)	(4)	(5)	(6)
Ln. Direct Water Use	-0.0579***	-0.0561***	-0.0035	-0.0879***	-0.0867***	-0.0158*
	(-3.688)	(-3.916)	(-0.4291)	(-5.164)	(-5.524)	(-1.979)
Ln. Indirect Water Use	0.1234***	0.1257***	0.1589***			
	(14.87)	(15.10)	(12.92)			
Ln. Total Water Use				0.1431***	0.1459***	0.1224***
				(12.55)	(13.19)	(11.10)
Foreign	-1.991***	-2.170***		-1.928***	-2.103***	
	(-7.152)	(-7.484)		(-6.805)	(-7.314)	
US Inv.	-1.460***			-1.385***		
	(-4.469)			(-4.192)		
Foreign × US Inv.	0.6830	0.7210		0.5612	0.5945	
	(1.175)	(1.291)		(0.9538)	(1.059)	
Ln. Direct Water Use × Foreign	-0.0092	-0.0135	0.0058	-0.0134	-0.0178	0.0002
	(-0.5606)	(-0.9329)	(0.6525)	(-0.7752)	(-1.155)	(0.0229)
Ln. Direct Water Use × US Inv.	0.0681***	0.0672***	-0.0067	0.0627***	0.0616**	-0.0082
	(3.221)	(2.964)	(-0.6596)	(2.895)	(2.653)	(-0.8425)
Ln. Direct Water Use × Foreign × US Inv.	-0.0856***	-0.0768***	-0.0015	-0.0768***	-0.0678**	0.0022
	(-3.355)	(-3.036)	(-0.1223)	(-2.910)	(-2.590)	(0.1804)
Implied effect by group						
Non-US, Domestic	-0.0579***	-0.0561***	-0.0035	-0.0879***	-0.0867***	-0.0158**
	(-3.69)	(-3.92)	(-0.43)	(-5.16)	(-5.52)	(-1.98)
Non-US, Foreign	-0.0670***	-0.0696***	0.0023	-0.1013***	-0.1045***	-0.0156***
	(-5.33)	(-6.40)	(0.72)	(-7.66)	(-8.96)	(-3.78)
US, Domestic	0.0102	0.0112	-0.0101*	-0.0253**	-0.0251**	-0.0240***
	(0.80)	(0.79)	(-1.71)	(-2.16)	(-1.97)	(-3.86)
US, Foreign	-0.0845***	-0.0792***	-0.0058	-0.1154***	-0.1107***	-0.0216***
	(-5.04)	(-5.13)	(-1.44)	(-7.28)	(-7.43)	(-5.48)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Quarter/Year	Yes	Yes		Yes	Yes	
Institution x Quarter/Year		Yes	Yes		Yes	Yes
Institution x Firm			Yes			Yes
Observations	21,480,382	21,476,050	21,314,618	21,480,382	21,476,050	21,314,618
R^2	0.52322	0.61065	0.87460	0.52256	0.60998	0.87451

pattern, whereas inclusion appears to reflect a within-relationship, time-varying response. US investors' domestic holdings differ from this pattern: significant in every specification, of similar magnitude throughout, roughly 0.004. US investors' foreign holdings show almost no association at all, significant only marginally in specification (6) and not in any other. This is also a complement to the pattern found for portfolio share, though a different kind of complement than the one found for non-US investors. In the share results, US investors' foreign holdings were the more robust group and US investors' domestic holdings the partial exception; here, the reverse holds. Taking

Table 17: Portfolio Inclusion and Water Use: Foreign and US Investor Status

This table reports regressions of portfolio inclusion on *Ln. Direct Water Use*, interacted with indicators for foreign and US-domiciled investor status. Implied effects for each of the four investor groups, non-US domestic, non-US foreign, US domestic, and US foreign, are reported below the interaction terms. Variable definitions are provided in Table 2. All regressions include a constant, and the same accounting controls as in Table 3, and are weighted by assets under management, lagged one quarter. Columns (1) and (4) include quarter/year fixed effects; columns (2) and (5) additionally include institution-by-quarter/year fixed effects; columns (3) and (6) replace quarter/year with institution-by-firm fixed effects. Standard errors are double-clustered at the institution and quarter/year level. Robust t-statistics are presented in parentheses. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Inclusion	(1)	(2)	(3)	(4)	(5)	(6)
Ln. Direct Water Use	-0.0005	-0.0027	-0.0053***	-0.0008	-0.0036	-0.0058***
	(-0.3607)	(-1.325)	(-4.792)	(-0.4993)	(-1.642)	(-5.089)
Ln. Indirect Water Use	0.0016*	0.0041***	0.0059***			
	(1.982)	(4.310)	(2.991)			
Ln. Total Water Use				0.0015	0.0045***	0.0045***
				(1.484)	(3.697)	(2.713)
Foreign	-0.1389***	-0.1819***		-0.1386***	-0.1808***	
	(-3.854)	(-4.961)		(-3.870)	(-4.997)	
US Inv.	0.0677			0.0677		
	(1.356)			(1.365)		
Foreign × US Inv.	0.0035	0.0135		0.0030	0.0113	
	(0.0794)	(0.3265)		(0.0696)	(0.2774)	
Ln. Direct Water Use × Foreign	0.0031**	0.0049***	0.0039***	0.0031**	0.0049***	0.0037***
	(2.211)	(2.872)	(3.123)	(2.219)	(2.891)	(2.982)
Ln. Direct Water Use × US Inv.	-0.0031	-0.0012	0.0010	-0.0031	-0.0013	0.0010
	(-1.486)	(-0.4739)	(0.7357)	(-1.505)	(-0.5149)	(0.7283)
Ln. Direct Water Use × Foreign × US Inv.	0.0013	-0.0021	-0.0001	0.0013	-0.0019	-3.93×10^{-5}
	(0.4820)	(-0.7748)	(-0.0729)	(0.5018)	(-0.7293)	(-0.0232)
Implied effect by group						
Non-US, Domestic	-0.0005	-0.0027	-0.0053***	-0.0008	-0.0036	-0.0058***
	(-0.36)	(-1.33)	(-4.79)	(-0.50)	(-1.64)	(-5.09)
Non-US, Foreign	0.0026*	0.0022	-0.0014**	0.0023	0.0012	-0.0021***
	(1.95)	(1.32)	(-2.43)	(1.63)	(0.66)	(-2.98)
US, Domestic	-0.0036***	-0.0040***	-0.0043***	-0.0039***	-0.0049***	-0.0048***
	(-3.39)	(-4.54)	(-6.36)	(-3.86)	(-6.44)	(-5.75)
US, Foreign	0.0008	-0.0011	-0.0006	0.0005	-0.0020	-0.0011**
	(0.53)	(-0.78)	(-1.11)	(0.35)	(-1.28)	(-2.12)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Quarter/Year	Yes	Yes		Yes	Yes	
Institution x Quarter/Year		Yes	Yes		Yes	Yes
Institution x Firm			Yes			Yes
Observations	28,753,989	28,752,939	28,703,451	28,753,989	28,752,939	28,703,451
R^2	0.04261	0.21889	0.53173	0.04260	0.21883	0.53172

portfolio share and inclusion together, water use produces no meaningful domestic-foreign split for either group, in contrast to water levels and water stress. For non-US investors, a small, economically negligible residual remains in inclusion: domestic falls roughly 1.0 to 1.1 percentage points more than foreign. For US investors, the two margins offset almost exactly, consistent with no net domicile split.

At headquarters, the investor-level results are consistent across all three water measures with the pattern documented at the firm level; at asset locations, they are noisier, consistent with the weaker theoretical prediction there. The investor-level results also show which investors and margins account for the effects found. Non-US domestic investors drive the headquarters association for both water levels and water stress. Declining water levels are associated with smaller portfolio shares (the intensive margin) among non-US domestic holdings, both across firms within a given investor's portfolio and within a specific investor's holding of the same firm over time; inclusion (the extensive margin) shows the same association across firms within a portfolio, but not within a specific holding over time. Water stress, which incorporates a firm's own contribution to these conditions rather than exposure to them alone, shows the same pattern: portfolio share is associated with water stress both across firms within a portfolio and within a specific holding over time, while inclusion is associated with it only across firms within a portfolio. Water use, evaluated independent of local conditions, shows a persistent association with both margins, but one that does not differ by domicile, consistent with a firm-level transition risk distinct from the physical risk this paper's model formalizes.

A US-specific pattern recurs across all three measures: US domestic holdings show no association with headquarters water levels or water stress, in contrast to the robust non-US domestic result, and this null result is not itself explained by the model as specified. Two candidate explanations, that these are large, high-return holdings for which the cost of divestment exceeds the value protected elsewhere in the portfolio, or that engaging directly with management is lower-cost than divestment for these investors, are offered but not tested directly.

5. Conclusion

This paper documents a not-in-my-backyard effect in portfolio choice, in which institutional investors tilt away from firms contributing to resource constraints in the economies to which they are most exposed. Indeed, I find that domestic institutional holdings are specifically lower for firms that contribute to local water scarcity at headquarters locations, while a comparable association for foreign ownership is absent. This domestic-foreign difference is difficult to reconcile with uniform risk pricing, which would predict an equal response regardless of domicile. The reduction in domestic ownership reflects both a decline in portfolio share and full exclusion, tilting and divesting alike, and is stable across horizons of up to fifteen years, making it difficult to reconcile with a transitory shock or an informational advantage among domestic investors. The effect is most pronounced among investors domiciled outside the United States.

Three measures of water scarcity underlie this analysis: satellite-derived water levels, firm-level water use, and a self-constructed measure of water stress combining the two. Water levels and water stress map onto two distinct components of the model developed in Section 2. Water levels captures an investor's exposure to water conditions at a given location. I find that domestic ownership falls as water levels decline at a firm's headquarters, consistent with the model's decision rule. Water stress, which combines a firm's own water use with local water levels, captures a firm's own contribution to depleting a shared reserve, and the cost that contribution imposes on itself and other firms sharing the reserve, rather than an investor's mere exposure to already-scarce conditions. Water stress forms the most precise test of the not-in-my-backyard incentive and produces robust results: the domestic-foreign asymmetry holds not only across firms within a given investor's portfolio, but also within a specific investor's holding of a specific firm over time, as that firm's own conditions change. Water use alone, evaluated independent of local conditions, isolates the case in which the model predicts no domicile-specific pattern, and none is found. A firm's water use alone reveals nothing about whether water binds its production. A robust, domicile-independent association with water use nonetheless remains, more consistent with a firm-level transition risk than with the physical, local risk this paper's model formalizes.

These findings contribute to the literature on portfolio allocation under risk, and on the home bias in particular. It studies a risk not yet considered in that literature: physical and local, arising from increasing resource scarcity, to which investors have financially rational reasons to respond given their own disproportionate exposure to it. The not-in-my-backyard incentive and the conceptual framework introduced here extend to any resource that is geographically bound, jointly used, and capable of binding production, such as biodiversity, arable land, or local energy grids. As resource constraints become more binding globally, understanding how investors respond to firms' own contribution to locally shared scarcity remains an important direction for future research.

References

Alok, S., Kumar, N., and Wermers, R. (2020, 3). Do Fund Managers Misestimate Climatic Disaster Risk? *The Review of Financial Studies*, *33*(3), 1146–1183.

Alves, R., De Waal, T., Hagens, M., Ten Bosch, E., and Van Dijk, M. (2025). Thirsty for Returns? The Impact of Water Risk on the Global Stock Market.

Barbiroglio, E. (2021, 5). *No Water No Microchips: What Is Happening In Taiwan?* Retrieved from https://www.forbes.com/sites/emanuelabarbiroglio/2021/05/31/no-water-no-microchips-what-is-happening-in-taiwan/

Bernstein, A., Gustafson, M. T., and Lewis, R. (2019, 11). Disaster on the horizon: The price effect of sea level rise. *Journal of Financial Economics*, *134*(2), 253–272. doi: 10.1016/j.jfineco.2019.03.013

Bloomberg. (2023, 9). *Fund Managers See Water Risk in Semiconductor Bets Being Mispriced.* Retrieved from https://www.bloomberg.com/news/articles/2023-09-12/fund-managers-see-growing-risk-semiconductor-bets-are-mispriced

Boermans, M. A., and Galema, R. (2025). Carbon home bias of European investors. *Journal of Corporate Finance*, *92*.

Bolton, P., Eskildsen, M., and Kacperczyk, M. (2024). Carbon Home Bias. *SSRN Work. Pap*, *4708844*.

Chaieb, I., Errunza, V., and Lu, L. Y. (2024). Sustainable Investing Home and Abroad. *Swiss Finance Institute Research Paper*, 24–71.

Chan, K., Covrig, V., and Ng, L. (2005, 6). What determines the domestic bias and foreign bias? Evidence from mutual fund equity allocations worldwide. *Journal of Finance*, *60*(3), 1495–1534.

Crook, S. (2023, 4). *After 25 Years, Cost of Water Rises.* Retrieved from https://topics.amcham.com.tw/2023/04/after-25-years-cost-of-water-rises/

Dasgupta, S., Huynh, T. D., and Xia, Y. (2023, 9). Joining Forces: The Spillover Effects of EPA Enforcement Actions and the Role of Socially Responsible Investors. *Review of Financial Studies*, *36*(9), 3781–3824.

Fama, E. F., and French, K. R. (1992). The Cross-Section of Expected Stock Returns. *The Journal of Finance*, *47*(2), 427–465.

Ferreira, M. A., and Matos, P. (2008, 6). The colors of investors' money: The role of institutional investors around the world. *Journal of Financial Economics*, *88*(3), 499–533.

Food and Agricultural Organization of the United Nations. (2022, 5). *The State of the World's Land and Water Resources for Food and Agriculture 2021 – Systems at break-*

ing point (Tech. Rep.). Rome: Food and Agricultural Organization of the United Nations. doi: 10.4060/cb9910en

French, K. R., and Poterba, J. M. (1991). Investor Diversification and International Equity Markets. *The American Economic Review*, *81*(2), 222–226.

Gerasimova, N., and Rohrer, M. (2023). Not by whom but where: ESG events, place attachment, and firm value. Retrieved from https://ssrn.com/abstract=4121755

Global Commission on the Economics of Water. (2024). *The Economics of Water* (Tech. Rep.).

Gordon, H. S. (1954). The Economic Theory of a Common Property Resource: The Fishery. *Journal of Political Economy*, *62*(2).

Hardin, G. (1968, 12). The Tragedy of the Commons. *Science*, *162*. Retrieved from http://science.sciencemag.org/

Hong, H., Li, F. W., and Xu, J. (2019, 1). Climate risks and market efficiency. *Journal of Econometrics*, *208*(1), 265–281. doi: 10.1016/j.jeconom.2018.09.015

Huynh, T. D., Li, F. W., and Xia, Y. (2025, 9). Something in the air: does air pollution affect fund managers' carbon divestment? *Review of Accounting Studies*, *30*(3), 2607–2634. doi: 10.1007/s11142-025-09875-7

Kai-yuan Teng. (2022, 6). *How Taiwan's expanding semiconductor industry deals with water shortages.* Retrieved from https://english.cw.com.tw/article/article.action?id=3236

Karolyi, G. A., and Stulz, R. M. (2003). Are Financial Assets Priced Locally or Globally? *Handbook of the Economics of Finance*, 975–1020.

Koijen, R. S. J., and Yogo, M. (2019). A Demand System Approach to Asset Pricing. *Journal of Political Economy*, *127*(4).

Lai, O. (2022, 4). *The Taiwan Water Shortage Dilemma.* Retrieved from https://earth.org/the-taiwan-water-shortage-dilemma/

Leontief, W. W. (1941). *The Structure of American Economy, 1919-1929.* Cambridge, MA: Harvard University Press.

Lewis, K. K. (1999). Trying to Explain Home Bias in Equities and Consumption. *Journal of Economic Literature*, *37*, 571–608.

Lin, O., and Syngle, E. (2021, 6). *Taiwan Drought Results in Rice Area Reduction and Crop Loss* (Tech. Rep.). United States Department of Agriculture.

McCahery, J. A., Sautner, Z., and Starks, L. T. (2016, 12). Behind the Scenes: The Corporate Governance Preferences of Institutional Investors. *Journal of Finance*, *71*(6), 2905–2932. doi: 10.1111/jofi.12393

Narvaez, L., Janzen, S., Eberle, C., and Sebesvari, Z. (2021). *Taiwan drought - Interconnected*

Disaster Risks (Tech. Rep.). United Nations.

Painter, M. (2020, 2). An inconvenient cost: The effects of climate change on municipal bonds. *Journal of Financial Economics*, *135*(2), 468–482. doi: 10.1016/j.jfineco.2019.06.006

Provencher, B., and Burt, O. (1993). The Externalities Associated with the Common Property Exploitation of Groundwater. *Journal of Environmental Economics and Management*, *24*, 139–158.

S&P Global. (2024, 2). *Sustainability Insights: TSMC And Water: A Case Study Of How Climate Is Becoming A Credit-Risk Factor.* Retrieved from https://www.spglobal.com/ratings/en/regulatory/article/240226-sustainability-insights-tsmc-and-water-a-case-study-of-how-climate-is-becoming-a-credit-risk-factor-s12992283

Strong, C., Kuzma, S., Vionnet, S., and Reig, P. (2020, 1). *Achieving Abundance: Understanding the Cost of a Sustainable Water Future* (Tech. Rep.). World Resources Institute. Retrieved from www.wri.org/

Van Nieuwerburgh, S., and Veldkamp, L. (2009, 6). Information immobility and the home bias puzzle. *Journal of Finance*, *64*(3), 1187–1215.

World Bank Group. (2016). *High and Dry: Climate Change, Water, and the Economy* (Tech. Rep.). World Bank Group.

Zaveri, E., Damania, R., and Engle, N. (2023). *Droughts and Deficits: Summary Evidence of the Global Impact on Economic Growth* (Tech. Rep.). World Bank Group. Retrieved from www.worldbank.org/gwsp

Zhang, K. (2024, 9). *How Water Scarcity Threatens Taiwan's Semiconductor Industry.* Retrieved from https://thediplomat.com/2024/09/how-water-scarcity-threatens-taiwans-semiconductor-industry/

Zhao, M., Geruo, A., Velicogna, I., and Kimball, J. S. (2017). A Global Gridded Dataset of GRACE Drought Severity Index for 2002-14: Comparison with PDSI and SPEI and a Case Study of the Australia Millennium Drought. *Journal of Hydrometeorology*, *18*, 2117–2129. Retrieved from http://dx.doi.org/10.1175/JHM-D-16-0182.s1. doi: 10.1175/JHM-D-16-0182.s1

A. Formal Statement and Proofs

This appendix states the two core results of the conceptual framework in Section 2 as a lemma and a proposition, and proves each formally. The lemma, in Section A.2, establishes the divergence between private and social marginal cost underlying Section 2.2. The proposition, in Section A.3, establishes the geographic asymmetry behind Predictions 1 and 2 in Section 2.3.

A.1. Setup: The Total Cost of a Firm's Water Use

Equation (3) in Section 2.2 defines $\text{TotalCost}_{a_1,\ell}$, the total cost of a_1's water use at location ℓ, as the sum of the direct cost a_1 bears itself and the indirect cost borne by every other firm $j \in N_\ell \setminus \{1\}$ operating at the same location, where N_ℓ denotes the set of firms operating at ℓ. This notation, N_ℓ and $\text{TotalCost}_{a_1,\ell}$, is used throughout the lemma and proposition that follow.

A.2. Lemma: Private versus Social Marginal Cost

LEMMA 1: *Consider a location ℓ with $|N_\ell| = n_\ell \geq 2$ firms. Suppose $Cost_{a_j}(\cdot)$ is weakly decreasing in $W_{\ell,t+1}$ for every $j \in N_\ell \setminus \{1\}$, with $\partial\, Cost_{a_j}/\partial\, W_{\ell,t+1} < 0$ for at least one such j. Suppose further that $W_{\ell,t+1}$ is given by Equation (2), with $\partial\, W_{\ell,t+1}/\partial\, WU_{a_1,\ell,t} = -1$, reflecting that firm a_1 operates at ℓ. Then*

$$\frac{\partial\; TotalCost_{a_1,\ell}}{\partial\, WU_{a_1,\ell,t}} > \frac{\partial\; Cost_{a_1}}{\partial\, WU_{a_1,\ell,t}},$$

This gap is weakly increasing in n_ℓ: each additional firm sharing the commons at ℓ for which water is a binding constraint widens the gap, and each additional firm for which capital instead binds leaves the gap unchanged; in neither case can the gap between marginal social and marginal private cost narrow.

Proof. Differentiating Equation (3) with respect to $WU_{a_1,\ell,t}$ and applying the chain rule,

$$\frac{\partial\, \text{TotalCost}_{a_1,\ell}}{\partial\, WU_{a_1,\ell,t}} = \frac{\partial\, \text{Cost}_{a_1}}{\partial\, W_{\ell,t+1}} \cdot (-1) + \sum_{j \in N_\ell,\, j \neq 1} \frac{\partial\, \text{Cost}_{a_j}}{\partial\, W_{\ell,t+1}} \cdot (-1) = \frac{\partial\, \text{Cost}_{a_1}}{\partial\, WU_{a_1,\ell,t}} - \sum_{j \in N_\ell,\, j \neq 1} \frac{\partial\, \text{Cost}_{a_j}}{\partial\, W_{\ell,t+1}}.$$

By assumption, $\partial\, \text{Cost}_{a_j}/\partial\, W_{\ell,t+1} \leq 0$ for every $j \in N_\ell \setminus \{1\}$, with strict inequality for at least one such j, so

$$- \sum_{j \in N_\ell,\, j \neq 1} \frac{\partial\, \text{Cost}_{a_j}}{\partial\, W_{\ell,t+1}} > 0.$$

Hence $\partial\, \text{TotalCost}_{a_1,\ell}/\partial\, WU_{a_1,\ell,t}$ exceeds $\partial\, \text{Cost}_{a_1}/\partial\, WU_{a_1,\ell,t}$ by this strictly positive term, the gap referred to in the Lemma. Each firm $j \in N_\ell \setminus \{1\}$ contributes a term $-\,\partial\, \text{Cost}_{a_j}/\partial\, W_{\ell,t+1}$ to this sum, which is strictly positive if water binds firm j's production and exactly zero if capital instead binds. Adding a firm to $N_\ell \setminus \{1\}$ therefore weakly increases the sum, and hence the gap, in either case, and strictly increases it if the added firm is water-constrained. $\square$

Lemma 1 establishes a gap between the marginal social and marginal private cost of a_1's water use. This gap reflects costs borne by other firms sharing location ℓ, and through them by any investor holding a position in those firms. This gap can only widen, never narrow, as more firms share the location.

A.3. Proposition: Geographic Asymmetry in Tilting

The predictions in Section 2.3 rely on a structural feature of headquarters location: it is always in the home market of a firm's domestic investors, and never in the home market of its foreign investors. The proposition below formalizes the asymmetry this structural feature implies.

PROPOSITION 1: *Let a_1 and b_1 be two firms headquartered in different countries, $hq(a_1) = C$ and $hq(b_1) = C' \neq C$. Suppose the two firms are otherwise identical: they face the same relation between water conditions and cost, $TotalCost_{a_1,C}(\cdot) = TotalCost_{b_1,C'}(\cdot) \equiv TC(\cdot)$ (the identical-cost-function assumption); they use the same amount of water at their respective headquarters (the equal-contribution assumption); and the cost to an investor of adjusting a position, $c(\cdot)$, is the same for both firms. Let I be an investor with home market C, so that $\theta_I^C > \theta_I^{C'}$, since exposure is highest at an investor's home market, as established in Section 2.3. Suppose further that neither a_1 nor b_1 operates at any location coinciding with C' or C respectively (the no-overlap assumption), so that $\theta_I^\ell \cdot TotalCost_{a_1,\ell}$ and $\theta_I^\ell \cdot TotalCost_{b_1,\ell}$ are negligible for $\ell \neq hq(a_1), hq(b_1)$.[5] Then there exist values of $TC(\cdot)$ and $c(\cdot)$, specified in the proof below, such that I tilts away from a_1 but not from b_1; the reverse cannot occur for any such values.*

Proof. The no-overlap assumption implies the sum in Equation (5) reduces to the headquarters term alone, for both a_1 and b_1. The equal-contribution and identical-cost-function assumptions further imply

$$TC \equiv TC(WU_{a_1,C,t}) = TC(WU_{b_1,C',t}), \qquad c \equiv c(\Delta Inv_{a_1}) = c(\Delta Inv_{b_1}).$$

Equation (5) therefore reduces, for each firm, to comparing c against $\theta_I^C \cdot TC$ (for a_1) and $\theta_I^{C'} \cdot TC$ (for b_1).

Because $\theta_I^C > \theta_I^{C'}$, we have $\theta_I^C \cdot TC > \theta_I^{C'} \cdot TC$ for any $TC > 0$. By the tilting condition in Equation (5), I tilts away from a_1 whenever $c < \theta_I^C \cdot TC$, and tilts away from b_1 whenever $c < \theta_I^{C'} \cdot TC$. Since $\theta_I^C \cdot TC$ is strictly larger than $\theta_I^{C'} \cdot TC$, values of c strictly between the two

[5] This assumption isolates the headquarters channel specifically; it does not rule out investors having elevated exposure to a firm's other locations, a separate channel accommodated by the general model in Equation (4) and explored empirically for asset locations in Section 4.

always exist whenever $TC > 0$; any such c satisfies the tilting condition for a_1 but not for b_1, establishing existence.

For the converse, tilting away from b_1 but not a_1 would require $c < \theta_I^{C'} \cdot TC$ and $c \geq \theta_I^{C} \cdot TC$ simultaneously, that is,

$$\theta_I^{C} \cdot TC \ \leq \ c \ < \ \theta_I^{C'} \cdot TC,$$

which is impossible since $\theta_I^{C} > \theta_I^{C'}$ implies $\theta_I^{C} \cdot TC > \theta_I^{C'} \cdot TC$. □

Proposition 1 is the formal counterpart to Predictions 1 and 2: the domestic and foreign asymmetry in tilting is not merely possible but is the only asymmetric outcome the model permits when the two firms are otherwise identical and home-market exposure is strictly higher than exposure elsewhere. Any empirically observed case of investors tilting more from an equally water-intensive firm headquartered outside their home market than from one headquartered inside it would be inconsistent with the model as stated.

B. Case Study

The Commons Externality in Practice: Semiconductors and Taiwan's 2021 Drought

Taiwan Semiconductor Manufacturing Company (TSMC), headquartered and producing primarily in Taiwan, is the world's largest semiconductor chip manufacturer; its production process is exceptionally water-intensive, and in 2020 and 2021 Taiwan experienced its most severe drought in over half a century. This appendix uses that episode to illustrate the externality formalized in Section 2.1.

Semiconductor chips are the computing components inside smartphones, cars, computers, and data centers. TSMC manufactures chips designed by other companies, including Apple, Nvidia, and Qualcomm, and produces roughly a quarter of the world's semiconductors and over 90 percent of its most advanced chips. Taiwan's semiconductor industry as a whole accounts for 14 percent of the country's GDP (Narvaez, Janzen, Eberle, and Sebesvari, 2021). Producing a chip requires hundreds of chemical and lithographic steps that etch microscopic circuits onto silicon wafers, and the wafer must be rinsed with ultra-pure water between nearly every step, since even microscopic contamination can destroy it. TSMC's Taiwan operations use over 150,000 tons of water per day, with its Southern Taiwan Science Park facilities alone consuming up to 99,000 tons daily; total consumption rose 70 percent between 2015 and 2019 (Barbiroglio, 2021; Zhang, 2024).

This dependence on water made TSMC particularly exposed when Taiwan's water supply itself came under threat. In 2020 and 2021, Taiwan experienced its most severe drought since 1964: Taiwan's typhoon season passed without a single storm making landfall, the first such occurrence in 56 years. Taiwan's reservoirs depend on this seasonal rainfall, and its absence left them unreplenished (Barbiroglio, 2021). By spring 2021, capacity had fallen below 50 percent at 17 of Taiwan's 19 major reservoirs. Two of the hardest-hit, Baoshan No. 2 in Hsinchu and Techi, were reduced to roughly 7 and 4 percent of capacity respectively (Lai, 2022). Water rationing measures ultimately extended to more than a million households and businesses across the island (Narvaez et al., 2021).

In response, the Taiwanese government intervened in two ways during 2021. Industrial users in major manufacturing hubs, including Taoyuan, Taichung, Hsinchu, and Miaoli, were ordered to cut water consumption by up to 15 percent (Zhang, 2024), a reduction modest enough to keep production running, in part because authorities simultaneously reallocated water away from agriculture toward these same industrial users. Irrigation was halted across 74,000 hectares of farmland, an area roughly the size of New York City, with farmers compensated at rates ranging from NT$82,000 to NT$93,000 per hectare for turning to alternative, less water-intensive use of their land (Lai, 2022; Lin and Syngle, 2021). TSMC's own global importance is a plausible factor behind this prioritization. The United States, Germany, and Japan were among the governments counting on Taiwanese production to relieve a global automotive chip shortfall, so any disruption to TSMC would have effects well beyond Taiwan (Zhang, 2024). That pressure may have contributed to the government's willingness to protect TSMC's water access ahead of other users.

The reallocation directly impacted TSMC's rivals for water. Rice farmers left roughly half of the season's planting area unplanted (Lai, 2022). Firms entirely outside the semiconductor sector were affected too: Denis Chen, vice president at Chimei, a petrochemical and plastics manufacturer with production plants in Tainan, described customers questioning orders over the drought: "Everyone was feeling the squeeze. There was talk of scaling down production. International customers saw news about the drought and asked if their orders would be affected" (Kai-yuan Teng, 2022). TSMC itself was not unaffected either. TSMC and other chipmakers, including Vanguard International Semiconductor and United Microelectronics Corp, resorted to trucking in water and drilling "drought-resistant" wells to maintain production (Zhang, 2024); TSMC alone was reported to spend over NT$0.5 billion (approximately $17.9 million) on water trucking in 2021, exceeding its original budget (Barbiroglio, 2021). TSMC's own disclosed estimate puts the revenue impact of the drought at 0.7 to 1.1 percent (Kai-yuan Teng, 2022).

Together, these two sets of costs illustrate the distinction formalized in Equation (3) between the direct cost TSMC bore itself and the indirect cost its water use imposed on others. The drought, combined with TSMC's global importance, triggered a government-mandated reallocation in which agricultural users, and the firms and communities that depended on them, bore a cost TSMC itself did not pay for directly. This indirect cost was likely larger than the model's baseline mechanism alone would predict, since TSMC was also shielded from the rationing other industrial users faced, letting it keep withdrawing water closer to its own unconstrained, profit-maximizing level than other firms could.

In the years since, Taiwan's government, credit analysts, and investors have all continued to treat the water scarcity exposure as material. The underlying conditions did not fully disappear after the acute 2021 episode. No typhoon made landfall again in 2022, and that year's rainfall fell to its lowest level in three decades. Beginning in February 2023, large-scale industrial water consumers were required to pay an additional dry-season tariff. This was the first change to Taiwan's water pricing in 25 years, a response to the accumulated pattern of drought years including 2021 (Crook, 2023). S&P Global Ratings' credit analysis of the firm estimates that, in a scenario where water supply management is executed poorly, TSMC's output could fall by as much as 10 percent relative to its 2030 forecast, treating water security explicitly as a factor in the firm's creditworthiness (S&P Global, 2024). Some investors report acting on this assessment directly: Robeco portfolio manager Vicki Chi states that her team has already adjusted semiconductor asset valuations to reflect water scarcity (Bloomberg, 2023).

This drought case illustrates the mechanism formalized in Section 2. It does not distinguish the behavior of investors domiciled in Taiwan from that of TSMC's foreign shareholders; establishing that distinction requires the systematic, firm-level and investor-level evidence developed in this paper.

C. Figures and Tables

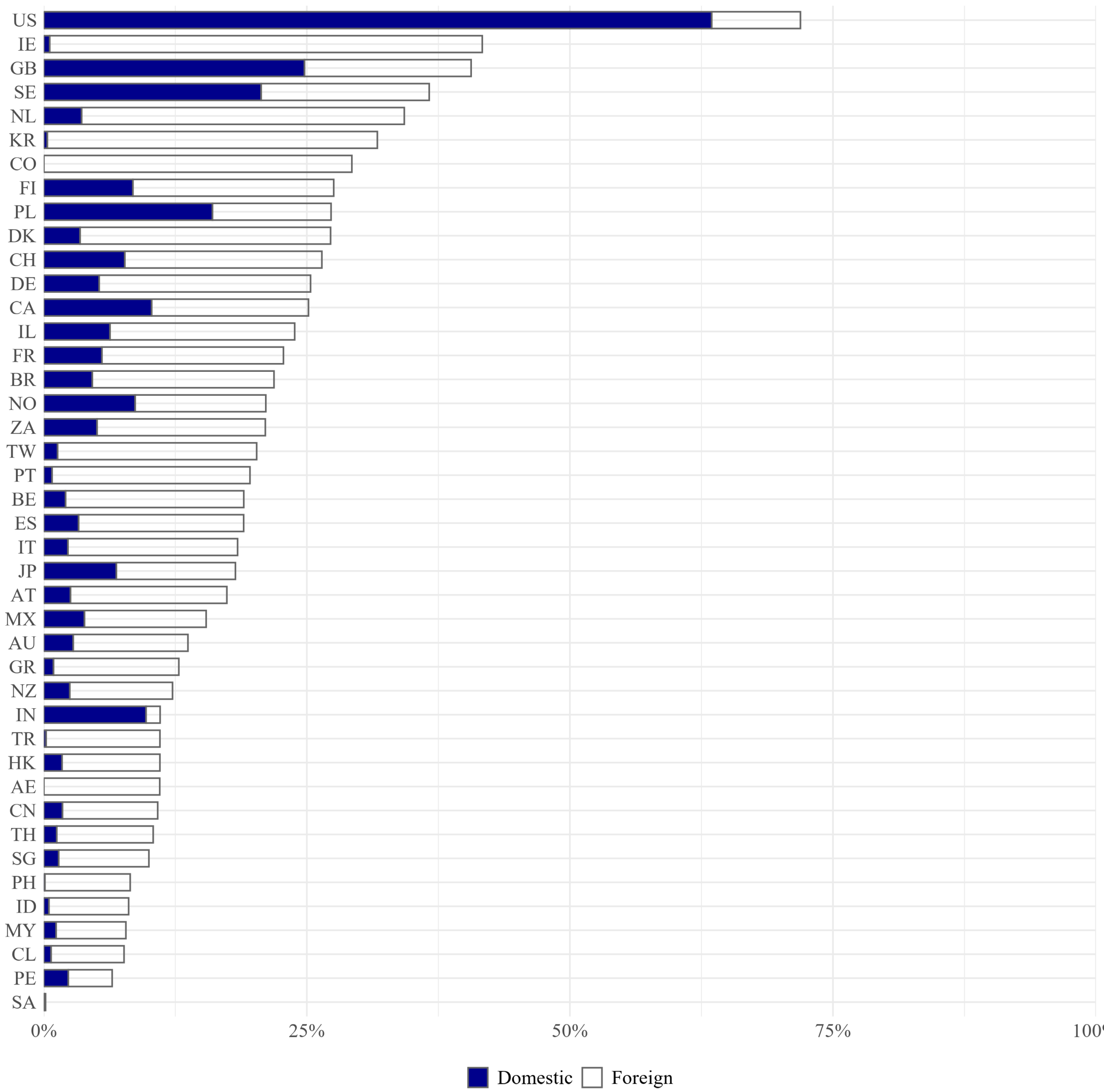

Figure C.1: Domestic and Foreign Institutional Ownership by Country

Table C.1: Country Distribution: Firms and Institutions

This table reports the number of unique firms and institutions by country, after matching with water and control variable data. The Firm-Level Sample columns report the firm count and percentage share of the firm-level sample, by country of domicile. The Inst.-Level Sample (Firms) columns report the firm count and percentage share of the institution-level sample, by country of domicile. The Inst.-Level Sample (Institutions) columns report the institution count and percentage share of the institution-level sample, by country of institution domicile.

	Firm-Level Sample		**Inst.-Level Sample (Firms)**		**Inst.-Level Sample (Institutions)**	
Country	**N**	**%**	**N**	**%**	**N**	**%**
Australia	336	5.147%	233	6.721%	115	1.054%
Austria	21	0.322%	14	0.404%	47	0.431%
Belgium	36	0.551%	18	0.519%	31	0.284%
Brazil	31	0.475%	27	0.779%	118	1.082%
Canada	371	5.683%	198	5.711%	304	2.787%
Chile	1	0.015%	1	0.029%	17	0.156%
China	291	4.458%	105	3.029%	140	1.283%
Colombia	2	0.031%	-	-	-	-
Denmark	30	0.460%	16	0.461%	35	0.321%
Finland	45	0.689%	29	0.836%	37	0.339%
France	152	2.328%	93	2.682%	252	2.310%
Germany	157	2.405%	91	2.625%	412	3.777%
Greece	14	0.214%	8	0.231%	7	0.064%
Hong Kong	255	3.906%	138	3.980%	122	1.118%
India	5	0.077%	2	0.058%	29	0.266%
Indonesia	67	1.026%	47	1.356%	5	0.046%
Ireland	19	0.291%	11	0.317%	34	0.312%
Israel	67	1.026%	35	1.010%	55	0.504%
Italy	54	0.827%	31	0.894%	75	0.688%
Japan	873	13.373%	586	16.902%	69	0.633%
Malaysia	60	0.919%	41	1.183%	29	0.266%
Mexico	56	0.858%	27	0.779%	28	0.257%
Netherlands	48	0.735%	23	0.663%	48	0.440%
New Zealand	41	0.628%	26	0.750%	12	0.110%
Norway	62	0.950%	33	0.952%	34	0.312%
Peru	5	0.077%	1	0.029%	2	0.018%
Philippines	39	0.597%	21	0.606%	3	0.028%
Poland	18	0.276%	7	0.202%	41	0.376%
Portugal	11	0.169%	7	0.202%	24	0.220%
Saudi Arabia	1	0.015%	1	0.029%	2	0.018%
Singapore	59	0.904%	30	0.865%	69	0.633%
South Africa	56	0.858%	26	0.750%	199	1.824%
South Korea	12	0.184%	8	0.231%	15	0.138%
Spain	52	0.797%	27	0.779%	151	1.384%

Continued on next page

Table C.1 – continued from previous page

	Firm-Level Sample		Inst.-Level Sample (Firms)		Inst.-Level Sample (Institutions)	
Country	**N**	**%**	**N**	**%**	**N**	**%**
Sweden	118	1.808%	85	2.452%	111	1.018%
Switzerland	94	1.440%	57	1.644%	316	2.897%
Taiwan	29	0.444%	24	0.692%	42	0.385%
Thailand	11	0.169%	7	0.202%	18	0.165%
Turkiye	25	0.383%	24	0.692%	5	0.046%
United Arab Emirates	1	0.015%	-	-	-	-
United Kingdom	319	4.887%	159	4.586%	640	5.867%
United States of America	2,584	39.583%	1,149	33.141%	7,088	64.974%
Total	6,528	100.000%	3,467	100.000%	10,909	100.000%

Table C.2: Water Levels and Institutional Ownership by Investor Origin, Rolling Averages

This table reports the results of the regressions of domestic and foreign institutional ownership on Δ *Water Levels HQ* (Panels A–B), and domestic and foreign institutional ownership on Δ *Water Levels Assets* (Panels C–D), using different rolling averages. *Rise* and *Fall* capture increases and decreases in water levels respectively. Other variable definitions are provided in Table 1. All regressions include a constant, the same accounting controls as in Table 3, and country×quarter/year fixed effects, with even-numbered models additionally including industry×quarter/year fixed effects. Standard errors are double-clustered at the firm and quarter/year level. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Panel A: Domestic Institutional Ownership – Headquarters

Institutional Ownership	3 Months	3 Months	1 Year	1 Year	5 Years	5 Years	15 Years	15 Years
Δ Water Levels HQ - Fall	11.8045***	13.0696***	12.6653***	14.0076***	13.8011**	16.0905**	28.5686**	32.1912**
	(3.0109)	(3.4084)	(3.0055)	(3.4073)	(2.2044)	(2.6398)	(2.1857)	(2.5169)
Δ Water Levels HQ - Rise	6.7416	6.4359	6.1783	5.9940	10.0270	9.4144	16.4411	14.9267
	(1.3523)	(1.3195)	(1.1451)	(1.1359)	(1.3522)	(1.2971)	(0.9375)	(0.8683)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes		Yes
Observations	168,400	168,384	168,354	168,338	167,750	167,734	88,202	88,195
R-squared	0.7750	0.7870	0.7751	0.7871	0.7758	0.7879	0.7636	0.7747

Panel B: Foreign Institutional Ownership – Headquarters

Institutional Ownership	3 Months	3 Months	1 Year	1 Year	5 Years	5 Years	15 Years	15 Years
Δ Water Levels HQ - Fall	2.6497	4.0336	2.4033	3.9494	1.7355	5.0000	2.5077	9.9659
	(0.9435)	(1.4173)	(0.8201)	(1.3330)	(0.4294)	(1.2272)	(0.3218)	(1.2895)
Δ Water Levels HQ - Rise	0.0370	-1.2958	-0.0587	-1.6471	-1.0758	-4.0250	-2.5551	-11.6296
	(0.0142)	(-0.4933)	(-0.0209)	(-0.5795)	(-0.2984)	(-1.1263)	(-0.2951)	(-1.3790)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes		Yes
Observations	168,400	168,384	168,354	168,338	167,750	167,734	88,202	88,195
R-squared	0.3659	0.3991	0.3659	0.3992	0.3666	0.4004	0.3894	0.4235

Panel C: Domestic Institutional Ownership – Asset Locations

Institutional Ownership	3 Months	3 Months	1 Year	1 Year	5 Years	5 Years	15 Years	15 Years
Δ Water Levels Assets - Fall	-0.3815	-0.8021	-0.7752	-1.2567	-1.7936	-1.8898	-3.2855	-2.6122
	(-0.1038)	(-0.2456)	(-0.2047)	(-0.3714)	(-0.3929)	(-0.4672)	(-0.3348)	(-0.3366)
Δ Water Levels Assets - Rise	17.8253*	20.0883*	21.4746*	24.3554**	36.1396**	38.6960**	76.5876**	74.7530**
	(1.7031)	(1.9310)	(1.8432)	(2.1057)	(2.3039)	(2.4544)	(2.1718)	(2.1428)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes		Yes
Observations	29,578	29,145	29,578	29,145	29,578	29,145	15,064	14,881
R-squared	0.8067	0.8251	0.8067	0.8252	0.8070	0.8255	0.8030	0.8204

Panel D: Foreign Institutional Ownership – Asset Locations

Institutional Ownership	3 Months	3 Months	1 Year	1 Year	5 Years	5 Years	15 Years	15 Years
Δ Water Levels Assets - Fall	6.5973***	5.2559**	6.6989**	5.3613**	7.4665**	5.8388*	10.3683	7.6615
	(2.7225)	(2.0808)	(2.6885)	(2.0616)	(2.5863)	(1.8620)	(1.6671)	(1.1121)
Δ Water Levels Assets - Rise	-0.0508	-1.1609	0.0819	-1.2595	-3.1144	-4.0139	-7.8656	-7.9690
	(-0.0060)	(-0.1344)	(0.0088)	(-0.1317)	(-0.2429)	(-0.3067)	(-0.2771)	(-0.2754)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes		Yes
Observations	29,578	29,145	29,578	29,145	29,578	29,145	15,064	14,881
R-squared	0.3901	0.4416	0.3900	0.4416	0.3897	0.4414	0.4180	0.4684

Table C.3: Water Stress and Institutional Ownership by Investor Origin, Rolling Averages

This table reports the results of the regressions of domestic and foreign institutional ownership on *Water Stress HQ* (Panels A–B), and domestic and foreign institutional ownership on *Water Stress Assets* (Panels C–D), using different rolling averages. *Rise* and *Fall* capture increases and decreases in water levels respectively. Other variable definitions are provided in Table 1. All regressions include a constant, the same accounting controls as in Table 3, and country×quarter/year fixed effects, with even-numbered models additionally including industry×quarter/year fixed effects. Standard errors are double-clustered at the firm and quarter/year level. ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

Panel A: Domestic Institutional Ownership – Headquarters								
Institutional Ownership	3 Months	3 Months	1 Year	1 Year	5 Years	5 Years	15 Years	15 Years
Water Stress HQ	-0.6194***	-0.5547***	-0.6058***	-0.5444***	-0.5548***	-0.4968**	-0.5235**	-0.5305**
	(-3.2381)	(-2.8234)	(-3.1466)	(-2.7461)	(-2.8298)	(-2.4567)	(-2.2930)	(-2.2706)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes		Yes
Observations	99,934	99,899	99,927	99,892	99,654	99,618	63,061	63,055
R-squared	0.8379	0.8482	0.8379	0.8482	0.8387	0.8490	0.8161	0.8272
Panel B: Foreign Institutional Ownership – Headquarters								
Institutional Ownership	3 Months	3 Months	1 Year	1 Year	5 Years	5 Years	15 Years	15 Years
Water Stress HQ	-0.3547***	-0.3618***	-0.3468***	-0.3513***	-0.3267***	-0.3281**	-0.2688**	-0.2717**
	(-3.0220)	(-2.8863)	(-2.9627)	(-2.8041)	(-2.7955)	(-2.6326)	(-2.2379)	(-2.1851)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes		Yes
Observations	99,934	99,899	99,927	99,892	99,654	99,618	63,061	63,055
R-squared	0.3949	0.4429	0.3948	0.4429	0.3959	0.4445	0.4209	0.4658
Panel C: Domestic Institutional Ownership – Asset Locations								
Institutional Ownership	3 Months	3 Months	1 Year	1 Year	5 Years	5 Years	15 Years	15 Years
Water Stress Assets	-0.2352	-0.2189	-0.2384	-0.2151	-0.2584	-0.2527	-0.1980	-0.2739
	(-0.7982)	(-0.7896)	(-0.8053)	(-0.7640)	(-0.8705)	(-0.8979)	(-0.6791)	(-1.0602)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes		Yes
Observations	18,226	17,911	18,226	17,911	18,226	17,911	10,347	10,182
R-squared	0.8930	0.9085	0.8930	0.9085	0.8930	0.9086	0.8884	0.9029
Panel D: Foreign Institutional Ownership – Asset Locations								
Institutional Ownership	3 Months	3 Months	1 Year	1 Year	5 Years	5 Years	15 Years	15 Years
Water Stress Assets	-0.9343***	-0.8598**	-0.9267***	-0.8503**	-0.8913***	-0.8228**	-0.9939***	-0.9209***
	(-3.0327)	(-2.5895)	(-3.0228)	(-2.5720)	(-2.9567)	(-2.5692)	(-3.3193)	(-3.0843)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country x Quarter/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Quarter/Year		Yes		Yes		Yes		Yes
Observations	18,226	17,911	18,226	17,911	18,226	17,911	10,347	10,182
R-squared	0.5008	0.5714	0.5008	0.5713	0.5005	0.5712	0.5268	0.5955

Internet Appendix

Table IA.1: FactSet Institution Types

Sub Type	Entity Description	Cat.	Category Description	Active
MM	Market Maker	1	Broker	Yes
BM	Bank Management Division	1	Broker	Yes
IB	Investment Banking	1	Broker	Yes
ST	Stock borrowing/lending	1	Broker	Yes
BR	Broker	1	Broker	Yes
CP	Corporate	2	Private Banking	No
CU	Custodial	2	Private Banking	Yes
VC	Venture capital/Pvt equity	2	Private Banking	Yes
PB	Private Banking Portfolio	2	Private Banking	Yes
FY	Family Office	2	Private Banking	Yes
FH	Fund of Hedge Funds Manager	3	Hedge Fund	Yes
FF	Fund of Funds Manager	3	Hedge Fund	Yes
FU	Fund	3	Hedge Fund	Yes
AR	Arbitrage	3	Hedge Fund	Yes
HF	Hedge Fund Company	3	Hedge Fund	Yes
FS	Fund Distributor	3	Hedge Fund	Yes
IA	Investment Advisor	4	Investment Advisor	Yes
IC	Investment Company	4	Investment Advisor	Yes
RE	Research Firm	4	Investment Advisor	Yes
PP	Real estate manager	4	Investment Advisor	Yes
SB	Subsidiary Branch	4	Investment Advisor	Yes
MF	Mutual fund manager	4	Investment Advisor	Yes
ML	Master Ltd part	4	Investment Advisor	Yes
FO	Foundation/Endowment Manager	5	Long-term	No
SV	Sovereign Wealth Manager	5	Long-term	No
IN	Insurance company	5	Long-term	No
PF	Pension funds	5	Long-term	No
GV	Government/Fed/local/agency	6	Government	No
–	Others	7	Other stakeholders	No

Table IA.2: Institution Type Composition

This table reports the composition of institution types in the final, matched sample. N reports the number of unique institutions ever classified in each entity type over the sample period; % of N reports each type's share of total N. AUM, expressed in millions of U.S. dollars, reports each type's average assets under management per institution-quarter. % of AUM reports each type's average share of total assets under management, computed by first calculating each type's share of total AUM within each quarter and then averaging that share across quarters.

Entity Description	**Category**	**N**	**% of N**	**AUM**	**% of AUM**
Market Maker	Broker	7	0.06%	550.51	0.01%
Bank Management Division	Broker	4	0.04%	36,356.26	0.25%
Broker	Broker	111	1.02%	4,347.32	1.05%
Corporate	Private Banking	83	0.76%	452.67	0.05%
Venture capital/Pvt equity	Private Banking	78	0.72%	563.51	0.04%
Private Banking Portfolio	Private Banking	1,991	18.25%	717.42	2.99%
Family Office	Private Banking	34	0.31%	950.98	0.08%
Fund of Hedge Funds Manager	Hedge Fund	17	0.16%	1,068.89	0.04%
Fund of Funds Manager	Hedge Fund	16	0.15%	4,165.25	0.16%
Fund	Hedge Fund	2	0.02%	9.26	0.00%
Hedge Fund Company	Hedge Fund	1,577	14.46%	1,386.88	3.57%
Fund Distributor	Hedge Fund	11	0.10%	800.91	0.02%
Investment Advisor	Investment Advisor	6,209	56.92%	4,167.36	61.67%
Investment Company	Investment Advisor	4	0.04%	2,056.52	0.02%
Research Firm	Investment Advisor	1	0.01%	75.75	0.00%
Real estate manager	Investment Advisor	5	0.05%	101.45	0.00%
Mutual fund manager	Investment Advisor	529	4.85%	16,481.47	25.80%
Foundation/Endowment Manager	Long-term	13	0.12%	1,911.43	0.03%
Sovereign Wealth Manager	Long-term	9	0.08%	6,053.75	0.05%
Insurance company	Long-term	75	0.69%	1,539.84	0.24%
Pension funds	Long-term	126	1.16%	12,282.46	3.85%
Total		10,902	100.00%	96,039.90	100.00%

Table IA.3: Country Reference Table

Country	ISO	ISO3	Region	Market
Argentina	AR	ARG	Latin America	EM
Australia	AU	AUS	Asia Pacific	DM
Austria	AT	AUT	Europe	DM
Belgium	BE	BEL	Europe	DM
Brazil	BR	BRA	Latin America	EM
Canada	CA	CAN	North America	DM
Chile	CL	CHL	Latin America	EM
China	CN	CHN	Asia Pacific	EM
Colombia	CO	COL	Latin America	EM
Czechia	CZ	CZE	Europe	EM
Denmark	DK	DNK	Europe	DM
Egypt	EG	EGY	Middle East	EM
Finland	FI	FIN	Europe	DM
France	FR	FRA	Europe	DM
Germany	DE	DEU	Europe	DM
Greece	GR	GRC	Europe	EM
Hong Kong	HK	HKG	Asia Pacific	DM
Hungary	HU	HUN	Europe	EM
India	IN	IND	Asia Pacific	EM
Indonesia	ID	IDN	Asia Pacific	EM
Ireland	IE	IRL	Europe	DM
Israel	IL	ISR	Middle East	DM
Italy	IT	ITA	Europe	DM
Japan	JP	JPN	Asia Pacific	DM
Kuwait	KW	KWT	Middle East	EM
Luxembourg	LU	LUX	Europe	DM
Malaysia	MY	MYS	Asia Pacific	EM
Mexico	MX	MEX	Latin America	EM
Morocco	MA	MAR	Africa	FM
Netherlands	NL	NLD	Europe	DM
New Zealand	NZ	NZL	Asia Pacific	DM
Norway	NO	NOR	Europe	DM
Pakistan	PK	PAK	Middle East	EM
Peru	PE	PER	Latin America	FM
Philippines	PH	PHL	Asia Pacific	EM
Poland	PL	POL	Europe	EM
Portugal	PT	PRT	Europe	DM
Qatar	QA	QAT	Middle East	EM
Romania	RO	ROU	Europe	EM
Russia	RU	RUS	Europe	EM
Saudi Arabia	SA	SAU	Middle East	EM
Singapore	SG	SGP	Asia Pacific	DM
South Africa	ZA	ZAF	Africa	EM

Continued on next page

Table IA.3 – continued from previous page

Country	**ISO2**	**ISO3**	**Region**	**Market**
South Korea	KR	KOR	Asia Pacific	EM
Spain	ES	ESP	Europe	DM
Sweden	SE	SWE	Europe	DM
Switzerland	CH	CHE	Europe	DM
Taiwan	TW	TWN	Asia Pacific	EM
Thailand	TH	THA	Asia Pacific	EM
Turkiye	TR	TUR	Europe	EM
United Arab Emirates	AE	ARE	Middle East	EM
United Kingdom	GB	GBR	Europe	DM
United States of America	US	USA	North America	DM

Table IA.4: Country Distribution: Before versus After Matching

This table compares the number of unique institutions and firms by country before and after matching with water and control variable data. % Retained reports the share of the pre-match count that remains after matching.

	Institutions			Firms		
Country	Before	After	% Retained	Before	After	% Retained
Argentina	1	1	100.00%	29	0	0.00%
Australia	115	115	100.00%	1,201	233	19.40%
Austria	48	47	97.92%	56	14	25.00%
Belgium	31	31	100.00%	79	18	22.78%
Brazil	122	118	96.72%	326	27	8.28%
Canada	305	304	99.67%	2,300	198	8.61%
Chile	17	17	100.00%	77	1	1.30%
China	143	140	97.90%	4,488	105	2.34%
Colombia	0	0	0.00%	23	1	4.35%
Czechia	7	7	100.00%	2	0	0.00%
Denmark	35	35	100.00%	110	16	14.55%
Egypt	1	0	0.00%	89	0	0.00%
Finland	37	37	100.00%	98	29	29.59%
France	254	252	99.21%	426	93	21.83%
Germany	412	412	100.00%	492	91	18.50%
Greece	7	7	100.00%	137	8	5.84%
Hong Kong	122	122	100.00%	761	138	18.13%
Hungary	8	8	100.00%	16	0	0.00%
India	33	29	87.88%	1,018	2	0.20%
Indonesia	5	5	100.00%	270	47	17.41%
Ireland	34	34	100.00%	67	11	16.42%
Israel	55	55	100.00%	351	35	9.97%
Italy	75	75	100.00%	236	31	13.14%
Japan	69	69	100.00%	2,910	586	20.14%
Kuwait	2	1	50.00%	91	0	0.00%
Luxembourg	90	90	100.00%	35	0	0.00%
Malaysia	30	29	96.67%	598	41	6.86%
Mexico	28	28	100.00%	81	27	33.33%
Morocco	0	0	0.00%	22	0	0.00%
Netherlands	49	48	97.96%	87	23	26.44%
New Zealand	12	12	100.00%	80	26	32.50%
Norway	34	34	100.00%	186	33	17.74%
Pakistan	11	1	9.09%	240	0	0.00%
Peru	2	2	100.00%	40	1	2.50%
Philippines	3	3	100.00%	93	21	22.58%
Poland	41	41	100.00%	173	7	4.05%
Portugal	24	24	100.00%	33	7	21.21%
Qatar	4	1	25.00%	44	0	0.00%
Romania	16	12	75.00%	71	0	0.00%

Continued on next page

Table IA.4 – continued from previous page

Country	Institutions			Firms		
	Before	After	% Retained	Before	After	% Retained
Russia	2	2	100.00%	31	0	0.00%
Saudi Arabia	2	2	100.00%	178	1	0.56%
Singapore	70	69	98.57%	359	30	8.36%
South Africa	206	199	96.60%	172	26	15.12%
South Korea	16	15	93.75%	1,638	8	0.49%
Spain	151	151	100.00%	144	27	18.75%
Sweden	112	111	99.11%	563	85	15.10%
Switzerland	317	316	99.68%	194	57	29.38%
Taiwan	42	42	100.00%	1,506	24	1.59%
Thailand	18	18	100.00%	528	7	1.33%
Turkiye	5	5	100.00%	334	24	7.19%
United Arab Emirates	12	5	41.67%	69	0	0.00%
United Kingdom	642	640	99.69%	904	159	17.59%
United States of America	7,117	7,088	99.59%	5,011	1,149	22.93%
Total	10,994	10,909	99.23%	29,067	3,467	11.93%

Table IA.5: Largest Institutions by Year: North America

This table reports the three largest institutional investors in each year, ranked by their maximum assets under management (AUM) across the year's four quarters. AUM is expressed in millions of U.S. dollars.

Year	Name	Country	AUM
2012	The Vanguard Group, Inc.	United States of America	643,441.2
	BlackRock Fund Advisors	United States of America	570,645.4
	SSgA Funds Management, Inc.	United States of America	495,581.5
2013	The Vanguard Group, Inc.	United States of America	887,281.8
	BlackRock Fund Advisors	United States of America	755,378.7
	SSgA Funds Management, Inc.	United States of America	660,792.5
2014	The Vanguard Group, Inc.	United States of America	1,027,168.0
	BlackRock Fund Advisors	United States of America	832,688.7
	SSgA Funds Management, Inc.	United States of America	722,801.1
2015	The Vanguard Group, Inc.	United States of America	1,175,891.2
	BlackRock Fund Advisors	United States of America	853,966.2
	SSgA Funds Management, Inc.	United States of America	694,887.7
2016	The Vanguard Group, Inc.	United States of America	1,397,201.0
	BlackRock Fund Advisors	United States of America	929,613.0
	SSgA Funds Management, Inc.	United States of America	715,996.8
2017	The Vanguard Group, Inc.	United States of America	1,823,245.2
	BlackRock Fund Advisors	United States of America	1,208,500.1
	SSgA Funds Management, Inc.	United States of America	833,739.7
2018	The Vanguard Group, Inc.	United States of America	2,027,311.4
	BlackRock Fund Advisors	United States of America	1,268,956.7
	SSgA Funds Management, Inc.	United States of America	885,735.4
2019	The Vanguard Group, Inc.	United States of America	2,278,282.0
	BlackRock Fund Advisors	United States of America	1,399,356.1
	SSgA Funds Management, Inc.	United States of America	962,855.9
2020	The Vanguard Group, Inc.	United States of America	2,540,994.7
	BlackRock Fund Advisors	United States of America	1,596,794.6
	SSgA Funds Management, Inc.	United States of America	1,084,294.0
2021	The Vanguard Group, Inc.	United States of America	3,228,902.6
	BlackRock Fund Advisors	United States of America	2,001,423.3
	SSgA Funds Management, Inc.	United States of America	1,429,739.2
2022	The Vanguard Group, Inc.	United States of America	3,131,451.5
	BlackRock Fund Advisors	United States of America	1,931,655.5
	SSgA Funds Management, Inc.	United States of America	1,386,915.4
2023	The Vanguard Group, Inc.	United States of America	3,544,626.8
	BlackRock Fund Advisors	United States of America	2,051,467.5
	SSgA Funds Management, Inc.	United States of America	1,418,846.8
2024	The Vanguard Group, Inc.	United States of America	4,367,326.5
	BlackRock Fund Advisors	United States of America	2,544,566.6
	SSgA Funds Management, Inc.	United States of America	1,773,544.2

Table IA.6: Largest Institutions by Year: Europe

This table reports the three largest institutional investors in each year, ranked by their maximum assets under management (AUM) across the year's four quarters. AUM is expressed in millions of U.S. dollars.

Year	Name	Country	AUM
2012	Capital International Ltd.	United Kingdom	112,759.4
	BlackRock Investment Management (UK) Ltd.	United Kingdom	97,280.4
	APG Asset Management NV	Netherlands	86,874.8
2013	Capital International Ltd.	United Kingdom	137,305.5
	BlackRock Investment Management (UK) Ltd.	United Kingdom	133,350.2
	BlackRock Advisors (UK) Ltd.	United Kingdom	112,025.6
2014	BlackRock Investment Management (UK) Ltd.	United Kingdom	139,053.0
	Capital International Ltd.	United Kingdom	135,548.2
	BlackRock Advisors (UK) Ltd.	United Kingdom	124,531.6
2015	BlackRock Investment Management (UK) Ltd.	United Kingdom	152,217.3
	Capital International Ltd.	United Kingdom	128,140.4
	BlackRock Advisors (UK) Ltd.	United Kingdom	113,110.4
2016	BlackRock Investment Management (UK) Ltd.	United Kingdom	144,435.7
	Capital International Ltd.	United Kingdom	120,826.8
	Dimensional Fund Advisors Ltd.	United Kingdom	116,626.5
2017	BlackRock Investment Management (UK) Ltd.	United Kingdom	175,671.4
	BlackRock Advisors (UK) Ltd.	United Kingdom	155,349.0
	Capital International Ltd.	United Kingdom	146,001.5
2018	BlackRock Investment Management (UK) Ltd.	United Kingdom	195,753.2
	BlackRock Advisors (UK) Ltd.	United Kingdom	162,216.9
	Dimensional Fund Advisors Ltd.	United Kingdom	153,337.3
2019	BlackRock Investment Management (UK) Ltd.	United Kingdom	242,756.3
	BlackRock Advisors (UK) Ltd.	United Kingdom	192,376.4
	Capital International Ltd.	United Kingdom	160,891.6
2020	BlackRock Investment Management (UK) Ltd.	United Kingdom	321,258.3
	BlackRock Advisors (UK) Ltd.	United Kingdom	245,570.2
	Capital International Ltd.	United Kingdom	192,745.6
2021	BlackRock Investment Management (UK) Ltd.	United Kingdom	405,135.9
	BlackRock Advisors (UK) Ltd.	United Kingdom	351,935.5
	Dimensional Fund Advisors Ltd.	United Kingdom	198,347.5
2022	BlackRock Investment Management (UK) Ltd.	United Kingdom	381,350.9
	BlackRock Advisors (UK) Ltd.	United Kingdom	340,805.4
	Dimensional Fund Advisors Ltd.	United Kingdom	191,682.6
2023	BlackRock Advisors (UK) Ltd.	United Kingdom	385,861.0
	BlackRock Investment Management (UK) Ltd.	United Kingdom	351,897.0
	Amundi Asset Management SA (Investment Management)	France	182,624.4
2024	BlackRock Advisors (UK) Ltd.	United Kingdom	497,779.3
	BlackRock Investment Management (UK) Ltd.	United Kingdom	440,483.3
	Amundi Asset Management SA (Investment Management)	France	225,750.4

Table IA.7: Largest Institutions by Year: Asia

This table reports the three largest institutional investors in each year, ranked by their maximum assets under management (AUM) across the year's four quarters. AUM is expressed in millions of U.S. dollars.

Year	**Name**	**Country**	**AUM**
2012	Nikko Asset Management Co., Ltd.	Japan	51,299.4
	Nomura Asset Management Co., Ltd.	Japan	30,851.9
	Abrdn Asia Ltd.	Singapore	21,558.8
2013	Nikko Asset Management Co., Ltd.	Japan	55,986.3
	Nomura Asset Management Co., Ltd.	Japan	44,681.8
	Asset Management One Co., Ltd.	Japan	25,034.1
2014	Nikko Asset Management Co., Ltd.	Japan	55,672.8
	Nomura Asset Management Co., Ltd.	Japan	49,941.3
	National Pension Service of Korea	South Korea	35,716.6
2015	Nikko Asset Management Co., Ltd.	Japan	62,335.2
	Nomura Asset Management Co., Ltd.	Japan	59,316.8
	National Pension Service of Korea	South Korea	37,190.1
2016	Nomura Asset Management Co., Ltd.	Japan	72,617.4
	Nikko Asset Management Co., Ltd.	Japan	71,174.9
	Asset Management One Co., Ltd.	Japan	43,180.1
2017	Nomura Asset Management Co., Ltd.	Japan	102,979.2
	Nikko Asset Management Co., Ltd.	Japan	96,998.4
	Daiwa Asset Management Co. Ltd.	Japan	53,511.1
2018	Nomura Asset Management Co., Ltd.	Japan	120,399.3
	Nikko Asset Management Co., Ltd.	Japan	116,053.7
	Daiwa Asset Management Co. Ltd.	Japan	59,501.1
2019	Nikko Asset Management Co., Ltd.	Japan	146,888.9
	Nomura Asset Management Co., Ltd.	Japan	143,428.9
	National Pension Service of Korea	South Korea	74,297.1
2020	Nomura Asset Management Co., Ltd.	Japan	192,801.2
	Nikko Asset Management Co., Ltd.	Japan	180,812.7
	National Pension Service of Korea	South Korea	104,514.9
2021	Nomura Asset Management Co., Ltd.	Japan	204,248.8
	Nikko Asset Management Co., Ltd.	Japan	189,709.4
	Daiwa Asset Management Co. Ltd.	Japan	99,779.1
2022	Nomura Asset Management Co., Ltd.	Japan	184,710.3
	Nikko Asset Management Co., Ltd.	Japan	178,511.3
	Daiwa Asset Management Co. Ltd.	Japan	88,645.4
2023	Nomura Asset Management Co., Ltd.	Japan	196,792.3
	Nikko Asset Management Co., Ltd.	Japan	171,360.8
	Daiwa Asset Management Co. Ltd.	Japan	92,220.1
2024	Nomura Asset Management Co., Ltd.	Japan	229,823.0
	Nikko Asset Management Co., Ltd.	Japan	192,130.5
	Mitsubishi UFJ Kokusai Asset Management Co., Ltd.	Japan	134,831.8