

Frictions to intranational investment*

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Abstract

Despite unhalted technological progress in transport and communication infrastructure over the past century, geographical and cultural distance remain major obstacles to the flow of goods and production factors to date. In this paper, we show that geographical and cultural distance forcefully shape *intranational* investment flows in Norway, preventing an efficient allocation of capital to firms. To that end, we derive a structural gravity equation of investment from a general equilibrium model with multiple locations, multiple assets, and information frictions. Based on the model, we identify frictions related to geographical distance, travel time, administrative borders, and language differences and quantify the loss in terms of portfolio efficiency caused by each individual friction and by gravity as a whole. We also aim to study the impact of major infrastructure developments during the 2000s through the lens of the model: The politically-driven roll-out of broadband internet access across the country and the rapid expansion of the flight route network driven by Norwegian Airlines. Finally, we aim to deliver ex-ante predictions for the effects of a railway line connecting Northern Norway to the country's main rail network, as well as the effects of a change to the speed limit on major road connections.

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1 Introduction

The international equity home bias is well documented. But what happens “at home”?

In this paper we study the patterns of *intranational* investment and document how domestic frictions — just like *between* countries — lead to an uneven distribution of equity holdings *within* countries.

We build on two related strands of the literature. First, *gravity*-like patterns of domestic financial flows — across all different types of investors — have been documented. Coval and Moskowitz (1999) show that for US fund managers holdings in 1995 internal distance matters. Similarly, for venture capital investments (Cumming and Dai, 2010) and crowd funding (Lin and Viswanathan, 2016; Guenther, Johan, and Schweizer, 2018) a strong home bias exists and the physical distance between investor and recipient matters. Bank lending has also been documented to follow a strong gravity-like pattern. Grinblatt and Keloharju (2001) document that for Finnish equity holdings and trades of 97 publicly traded companies distance, language, and culture matter, more so for less savvy households and financial institutions. Petersen and Rajan (2002) note that there appears to be a dampening effect over time, as US small businesses over time are located further from their lending banks. *Corporate* investment, too, has been shown to follow these patterns, similar to what has been documented internationally in the literature on foreign direct investment. Giroud (2013) show a strong relationship between proximity to a subsidiary and plant-level investment. Uysal, Kedia, and Panchapagesan (2008) document differences in profitability of local vs non-local takeovers.

Second, this paper builds on theoretical foundations for gravity of financial flows, usually with an international dimension. Coeurdacier and Martin (2009) investigate the geography of asset trade and the Euro, documenting insiders and outsiders. In their theoretical model, portfolio diversification derives from an assumption of a distribution of projects across countries, which pay off in distinct states of the world. Asset prices differ across locations due to gravity-related cost. Okawa and Wincoop (2012), to which our theoretical model below is closely related, formulate a “gravity equation for international finance”, where gravity-related frictions add noise to the uncertainty surrounding returns in foreign locations. The gravity equations derived by Coeurdacier and Martin (2009) and Okawa and Wincoop (2012) are both based on strong assumption on the correlation pattern of returns across location. A key tenet of Okawa and Wincoop (2012) is to show that more general assumptions come at the cost of deviations from the traditional so-called structural gravity equation in international trade. Pellegrino, Spolaore, and Wacziarg (2021) sketch a theoretical framework for a gravity equation of international capital flows that takes inspiration from Eaton and Kortum (2002), while departing customary notions of risk-return trade-offs.

Our paper contributes to these strands of the literature along multiple lines: First, we document strong gravity-like patterns in investment decision at the micro-level between investors and firms using highly-detailed Norwegian data. Second, we construct a structural model for investment based on a risk-return trade-off and allowing for a general covariance pattern among the returns in different locations. In line with the results of Okawa and Wincoop (2012), the model predicts that bilateral investment deviates from structural gravity. However, we show that investment still follows a gravity-like structure, that is intuitive and tractable. Third, we use this model to evaluate the impact of changes in bilateral frictions by means of counterfactual analyses.

The remainder of this paper is structured as follows. In section 2 we use detailed data from Norway to give an ad-hoc overview of investment patterns over space. We set up a model in section 3 that rationalizes these stylized facts. We then quantify the model in section 5 and perform a number of counterfactual experiments in section 6. Section 7 concludes.

2 Stylized Facts

Holding the origin location of investment, migration, trade or many other economic exchanges fixed, the spatial distribution is highly uneven. This observation of so-called gravity has been well documented — in particular for interactions between countries. We now use detailed Norwegian micro-data to show that such patterns hold for domestic investments as well.

2.1 Data on Financial Asset Holdings

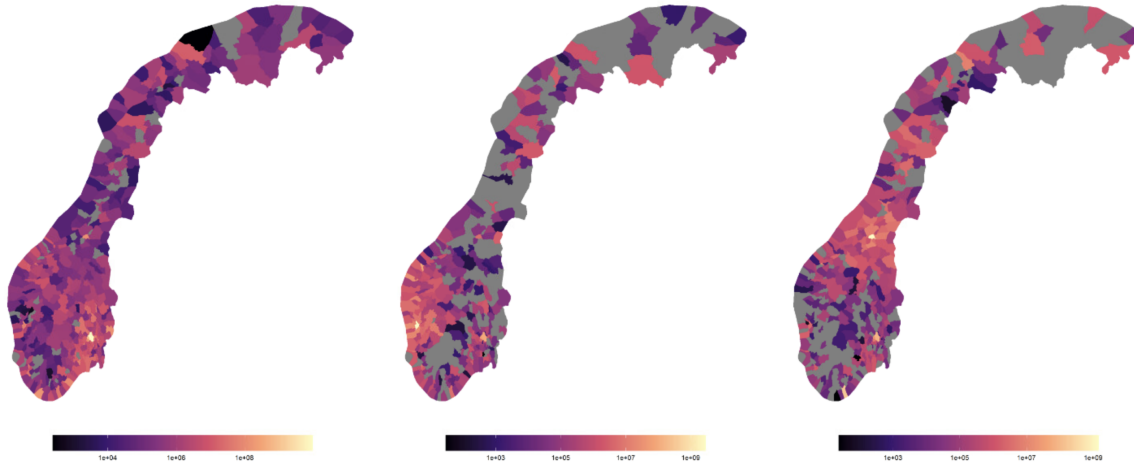
Our variable main variables of interest are derived from Norwegian equity ownership data collected by the country’s tax authority. The dataset has information on the number of shares and their nominal value by owner (individual or other legal person), as well as the share’s issuer, i.e. the firm, all at the annual level.¹ The data covers the time from 2004 to 2017 and includes around 310,000 firms and around 1.02 million individual owners, covering the universe of domestic financial asset holdings.²

The data is supplemented by a number of auxiliary datasets that allow us to geolocate the individual’s residence by zip-code and year (Population register), the firm’s location, age, subsidiaries, and plants by year (Firm register), as well as the firm’s sales, profits, and other balance sheet items (Database of Tax filings). While we observe the data at the micro-level, for the rest of the paper we aggregate the figures at different geographical levels — county (*fylker*), municipality

¹We disregard firms that are pure financial vehicles, identified as firms that do not report sales in any year in during our sample period.

²About 20% of Norwegian nominal share capital is foreign owned. Whereas the (value) share of foreign assets in the average Norwegian household’s portfolio, calculated using data from the IMF’s CPIS and the Norwegian Tax Authority, was 16% in 2017.

Figure 1: Investments from Oslo, Bergen and Trondheim



Note: The maps show the total value of investments in the destination municipality (*kommuner*) from Oslo (left), Bergen (center) and Trondheim (right). Gray-shaded areas have no investment from the respective origin municipality.

(*kommuner*) and basic statistical unit (*grunnkretser*).³

Figure 1 plots the absolute nominal values of investment of the municipalities of Oslo (left), Bergen (center) and Trondheim (right) in all 422 municipalities. Three empirical regularities are visible in plain sight:

1. *Home bias:* By far the largest investments are recorded in the same municipality. This regularity mirrors the results from the international home bias.
2. *Size:* The largest investments outside the local municipality are observed in the large cities — Oslo, Bergen, Trondheim and Stavanger. This positive elasticity of city size towards size of investment is one of pillars of the gravity equation.
3. *Distance:* By and large investments are higher the closer they are located to the investor's location. This negative elasticity of investments to distance is again observed in the related literature on financial flows, trade and migration.

Aside from the physical distance between two locations, other frictions are often observed to inhibit an even spatial distribution of investment, but also trade and migration. The reason why an investor may prefer to invest in one firm over another — abstracting from features of the specific firm — may be related to *bilateral* frictions between the two locations.

³Our analysis predates the 2020 reform of administrative areas that has reduced the number of counties from 19 to 11 and the number of municipalities from 422 to 356. The postal code reform of 1999 takes place before.

Data on Bilateral Frictions

As common in the gravity literature, physical distance between two locations serves as proxy for spatial frictions. E.g., longer travel times between the investor’s residence and the firm’s location could make it more difficult to observe business dealings. We compute bilateral travel times and road distances by car between these is computed using Open Source Routing Machine and Open Street Map data. Population-weighted great circle distances are computed following Hinz, 2019. The median distance and travel time between municipalities are 367 km and 9 hours, respectively. The maximum distance (travel time) is 1758 km (48.5 hours).

Another friction may be related to the language. There are two standards of written Norwegian — Nynorsk and Bokmål — that are clustered geographically. Bokmål is the main language for about 90 % of the population. Language differences by municipality are coded according to official declaration.⁴ Similarly, political leanings may be an expression of underlying differences, which we capture by the political position of a municipality’s ruling party — left, center or conservative.⁵

Finally, we include a Social Connectedness Index that measures the extent to which people within and across municipalities are connected via the social network facebook.⁶

2.2 Ad-hoc Gravity Estimation

We therefore estimate the following “ad-hoc” gravity equation:

$$A_{ij,t} = \exp \left(\mathbf{z}_{ij,t}' \boldsymbol{\beta}_z + \lambda_{i,t} + \psi_{j,t} \right) \quad (1)$$

where $\mathbf{z}_{ij,t}$ is the vector of variables of interest and $\boldsymbol{\beta}_z$ the respective coefficients. $\lambda_{i,t}$ and $\psi_{j,t}$ are origin \times year and destination \times year fixed effects, respectively. We use a customary Pseudo-Poisson Maximum Likelihood estimator following Silva and Tenreyro (2006) and cluster standard errors on origin, destination, and year following Egger and Tarlea (2015).

Table 1 reports the coefficients of estimating equation (1) with different specifications of $\mathbf{z}_{ij,t}$. In column (1) we “replicate” econometrically the three empirical findings from figure 1: We regress the financial holdings from one municipality in another on each location’s population, a dummy indicating whether the two locations coincide, as well as the bilateral great-circle distance between the two. The coefficients support the prior findings. Investments in the home location are about $\exp(2.61) \approx 13.6$ times higher than in a comparable location — pointing to a large home bias. The same holds for size: The larger the two locations in terms of population the higher the bilateral investments. Ceteris paribus, a 10 % larger population of the origin location is associated with a 6.5 % larger investment, 7.3 % larger for a 10 % larger destination location

⁴One quarter of Norwegian municipalities have declared Nynorsk as their official language form, accounting for about 12% of the Norwegian population. Source: <https://en.wikipedia.org/wiki/Nynorsk>.

⁵We source these data from Fiva H., Askill H., and Natvik J. (2020).

⁶Source: <https://dataforgood.fb.com/tools/social-connectedness-index/>

Table 1: Ad-hoc Gravity Regression

| | Dependent variable: Nominal holdings $s_{ij,t}$ | | | | |
|-----------------------------|---|----------------------|----------------------|----------------------|----------------------|
| | (1) | (2) | (3) | (4) | (5) |
| log(Population Origin) | 0.652*** (0.128) | - (-) | - (-) | - (-) | - (-) |
| log(Population Destination) | 0.734*** (0.122) | - (-) | - (-) | - (-) | - (-) |
| Same municipality | 2.610*** (0.456) | 2.500*** (0.415) | 2.695*** (0.471) | - (-) | - (-) |
| log(Distance) | -1.057*** (0.065) | -1.271*** (0.066) | -0.977*** (0.900) | -0.081 (0.183) | -0.689*** (0.096) |
| log(Travel Time) | - (-) | - (-) | - (-) | -0.807*** (0.224) | - (-) |
| Contiguity | - (-) | 0.872*** (0.186) | 0.922*** (0.294) | 0.944*** (0.143) | 0.930*** (0.141) |
| Same language | - (-) | - (-) | 0.907** (0.294) | 0.157 (0.110) | 0.121 (0.117) |
| Same ruling party | - (-) | - (-) | 0.356* (0.140) | -0.006 (0.041) | 0.004 (0.042) |
| Social connectedness | - (-) | - (-) | 0.212*** (0.048) | 0.385*** (0.063) | 0.429*** (0.053) |
| Fixed effects | - | <i>it, jt</i> | <i>it, jt</i> | <i>it, jt</i> | <i>it, jt</i> |
| Sample size | 2,493,176 | 2,493,176 | 2,493,176 | 2,486,847 | 2,486,847 |

Notes: Intercept in column (1) is suppressed. Standard errors clustered on origin, destination, and year in parenthesis. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

population. Finally, the bilateral distance clearly matters as well: For every % increase in distance from the investor's location, the amount of investment decreases by about 1 %. Hence, the estimated distance elasticity is very much of the same magnitude as those found in the related literature. In column (2) we control for other investor and firm location specifics with origin and destination fixed effects and include another standard gravity control variable, contiguity. As usual, the coefficient is significant and positive, indicating a strong preference of investors for investments in the vicinity of their municipality. The other two remaining coefficients on distance and same municipality remain very similar to the previous specification. We add further customary gravity variables in column (3) capturing similarity in cultural traits. Specifically, we add an indicator for whether the two municipalities share their official written standard of Norwegian — Nynorsk or Bokmål, or both and an indicator for whether the local government in both locations is dominated by a party from the same corner of the political spectrum. Both coefficients are positive and significant, albeit only at the 10 %-level for the latter. Moreover, we add the Social Connected Index as additional variable capturing the extent of the social and professional network spanning two locations via friendships on facebook. Social connectedness is strongly positively correlated with bilateral investment. In column (4) we include road travel times between the two locations, as Norway's mountainous topology often makes short

great-circle distances cumbersome to cover. And indeed, the coefficient for travel time is highly significant and around -1 , while the coefficient for the great-circle distance becomes small and statistically insignificant. The magnitude of the cultural variables drops markedly; and both become insignificant. One caveat of this specification is that within-municipalities are dropped due to a lack of local travel times. In column (5) we therefore re-estimate the specification from column (3) and find that the latter results are in fact driven by the change in the sample, whereas the remarkable change in the distance coefficient is indeed due to the inclusion of travel time.

Overall these reduced form “ad-hoc” gravity estimations underline the picture the raw data has painted: Similar to the international level, *intranational* gravity-like frictions appear to be strong determinants of the spatial distribution of domestic investment.

Table 2: Broadband coverage

| | Dependent variable: Nominal holdings $s_{ij,t}$ | | |
|---|---|----------------------|--------------------|
| | (1) | (2) | (3) |
| log(Travel Time) | -0.813*** (0.126) | -0.937*** (0.121) | - (-) |
| Contiguity | 0.929*** (0.148) | 0.896*** (0.152) | - (-) |
| Same language | 0.072 (0.139) | 0.073 (0.141) | - (-) |
| Same ruling party | 0.041 (0.066) | 0.033 (0.073) | - (-) |
| Social connectedness | 0.373*** (0.066) | 0.365*** (0.066) | - (-) |
| log(Travel Time) \times Broadband coverage in origin | - (-) | 0.126*** (0.041) | 0.046** (0.020) |
| Fixed effects | it, jt | it, jt | it, jt, ij |
| Sample size | 1,243,213 | 1,193,243 | 222,167 |

Notes: Standard errors clustered on origin, destination, and year in parenthesis.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

In table 2 we include another interaction in the specification, namely interacting travel time with a measure of broadband coverage in the origin location. The effect is clear: The coefficient in column (2) is *positive* and highly significant, meaning the further away an investment is located, the more it matters whether the investors location is well-equipped with a broadband internet connection that reduces information frictions. The result is confirmed when including an extra set of bilateral ij fixed effects in column (3), purging all time-invariant bilateral variation.

To study the quantitative importance of spatial frictions for the allocation of capital across Norway, we now turn to a structural model of investment.

3 Theory

The model economy is comprised of J regions, indexed by i, j . Every region features a measure of representative firms and a representative investor. Firms' sales are subject to shocks, rendering the return to holding shares stochastic. Capital is the only factor of production and equity is the only form of capital available to firms. Investors may also invest in a risk-free asset.

3.1 The Investor's Optimization Problem

The investor (from location) i chooses investments (the number of shares of the representative firms from j) to maximize lifetime utility

$$U_{i,t} = E \left[\sum_{s=0}^{\infty} \beta^s u(C_{i,t+s}) \right] \quad (2)$$

subject to the per-period budget constraint

$$C_{i,t+1} = W_{i,t+1} - \mathbf{a}_{i,t+1}' \mathbf{v}_{t+1} - a_{i,t+1}^f, \quad (3)$$

where $\mathbf{a}_{i,t}' = [a_{i1,t}, \dots, a_{ij,t}, \dots, a_{iJ,t}]$ is a vector of investments in assets $j = 1, \dots, J$ and $\mathbf{v}_t = [v_{1,t}, \dots, v_{j,t}, \dots, v_{J,t}]$ is the corresponding vector of asset prices and $a_{i,1}^f$ is the risk-free investment, subject to the equation of motion for wealth

$$W_{i,t+1} = \mathbf{a}_{i,t}' \mathbf{s}_{t+1} + a_{i,t}^f R_{t+1}^f, \quad (4)$$

where $\mathbf{s}_t = [s_{1,t}, \dots, s_{j,t}, \dots, s_{J,t}]$ is the vector of asset payoffs, and subject to the transversality condition. The first-order condition w.r.t. $a_{i,t}^f$ implies

$$E[m_{i,t+1}] = \frac{1}{R_{t+1}^f} \quad (5)$$

and the first-order condition w.r.t. $a_{ij,t}$ yields the Stochastic Euler equation

$$v_{j,t} = E_t[m_{i,t+1} s_{j,t+1}] \quad \text{with} \quad m_{i,t+1} = \beta \frac{u'(C_{i,t+1})}{u'(C_{i,t})}. \quad (6)$$

Defining (gross) stock returns as

$$R_{j,t+1} = \frac{s_{j,t+1}}{v_{j,t}}, \quad (7)$$

and using (5), Eq. (6) can be written as

$$1 = \frac{E_t[R_{j,t+1}]}{R^f} + \text{Cov}_t[m_{i,t+1}, R_{j,t+1}] \quad (8)$$

We approximate $m_{i,t+1}$, the stochastic discount (SDF), with a linear function of the portfolio return. I.e.,

$$m_{i,t+1} = \bar{\zeta}_{i,t} + \zeta_{i,t} R_{i,t+1}^W \quad \text{with} \quad R_{i,t+1}^W = \alpha_{i,t}^f R_{t+1}^f + \alpha_{i,t}' \mathbf{R}_{t+1} \quad (9)$$

where $\alpha_{i,t}' = [\alpha_{i1,t}, \dots, \alpha_{ij,t}, \dots, \alpha_{iJ,t}]$ is the vector of portfolio shares with typical element $\alpha_{ij,t} = \frac{a_{ij,t} v_{j,t}}{A_{i,t}}$, $\alpha_{i,t}^f$ is the portfolio share of the risk-free investment, and $A_{i,t} = \sum_{j=1}^J a_{ij,t} v_{j,t} + a_{i,t}^f$ is the value of the portfolio.⁷ Then,

$$\text{Cov}[m_{i,t+1}, R_{j,t+1}] = \zeta_{i,t} \sum_{j'=1}^J \alpha_{ij',t} \sigma_{j,j'} \quad (10)$$

where $\sigma_{j,j'}$ is a typical element of the covariance matrix of returns Σ_t .⁸ Rewriting (8) in matrix

⁷Eq. (9) is the key equation of the classical conditional Capital Asset Pricing Model. There are several combinations of assumptions on the distribution of returns and/or the utility function that are consistent with Eq. (9); see Cochrane (2000).

⁸Eq. (10) is derived by substituting for $m_{i,t+1}$ and $R_{i,t+1}^W$ with the linear expressions in (9) and by rewriting the covariance with the weighted sum of returns as the weighted sum of the covariances of individual returns, which

notation and using (10), we have

$$\mathbf{1} = \frac{1}{R^f} E_t [\mathbf{R}_{t+1}] + \zeta_{i,t} \mathbf{\Sigma}_t \boldsymbol{\alpha}_{i,t}, \quad (12)$$

which can be solved for the portfolio shares as

$$\boldsymbol{\alpha}_{i,t} = \frac{1}{-\zeta_{i,t}} \mathbf{\Sigma}_t^{-1} \left(\frac{1}{R^f} E_t [\mathbf{R}_{t+1}] - \mathbf{1} \right). \quad (13)$$

3.2 The Firm's Optimization Problem

Firms choose inputs in order to maximize their shareholder value net of the current cost of operating the firm. The shareholder value is given by the share price multiplied by the number of shares per firm, which we normalize to one.

Let $\pi_{j,t+1}$ denote the dividend paid by firm j , which equals the profit of firm j provided that the firm distributes all of its profit to shareholders. Then, the payoff from owning a share of firm j , $s_{j,t+1}$, may be written as

$$s(k)_{j,t+1} = \pi(k)_{j,t+1} + v(k)_{j,t+1}. \quad (14)$$

Substituting (14) into (6) and iterating forward, we may write the share price as the discounted value of all future profits:

$$v(k)_{j,t} = E_t \left[\sum_{s=0}^{\infty} \beta^s m_{i,t+s} \pi(k)_{j,t+s} \right]. \quad (15)$$

The firm's maximization problem reads

$$\max_k v(k)_{j,t} - b(k)_{j,t} \quad (16)$$

where k is the capital input and $b(k)_{j,t}$ denotes the cost of operating firm j at scale k . We use $b_{j,t}$ to denote the optimum cost corresponding to the optimal input k_t^* . Likewise, $\pi_{j,t+s}$ and $s_{j,t+s}$ denote the optimum payoff and the optimum profit.

3.3 General Equilibrium

Let the measure of representative firms in region j be denoted by $N_{j,t}$. Then, market clearing for equity requires

$$N_{j,t} = \sum_i a_{ij,t} \quad \Leftrightarrow \quad N_{j,t} v_{j,t} = \sum_i \alpha_{ij,t} A_{i,t}. \quad (17)$$

Equilibrium with free entry. Free entry implies that the net present value of creating a firm is zero. That is, the free entry requires that the value of a firm's equity, reflecting shareholders' gives

$$Cov[m_{i,t+1}, R_{j,t+1}] = \zeta_{i,t} Cov[R_{i,t+1}^W, R_{j,t+1}] = \zeta_{i,t} \sum_{j'} Cov[\alpha_{ij',t} R_{j',t+1}, R_{j,t+1}] = \zeta_{i,t} \sum_{j'=1}^J \alpha_{ij',t} \sigma_{j,j'}. \quad (11)$$

willingness to pay for ownership of the firm, be equal to the cost of operating the firm. That is,

$$v_{j,t} - b_{j,t} = 0. \quad (18)$$

Hence, share prices in the free-entry equilibrium are determined by a firm's optimum cost. The number of firms is determined by the market clearing condition (17).

Equilibrium with fixed numbers of firms. In an equilibrium with a fixed number of firms, asset prices are jointly determined by investors' FOCs (6) and the market clearing condition (17).

4 Implementing Gravity Frictions

We introduce information frictions similar to Okawa and Wincoop (2012) as a bilateral add-on to the variance of an asset, with the add-on reflecting additional noise induced by a lack of information about the asset from region i on the part of investor j . We denote the information friction with τ_{ij} . Like Okawa and Wincoop (2012), we assume that the variance of asset j from investor i 's point of view is $\sigma_{jj}^i = \tau_{ij}^2 \sigma_{jj}$, where σ_{jj} is the actual variance of R_j . Moreover, extending Okawa and Wincoop (2012), we allow for arbitrary correlations between all regions' returns, measured by the covariance matrix Σ . Let $\sigma_{jk} = \rho_{jk} \sqrt{\sigma_{jj}} \sqrt{\sigma_{kk}}$ denote the actual covariance between R_j and R_k , where ρ_{jk} is the correlation coefficient. Then, like an asset's variance, its covariance as perceived by investor i is augmented by information frictions. That is, $\sigma_{jk}^i = \tau_{ij} \tau_{ik} \sigma_{jk}$. The covariance matrix of returns from i 's point of view is then

$$\Sigma^i = T_i \Sigma T_i$$

where T_i is a diagonal matrix with element (j, j) equal to τ_{ij} . Then, the portfolio shares with an i -specific covariance matrix are

$$\alpha_{i,t} = \frac{1}{\zeta_{i,t} R_{t+1}^f} (\Sigma_t^i)^{-1} \left(E_t [\mathbf{R}_{t+1}] - \mathbf{R}_{t+1}^f \right) = \frac{1}{\zeta_{i,t} R_{t+1}^f} T_i^{-1} \Sigma^{-1} T_i^{-1} \left(E_t [\mathbf{R}_{t+1}] - \mathbf{R}_{t+1}^f \right). \quad (19)$$

where T_i^{-1} is a diagonal matrix with element (j, j) equal to $1/\tau_{ij}$.

Total bilateral investment then follows as

$$A_{ij} = \alpha_{ij} A_i = \frac{1}{\zeta_i R^f} \frac{1}{\tau_{ij}} c_{ij} A_i,$$

where $c_{ij} = \sum_k \frac{\tilde{\sigma}_{jk}(E[R_k] - R^f)}{\tau_{ik}}$ and $\tilde{\sigma}_{jk}$ is an element of Σ^{-1} . That is, we arrive at a gravity-style equation, featuring *two* bilateral terms: Direct frictions τ_{ij} and *indirect* frictions related to the covariance of j 's return with all other regions' returns.⁹ The presence of c_{ij} and its correlation with τ_{ij} implies that standard gravity equations for investment, alike the ones we estimate in

⁹The impact of bilateral frictions on the bilateral investment and the structure of the covariance component $c_{ij,t}$ is

Section 2, are generally not consistent with a structural model for investment if asset returns are correlated across destinations. Only in the special case of zero covariances considered by Okawa and Wincoop (2012), c_{ij} collapses to c_j , such that bilateral shareholdings are log-linearly related to the frictions τ_{ij} . In what follows, we thus use a non-linear estimator together with data on the distribution of returns to estimate the frictions.

5 Quantification

5.1 Model-based Quantification of Bilateral Frictions

We use Eq. (19) together with data on the number of bilateral share holdings and the empirical distribution of profits across regions to identify the bilateral frictions.

Specifically, we rewrite the $J \times J$ first-order conditions summarized in (19) as

$$E[R_j] - R^f = \sum_k^J \dot{\tau}_{ij} \dot{\tau}_{ik} \dot{\alpha}_{ik} \tilde{\sigma}_{jk}, \quad (20)$$

where we have defined $\dot{\tau}_{ij} = \tau_{ij} \sqrt{\zeta_i R^f \alpha_i}$ as a scaled friction subsuming the investor-specific utility parameter ζ_i , the share of investor i 's total investment in risky assets denoted by $\alpha_i = \sum_j \alpha_{ij}$, and the risk-free rate. Furthermore, we denote with $\dot{\alpha}_{ij} = \frac{\alpha_{ij}}{\sum_k \alpha_{ik}}$ the share of asset j in the *risky* portfolio (in contrast to α_{ij} , which denotes the assets share in the total portfolio). We solve the system of $J \times J$ equations for $J \times J$ values of $\dot{\tau}_{ij}$ under the constraint that $\dot{\tau}_{ij} > 0$. To determine the scaling factor $\zeta_i R^f \alpha_i$ we impose the normalization $\tau_{ii} = 0 \forall i$, which implies $\dot{\tau}_{ii} = \sqrt{\zeta_i R^f \alpha_i}$ and $\tau_{ij} = \frac{\dot{\tau}_{ij}}{\dot{\tau}_{ii}}$.

5.2 Data and Calibration

We use the data on nominal shareholdings from Section 2.1 together with information on share prices and profits to inform equation (20) and to calibrate the baseline of our model to a given base year t .

straightforward to see in a two-country example with $i = 1, 2$. Total bilateral investment from i to 1 is then

$$A_{i1} = \alpha_{i1} A_i = \frac{1}{\zeta_i R_f} \frac{1}{\tau_{i1}} c_{i1} A_i.$$

Using R_j^e as a shorthand for $E[R_j] - R^f$ and dropping time indices for simplicity, the portfolio shares are equal to

$$\begin{aligned} \alpha_{i1} &= \frac{1}{\zeta_i R_f} \left(\frac{1}{\tau_{i1}^2} s_{11} R_1^e + \frac{1}{\tau_{i1} \tau_{i2}} s_{12} R_2^e \right) = \frac{1}{\zeta_i R_f} \frac{1}{\tau_{i1}} \left(\frac{1}{\tau_{i1}} s_{11} R_1^e + \frac{1}{\tau_{i2}} s_{12} R_2^e \right) \\ \alpha_{i2} &= \frac{1}{\zeta_i R_f} \left(\frac{1}{\tau_{i1} \tau_{i2}} s_{21} R_1^e + \frac{1}{\tau_{i2}^2} s_{22} R_2^e \right) = \frac{1}{\zeta_i R_f} \frac{1}{\tau_{i2}} \left(\frac{1}{\tau_{i1}} s_{21} R_1^e + \frac{1}{\tau_{i2}} s_{22} R_2^e \right). \end{aligned}$$

and the covariance component is $c_{i1} = \frac{1}{\tau_{i1}} s_{11} R_1^e + \frac{1}{\tau_{i2}} s_{12} R_2^e$.

We combine information on the book value of all public firms observed in the register data with share prices information from three different sources to obtain a measure of the market value of each public firm in Norway. i) For listed firms we use the end-of-year price at which the firms stocks were traded on the Oslo stock exchange. ii) For a subset of non-listed firms we have information on share prices from over-the-counter transactions taking place on the NOTC exchange. iii) For all public firms, nominal share prices and share premia are recorded in the register data whenever firms issue new shares. Taking all three sources together, we obtain information on share prices in at least one year for about half of our set of firms. To obtain a measure of the value of share holdings for the remaining firms, we project the observed book-to-market ratios on firm age and municipality \times sector fixed effects and then predict book-to-market ratios for the rest of the sample.¹⁰

We compute the expected return to the aggregate investment at the municipality level in accordance with Eq. (14) as $E[R_j] = \frac{\bar{\pi}_j + \bar{v}_j}{\bar{v}_j}$, where $\bar{\pi}_j$ and \bar{v}_j denote the sum of the profits and market values of all firms in municipality j , averaged over a period of ten years preceding the base year of our counterfactual. Firm profits are obtained from the accounting data reported to the tax authorities. Under the assumption that firm values are constant, we obtain the covariance matrix of returns across regions from the pairwise covariances of $\frac{\pi_{j,t}}{v_j}$ and $\frac{\pi_{k,t}}{v_k} \forall k, j$, calculated over a period of ten years preceding the base year of our counterfactual.

5.3 Frictions and Gravity

Additionally, we can relate the model-implied bilateral frictions to the customary bilateral gravity variables also employed above in the “ad-hoc” estimation of the gravity equation. Specifically, we estimate

$$\tau_{ij,t} = \exp(\mathbf{z}'_{ij,t} \boldsymbol{\beta}_z + \lambda_{i,t}) \quad (21)$$

where $\mathbf{z}_{ij,t}$ is again a vector of variables of interest and $\boldsymbol{\beta}_z$ the vector of corresponding coefficients and $\lambda_{i,t}$ is an origin fixed effect.

Table 3 displays the results.

TO BE COMPLETED

6 Counterfactuals

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7 Conclusion

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¹⁰Sectors are defined at the 3-digit level of the NACE 2007 classification.

Table 3: Regression of Model-based Frictions

| | Dependent variable: Nominal holdings $_{ij,t}$ | | |
|----------------------|--|-----------------------|-----------------------|
| | (1) | (2) | (3) |
| log(Travel Time) | 0.519* (0.279) | 0.450 (0.318) | .666** (.325) |
| Same County | - (-) | -14.857*** (1.048) | -14.126*** (2.248) |
| Contiguity | - (-) | -1.915 (6.478) | 1.449 (5.531) |
| Same language | - (-) | - (-) | 0.506 (0.779) |
| Same ruling party | - (-) | - (-) | 1.412 (1.697) |
| Social connectedness | - (-) | - (-) | -0.197 (0.741) |
| Sample size | 323 | 323 | 323 |

Notes: Standard errors clustered on origin, destination, and year in parenthesis.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

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A Estimations

Table 4: Ad-hoc Gravity Regression with Shares

| | Dependent variable: Share of holdings $s_{ij,t}$ | | | | |
|---|--|----------------------|----------------------|----------------------|----------------------|
| | (1) | (2) | (3) | (4) | (5) |
| log(Population Origin) | 0.285*** (0.081) | - (-) | - (-) | - (-) | - (-) |
| log(Population Destination) | 0.864*** (0.127) | - (-) | - (-) | - (-) | - (-) |
| Same municipality | 2.426*** (0.410) | 1.644*** (0.301) | 1.982*** (0.398) | - (-) | - (-) |
| log(Distance) | -1.192*** (0.071) | -1.970*** (0.075) | -1.570*** (0.118) | -0.202 (0.147) | -1.365*** (0.119) |
| log(Travel Time) | - (-) | - (-) | - (-) | -1.360*** (0.107) | - (-) |
| Contiguity | - (-) | 0.736*** (0.146) | 0.828*** (0.155) | 0.757*** (0.093) | 0.797*** (0.084) |
| Same language | - (-) | - (-) | 0.440 (0.310) | 0.137 (0.220) | 0.119 (0.214) |
| Same ruling party | - (-) | - (-) | 0.166 (0.156) | -0.156 (0.176) | -0.138 (0.172) |
| Social connectedness | - (-) | - (-) | 0.316*** (0.089) | 0.342*** (0.080) | 0.4512*** (0.074) |
| Fixed effects | - | it, jt | it, jt | it, jt | it, jt |
| Sample size | 1,926,974 | 2,493,176 | 2,493,176 | 2,486,847 | 2,486,847 |
| Notes: Intercept in column (1) is suppressed. Standard errors clustered on origin, destination, and year in parenthesis. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ | | | | | |