Frictions to intranational investment

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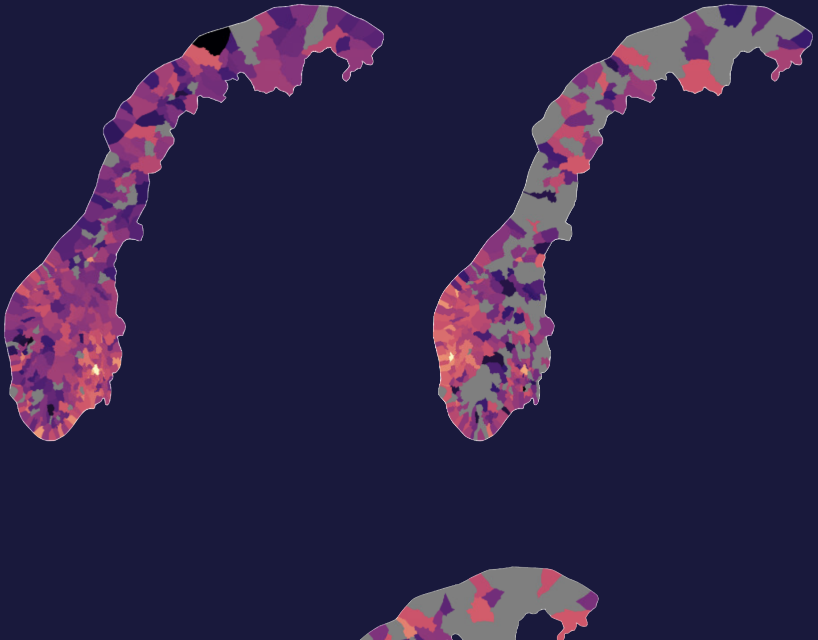


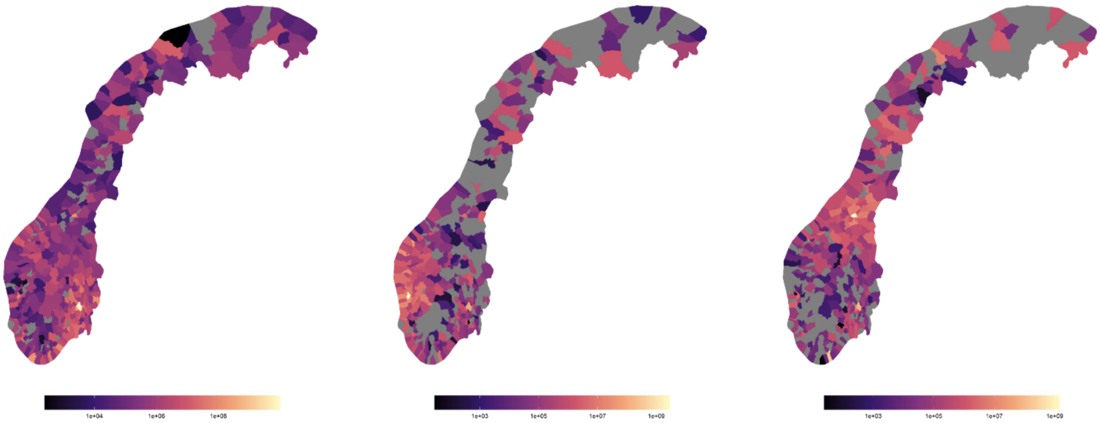
What this paper is about

- Strong gravity-like forces for *intranational* investment
- Exhaustive dataset and structural model
- (Plan to) run counterfactuals: Infrastructure improvements and spatial distribution of investments

Road map

1. Data and stylized facts
2. Related literature and background
3. Theory
4. Model calibration
5. Outlook: Counterfactuals

Stylized facts



→ Gravity classics: Home bias, size, distance, . . .

Financial Asset Holdings

- Norwegian equity ownership data collected by the country's tax authority
- Number of shares and their nominal value by owner, issuer
- Annual data for years between 2004 to 2017
- around 310,000 firms and around 1.02 million individual owners

$\rightarrow$ universe of domestic financial asset holdings

$\rightarrow$ in 2017: $\approx$ 20% of nominal share capital foreign owned, value share of foreign assets $\approx$ 16%

Auxiliary datasets

- Location of individuals (Population register)
- Firm location, age, subsidiaries, and plants by year (Firm register)
- Firm sales, profits, and other balance sheet items (Database of tax filings)

→ Spatial aggregation to county (*fylker*), municipality (*kommuner*) and basic statistical unit (*grunnkretser*)

Bilateral frictions

- Bilateral travel times and road distances by car: Open Source Routing Machine and Open Street Map data
- Population-weighted great circle distances
- Standards of written Norwegian: Nynorsk and Bokmål
- Municipality's ruling party
- Social Connectedness Index from Facebook
- Broadband coverage

Ad-hoc Gravity Estimation

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

- $A_{ij,t}$ nominal holdings of individuals from *i* in firms in *j* at time *t*
- $\mathbf{z}_{ij,t}$ 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
- Pseudo-Poisson Maximum Likelihood estimator

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

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

Ad-hoc Gravity Estimation

- Investments in home location about $\exp(2.61) \approx 13.6$ times higher than in comparable location
- 10 % larger population of origin (destination) location associated with 6.5 % (7.3 %) larger investment
- 1 % increase in distance decreases investments by about 1 %
- Contiguity, language, political preferences, social connectedness matter

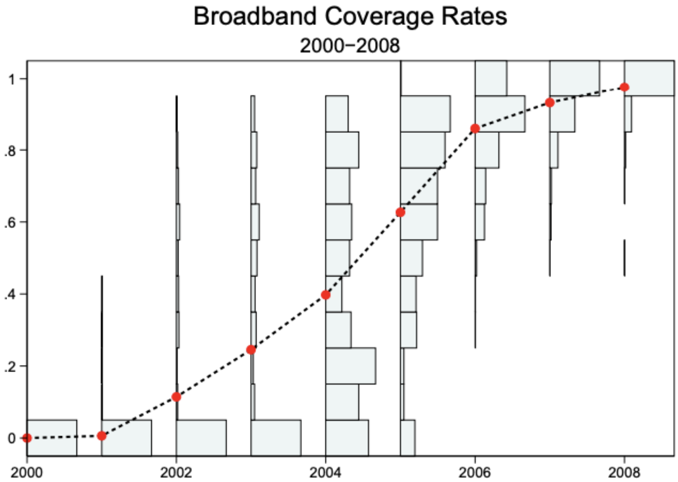
$\rightarrow$ Results similar to *international* frictions

Information frictions

- Frictions may be related to information or communication cost
- Did better internet access reduce frictions and improve allocation of capital?

→ Idea: Exploit variation in broadband roll-out over time and space

Broadband roll-out: Share of households covered



Source: Bhuller et al. 2013

	Dependent variable: Nominal holdings$_{ij,t}$		
	(1)	(2)	(3)
log(Travel Time)	-0.813***	-0.937***	-
	(0.126)	(0.121)	(-)
Contiguity	0.929***	0.896***	-
	(0.148)	(0.152)	(-)
Same language	0.072	0.073	-
	(0.139)	(0.141)	(-)
Same ruling party	0.041	0.033	-
	(0.066)	(0.073)	(-)
Social connectedness	0.373***	0.365***	-
	(0.066)	(0.066)	(-)
log(Travel Time) $\times$	-	0.126***	0.046**
Broadband coverage in origin	(-)	(0.041)	(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. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Related literature and context

Literature

Home and local bias in investment

- International: French & Poterba (1991), Coeurdacier and Rey (2013),…
- Intranational: Coval & Moskowitz (1999) — US fund holdings; Cumming & Dai (2010) — VC; Lin & Viswanathan, (2016), Guenther, Johan & Schweizer (2018) — crowd funding; Grinblatt & Keloharju (2001) — equity; Giroud (2013) — corporate investment

Structural models for gravity in international finance

- Martin & Rey (2004,2009); Okawa & van Wincoop (2012); Pellegrino et al. (2021)

Economic effects of the broadband expansion in Norway

- Bhuller et al. (2013), Akerman et al. (2019), Hvide et al. (2021)

Theory

Basic setup

- Economy comprised of J regions, indexed i, j
- Representative firms and representative investor in each region
- Capital only factor of production, equity only form of capital
- Firms' sales are subject to shocks, return to shares stochastic
- Investors may also invest in risk-free asset, denoted f

Investor problem

- Investor from *i* chooses number of shares from *j* to maximize lifetime utility

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

$$C_{i,t+1} = W_{i,t+1} - \mathbf{a_{i,t+1}}'\mathbf{v_{t+1}} - a^f_{i,t+1},$$

$$W_{i,t+1} = \mathbf{a_{i,t}}'\mathbf{s_{t+1}} + a^f_{i,t}R^f_{t+1}$$

- $\mathbf{a_{i,t}}' = [a_{i1,t}, ..., a_{ij,t}, ..., a_{iJ,t}]$ is vector of investments in assets $j = 1, ..., J$
- $\mathbf{v_t} = [v_{1,t}, ..., v_{j,t}, ..., v_{J,t}]$ is vector of asset prices, $a^f_{i,1}$ risk-free investment
- $\mathbf{s_t} = [s_{1,t}, ..., s_{j,t}, ..., s_{J,t}]$ is vector of asset payoffs

Investor problem

- FOC w.r.t. $a^f_{i,t}$ and $a_{ij,t}$: $E[m_{i,t+1}R^f_{t+1}] = 1$ and $E[m_{i,t+1}s_{j,t+1}] = v_{j,t}$
- $m_{i,t+1} = \beta \frac{u'(C_{i,t+1})}{u'(C_{i,t})}$, stochastic discount factor (SDF), approximated as

$$m_{i,t+1} = \overline{\zeta}_{i,t} + \zeta_{i,t} R^W_{i,t+1} \quad \text{with} \quad R^W_{i,t+1} = \alpha^f_{i,t} R^f_{t+1} + \boldsymbol{\alpha}'_{i,t} \boldsymbol{R}_{t+1}$$

- vector of portfolio shares $\boldsymbol{\alpha}'_{\boldsymbol{i,t}} = [\alpha_{i1,t}, ..., \alpha_{ij,t}, ..., \alpha_{iJ,t}]$ with elements $\alpha_{ij,t} = \frac{a_{ij,t} v_{j,t}}{A_{i,t}}$
- vector of gross returns $\boldsymbol{R}_{t+1}$ with elements $R_{j,t+1} = \frac{s_{j,t+1}}{v_{j,t}}$
- value of the portfolio $A_{i,t} = \sum_{j=1}^{J} a_{ij,t} v_{j,t} + a^f_{i,t}$ with $\alpha^f_{i,t}$ share of risk-free asset

$\rightarrow$ several assumptions consistent with specification of SDF (Cochrane, 2000)

Investor problem

- Stochastic Euler equation (FOC w.r.t. $a_{ij,t}$) can be rewritten as

$$\frac{E_t\left[R_{j,t+1}\right]}{R^f} + Cov_t\left[m_{i,t+1}, R_{j,t+1}\right] = 1$$

- Using SDF, latter term can be written as $Cov\left[m_{i,t+1}, R_{j,t+1}\right] = \zeta_{i,t}\sum_{j'=1}^{J}\alpha_{ij',t}\sigma_{j,j'}$
- Then

$$\frac{1}{R^f}E_t\left[\mathbf{R_{t+1}}\right] + \zeta_{i,t}\boldsymbol{\Sigma_t}\boldsymbol{\alpha_{i,t}} = \mathbf{1}$$

$$\iff \boldsymbol{\alpha_{i,t}} = \frac{1}{-\zeta_{i,t}}\boldsymbol{\Sigma_t}^{-1}\left(\frac{1}{R^f}E_t\left[\mathbf{R_{t+1}}\right] - \mathbf{1}\right)$$

- $\boldsymbol{\Sigma_t}$ covariance matrix of returns with elements $\sigma_{j,j'}$

Frictions — Okawa & van Wincoop (2012)

- Information frictions similar to Okawa & van Wincoop (2012)
- Variance of asset *j* from investor *i*'s point of view:

$$\sigma_{jj}^{i} = \tau_{ij}^{2}\sigma_{jj}$$

where σ_{jj} is the actual variance of R_j

Frictions — Generalization

- Now: Allowing arbitrary correlations between all regions' returns
- *Covariance* as perceived by investor i is distorted by information frictions:

$$\sigma^i_{jk} = \tau_{ij}\tau_{ik}\sigma_{jk}$$

  where σ_{jk} denotes the actual covariance between R_j and R_k
- Covariance matrix of returns from i's point of view is then

$$\boldsymbol{\Sigma^i} = \boldsymbol{T_i}\Sigma\boldsymbol{T_i}$$

  where $\boldsymbol{T_i}$ is a diagonal matrix with element (i, j) equal to τ_{ij}

- Portfolio shares with *i*-specific covariance matrix then

$$\boldsymbol{\alpha_{i,t}} = \frac{1}{\zeta_{i,t} R^f_{t+1}} (\boldsymbol{\Sigma^i_t})^{-1} \left(E_t \left[\mathbf{R_{t+1}} \right] - \mathbf{R^f_{t+1}} \right)$$
$$= \frac{1}{\zeta_{i,t} R^f_{t+1}} \boldsymbol{T_i}^{-1} \boldsymbol{\Sigma^{-1}} \boldsymbol{T_i}^{-1} \left(E_t \left[\mathbf{R_{t+1}} \right] - \mathbf{R^f_{t+1}} \right)$$

with $\tilde{\sigma}_{ij}$ being an element of $\boldsymbol{\Sigma^{-1}}$

Bilateral investment with frictions

- Dropping time dimension, total bilateral investment then

$$
\begin{aligned}
A_{ij} &= \alpha_{ij} A_i \\
&= \frac{1}{\zeta_i R^f} \frac{1}{\tau_{ij}} c_{ij} A_i \\
\text{with} \quad c_{ij} &= \sum_k \frac{\tilde{\sigma}_{jk}(E[R_k] - R^f)}{\tau_{ik}}
\end{aligned}
$$

- Gravity-style equation, featuring *two* bilateral terms
- Direct frictions τ_{ij}
- *Indirect* frictions related to the covariance of *j*'s return with all other regions' returns

Quantification

Quantification

- Solving for model-implied bilateral frictions
- $J \times J$ Euler equations
- Data on the bilateral share holdings, prices, and empirical distribution of profits

Euler equations

Rewrite $J \times J$ Euler equation as

$$\mathrm{E}[R_j] - R^f = \sum_k^J \dot{\tau}_{ij}\dot{\tau}_{ik}\dot{\alpha}_{ik}\tilde{\sigma}_{jk} \qquad \text{where}$$

$$\dot{\tau}_{ij} = \tau_{ij}\sqrt{\zeta_i R^f \alpha_i} \qquad \text{and} \qquad \dot{\alpha}_{ij} = \frac{\alpha_{ij}}{\alpha_i}$$

- Normalize domestic frictions: $\tau_{ii} = 1 \Rightarrow \dot{\tau}_{ii} = \sqrt{\zeta_i R^f \alpha_i}$ and $\tau_{ij} = \frac{\dot{\tau}_{ij}}{\dot{\tau}_{ii}}$

$\rightarrow$ Calculate $J \times J$ scaled frictions $\dot{\tau}_{ij}$ using data on $\mathrm{E}[R_j] - R^f$, $\dot{\alpha}_{ij}$

Data

- Share prices v_j stock exchange, over-the-counter transactions, share emissions

$\rightarrow$ extrapolation of missing share prices via industry$\times$ municipality FEs and firm age

$\rightarrow$ portfolio shares $\dot{\alpha}_{ij} = \frac{v_j a_{ij}}{\sum_k v_k a_{ik}}$

- Expected returns $\mathrm{E}[R_j] = 1 + \frac{\bar{\pi}_j}{\bar{v}_j}$

$\rightarrow$ $\bar{\pi}_j / \bar{v}_j$ sum of profits/market values of public firms in j, average over 10 years

- Covariance matrix of returns $\mathrm{Cov}\left[\frac{\pi_j}{v_j}, \frac{\pi_k}{v_k}\right]$ $\forall\, k, j$, computed over ten years

	Dependent variable: Model-implied frictions τ_{ij}	
	(1)	(2)
log(Travel Time)	0.519*	0.666**
	(0.279)	(.325)
Same County	-	-14.126***
	(-)	(2.248)
Contiguity	-	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

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

Outlook: Counterfactuals

Plan for Counterfactual Analysis

Quantify impact on spatial allocation of capital, efficiency of optimal portfolio, utility

- broadband roll-out
- geography, administrative and cultural barriers, transport infrastructure investments

Conclusions

- Gravity-type frictions to investment are not an international phenomenon
- Matter just as much for domestic capital markets
- Plan: Quantify impact of broadband access

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Firm problem and general equilibrium

- Firms choose inputs to maximize shareholder value net of the current cost of operating the firm
- $N_{j,t}$ number of firms in j at time t, market clearing for equity then

$$N_{j,t} = \sum_i a_{ij,t} \qquad \Leftrightarrow \qquad N_{j,t} v_{j,t} = \sum_i \alpha_{ij,t} A_{i,t}$$

- Equilibrium with free entry: willingness to pay for ownership equals cost of operating
- Equilibrium with fixed $N_{j,t}$: asset prices jointly determined by investor's Euler equation and market clearing condition