The Reign of the Great Banks:

Financial Development and Firms' Real Economic Activity in Imperial Germany

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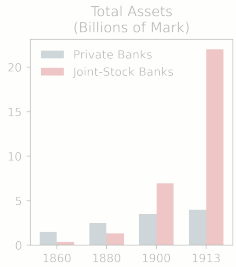
Research Objective & Motivation

We study the real effects of financial development on firms' economic activity, exploring **the evolution of the banking landscape** in Imperial Germany, 1896-1914.

Imperial Germany (1871-1918) as a real world lab for financial development:



- Period of rapid industrialization & globalization.
- General incorporation legislation.
  $\Rightarrow$ Surge in demand for credit.
- Foundation of *Reichsbank* acting as "lender of last resort" (James, 1997).
- Emergence of large joint-stock credit banks.
  $\Rightarrow$ High credit volumes
  $\Rightarrow$ *Long-term* credit

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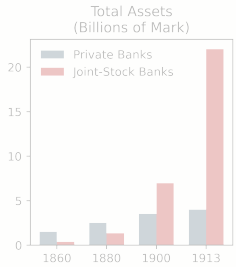

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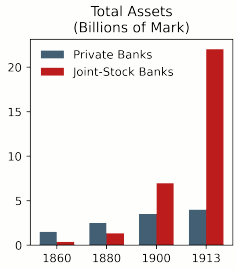

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Period 1896 - 1914: The Expansion of the *Great Banks*

The second half of the empire's life (1896-1918) is of particular interest:

- Established institutions; overall economic growth & moderate volatility.
- With the exception of the 1900-1902 crisis.
- This crisis triggered a transformation of the banking sector.

Before the crisis

- Eight *Great Banks* had emerged, providing a range of financial services.
- Strong within-country heterogeneity of financial development.

After the crisis

- Disproportional growth in importance of the *Great Banks* through...
  - ... geographic expansion.
  - ... increased control over the industry and the financial sector.
- $\rightarrow$ Reduction in financial development heterogeneity.

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Potential Economic Mechanisms

A priori, the effects of the banking sector's transformation on firm-level activities are not clear:

(1) Financial development trough the *Great Bank's* expansion might increase access to finance.

→ Proximity to banks facilitates financing and spurs firm performance.
(Tilly, 1967; Beck et al., 2019; Bellucci et al., 2019; Herpfer et al., 2023)

→ "Enabling vs. disciplining effect" of financing constraints on investment and firm output.
(Manso, 2011; Garicano & Steinwender, 2016; Cerqueiro et al., 2017)

(2) The *Great Bank's* dominance spread business know-how but also concentrated power:

→ By enforcing their dominant position, banks may exert downward pressure on loan conditions, hampering firm performance. (Rice & Strahan, 2010; Cornaggia et al., 2015)

→ Strategic investors can significantly enhance business operations, e.g., by providing advice, monitoring, networking etc. (Hellmann & Puri, 2002; Davis et al., 2014; Bernstein et al., 2016)

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This Paper...

... examines the effects of financial development on real economic activities using a well-suited historical setting and unique data.

→ Leverage novel data constructed using the latest AI technology developments:

- Firm information and financial data on the universe of German joint-stock companies
- Hand-collect geolocations of (firms and) banks on the branch level, consistently over time.
- Previously unexploited information on fiscal agencies (so-called "Zahlstellen") providing a unique firm-bank link.
- ⇒ Unique data on 7,646 firms and the eight *Great Banks* for the years 1896–1914.

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Variation over time

- We exploit changes in the firms' geographic proximity to the *Great Banks* over time (*EEA* scores)

Endogeneity issues

- *Great Banks* do not randomly expand

→ Exclusion of direct firm-bank links

→ Exclusion of firms in the neighborhood of branches

→ Second source of variation

Cross-sectional variation

- We exploit industry dependence on external financing.

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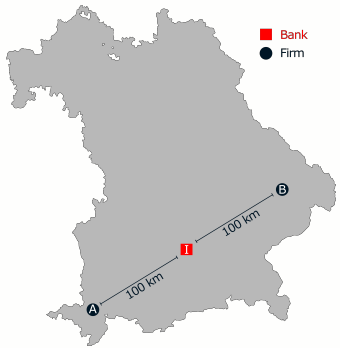

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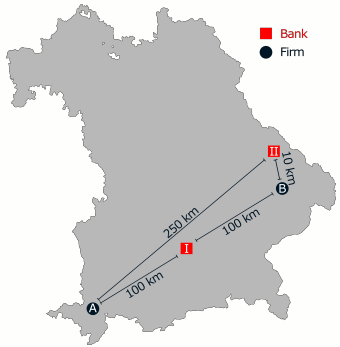

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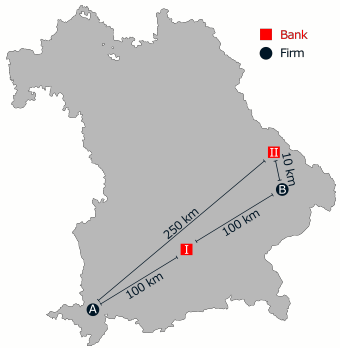

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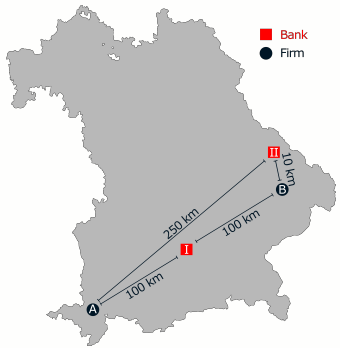

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Preliminary Results

1. **Descriptive findings:**
   - First firm-level statistics on majority of joint-stock companies in Imperial Germany, 1896–1914.
   - First quantitative analysis of the banking sector's transformation following the 1900-1902 crisis.
     - Geographic *Great Bank* branch network.
     - Firm-bank network.
     - Peripheral states experience most pronounced changes.

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   - Financial development of the banking sector increased firm debt financing.
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2. The Banking Sector's Transformation: Context and Descriptive Findings
3. Empirical Strategy and Preliminary Results
4. Summary, Outlook, and Conclusion
5. Excursus: Matching Framework `NeerMatch` (Karapanagiotis & Liebald, 2023)

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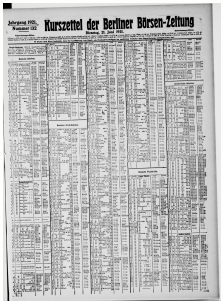
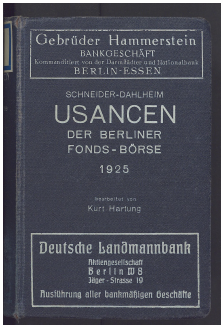
Data Sources

We extract information from different sources

1. Handbuch der Deutschen Aktiengesellschaften (HdAG)
2. Berliner Börsenzeitung (BZZ)
3. Usancen der Berliner Fonds-Börse





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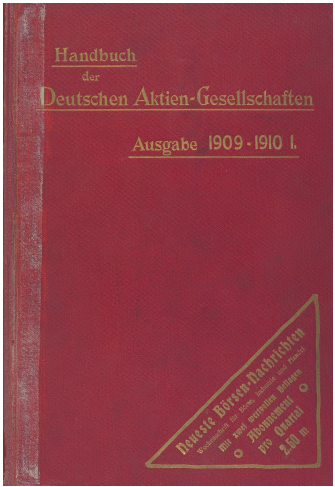

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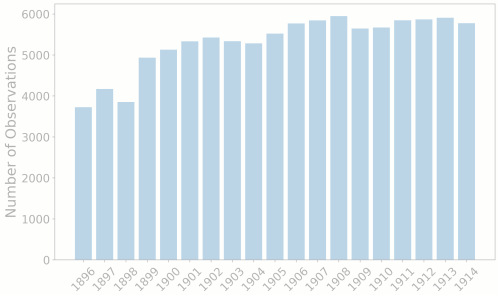

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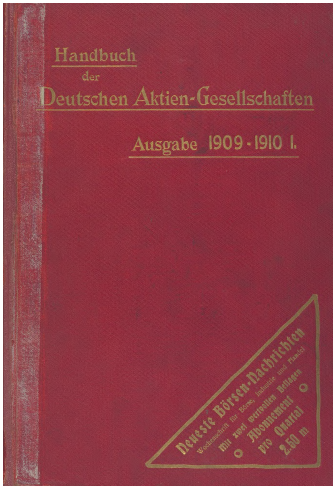

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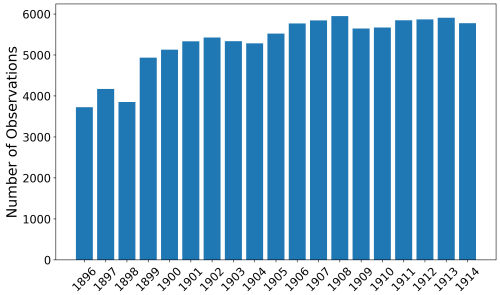

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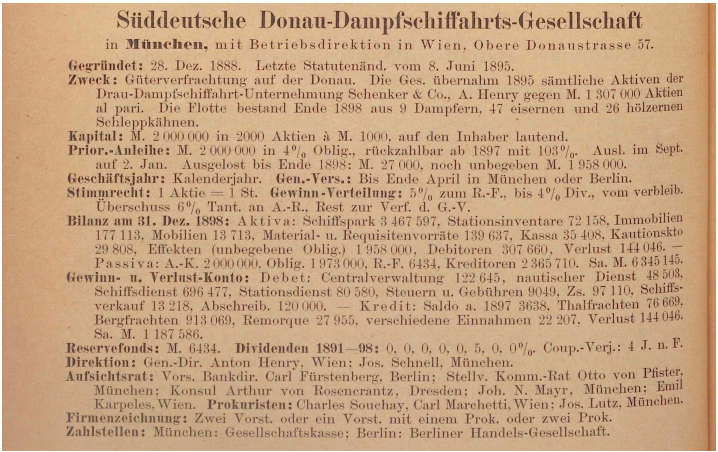

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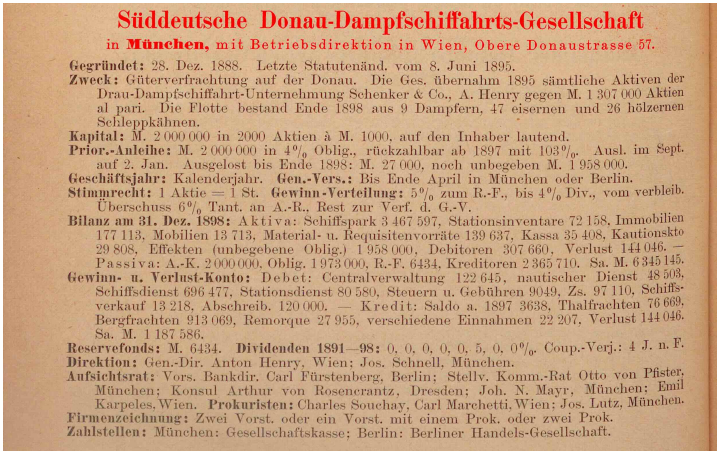

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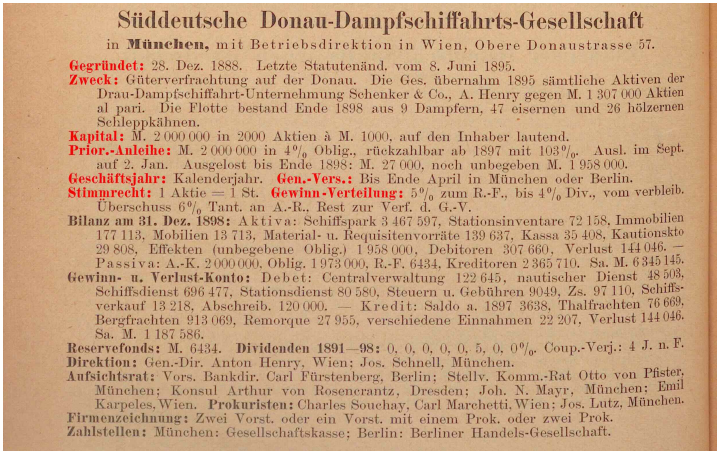

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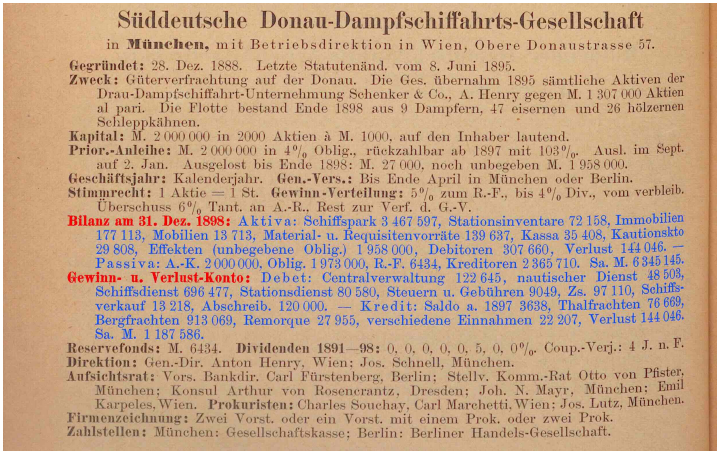

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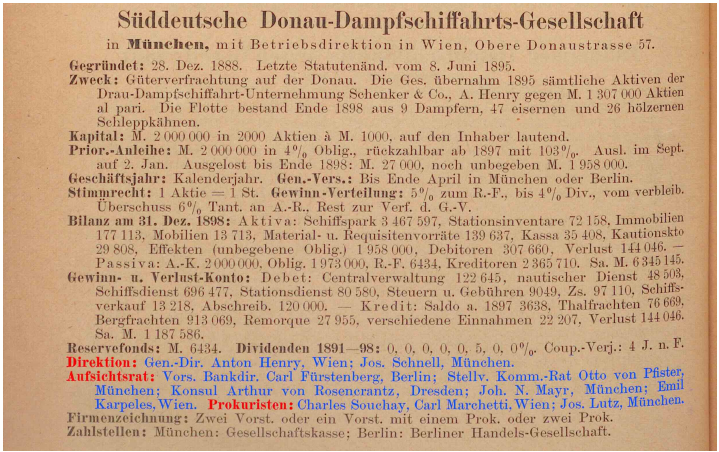

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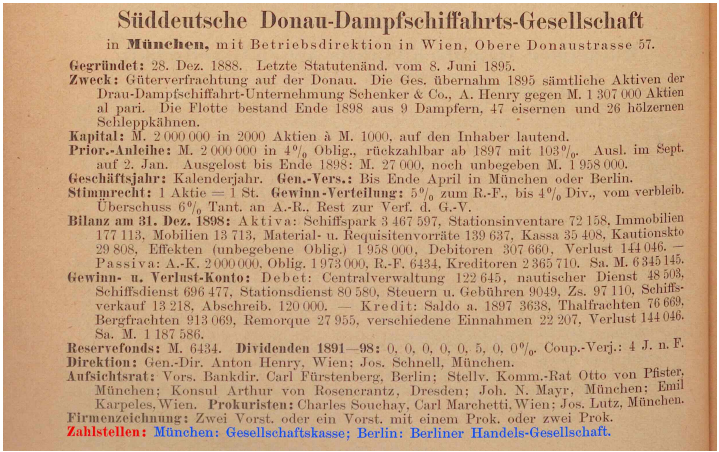

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Data Generation Process in a Nutshell

Optical Character Recognition (OCR)
- Project partner UB Mannheim
- incl. scanning, pre-processing, line straightening
- `Tesseract 5.x`

Input & derived Layer
- OCR Output to PostgresSQL instance
- Line type classification
- Collapsing to firm-year level

Linking Layer
- Introduce panel ID to cross-sectional data
- `NeerMatch` (Machine Learning Similarity Encoding Matching)
- Firms & persons

Combination & export layer
- Parsing
- Harmonization

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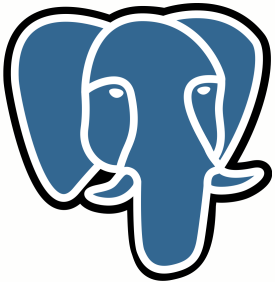

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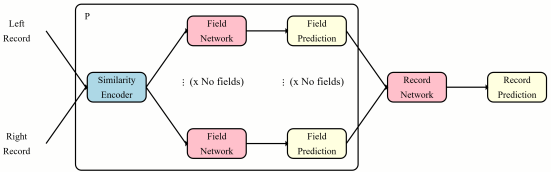

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Sample Generation and Description

- Following this procedure, we obtain 100,996 firm-year entries for 1896–1914.
- We drop observations with missing assets and those with inconsistent balance sheet sums.
- As a precautious step, we exclude observations with likely OCR errors and singletons.
- We manually checked location and industry information.

→ Final data: 61,460 observations, 7,646 individual firms, 24 states, 49 industrial sectors.

Variable	Obs.	Mean	SD	Q25	Median	Q75
TotalAssets (in million M.)	61460	3.92	5.41	0.90	1.94	4.23
AssetGrowth	51904	0.04	0.10	-0.01	0.01	0.07
PPE (in million M.)	61460	1.26	1.57	0.23	0.68	1.58
Tangibility	61460	0.44	0.28	0.21	0.45	0.65
DebtRatio	61460	0.50	0.21	0.36	0.50	0.64
CashRatio	61460	0.04	0.07	0.00	0.01	0.05
Depreciation (in million M.)	61460	0.06	0.10	0	0.02	0.07
Profitability (RoA)	61460	0.03	0.05	0	0.02	0.05
Age	61460	17.36	13.13	7	14	26

Industry Overview Geography

State	Obs.	in Percent
Preußen	31274	50.89
Sachsen	6619	10.77
Bayern	5756	9.37
Baden	2619	4.26
Elsaß-Lothringen	1993	3.24
Hamburg	1952	3.18
Württemberg	1942	3.16
Bremen	1506	2.45
Braunschweig	1478	2.40
Hessen	1054	1.71

Quality Check: Estimating a Capital Structure Equation

Dep. Variable	Debt-to-Asset Ratio	
	(1)	(2)
log(Revenue)	0.021***	0.016***
	(0.001)	(0.001)
Tangibility	0.014*	0.022***
	(0.007)	(0.007)
CashRatio	-0.067***	-0.089***
	(0.018)	(0.017)
Profitability	-0.303***	-0.247***
	(0.022)	(0.022)
Year FE		✓
Firm FE	✓	✓
R^2 (adjsuted)	0.706	0.720
N	60587	60587

- As a validation check, we estimate a common capital structure equation (Frank & Goyal, 2008):

$$Debt = f(FirmSize,\ Collateral,\ Cash,\ Profitability)$$

- All coefficients show the expected sign, emphasizing the validity of the data.

Agenda

1. Data and Sample Construction
2. The Banking Sector's Transformation: Context and Descriptive Findings
3. Empirical Strategy and Preliminary Results
4. Summary, Outlook, and Conclusion
5. Excursus: Matching Framework `NeerMatch` (Karapanagiotis & Liebald, 2023)

Institutional Context

Political, financial economic integration

- Foundation of the German Empire (1871)
- Unified Commercial (HGB) and Civil Code (BGB) (1900)
- Establishment of the *Reichsbank* (1876)
- Monetary union with introduction of the *Mark* (1871-1876)

Major pieces of legislation

- General incorporation & end of concession system (1870)
- 1884 Corporations Act: Strengthening Banks' Systemic Role (Burhop et al., 2018)

Increased Demand for (long-term) financing

- Emergence of modern industrial enterprises (Fohlin, 2007)
- Rapid economic growth
- Globalization required large-scale, fixed investment

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Different Types of Banks

Private Bank

- Operating locally since the late 18th century.
- Predominantly invested in low-risk securities.
- Provision of short-term finance & investment banking services.

Cooperatives

- Emerged in the 1850s.
- Urban regions: short-term credit to private small businesses.
- Rural areas: long-term credit to the agricultural sector.

Joint-Stock Credit Banks

- Initially founded to increase the capital base.
- Universal banking: wide array of services Levine 2005
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Among the joint-stock banks, eight so-called *Great Banks* stood out: Related Literature

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- Used proxy voting rights to appoint board members, allowing them to actively shape company policies and strategies (Guinnane, 2002).

Crisis of 1900-1902 as catalyst:

- Need for risk diversification & chance to further increase dominance
  → Geographic expansion
- "The reign of the banks over the industrial capital" (Hilferding, 1910)

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- Disconto Gesellschaft
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Closeness to industry: "*German banks [...] established the closest possible relations with industrial enterprises [, accompanying them] from the cradle to the grave, from establishment to liquidation throughout all the vicissitudes of its existence.*" (Gerschenkron, 1962, p.14)

Control over industry: "*Banks acquired a formidable degree of ascendancy over industrial enterprises, which extended far beyond the sphere of financial control into that of entrepreneurial and managerial decisions.*" (Gerschenkron, 1962, p.14)

Exertion of control:

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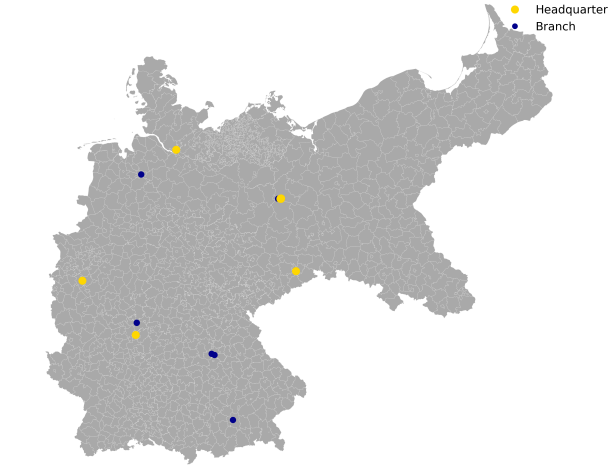
Evidence on the expansion of the Great Banks across Imperial Germany (1896–1914)



1896

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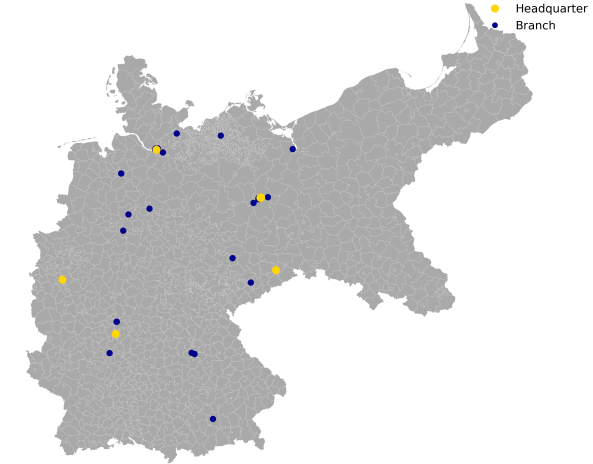

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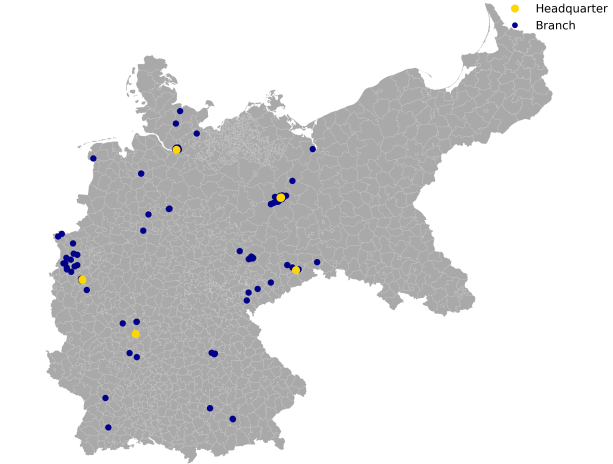

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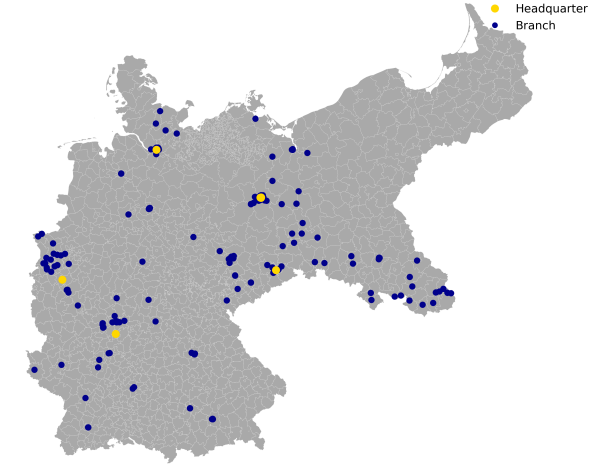

1914

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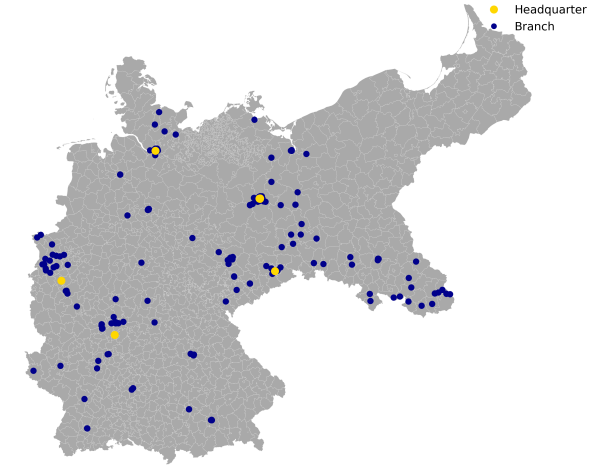
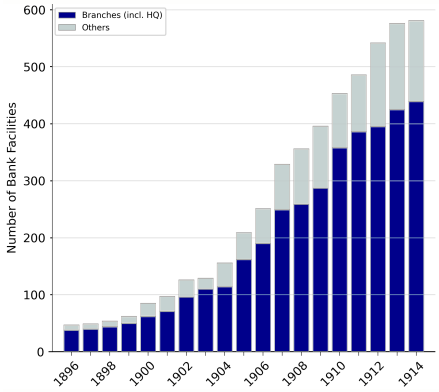
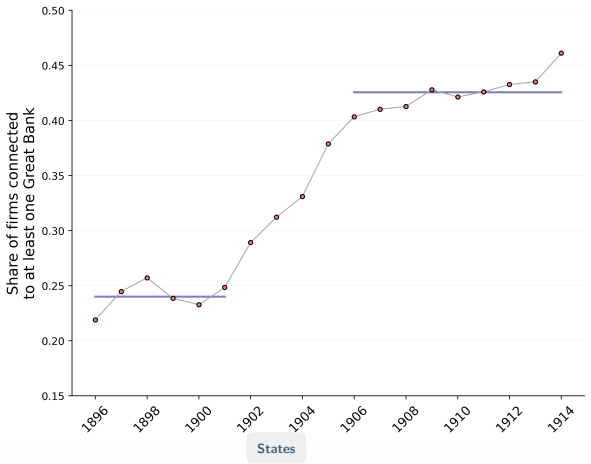




The Transformation of the Banking Sector in Imperial Germany

The number of firms linked to the Great Banks surged, especially since the early 1900s.

"[...] *the fiscal agencies* ["Zahlstellen"] *supply a means whereby the industrial connections of the great banks may be measured.*" (Riesser, 1911, p.370)



Agenda

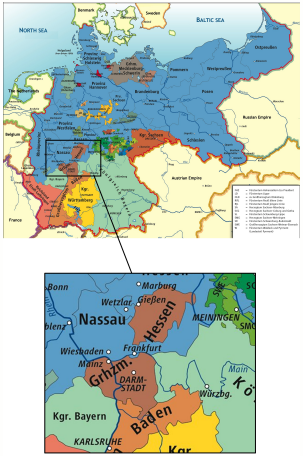
1. Data and Sample Construction
2. The Banking Sector's Transformation: Context and Descriptive Findings
3. Empirical Strategy and Preliminary Results
4. Summary, Outlook, and Conclusion
5. Excursus: Matching Framework `NeerMatch` (Karapanagiotis & Liebald, 2023)

Intuition

- **Goal:** Estimate the causal effect of financial development on firms' real economic activity
- We use firms' geographic exposure to Great Banks to quantify financial development.
- To identify the effect of bank exposure, we utilize cross-sectional variation in the sectoral-level dependence on external financing to distinguish more or less affected firms.

The Relevance of Geographical Proximity

Relevance of geographical proximity on a regional level – annecdotal evidence



"German entrepreneurs could locate anywhere in the German free-trade zone and produce for the entire market. Bankers also used the federal structure to evade early limitations on banking activity. If Frankfurt [...] refused to grant a bank charter, financial entrepreneurs could set up a bank in nearby Darmstadt and provide the same services to firms in Frankfurt [...]. [...] this happened in the case of the [...] Darmstädter Bank." (Guinnane, 2002, p.11)

Defining the Exposure Variable

- Banks at medium distance are just as important as banks in the neighborhood.
- Unlike in modern times, banks at large distances are unlikely relevant.

To incorporate these points, we compute an Exposure to Economic Activity (***EEA***) score:

$$\boldsymbol{EEA}_{it} = \sum_{b \in B_t} \omega_b (1 + r)^{-\delta_{ib}}$$

Where:

- B_t is the set of all branches of *Great Bank* in year t.
- δ_{ib} is the distance (in km) between firm i and bank branch $b \in B$.
- The parameter $r \in (0, 1]$ captures the importance of distant branches for a firm's EEA score.
- The parameter ω_b captures how much bank b contributes to a firm's EEA score.

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- The parameter ω_b captures how much bank b contributes to a firm's EEA score.

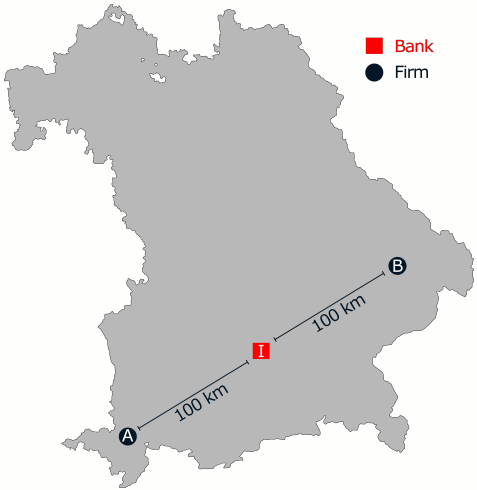
The *EEA Score*'s Intuition

$$EEA_{it} = \sum_{b \in B_t} \omega_b \, (1 + r)^{-\delta_{ib}}$$

We assume:

$r = 0.03$ (Liebald, 2024) & $\omega = (B - b + 1)/B$

The *EEA Score*'s Intuition



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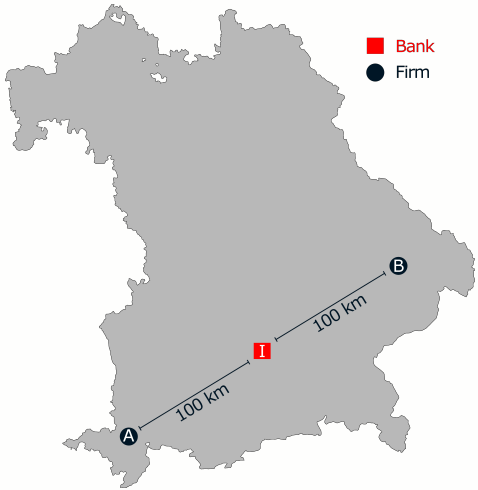


$$EEA_{it} = \sum_{b \in B_t} \omega_b \, (1+r)^{-\delta_{ib}}$$

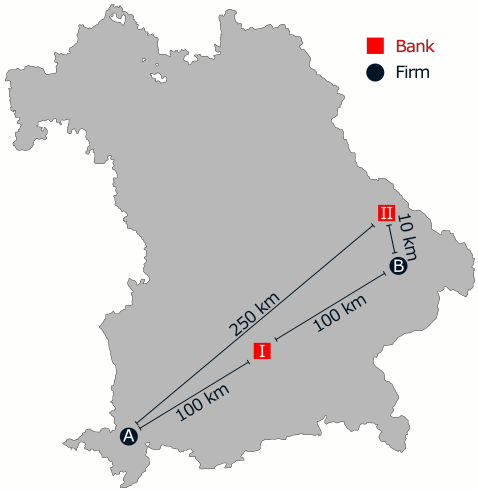
We assume:

$r = 0.03$ (Liebald, 2024) & $\omega = (B - b + 1)/B$

Firm A: $EEA_{t=1} = 1(1.03)^{-100} = \mathbf{0.052}$

Firm B: $EEA_{t=1} = 1(1.03)^{-100} = \mathbf{0.052}$

The *EEA Score*'s Intuition



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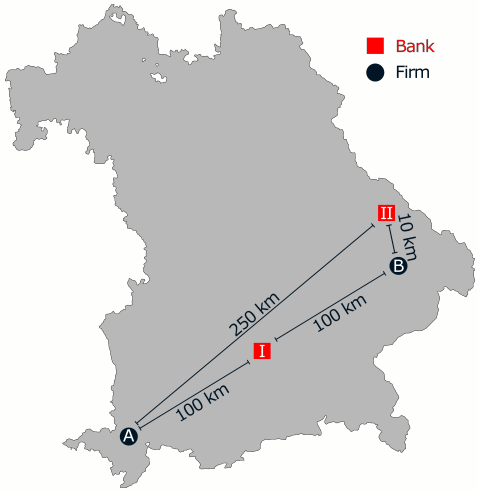

$$EEA_{it} = \sum_{b \in B_t} \omega_b \, (1+r)^{-\delta_{ib}}$$

We assume:

$r = 0.03$ (Liebald, 2024) & $\omega = (B - b + 1)/B$

Firm A: $EEA_{t=2} = 1(1.03)^{-100} + \frac{1}{2}(1.03)^{-250} = \mathbf{0.053}$

Firm B: $EEA_{t=2} = 1(1.03)^{-10} + \frac{1}{2}(1.03)^{-100} = \mathbf{0.796}$

EEA Scores | Exp. vs. Power-Law Decay

Baseline Specification

- **Goal:** Estimate the causal effect of financial development on firms' real economic activity

$$Y_{it} = \beta_0 + \boldsymbol{\beta_1}(EEA_{it} \times FinDep_i) + Z_{it} + \lambda_t + \varphi_i + \varepsilon_{it}$$

- We consider firms debt financing, growth, and profitability as dependent variables (Y_{it}).
- $EEA = 1$ if firm i's *EEA* score is above the Q50 *EEA* score measured in 1901, and zero otherwise.
- $FinDep = 1$ if firm i operates in capital-intensive sectors (e.g., Mining, Chemicals, Transportation)
- We control for firm and year fixed effects (λ_t and φ_i) and firm-level controls (Z_{it}).
- Standard errors are clustered on the firm level; ε_{it} is the error term.

Importantly: direct firm-bank links are excluded, i.e., firms with a *Great Bank* as main lender and firms within 10km distance of a *Great Bank*. The sample is all post-crisis years, 1902–1914.

Financial Development and Debt Financing

Dep. Variable	Debt-to-Asset Ratio		
	(1)	(2)	(3)
EEA × *FinDep*	0.040***	0.030***	0.021**
	(0.012)	(0.010)	(0.009)
EEA	-0.023***	-0.023***	-0.016**
	(0.009)	(0.007)	(0.007)
FinDep	-0.104***		
	(0.011)		
Minimum Dist. (km)	10	10	10
Year FE		✓	✓
Firm FE		✓	✓
Firml-Level Controls			✓
$\overline{Y}$	0.496	0.496	0.496
N	18837	18837	18837

Financial Development and Debt Financing

Dep. Variable	Debt-to-Asset Ratio		
	(1)	(2)	(3)
EEA × *FinDep*	0.040***	0.030***	0.021**
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FinDep	-0.104***		
	(0.011)		
Minimum Dist. (km)	10	10	10
Year FE		✓	✓
Firm FE		✓	✓
Firml-Level Controls			✓
$\overline{Y}$	0.496	0.496	0.496
N	18837	18837	18837

- Post-crisis shifts in regional exposure to *Great Banks* raise debt financing of *FinDep* firms.
- The treatment effect (0.021) is economically significant, suggesting a 4.3% debt-ratio increase.

Financial Development and Debt Financing

Dep. Variable	Debt-to-Asset Ratio						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
EEA × *FinDep*	0.040***	0.030***	0.021**	0.022**	0.021**	0.022**	0.034**
	(0.012)	(0.010)	(0.009)	(0.010)	(0.010)	(0.011)	(0.014)
EEA	-0.023***	-0.023***	-0.016**	-0.019***	-0.018**	-0.027***	-0.033***
	(0.009)	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)	(0.010)
FinDep	-0.104***						
	(0.011)						
Minimum Dist. (km)	10	10	10	20	30	40	50
Year FE		✓	✓	✓	✓	✓	✓
Firm FE		✓	✓	✓	✓	✓	✓
Firml-Level Controls			✓	✓	✓	✓	✓
$\overline{Y}$	0.496	0.496	0.496	0.495	0.495	0.494	0.492
N	18837	18837	18837	16444	14009	11846	9203

- Post-crisis shifts in regional exposure to *Great Banks* raise debt financing of *FinDep* firms.
- The treatment effect (0.021) is economically significant, suggesting a 4.3% debt-ratio increase.
- There are geographical spillovers of up to 50 km.
- However, the effect vanishes with increasing distance to closest *Great Bank*.

Financial Development and Debt Financing

Dep. Variable	Debt-to-Asset Ratio									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EEA × *FinDep*	0.040***	0.030***	0.021**	0.022**	0.021**	0.022**	0.034**	0.010	0.012	-0.022
	(0.012)	(0.010)	(0.009)	(0.010)	(0.010)	(0.011)	(0.014)	(0.020)	(0.042)	(0.090)
EEA	-0.023***	-0.023***	-0.016**	-0.019***	-0.018**	-0.027***	-0.033***	-0.016	-0.014	-0.035
	(0.009)	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)	(0.010)	(0.015)	(0.025)	(0.038)
FinDep	-0.104***									
	(0.011)									
Minimum Dist. (km)	10	10	10	20	30	40	50	60	70	80
Year FE		✓	✓	✓	✓	✓	✓	✓	✓	✓
Firm FE		✓	✓	✓	✓	✓	✓	✓	✓	✓
Firml-Level Controls			✓	✓	✓	✓	✓	✓	✓	✓
$\overline{Y}$	0.496	0.496	0.496	0.495	0.495	0.494	0.492	0.494	0.496	0.495
N	18837	18837	18837	16444	14009	11846	9203	6932	5514	4411

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Financial Development and Real Economic Activity

Dep. Variable	Debt-to-Asset Ratio	log(TotalAssets)	PPE-Ratio	log(Revenue)	RoA
	(1)	(2)	(3)	(4)	(5)
EEA × *FinDep*	0.021**	0.078***	0.005	0.186**	0.004
	(0.009)	(0.025)	(0.011)	(0.087)	(0.003)
Minimum Dist. (km)	10	10	10	10	10
Year FE	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓
Firm-Level Controls	✓	✓	✓	✓	✓
$\overline{Y}$	0.496	14.244	0.473	12.201	0.028
N	18837	18837	18837	18837	18837

- Firms that raise debt financing after post-crisis shifts in regional exposure to *Great Banks* exhibit significant higher asset and revenue growth than control group firms.
- No such effects are discovered for profitability and fixed assets.

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Minimum Dist. (km)	10	10	10	10	10
Year FE	✓	✓	✓	✓	✓
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Firm-Level Controls	✓	✓	✓	✓	✓
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Split Sample Regressions

Dep. Variable	Debt-to-Asset Ratio			log(Revenue)		
	Full Sample	$\downarrow EEA^{OB}$	$\uparrow EEA^{OB}$	Full Sample	$\downarrow EEA^{OB}$	$\uparrow EEA^{OB}$
	(1)	(2)	(3)	(4)	(5)	(6)
$EEA \times FinDep$	0.021**	0.027**	-0.007	0.186**	0.373***	-0.094
	(0.009)	(0.012)	(0.015)	(0.087)	(0.133)	(0.107)
Minimum Dist. (km)	10	10	10	10	10	10
Year FE	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓
Firm-Level Controls	✓	✓	✓	✓	✓	✓
$\overline{Y}$	0.496	0.493	0.500	12.201	12.022	12.374
N	18837	9061	9545	18837	9061	9545

- Debt financing and revenues increase more strongly for firms exposed to relatively low degrees of ex-ante exposure to other joint-stock banks.

  $\Rightarrow$ Supports "Access to Finance"-argument.
- No such difference can be found for total assets.

Split Sample Regressions

Dep. Variable	Debt-to-Asset Ratio			log(Revenue)		
	Full Sample	$\downarrow EEA^{OB}$	$\uparrow EEA^{OB}$	Full Sample	$\downarrow EEA^{OB}$	$\uparrow EEA^{OB}$
	(1)	(2)	(3)	(4)	(5)	(6)
$EEA \times FinDep$	0.021**	0.027**	-0.007	0.186**	0.373***	-0.094
	(0.009)	(0.012)	(0.015)	(0.087)	(0.133)	(0.107)
Minimum Dist. (km)	10	10	10	10	10	10
Year FE	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓
Firm-Level Controls	✓	✓	✓	✓	✓	✓
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	(0.009)	(0.012)	(0.015)	(0.087)	(0.133)	(0.107)
Minimum Dist. (km)	10	10	10	10	10	10
Year FE	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓
Firm-Level Controls	✓	✓	✓	✓	✓	✓
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Minimum Dist. (km)	10	10	10	10	10	10
Year FE	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓
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Outlook

- Several small (but important) data issues will keep us occupied. Most importantly, we plan to add firm-level patent information.
- We plan to augment the current data by utilizing person-level information to further enhance firm-bank network construction.
- This allows us to also investigate a further dimension $\rightarrow$ *Great Banks* as strategic investors.

Summary

- We systematically extract and process historical firm-level data on a large scale.
- This includes several previously unexplored dimensions, including consistent granular data for a panel of (mostly unlisted) firms, detailed bank data, and their geographical networks.

- We investigate this unique data to study financial development at the dawn of the modern Germany, 1896 – 1914, and its implications for firm-level activities.
- Exploring the emergence of *Great Banks* (hopefully) allows us to draw causal inferences on the effect of financial market development on real economic outcomes.

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A Matching Problem

Left dataset

(index)	Surname (alphanumeric)	First Name (alphanumeric)	Address (alphanumeric)	Height (in cm) (numeric)
1	Mueller	S.	Torkelsgatan 12, 75329 Uppsala	188
2	Musterman	Max	Hauptstr. 1, 64560 Riedstadt	175
3	...	...	...	...

A Matching Problem

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(index)	Surname (alphanumeric)	First Name (alphanumeric)	Address (alphanumeric)	Height (in cm) (numeric)
1	Mueller	S.	Torkelsgatan 12, 75329 Uppsala	188
2	Musterman	Max	Hauptstr. 1, 64560 Riedstadt	175
3	...	...	...	...

Right dataset

(index)	Surname (alphanumeric)	First Name (alphanumeric)	Address (alphanumeric)	Height (in cm) (numeric)
1	Mueller	Sebastian	Motzstraße. 22, 12163 Berlin	187
2	Jonasson	Jonas	Krukmakargatan 1, 11851 Stockholm	1.8
3	...	...	...	...

A Matching Problem

Period 1 dataset

(index)	Surname (alphanumeric)	First Name (alphanumeric)	Address (alphanumeric)	Height (in cm) (numeric)
1	Mueller	S.	Torkelsgatan 12, 75329 Uppsala	188
2	Musterman	Max	Hauptstr. 1, 64560 Riedstadt	175
3	...	...	...	...

Period 2 dataset

(index)	Surname (alphanumeric)	First Name (alphanumeric)	Address (alphanumeric)	Height (in cm) (numeric)
1	Mueller	Sebastian	Motzstraße. 22, 12163 Berlin	187
2	Jonasson	Jonas	Krukmakargatan 1, 11851 Stockholm	1.8
3	...	...	...	...

Period 3 dataset

(index)	Surname (alphanumeric)	First Name (alphanumeric)	Address (alphanumeric)	Height (in cm) (numeric)
1	Müller	Sebastian	Motzstr. 23, 12163 Berlin	187
2	Hans-Walter	Schreiber	Hauptstraße 1, 60528 Frankfurt	1.8
3	...	...	...	...

The Traditional Way

Traditional Approach

- Pick one (or sometimes more) column pair(s) (e.g., Surname∼Surname & Address∼Address)
- Pick one similarity metric (e.g., *Levenshtein distance*)
- Perform pairwise calculations and manually assign weights of column pairs
- Set arbitrary *distance* threshold

Challenges

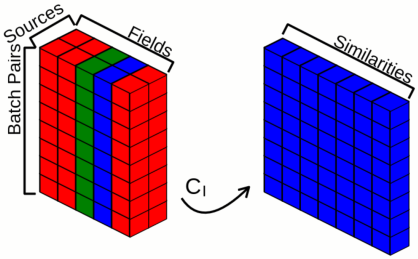
- Which distances to pick?
- What are the correct weights?
- What threshold makes sense?

Solution

Neer Match (Utilities)...

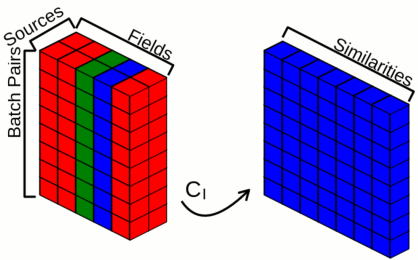
- Compares each record from *Left* with each record from *right*
- Accounts for a multitude of column pairs.
- Allows to utilize a variety of similarity functions simultaneously per column pair
  (e.g., Levenshtein, Jaro-Winkler, Euclidean, token set, etc.)
- Trains classifier returning a probability whether a record-pair is a match.
  → *Learns* the weights of individual column pairs in different scenarios.
  → *Learns* which similarity metric works best for individual column pairs.
  → Provision of manually labeled training data is required

Encoding Transformation

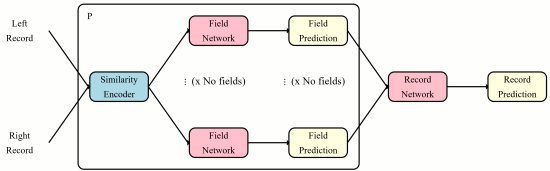


Intution

Encoding Transformation

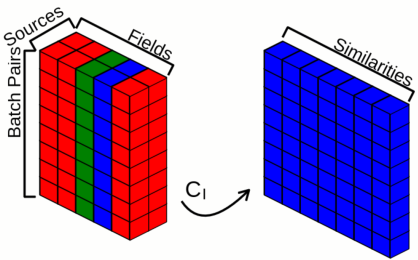


Network Architecture

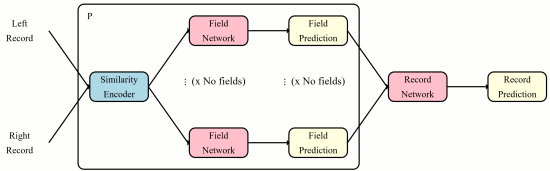


Intution

Encoding Transformation



Network Architecture



- The calculations of the similarity encoder are embarrassingly parallelizable
- Reduces need for blocking technologies

NeerMatch Benchmark Performance (2023)

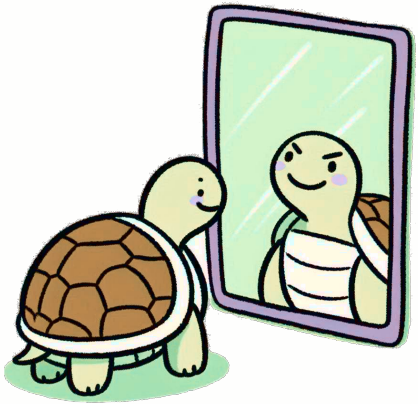
		F-score		
EM System	Source	DBLP-ACM	Abt-Buy	Amazon-GoogleProducts
Magellan	Mudgal et al. (2018)	98.4	43.6	49.1
DeepER	Ebraheem et al. (2018)	96.0		98.6
DeepMatcher	Mudgal et al. (2018)	98.4	62.8	69.3
Ditto	Y. Li et al. (2020)	99.0		75.6
AdaMEL-hyb	Jin et al. (2021)	98.9		65.1
RuleSynth	Singh et al. (2017)	92.6		63.8
CorDEL	Wang et al. (2020)	99.2	64.9	70.2
AutoFJ	P. Li et al. (2021)	97.7	61.3	
ZeroER	Wu et al. (2020)	96.0	52.0	48.0
NeerMatch	This Article	99.8	76.6	83.6
NeerMatch **Rank**		1.	1.	2.

$$F\ Score = 2 \times \frac{Precision \times Recall}{Precision + Recall}$$

$$Precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$

Links



- www.py-neer-match.pikappa.eu/
- www.marius-liebald.de/py-neer-utilities/

It is easy to use!

Training a Model

- Required data Structure `left`, `right` & `matches`
- `similarity_map`
- Preparation (Harmonization, Data Enrichment, Restructuring, Splitting)
- Initialization, Compilation, and Fitting of the Model
- `Model.save()`

Generating a Panel ID

- `Model.load()` the previously exported model
- Implementation of Identical Preparation Steps
- Blocking
- `GenerateID()`

Thanks a lot for listening!

Appendix

Private Equity (PE) Practices

Back

PE firms implement three sets of changes (S. N. Kaplan & Strömberg, 2009)

- Financial engineering
  - Management incentives via stock and options (S. Kaplan, 1989a)
  - Debt restructuring to reduce *Free Cash Flow Problems* and increase interest tax shield (Jensen, 1986; S. Kaplan, 1989b)
- Governance engineering
  - Control over the firms' board
  - Active governance trough frequent meetings (Acharya et al., 2013)
  - Personel decisions (management replacement and board composition) (Acharya et al., 2013; Hellmann & Puri, 2002)
- Operational engineering (Gompers et al., 2015)
  - redefining the company's strategy / business model
  - cost reduction, etc.

Anecdotal Evidence

Back

The *new* role of the *Great Banks*: The case of Mannesmannröhren-Werk AG

MANNESMANN

- Founded in 1890 in Berlin, the company's home bank had been *Deutsche Bank*
- After the economic crisis of 1900, Deutsche Bank "*essentially took over the firm*": (Gall *et al.* 1995; Guinnane 2002)
  - Reorganized management board.
  - Directed investment decisions.
  - Business restructuing in 1908.
- Mannesmann first developed into Germany's leading industrial-pipe producer and subsequently became one of Germany's largest steel producer.
- Geographic proximity as key driver to extert control: both Mannesmann and Deutsche Bank were headquartered in Berlin.

Sectoral Distribution of Sample Firms

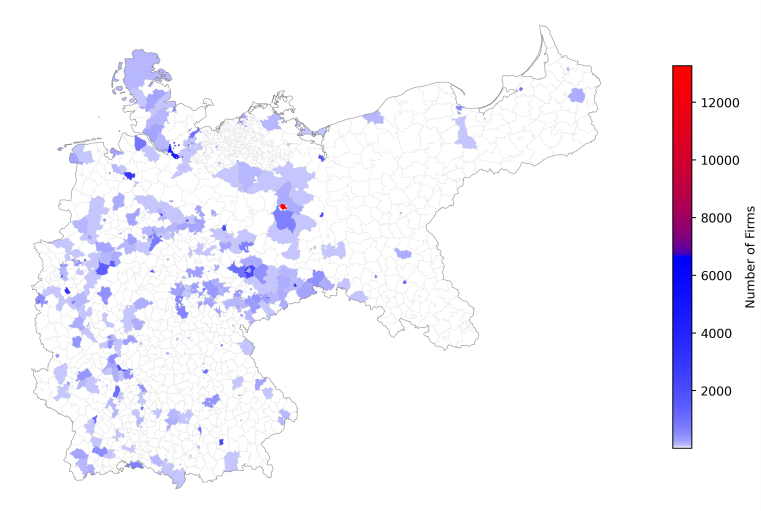
Back

Sector	Obs.	Percent	Median Firm Size (in Million Marks)
Breweries	7680	12.50	2.01
Textiles	5626	9.16	2.63
Machinery, Foundries & Steel	4977	8.10	2.07
Building Materials & Industrial Minerals	4430	7.21	1.35
Credit Banking	3792	6.17	5.63
Mining & Metals	3522	5.73	4.70
Construction Finance & Real Estate	2857	4.65	2.16
Sugar Production	2833	4.61	1.23
General Transportation	2502	4.07	1.94
Chemicals & Plastics	2329	3.79	2.23
Metal Industry	2012	3.27	1.79
Electrical Equipment & Utilities	1671	2.72	2.88
Utilities	1618	2.63	0.40
Railways	1515	2.47	2.26
Paper Production	1469	2.39	1.88
Printing & Publishing	1422	2.31	0.76
General Food & Beverage	1243	2.02	1.18
Steamship & Harbor Services	1187	1.93	1.74
General Banking	1151	1.87	2.27
Mills & Bakeries	1057	1.72	1.45

Geographic Distribution of Sample Firms

Back

State	Obs.	in Percent
Preußen	31274	50.89
Sachsen	6619	10.77
Bayern	5756	9.37
Baden	2619	4.26
Elsaß-Lothringen	1993	3.24
Hamburg	1952	3.18
Württemberg	1942	3.16
Bremen	1506	2.45
Braunschweig	1478	2.40
Hessen	1054	1.71
Anhalt	551	0.90
Oldenburg	502	0.82
Mecklenburg-Schwerin	340	0.55
Sachsen-Meiningen	305	0.50
Reuß jüngerer Linie	297	0.48
Sachsen-Altenburg	294	0.48
Lübeck	284	0.46
Sachsen-Coburg-Gotha	175	0.28
Schwarzburg-Sondershausen	158	0.26
Lippe	146	0.24
Mecklenburg-Strelitz	141	0.23
Schwarzburg-Rudolstadt	117	0.19
Reuß älterer Linie	72	0.12
Waldeck und Pyrmont	12	0.02



The Financial System' Five Main Functions

Back

The financial system' five main functions (intermediaries & markets):

1. Production of ex-ante information about investment opportunities.
2. Ex-post monitoring of investments.
3. Trading, diversifications, and management of risks.
4. Mobilization and pooling of savings.
5. Exchange of goods and services.

- Source Levine (2005)

Related Literature on *Great Banks*

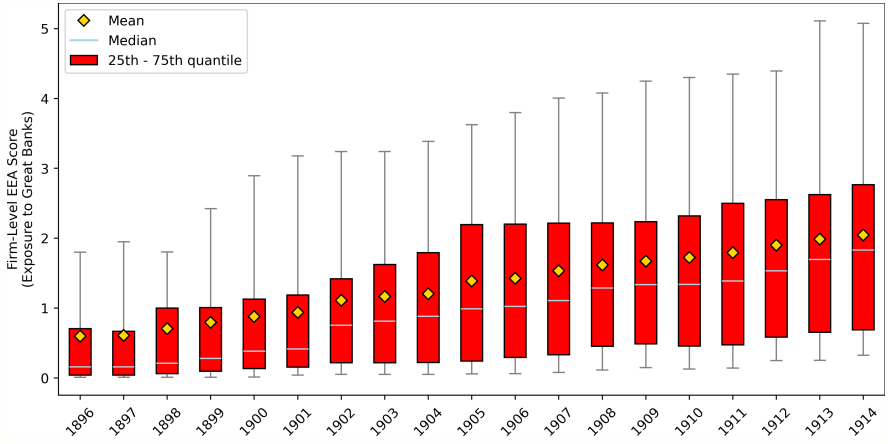
Back

- A notable body of research **qualitatively** investigates the Banking-Growth-Nexus in Imperial Germany. (Jeidels, 1905; Hilferding, 1910; Riesser, 1911; Gerschenkron, 1962; Kindleberger, 2015)

- Only few **quantitative** studies exist:
  - Burhop (2006) Time series analyses of aggregate capital stock and financial depth show that the *Great Banks* influenced economic development between 1851 and 1882 but not in later periods.
  - Becht & Ramirez (2003) Steel and mining firms with close links to the *Great Banks* were less liquidity constraint in the early 20th century.
  - Fohlin (1998) Investment of firms connected to the *Great Banks* is more sensitive to internal liquidity than for others.
  - Fohlin (2007) No correlation between firm performance and connection to the *Great Banks*.

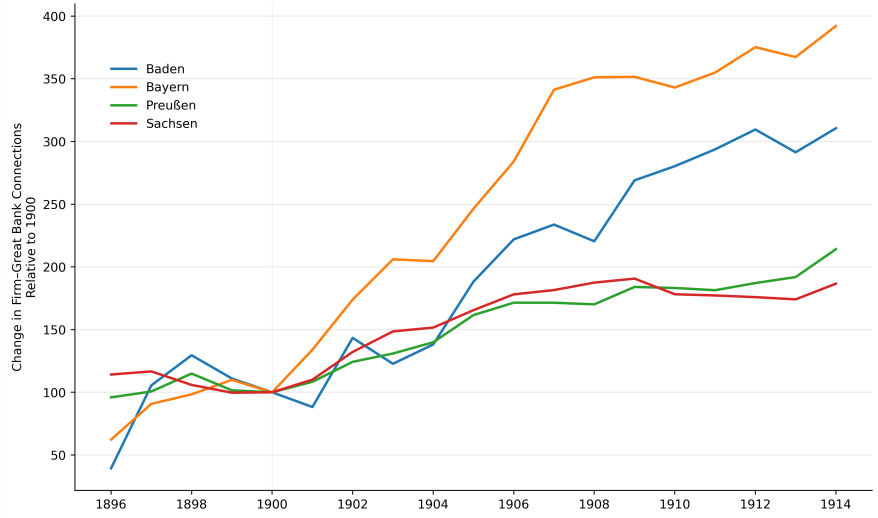
Exposure to *Great Banks* Over Time

Back



Great Bank-Firm Links Across States

Back

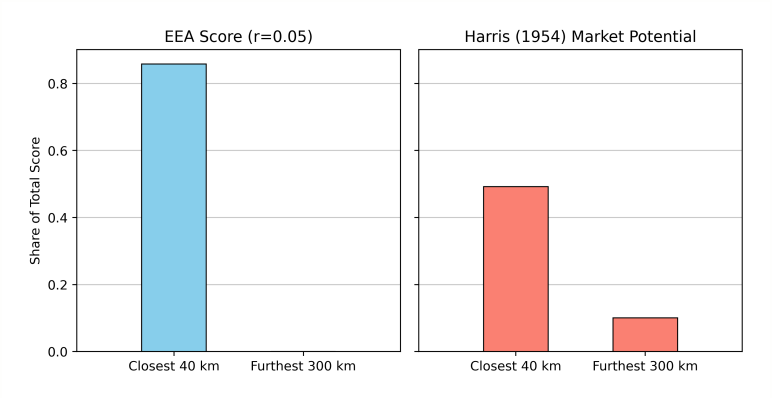


Exponential vs. Power-Law Decay

Back

$$EEA_i = \sum_{b \in B_t} (1 + r)^{-\delta_{ib}}$$

$$MP_i = \sum_{b \in B_t} \frac{M_b}{\delta_{ib}^{\alpha}}$$



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