Railroads and the Regional Concentration of Industry in Germany 1861 to 1882

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Abstract

This article analyzes the impact of improvements in market access on the regional concentration of industry in Germany during the second half of the 19th century. The expansion of market access can promote the dispersion of industry if cheaper land and labor provide incentives for industry location outside of existing manufacturing centers. On the other hand, better market access can increase the value of manufacturing centers that provide economies of scale and agglomeration, encouraging geographic concentration. The results show that better market access had a positive impact on industry growth in regions with above median levels of per capita manufacturing employment. For regions below this mark the impact was negative, indicating that better market access contributed to the concentration of early industrial development.

1 Introduction

The introduction of railroads in the 19th century lowered transportation costs on routes where rivers and canals were not available or unreliable, making it easier for manufacturers to reach customers in distant markets. In Germany two large river systems around the Rhine in the West and the Elbe in the East supported trade, but they were not connected through a waterway until the completion of the "Mittellandkanal" in 1938. This suggests that railroads had the potential to greatly reduce transportation costs between these two systems. The first railroad opened in 1835 with a short

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track of 7.5 km and like other early railroads it did not attract cargo traffic because the high cost of transshipment made its incorporation into longer trade routes too expensive (Heinze and Kill 1988). The first connection between the Rhine and the Elbe was achieved in 1847 and the boom in railroad construction that followed over the next thirty years created a dense network across all states that formed the German Empire in 1871. This was not a national network in the strictest sense because infrastructure policy remained at the state level even after unification, but the association "Verein Deutscher Bahnverwaltungen" coordinated technical standards and ticketing across state lines.

The goal of this article is to investigate the impact of these transportation improvements on the diffusion of industrial development. As railroad construction took off in the middle of the 19th century, so did early industrialization in Germany. Total manufacturing employment increased from about 9 percent of the population in 1846 to about 13 percent in 1882[1], water and steam powered factories displaced smaller workshops, and coal supplanted charcoal as the standard fuel for many industries. In this setting improvements in transportation could have had two very different effects on the diffusion of industry. On the one hand, railroad construction and falling freight rates could have promoted the growth of industry in regions without traditional manufacturing centers where land and labor were presumably cheaper. Better transportation could have improved the position of manufacturers in these regions by lowering the cost of shipping industrial output to larger markets. Recent studies about the impact of transportation investment in developing countries provide empirical evidence for this dispersion effect in the immediate surroundings of industrial centers. Baum-Snow et al. (2013) show that the construction of railways and ringroads in China has led to the relocation of manufacturing from central cities to surrounding areas. Similarly, Rothenberg (2011) finds that road improvements have induced Indonesian manufacturing firms to locate outside of existing industry agglomerations in neighboring regions.

On the other hand, the same transportation improvements could have increased the value of existing manufacturing centers, encouraging further geographic concentration. High transportation costs can enable manufacturers in the periphery to compete against producers in manufacturing centers because they create protective barriers around regional markets. By removing these barriers railroads could have led to a decline of manufacturing in regions with relatively low employment in industry. Empirical evidence for this effect is found by Faber (2012), who observes lower industrial GDP growth in peripheral regions that were included in China's national highway network compared to similar areas outside of the network. This result suggests that the dispersion of industry in the immediate neighborhood of existing industrial centers might be outweighed by foregone industrial growth in farther peripheral regions. Historical evidence about early industrialization in Japan lends further support to this interpretation. Tang (2013) shows a positive relationship between railroad access and the number of manufacturing start-ups in densely populated prefectures but finds a negative relationship in prefectures with low population densities.

[1] Own calculation based on population and employment estimates in Tables 1 (p.172f) and Tables 15 (p.196f) in Hoffmann (1965)

This article contributes to this empirical literature by exploring the diffusion of industrial development. To study industrialization at the regional level I use data on manufacturing employment in 72 regions in the area of the German Zollverein and the later German Empire in 1861, 1875, and 1882. These regions were the districts or "Regierungsbezirke" of the German states with a median population of approximately 460,000. This is an important point because I measure industrial development by the growth in per capita manufacturing employment, which is only sensible for relatively large spatial units that have a mix of employment in different sectors. The data are combined with information about the location of railroads and navigable waterways which makes it possible to measure improvements in transportation at the regional level using an index of market access. In the analysis changes in market access are interacted with per capita manufacturing to allow for a differential effect of better transportation on regions with different levels of industrial employment. The endogeneity of market access is addressed by an instrumental variable approach that uses distance and the growth of the national transportation network to instrument for transportation costs.

The results show that improvements in market access had a positive impact on manufacturing growth in regions with above median levels of per capita manufacturing employment. For regions below this mark the impact was negative, implying that better transportation increased the spatial concentration of manufacturing. Motivated by this finding, I investigate the regional diversity within manufacturing to find evidence for the mechanism behind this effect. A reduction in the diversity within manufacturing would suggest that spatial concentration was driven by gains from specialization. The results show that better market access decreased the diversity within manufacturing in regions with above median levels of per capita employment in manufacturing, but did not have a significant effect on diversity in regions below this mark. This suggests that better transportation increased the spatial concentration of industry by raising the competitive advantage of specialized manufacturing centers.

2 Empirical Framework

The goal of this analysis is to investigate the impact of transportation improvements on the regional distribution of industry, which requires measurement of transportation costs at the regional level. The argument that better transportation would affect the diffusion of industry is about the integration of regional markets; therefore I measure transportation costs using an index of market access that sums over all regional sources of demand and weighs each one by the cost of reaching the particular region. The original index was developed by Harris (1954) and has been applied in different modifications in a large literature on industry location. I use a version of this index that approximates the size of each market j by its population $P_{j,t}$ and captures transportation costs between two regions i and j by the minimum cost of shipping one ton of goods from one regional capital town to another using railroads, waterways, and coastal shipping.[2] This cost is denoted by $C_{ij,t}$ and the full index is given by

$$Access_{i,t} = \sum_{j=1}^{J} \frac{1}{C_{ij,t}} P_{j,t} \tag{1}$$

Improvements in market access are measured by the simple difference between index values from periods t to $t+1$

$$\Delta Access_{i,t} = Access_{i,t+1} - Access_{i,t} \tag{2}$$

The advantage of this index over an indicator for inclusion in the transportation network surely depends on the circumstances to be analyzed. Most regional capitals in my sample had access to a river or a railroad by the beginning of the study period but these points of access provided very different degrees of integration depending on the connections between them.

I assess the stage of regional industrialization by the level of per capita employment in manufacturing. A more common approach is to count the number of new establishments, but this is problematic for the study of early industrialization. Because factories displaced small workshops regions often lost establishments even as they gained employment in large numbers. The advantage of using employment is therefore that it accounts for the expansion of industry through new establishments as well as the growth of existing establishments. The employment numbers are weighted by the regional population to control for differences in the size of districts. Industrial development is again assessed by the simple difference between manufacturing employment from periods t to $t+1$

$$\Delta Industry_{i,t} = Industry_{i,t+1} - Industry_{i,t} \tag{3}$$

I use a simple regression model to estimate the impact of better market access on industrial development. The equation is given by

$$\Delta Industry_{i,t} = \beta_0 + \beta_1 Industry_{i,t} + \beta_2 \Delta Access_{i,t} + \beta_3 \Delta Access_{i,t} \times Industry_{i,t} + X_{i,t} + \epsilon_{i,t} \tag{4}$$

The interaction term $\Delta Access_{i,t} \times Industry_{i,t}$ allows the impact of improvements in market access to vary across regions with different levels of industrial employment. The level of industrial employment is also included as a separate independent variable to control for differential growth that is unrelated to transportation improvements.

The vector of control variables $X_{t,i}$ includes a region's access to coal and lignite, measured by indicators that are equal to one for regions with annual production above 10,000 tons.[3] The transition

[2] Straight line distances are included in the network to approximate road connections where none of these transportation modes were available.

[3] As a robustness check I also use measures of access to coal and lignite that consider the minimum cost of importing one ton of fuel from these mining regions.

from charcoal to coal as the main fuel in many manufacturing industries suggests that these endowments provided an advantage for regional industrialization. In addition $X_{t,i}$ includes provincial and year fixed effects. Figure 4 shows the ten provinces that are identical to the large German states of 1861 with the exception of Prussia, which is divided into three parts to account for the special status of East Prussia and the addition of the Rhineland and Westphalia in 1815. The provincial effects are meant to control for differences in taxation, education, and other policies that affected industrial development. These differences are assumed to be constant over the study period because many policy tools remained at the state level even after unification in 1871. Therefore, the provincial effects also control for broad geographic differences like ruggedness and forest cover in the South and a milder climate in the North.

The identifying assumption for this model is that any unobserved factors which influenced the growth of manufacturing were uncorrelated with the right hand side variables of interest

$$E(\epsilon_{it}|Industry_{i,t}, \Delta Access_{i,t}, \Delta Access_{i,t} \times Industry_{i,t}, X_{i,t}) = 0 \tag{5}$$

This requires that improvements in market access were not motivated by the prospect of industrial development, which must be unlikely for two different reasons. First, railroad projects were often initiated and financed by local commercial groups, therefore regions with higher expected gains from transportation improvements would have been more likely to succeed in completing a railroad. Similarly, the prospect of industrial jobs affected the movement of population, which could introduce additional bias in the market access variable.

To address these concerns I instrument for market access using

$$Access_{i,t}^{IV} = \sum_{j=1}^{J} \frac{\text{Network}_t}{D_{ij,}} P_{j,t-26} \tag{6}$$

where D_{ij} is the straight line distance between region i and region j and $Network_t$ is the total length of the German transportation network. The idea behind this first part of the instrument is that the cost for transporting goods between i and j should be a function of the distance between these regions if a direct connection exists. If there is no direct connection, transportation costs could be much higher because goods would have to travel a circuitous route. Additional railroad construction makes it more likely that a direct connection exists, so that $C_{ij,t}$ should also be inversely correlated with the length of the national transportation network Network_t. To minimize endogeneity of the population measure I use the regional population lagged by 26 years as an instrument for the current population.

In the second part of the analysis investigate changes in the regional specialization within manufacturing using data on employment in different manufacturing industries. I use a Herfindahl index proposed by Duranton and Puga (2000) that sums over each industry k's share of the total employment in manufacturing in region *i*. The authors make an adjustment for each sector's share in national manufacturing employment, which is important for this setting to account for changes in the industry structure over time. The final index of relative regional diversity is given by

$$RDI_{it} = 1/\sum_{k=1}^{K} |s_{ik} - s_k| \tag{7}$$

The value of RDI_{it} increases as employment is distributed across more industries. The adjustment means that the index also becomes larger as the industrial structure in a regions becomes more similar to that of the national economy. This means that low values of RDI_{it} can be used to single out regions with high levels of specialization that look different from a mini replica of the larger economy. Changes in the degree of regional specialization are again measured by the simple difference in the index from periods *t* to *t+1*

$$\Delta RDI_{i,t} = RDI_{i,t+1} - RDI_{i,t} \tag{8}$$

3 Features of the Data

My data covers 1861, 1875, and 1875 and comes from two main sources. The measurement of market access is based on shapefiles of all railroads, rivers, and canals in each of the three years in the sample, which were created by Kunz and Zipf (2008). Figure 1 shows the growth of this transportation network from 1861 to 1882. A careful reading of the top map shows that most district capitals had access to a waterway or a railroad in 1861, but the connections between nearby districts could still be circuitous. By 1882 the network has direct connections between most pairs of district capitals. I combine these digital maps with the information on freight rates in Table 2 to calculate the minimum shipping cost for one ton of goods between each pair of regions in each census year (Falzarano et al. 2007).[4] The summary statistics in Tables 3 show that railroad construction and falling freight led to a reduction in the average shipping costs by almost 50 percent between 1861 and 1882. In comparison the population increase between these years was relatively small, which implies that the improvement in market access shown at the bottom of the table was mainly driven by the reduction in shipping costs.

Regional industrialization is measured using data from the manufacturing censuses of the German Zollverein in 1861 and the German Empire in 1875 and 1882, which report employment in up to 87 districts and 200 industries. However, changes in the boundaries of these districts and different classifications of manufacturing require some aggregation, resulting in 72 regions and 23 industrial

[4]I use the district capital to measure the location of a district instead of the centroid, because in most cases the capital was located on the banks of a river or became the destination for the first railroad in the district, but the centroid was very often not located on the transportation network. In cases where a district capital was not connected to any railroad or river, I created a straight line "road" to fill in the missing distance and assigned the estimated freight rate for transportation on horse carriage.

sectors for the analysis. Figure 1 shows the regional differences in total per capita manufacturing across these districts with levels ranging from less than 6 to more than 18 percent. The concentration of dark color clearly shows the existence of manufacturing centers in the western Rhineland, southern Baden and Bavaria, and in central Saxony. These centers persist over the next twenty years with darker shades indicating even higher levels of industrial employment. However, the overall distribution of employment is more even in 1882 compared to 1861. In particular, several regions with initially very low levels of manufacturing employment in northern and central Germany have intermediate levels in 1882, showing evidence for the diffusion of industry.

The measurement of regional diversity uses a broad classification industries into 23 categories, which are shown in Table 1. The resulting pattern of regional diversity within manufacturing is shown in Figure 2, where darker colors indicate lower diversity or a higher degree of specialization. The first map at the top shows a high degree of specialization in the manufacturing centers of the western Rhineland and central Germany, but also in northeastern Prussia where per capita employment in manufacturing was very low. This reflects the fact that a region can be specialized because it employs a large number of workers in specific industries or because it lacks industrial employment and therefore its industrial structure is simpler than that of the national economy. In the analysis these two dimensions of industrial development are therefore investigated together. In 1882 there are fewer dark clusters of highly specialized regions that neighbor each other and regions of specialization seem to be spread out more across provinces. The change in the spatial pattern suggests that specialized industrial centers occupied fewer regions in 1882 compared to 1861, which is consistent with the idea that better transportation would encourage the concentration of industries.

4 Regression Results

The regression analysis shows that improvements in transportation did indeed have a differential impact on the growth of industry and industrial specialization in regions with different levels of manufacturing employment. Table 5 presents the coefficient estimates from two OLS regressions that measure growth over approximately ten years between consecutive censuses (1) and over approximately twenty years between the first and the last census year in the sample (2). In both regressions the negative coefficients for Δ *Access* indicate that improvements in market access reduced industrial growth in regions with low manufacturing employment. The positive coefficient for the interaction term Δ *Access* $\times$ *Industry* indicate a positive impact in regions with high levels of per capita manufacturing. This suggests that improvements in transportation did not contribute to the diffusion of industrial development but rather raised the spatial concentration of manufacturing. The finding is confirmed by the instrumental variable regression, which is shown in the last column. Comparing (2) and (3) shows that the estimates are statistically not distinguishable from each other, possibly because differences in industrial potential are captured by the level of manufacturing employment. The first stage of this regression in Table 4 indicates that the instruments are relatively strong with F-statistics above 75 and a combined Cragg-Donald Wald F-statistic of 51.42, which implies that the bias from weak instruments is no higher than 10 percent.

Figure 2 showed signs for the diffusion of industry between 1861 and 1882, which are confirmed by the negative coefficient on *Industry*. The estimate implies that regions with lower levels of manufacturing employment experienced higher growth and indicates that the railroad boom was counteracting the regional diffusion of industrialization that was taking place between 1861 and 1882. The coefficients on access to coal and lignite are positive as expected, but the indicator for coal production is not statistically significant. The manufacturing centers in the western Rhineland and central Saxony were part of the coal belt, but it is possible that this impact of coal endowments on industrial growth is already included in the effect of high manufacturing levels.

To illustrate the differential impact of the railroad boom, Figure 5 shows the marginal effect of improved market access over the range of per capita manufacturing employment in the sample. Using the coefficients from the short term growth regression the impact of better market access turns positive when per capita employment is equal to 9.9283 percent or the 56th percentile of the distribution. The results from the long term growth regression imply a turning point at employment equal to 10.2139 percent in the OLS regression and 10.1223 from the 2SLS estimates. The confidence bands locate the turning point between 7.6659 and 11.7238, which implies with 95 percent certainty that better market access had a negative impact on industrial growth in regions below this mark and a positive impact in regions above. The average short term growth in market access across all regions in the sample was 81.50 and the average rise between 1861 and 1882 was 161.46. In the regression market access is divided by 100 to adjust the size of the coefficients, therefore the effect of an average increase in market access would be the number show on the vertical axis of the graph multiplied by 0.8150 or 1.6146 respectively. For example, for a region with five percent of the population in manufacturing the average increase in market access meant a reduction in industrial employment of 3.7912 percentage points in the short run.

The second part of the analysis shows a very similar result for the impact of improvements in market access on regional specialization within manufacturing. The positive coefficient on Δ *Access* suggests that better market access encouraged diversity within manufacturing, but Figure 6 shows that this effect is not statistically significant once the interaction Δ *Access* $\times$ *Industry* is taken into account. The combined marginal effects show that better market access decreased diversity within manufacturing in regions with manufacturing employment above 9.2338 percent or the 48th percentile based on the 2SLS results. The confidence bands indicate that with 95 percent certainty better market access reduced diversity in regions with manufacturing employment above 12.1461 percent. In other words, better access to regional markets made manufacturing centers less diverse and therefore more specialized, but it did not have a clear effect on specialization in regions with low industrial employment.

5 Conclusion

This article shows that the railroad boom affected industrial development very differently in different regions of the German Empire. Improvements in market access had a negative impact on industrial growth in regions with relatively low employment in manufacturing. But in regions with per capita employment above the median the impact of better market access was positive. This implies that manufacturers responded to lower transportation costs by concentrating production in fewer regions. The result is consistent with a small empirical literature that looks at the impact of railroad and highway access on industrial growth in peripheral regions with low population or low per capita GDP. I contribute to this literature by investigating the diffusion of industrial development and by providing empirical evidence for the mechanism that them together. The finding that better market access increased specialization in regions with high manufacturing employment provides empirical support for the argument that manufacturing centers expanded because better transportation allowed for higher gains from specialization in industrial clusters.

The analysis contributes more broadly to our understanding of the role that railroads played in German industrialization. Previous studies have focused on direct linkages between railroad construction, mining, and metal production (Fremdling 1979) or investigated the effects of railroads on commodity trade in grain and coal (Keller and Shiue 2008, Fremdling 1995). My findings are consistent with their argument that railroads improved the integration of regional markets in Germany. Through better market integration railroads then encouraged the growth of specialized industry clusters and contributed to regional differences in industrial development. The question which types of gains from specialization mattered most for this effect is left for future research.

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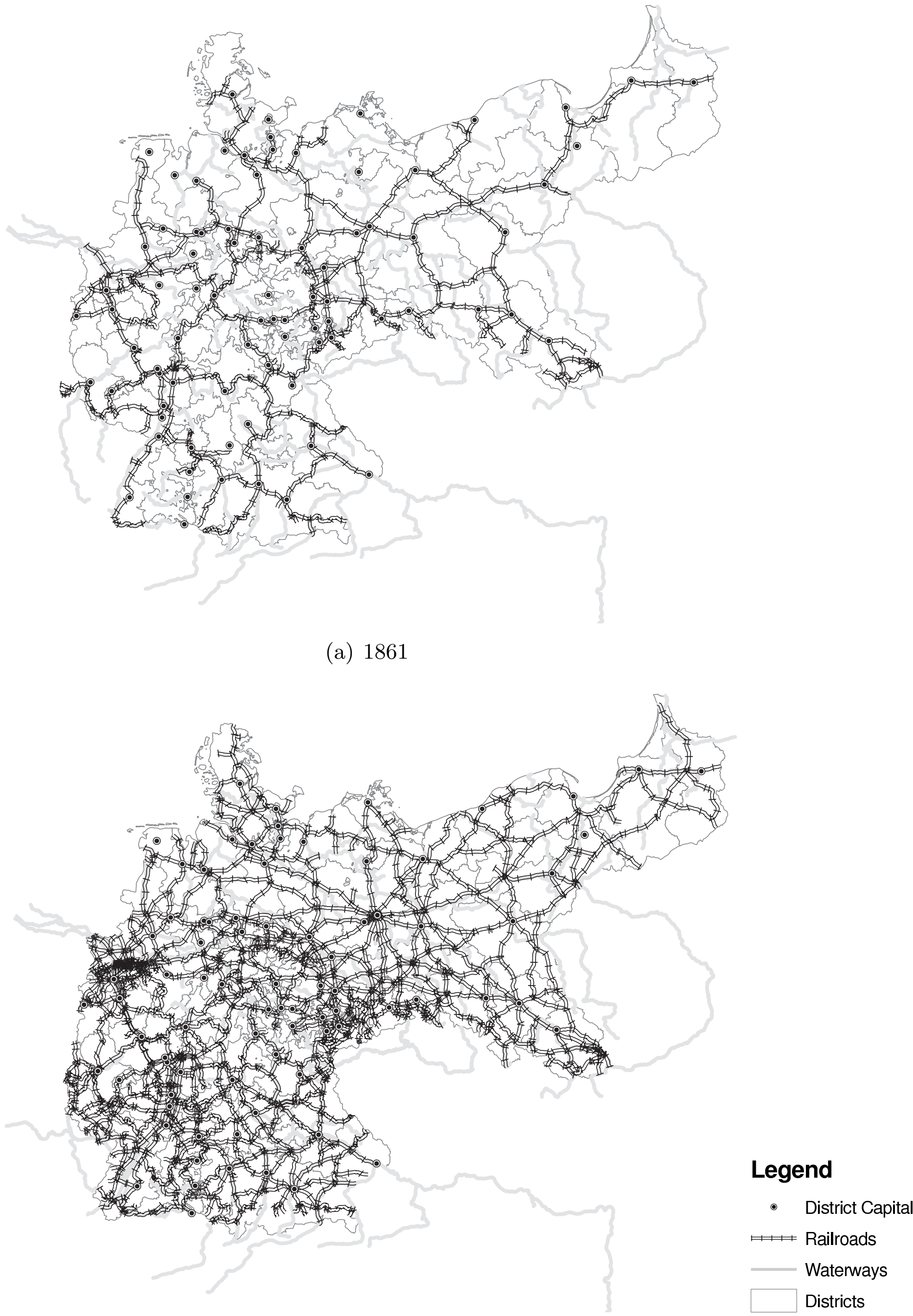
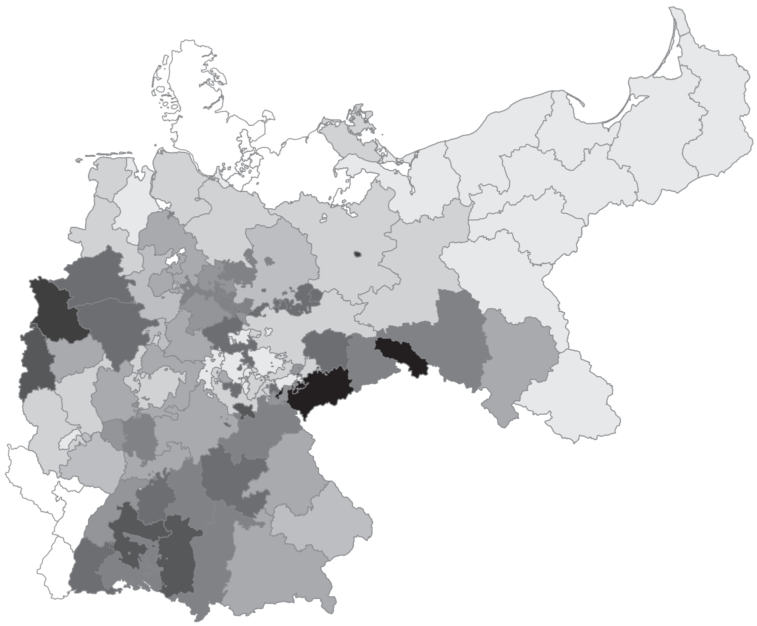


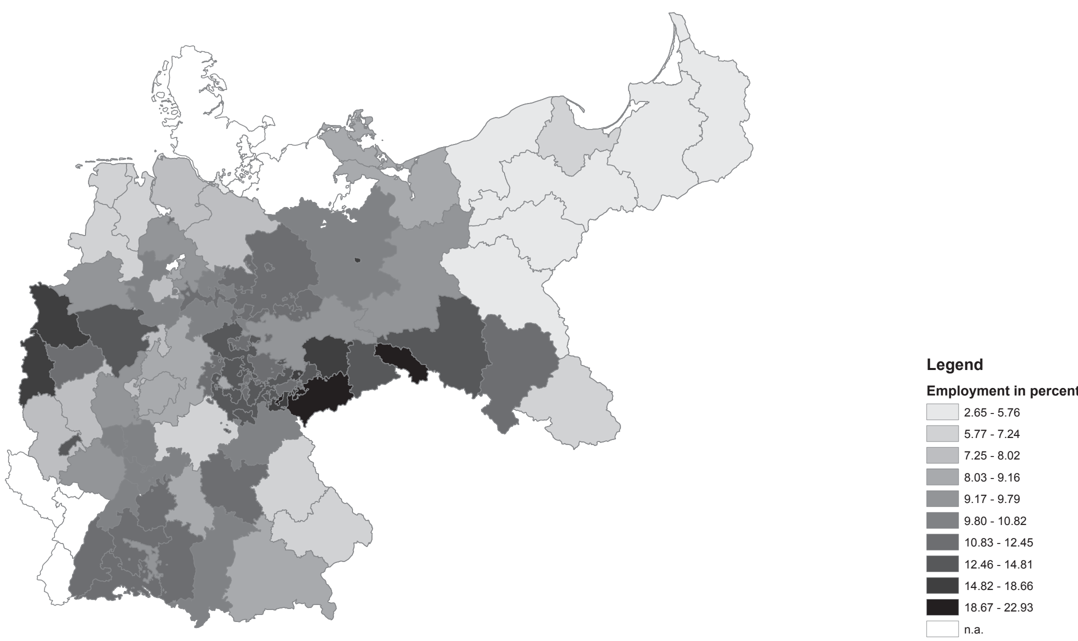
(a) 1861

(b) 1882

Figure 1: Waterways and Railroads in Germany in 1861 and 1882, Source: HGIS-Germany (Kunz and Zipf 2008)

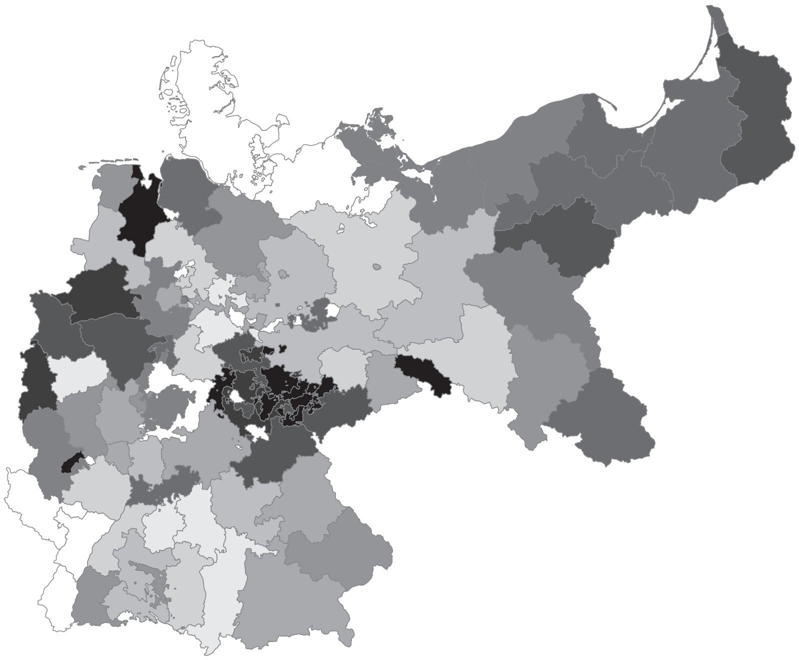


(a) 1861

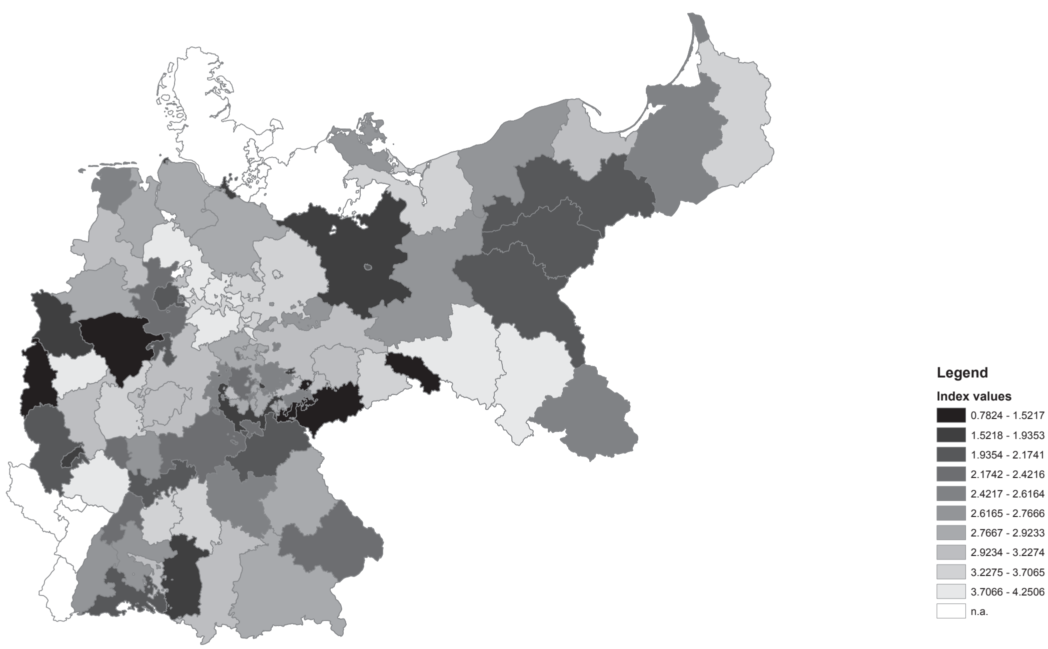


(b) 1882

Figure 2: Manufacturing per capita in 1861 and 1882, Sources: Tabellen der Handwerker und Fabriken des Zollvereins 1861 and Statistik des Deutschen Reich NF Vol.6 and Vol.7 (1885), HGIS-Germany (Kunz and Zipf 2008)



(a) 1861



(b) 1882

Figure 3: Diversity of manufacturing industries in 1861 and 1882, Sources: Tabellen der Handwerker und Fabriken des Zollvereins 1861 and Statistik des Deutschen Reich NF Vol.6 and Vol.7 (1885), HGIS-Germany (Kunz and Zipf 2008)

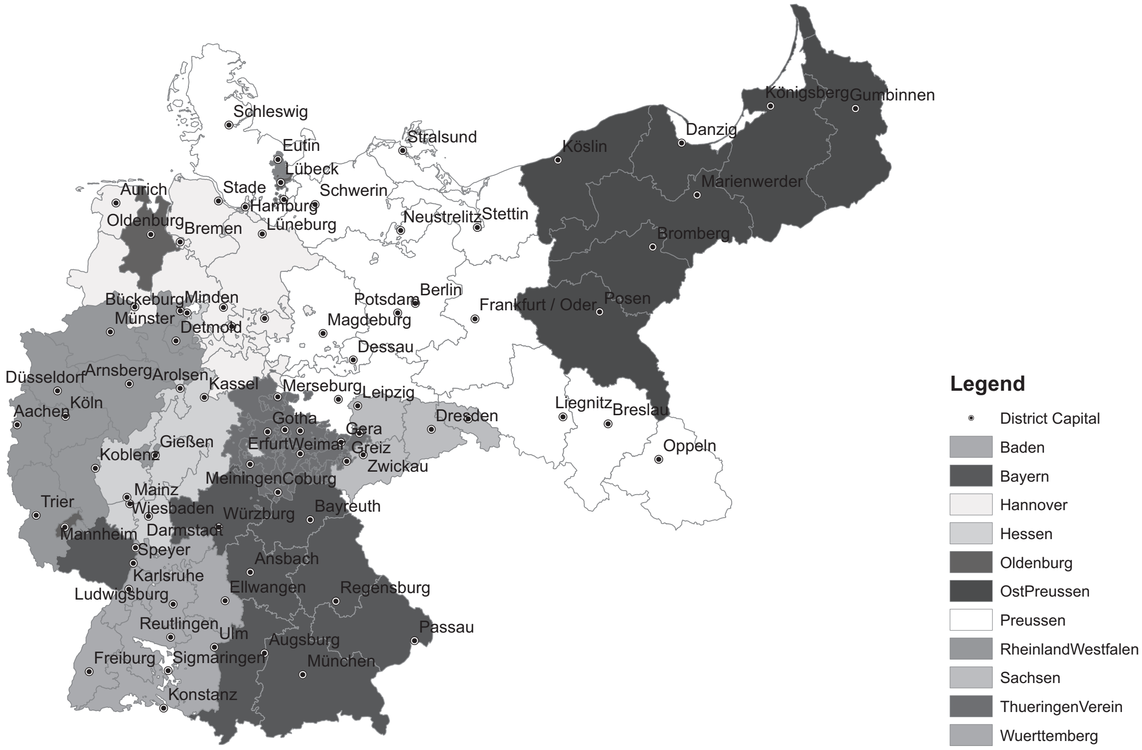


Figure 4: Division of Germany into 10 provinces following the boundaries of the large German states in 1861 with Prussia subdivided into 3 provinces, Source: HGIS-Germany (Kunz and Zipf 2008)

Table 1: Classification of industries

	Industries
Pottery	Porcelain, earthenware, bricks
Glass	Sheet glass, blown glass, mirrors
Iron and steel	Pig iron, cast iron, wrought iron, sheet iron, steel
Other nonprecious metals	Lead, nickel, zinc, copper
Precious metals	Silver, gold
Metal goods	Knives, needles, screws, hardware, wire goods
Machines	Ships, wagons, engines, firearms, tools
Instruments	Chronometers, telegraphs, lamps musical, mathematical, and surgical instruments
Chemicals	Chemicals, paints, explosives, fertilizer
Fats and oils	Soap, candles, natural oils, petroleum, lubricants, varnish
Cotton textiles	Cotton spinning and weaving
Linen textiles	Flax spinning, linen weaving
Wool textiles	Wool spinning and weaving
Silk textiles	Silk spinning and weaving
Knitting	Socks, knitted goods, lace
Textile finishing	Printing, dyeing, dressing
Wood work	Wooden pins, barrels, wood work, cabinets, baskets, wood carving
Paper	Paper, paper mache, paper tapestry
Leather	Tan mills, tanneries, driving belts, furs
Rubber	Rubber, rubber goods
Food	Flour, pasta, sugar, coffee, cured meat and fish, dairy, breweries, distilleries
Tobacco	Tobacco
Clothing	Hosiery, sewing, tailoring, millinery, hats, suspenders, corsets, shoes

Classification of industries into broad sectors for the calculation of regional diversity within manufacturing, based on Tabellen der Handwerker und Fabriken des Zollvereins 1861 and Statistik des Deutschen Reich NF Vol.6 and Vol.7 (1885)

Table 2: Average freight rates (Pfennig per ton kilometer)

Year	Waterways	Railroads	Roads	Ocean	Transshipment
1861	1.60[1]	4.65[4]	40[6]	1.53[7]	50[8]
1875	1.55[2]	3.42[4]	40[6]	1.21[7]	50[8]
1882	0.97[3]	3.02[5]	40[6]	1.05[7]	50[8]

National average freight rates for different modes of transportation and transshipment measured in Pfennig (100 Pfennig = 1 Mark) per ton kilometer between 1846 and 1882.
Sources:
[1] Average freight rate of shipments on the Elbe between Magdeburg, Dresden, and Hamburg in the year 1850 (Teubert 1918)
[2] Average freight rate of shipments on the Rhine between Strassburg, Saarbruecken, and Muehlhausen in the year 1869 (Teubert 1918)
[3] Average freight rate of shipments on rivers (1.68) and canals (1.42) in the German Empire in the year 1872 (Teubert 1918)
[4] Average freight rate of shipments on the Elbe between Aussig and Magdeburg in the year 1882 (Heubach 1898)
[5] Average freight rate for coal in the years 1848, 1860, and 1870 (Fremdling 1979)
[6] Freight rate for coal between Korbitz and Berlin in the year 1882 (Heubach 1898)
[7] Average freight rate on horse carriage in the year 1840 (Fremdling 1979)
[8] Average freight rate for coal in shipments from England to Hamburg in the years 1850/54, 1860/64, 187/75, and 1880/84 (Fremdling 1979)
[9] Estimated average transshipment price for 1 ton of cargo in 1913 (Regul 1933)

Table 3: Summary statistics for Market access

	Year	N	Mean	Std.Dev.	Min	Max
Shipping costs	1861	80	2,192.18	585.06	1,532.26	4,240.07
	1875	80	1,530.45	354.18	1,080.20	2,831.98
	1882	80	1,110.56	278.24	794.48	2,138.24
Population	1861	80	478,178	289,004	34,391	1,295,959
	1875	80	514,335	350,328	33,133	1,472,254
	1882	80	552,429	381,510	35,000	1,654,511
Market access	1861	80	507.66	288.56	55.90	1,324.96
	1875	80	555.98	351.75	65.44	1,513.29
	1882	80	644.69	428.40	85.95	2,437.33

Sources: Own calculations based on HGIS-Germany (Kunz and Zipf 2008) and freight rates from Fremdling (1979), Regul (1933), Teubert (1918), Heubach (1898)

Table 4: Instrumental Variables

	Δ Access	Δ Access $\times$ Industry
Industry	-0.8523	-0.1390
	(0.9628)	(0.1072)
Δ Access IV	3.0859***	-0.0095
	(1.3139)	(0.1464)
Δ Access IV $\times$ Industry	29.2192***	6.5358***
	(12.3067)	(1.3708)
Coal	-146.1723***	-16.4819***
	(42.9209)	(4.7807)
Lignite	-111.8923***	-13.7074***
	(43.0938)	(4.8000)
Provincial fixed effects	Yes	Yes
N	72	72
Partial R^2 (excluded instr.)	0.7346	0.7404
F-statistic (excluded instr.)	78.89	81.26
Cragg-Donald Wald F-statistic	51.42	

standard errors in parenthesis

Table 5: Regression for Manufacturing Growth

	Δ Industry		
	OLS		2SLS
	short term	long term	long term
Industry	-0.2859***	-0.4441***	-0.4739***
	(0.0462)	(0.0808)	(0.0812)
Δ Access	-9.3724***	-10.3682***	-11.9277***
	(3.4442)	(3.6667)	(4.0795)
Δ Access × Industry	0.9440***	1.0151***	1.1784***
	(0.3255)	(0.3256)	(0.3609)
Coal	2.2823	3.2178	3.2582
	(2.5692)	(4.3765)	(3.9257)
Lignite	4.7059**	8.84078**	9.4427***
	(2.6634)	(4.6874)	(4.2621)
Provincial fixed effect	Yes	Yes	Yes
Year fixed effects	Yes	No	No
N	154	72	72
adjusted R^2	0.6184	0.7071	0.7634
F-statistic	17.32	13.24	13.11

heteroskedasticity robust standard errors in parenthesis

For interpretation of the coefficients note that per capita manufacturing is measured in employees per 100 people. Market access is divided by 100.

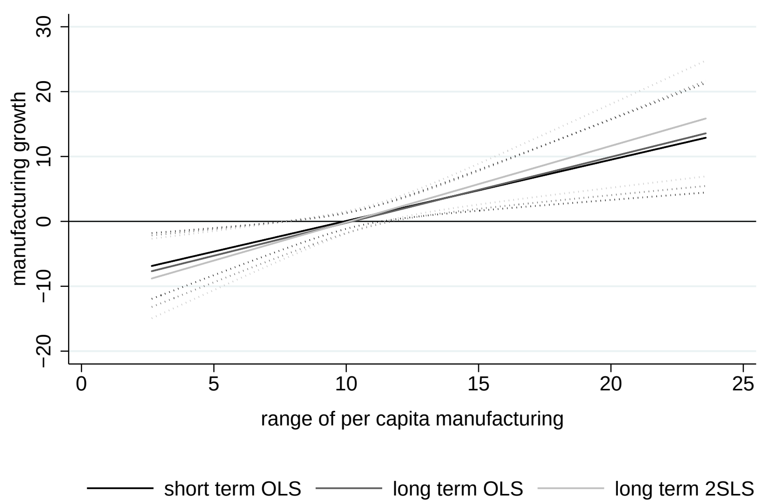


Figure 5: The graph shows the effect of an improvement in market access of 100 units on growth in per capita manufacturing employment. The solid lines show the estimated marginal effect and the dotted lines represent 95 % confidence intervals. The actual average improvement in market access was 81.50 in the short and 161.46 in the long term.

Table 6: Regression for Diversity in Manufacturing

	Δ Diversity OLS long term	2SLS long term
Δ Access	1.7218*	1.9334**
	(0.9445)	(0.9542)
Δ Access × Industry	-0.1859**	-0.2094***
	(0.0811)	(0.0809)
Coal	-0.0739	-0.0709
	(0.1527)	(0.1375)
Lignite	0.2262**	0.2177
	(0.1617)	(0.1459)
Provincial fixed effect	Yes	Yes
Year fixed effects	No	No
N	72	72
adjusted R^2	0.2619	0.3958
F-statistic	2.94	2.95

heteroskedasticity robust standard errors in parenthesis

For interpretation of the coefficients note that market access is divided by 100.

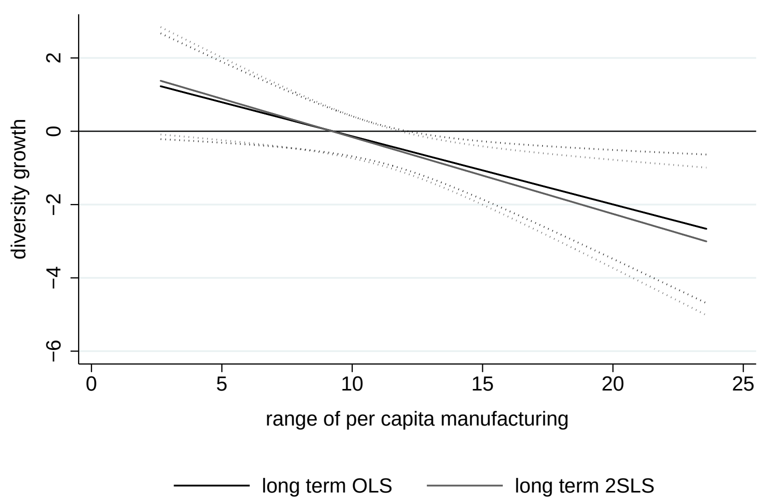


Figure 6: The graph shows the effect of an improvement in market access of 100 units on growth in industry diversity within manufacturing. The solid lines show the estimated marginal effect and the dotted lines represent 95 % confidence intervals. The actual average improvement in market access was 161.46 in the long term.