It's all in the Mail:
The Economic Geography of the German Empire

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Abstract

The transport revolution in the 19th century transformed mail services with the ideas of uniform pricing and universal access. This paper uses postal data and a New Economic Geography model to derive index values for local literacy, ability to trade and endowment values in the empirical setting of the German Empire. Extensive data about the whole postal network in 1876 and annual panel data about important towns afterwards is combined together with an extended set of location characteristics covering geographic endowments, infrastructure, institutions and cultural factors to identify the actual factors underlying the observed regional structure of the German Empire. This is combined with a novel approach to measure local applied literacy, which is a based on estimating the private mail volume for each location.

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[1] All errors are of course my own

1. Introduction

The spatial distribution of economic activity is far from uniform; its density ranges from essentially empty spaces, for example in deserts and high mountains, to extreme spikes in economic centres like New York, Paris or Tokyo. This uneven distribution is also visible in the population distribution, in particular in the existence of the high clustering areas of towns and cities. Identifying and understanding the forces shaping these distributions is an important step in addressing a number of economic and policy issues. These range from cost and benefits of infrastructure, the distribution of public services to urban and regional development policies. Here I provide such an investigation by identifying the forces underlying the spatial structure of the German Empire before World War I.

The central forces shaping these distributions then as now are agglomeration and dispersion forces. There is a substantial literature on the geography of regions and towns dating back to Marshall (cite) and even further to van Thuenen (cite), which addresses particular aspects of these forces. Nevertheless it remains a substantial challenge to disentangle the role of certain agglomeration and dispersion forces, which depend on the relative geographic position of economic actors, from the impact of location fundamentals, which depend on their absolute position. Some studies utilize natural experiments to identify the relative impact of the two (Redding and Sturm, 2008). Another approach is to utilize a theoretical model combining agglomeration forces and location endowments and calibrate it with location specific data

(Ploeckl, 2012).

This paper follows the second approach by utilizing postal data for the calibration of relevant location parameters that allow the identification of the impact of location characteristics and agglomeration on local population. The use of such data describing the extent of communication and information exchange in each location results in quantitative values for a number of characteristics for each location, namely a measure of applied literacy, of business activity, of the ability to trade and of an index value for a location's amenity.

The first step is based on the role of communication in the coordination of economic activity over space. Based on the empirical setting of the German empire in the late 19th century mail is the central medium of formal information exchange, private as well as commercial. The total mail volume is therefore the sum of private mail, written for personal purposes, and business mail, written for commercial purposes. Utilizing data from other communication services I estimate the relative size of the two components for each location. This allows to take the amount of private mail per head as a measure for applied literacy while the amount of business mail is taken a measure of commercial activity.

The second step uses the estimated amount of business mail and sets it in relationship to the empirical market potential of the respective location. This allows the calibration of a factor that shifts the distance component of the market potential measure. The resulting location specific value is

taken as the ability to trade of each location. The third step takes this ability value and incorporates it into a New Economic Geography model. This theoretical model then utilizes the population distribution, the relative distance between locations and the ability to trade to derive an index value for location endowments.

After its inception in 1871 Imperial Germany covered the territories of today's Germany, substantial parts of today's Poland and smaller areas of other contemporary states like France, Russia and Denmark. The country was rapidly industrializing and developing world-leading industries in a number of regions, while other parts still were still substantially dominated by agriculture. The newly formed empire also had a strong federal character with substantial rights for individual members states. One of the centralized functions however was the the Postal and Telegraph service, which was the result of elevating the Prussian service to an imperial service and having it absorb the services of other member states. The unification of the mail service also led to a equalization of service in terms of postage and associated regulations. This uniform service provision implies that that the conditions for using these postal services were identical all over the empire. The postal agency also improved its statistics section and collected a substantial amount of information about various postal activities. These statistical results, in particular local information, serve as the main data source for the analysis in this project.

[Add Results of the analysis] [Add Structure of the Paper]

2. History

2.1. German Empire

Germany was one of the last of the important European nations to develop into a centralized nation state. While other states like France and especially Great Britain had created a unified state much earlier Germany only developed a similar cohesion in 1871 with the foundation of the second German Empire.

The splintered nature of the German territories until that time went back until the end of Charlemagne's reign. The eastern part of his empire developed into what became later known as the Holy Roman Empire of German Nation. Its political structure developed into a hierarchy of sovereignties including the emergence of ecclesiastical territories. The emerging hierarchy saw the emperor, who usually also was the ruling sovereign of a number of territories, at top and a small number of influential princes that ruled over their own states. The rights of the emperor were fairly limited and over time the tension between him and the princes occasionally broke out in military conflict, especially during the time of religious war in the 16th and 17th century. This structure of multiple hundred sovereign territories with a supranational governance institution finally broke apart with Napoleon's victory over German states at the turn of the 19th century, which led the Habsburg ruler to surrender the German emperor title, leading to the demise of this institutional structure. Furthermore the secularization and mediatization process led to the consolidation of the sovereignties into a smaller

number of states. After Napoleon's loss the congress of Vienna redrew the boundaries again and about 40 German states emerged, ranging from free cities like Frankfurt, small and mid-sized states to the large European powers of Austria and Prussia. Although there was a new institution with the German Federation, the Deutsche Bund, it only had a very limited internal power and functioned mostly as a military and internal security pact (Cite). There were some multilateral co-operations in economic issues, most notably the Zollverein customs union of 1834, these were purely voluntary treaty between sovereign nations and usually did not cover the whole of the German federation (Cite).

The tension between Austria's and Prussia's claims to leadership in Germany escalated in the 1850's and 1860's until the full break-out of military conflict in 1866. Although most of the smaller German states allied themselves with Austria Prussia achieved a swift military victory. As a result it became the hegemonic power in Germany, pushed Austria out of Germany and annexed many of the smaller states. Additionally it created the Norddeutsche Bund, a formal union of German states north of the Main under Prussian leadership. After the combined German troops beat the French in 1871 the political structure of Germany was once more reorganized and the German empire was created as a federal structure of German states under the emperorship of the Prussian king (Cite).

Although the new empire had centralized political institutions in the Bundesrat, Reichstag and the Reichskanzler, the council of member state repre-

sentatives, the parliament and the chancellor, most practical executive issues remained however under the control of the individual states political structures. The close connection between the imperial offices and their Prussian counterparts, for example most chancellors were at the same time also prime minister of Prussia, implied that the imperial executive had in practice more power than it appeared on paper. There were also a number of immediate imperial offices, including the Reichspostamt, the administration of the postal service. This political structure persisted for over four decades and came to an end with Germany's defeat in the first World War (Cite.

Paragraph: Imperial Economic structure

2.2. Reichspost

In 1490 Maximilian I, who also ruled over the Netherlands at the time, acquired control over Tyrol in Austria and subsequently tasked the Tassis family to provide a postal relay service between the two territories. This postal course is commonly seen as the origin of the modern European postal system and with a southern extension into Italy provided the central backbone of the system for the following two centuries. By 1530 the relay system had been opened to the public and in 1597 emperor Rudolf II. went even further and declared the post an imperial privilege, effectively granting the Tassis family a postal monopoly (Behringer, 1990).

As the imperial power was severely limited, some of the princes disputed the emperors right to assert this privilege and the related monopoly. This le-

gal dispute was never fully resolved until the demise of the empire in 1806 and did not prevent them from establishing their own systems with a monopoly for the respective state. The most notable example is the Prussian system established permanently in 1649 in the wake of the peace of Westfalia. This existence of multiple systems persisted and left Germany after the the reordering of the political landscape in 1815 with about a dozen different postal systems and the related difficulties of sending mail between them (Behringer, 1990, 2003).

The increasing economic unification between the states also led to a push for a closer cooperation between the different system to facility easier communication within German territories. This came to a fruitful conclusion in 1850 when a number states agreed to create the Postal and Telegraph union. Regarding mail this agreement created a unified German postal area, making it substantially simpler to send letters to recipients in another postal area (cite)

The creation of the postal union coincided with some major structural changes to the systems. The introduction of prepaid mail through the use of stamps, started in Germany by Bavaria in 1849, the rise of the idea of universal access and the shift towards distance-independent pricing structurally changed the existing services, providing the framework for the continued expansion of the postal reach and in particular for the spread from towns into the countryside (cite).

Prussia's victory in 1866 and the subsequent creation of the Norddeutsche

Bund also led to the creation of a unified post service with the Prussian service taking over the existing structures in the other states of the North German federation and begin moved under the political jurisdiction of that structure. This also meant the end of the Taxis postal service, which had survived as a private monopoly for a number of Hessian and Thuringian states as well as Wuerttemberg (Behringer, 1990).

A similar expansion happened with the foundation of the German Empire in 1871, Baden's post service was folded into the Prussian system as was the formerly French service in Alsace-Lorraine and the complete postal service became an official agency of the new Empire. There was however one substantial difference, namely the role of Bavaria and Wuerttemberg. While in 1867 the postal systems of all member states of the new political structures had folded their systems into the common services, this did not happen with the new imperial mail. The two southern states, Bavaria and Wuerttemberg, insisted on a number of special autonomy rights in exchange for their agreement to become part of the new empire. One of these rights was the retention of an independent postal service. This meant that inside the new empire three distinct postal services operated. The size of the covered population however showed the relative disparity between them, the imperial mail serviced 36 million people, while the Bavarian service covered just over four million and the Wuerttemberg one close to two million (Hesse, 2002; Sautter, 1951).

The imperial mail service was headquartered in Berlin, the political seat

of the new imperial government. A structural reform in 1876 merged the previously distinct post and telegraph administrations into the new *Reichspost- und Telegraphenverwaltung*. This new agency was headed by the Generalpostmeister[2], who reported to the chancellor of the empire. The post was filled with Heinrich von Stephan, who also played a central role in the creation of the Universal Postal Union. The service was organized in 41 postal districts called Oberpostdirektionen. These districts lined up roughly with internal political boundaries though the match was far from perfect and substantial differences existed. This structure existed until the demise of the Empire in the wake of Germany's defeat in the first World War (Hesse, 2002; Sautter, 1951).

Although the Taxis family had carried the operational contingent risk of the mail services operated under imperial privilege as well as after the demise of this legal framework the postal service was not conceptualized as a business venture (Behringer, 1990). One formal example for that is that the Zollverein treaty, which regulated for which goods member states could assert public monopolies, did not list the postal service as such an undertaking (cite). Historically the provision of mail services was therefore considered more of a public good like security.

The figure in the appendix shows the quantitative expansion of the postal system in German states from its inception at the turn of the 16th century

[2]After 1880 the agency was headed by a *Staatssekretaer*, who still reported to the chancellor

until the early years of the empire. The number of places served by at least one of the different systems grows exponentially and reaches close to 3000 by the time the Reichspost is established. The number of places continues to grow and by XXX the number of offices[3] had reached XXX (cite). The related statistical investigation in the appendix shows that political and economic motives drive the expansion and illustrate the primacy of population and institutions rather than geography in the spatial diffusion pattern.

2.3. Framework

The theoretical framework used in the analysis consists of three distinct parts. The first is the separation of the mail in personal and business mail, the second is the derivation of the trade ability through a link between business mail and market potential and the third is the calculation of the amenity value through a New Economic Geography model.

2.4. Mail Volume

There are a number of measures that are used to characterize the human capital level on an aggregation scale above the individual. Examples are the average years of schooling, the share of people with specific degree's or especially in historical and development contexts the share of the population that is literate. There are a number of problems with these measures, some are simply binary indicators, some are input measures that may not have

[3] A number of locations had multiple branches therefore the number of locations served is substantially lower than this number.

the same impact and most are not systematic and regularly collected. The measure proposed here, residual, private mail per head, overcomes these issues.

More precisely the measure is the residual difference between total mail volume in a location and the predicted local business mail volume. Conceptually total mail volume is the sum of business and private mail, which implies that the estimation of business mail volume leads to an implicit prediction of private mail. Predicting business mail results not only in a local estimate for business mail but also in a general constant, which can be interpreted as nationwide, average private per capita mail, and a location residual. Since I use the residual directly obtained through a regression it is distributed around zero and it is not guaranteed that the predicted total private mail volume, constant plus residual, is positive for all locations[4].

The advantages of this measure are the local availability, it can be derived for each location for which mail volume and population is available, the output nature of the measure, mail is an output rather than an educational input, and its continuous nature, it does not run into some inbuilt thresholds. This makes it an ideal measure for the time period in question with its limited data availability and transition between a focus on literacy and the length of schooling.

The quantity of mail has been used in the economics and economic liter-

[4]If the prediction of business mail for a location is higher than a location's total mail volume the residual private mail will be negative.

ature in a number of ways. Crafts (1983) uses it to estimate gdp numbers, similarly Kenny (cite) shows the correlation between mail volume and a countries GDP. Panzer and others change the perspective and estimate the drivers of mail demand, in particular GDP (cite) . This however usually focuses on pricing and related market structures questions, omitting an investigation into the motives behind the mail sent.

Since there is no direct way to measure how much of the mail has personal and how much has business purposes I utilize an estimation approach not too far from Michalski (1937). The idea is to utilize other postal service measure, the number of telegrams, value packets, collection on delivery items and the total volume of money orders, which due to their nature are strongly correlated with business mail but not private mail. Using all locations a general prediction for the number of business mail items related to single one of each of these items is derived, which then combined with the actual volume in each locations results in a prediction of business mail for each.

While the private mail component is taken as a measure for applied literacy, the business mail volume provides an index of commercial activity.

[Add discussion about literacy and commercial index]

2.5. Trade Ability

The previous section split the mail into two components, private and business. While private mail serves as a measure for applied literacy, the volume of business mail in a location is further used to derive a measure of

the ability to trade.

Most empirical estimations of the gravity equation for trade include trade flow specific factors that increase or decrease these flows. One such example is a potential difference in language between the two trade partners. The focus in this literature is on the determining the impact of these factors on flows, border effects are a prime example. A further development in this vain are Jacks et al. (2010, 2011) , which use the flow size predicted by a gravity model and compare it to actual flows to infer trade costs between two countries. Here I take up this idea but modify it for the given context. Due to the homogeneity of the environment, the nature of the data and the large number of locations I shift the trade costs from being flow-specific to being sender-specific.

The underlying idea for the measure argues that each location has a specific ability to exchange information which in turn determines subsequently trade and transaction costs. This implies that the volume of business mail, which indicates the amount of relevant communication, reflects the volume of commercial transactions and can therefore be used to derived the trade ability measures. In particular the baseline assumption is that business mail volume equals market potential, formally:

$$BM_i = \sum_j b_i * \frac{Pop_j}{d_{ij}^2} * \frac{\sum_j BM_j}{Pop_j}$$

where BM_i is the volume of mail in town i, Pop_i is the population of

town i and d_{ij}^2 is the distance between locations i and j. The added factor b_i is the location specific

The resulting measure has two components, the first part that determines the relative transportation costs of the included locations while the second provides an absolute factor, which becomes especially relevant later on for analyzing developments over time. The measure can be interpreted as a fixed cost that is added multiplicatively to the standard distance, similar to modifying factors for gravity equations, and can therefore be translated in terms of distance added.

2.5.1. Amenity

The second part of the analysis is to use the derived ability index measure to calculate a location endowment index. This is done based on Redding and Sturm's multi-location version of Helpman's model about the size of regions (Redding and Sturm, 2008; Helpman et al., 1998). The following description is taken from Ploeckl (2012) The model developed by Redding and Sturm (2008) incorporates population as a mass of representative consumers, each of them living in a specific location. These consumers supply labor and are compensated with a location specific wage. Their labor also represents the sole factor of production. Locations produce horizontally differentiated manufacturing goods with the differentiation of these varieties based on the Dixit-Stiglitz form. The production process of each variety follows the standard increasing returns specification with a fixed cost and a constant marginal

cost. Varieties are produced under monopolistic competition and are traded between locations. Transportation costs are modeled as standard iceberg trading costs.[5] Additionally each location is endowed with a stock of a non-tradable amenity, the level of which is exogenously determined. The amenity is supplied perfectly inelastic for consumption by consumers at the location; the total expenditure on the amenity is redistributed to the consumers. The utility function of each consumer has the Cobb-Douglas form, with an index of manufacturing varieties and the amenity as the two consumption inputs. The demand from all locations for goods from a particular location is summarized as firm market access, while the total supply of varieties in a particular location is formally defined as consumer market access. Consumers are able to migrate freely between locations and are assumed to do based on the relative real wage.

The formal equilibrium of the model is a system of seven equations with seven unknowns[6]. Redding and Sturm show that the model has under certain conditions a unique, though not analytically tractable, solution. The equilibrium relies on exogenously given values for the amenity, H_c, and transportation costs, d_{ij}. To simplify the exposition, two market access measures are defined in terms of model variables and parameters, formally $FMA_c \equiv \Sigma_i(w_i L_i)(P_i^M)^{\sigma-1}(T_{ci})^{1-\sigma}$ and $CMA_c \equiv \Sigma_{n_i}(p_i T_{ic})^{1-\sigma}$.

[5]Empirically I use the distance between two locations as a proxy for trade costs.

[6]These are the real wage ω_c,the price of local varietiesp_c, town population L_c, number of varieties n_c, tradeables price index P_c^M, amenity price P_c^M, and total expenditure E_c.

One of the equilibrium equations models the real wage equalization between locations. A reformulation of this equation reveals the explicit link between local population size and the idea of agglomeration economies, represented as market access, as well as the importance of location fundamentals, modeled as the local amenity. Formally the link is shown in the central equation:

$$\ln L_c = \ln \chi + \frac{\mu}{\sigma(1-\mu)} \ln FMA_c + \frac{\mu}{(1-\mu)(\sigma-1)} \ln CMA_c + \ln H_c \quad (1)$$

where L_c is the population of town c, χ a collection of model parameters, FMA_c the firm market access of location c, CMA_c the customer market access of location c and H_c is the local amenity. μ and σ are model parameter, namely the consumption share of non-tradeables and the elasticity of substitution. The resulting scalars in the equation are positive[7], which implies a positive correlation between urban size and both market access measures as well as the amenity value.

The two market access measures model different aspects of market access. FMA_c, firm market access, represents the size of the markets local producers in c sell to. Increasing returns in the production process imply that a larger firm market access allows for cheaper production, higher profits, higher nominal and real wages and consequently a higher population. But the theoretical framework also takes the consumer side into account. CMA_c represents the

[7]This is implied by a condition for a unique equilibrium.

size of the market for consumers with regard to the range of varieties offered in location c. Given consumers love of variety a larger range of market suppliers reduces the price level, increases the real wage and attracts therefore a higher population.

The second factor explaining location size is H_c, the level of the amenity for location c. The framework uses a single value to model exogenously given, non-tradeable location factors. The amenity is included in the consumption basket of the consumers rather than in the production process. This inclusion in the consumption basket is combined with the assumption that consumers spend a fixed share of their income on the amenity, so a higher population for a given amenity level leads to a higher price due to the higher demand. This higher price leads to a reduction of the real wage and a dispersion effect for the population.

Location size is determined by real wage equalization, in the equilibrium it is therefore influenced by two agglomeration factors as well as two dispersion forces. The two mechanisms that attract people are the two above mentioned market access effects. A larger firm market access attracts more people due to a higher nominal wage and therefore a higher real wage. A larger consumer market access attracts more people due to a lower price level and therefore a higher real wage. A larger domestic market also implies more producers and therefore a competition effect that dilutes profits and therefore real wages. This acts as a dispersion force together with the described congestion effect for the amenity.

The model equilibrium contains the town populations L_c as a variable, while the amenity values, H_c, are exogenous. The uniqueness of the equilibrium however implies that the reverse also holds. If the population of each town is known then L_c can be treated as exogenous and H_c becomes the outcome variable. A numerical solution[8] for the model using given population numbers, as well as transportation costs, will therefore result in an implied amenity value for each location. Similar, given amenity values and transportation costs a numerical solution for population numbers can be derived. The following empirical tests are based on such implied values derived for different sets of amenity, population and transportation cost numbers. The necessary uniqueness of the equilibrium depends on the values of μ and σ, the consumption share of non-tradeables and the elasticity of substitution. Redding and Sturm demonstrates that it is guaranteed for $\sigma(1-\mu) > 1$. Solving for the equilibrium numerically obviously requires the selection of actual parameter values. The empirical analysis in this paper uses $\sigma = 4$ and $\mu = 0.25$, which follows Redding and Sturm, who demonstrate with a simulation exercise the empirical appropriateness of this choice.

The empirical analysis of Redding and Sturm (2008) treats the exogenously given amenity essentially as permanent and unchanging over time. Ploeckl (2012) argues that a wider interpretation of the amenity factor also

[8]The applied numerical algorithm, which searches over possible values of H such that the real wage is equalized between locations, is taken from Redding and Sturm (2008) as well.

should relax this particular assumption. This implies that not only changes to market access but also changes of the amenity can drive changes in the population distribution. Furthermore the central argument is that location fundamentals have now a variable part. They can adjust in such a way that with a relative short regularity the system is in equilibrium given the population distribution and the transport costs. This implies that certain, mostly non-physical factors for the location choice, for example nostalgia, that would shift the population 'off-equilibrium' can then be incorporated in the variable component of location fundamentals.

Real wage equality is another assumption that can be relaxed with a wider interpretation of the amenity term. The structure of the model is such that a systematic, underlying real wage differential can be masked by a different amenity level such that the model mechanism of real wage equalization, which drives mobility between locations, is taking this into account and does retain the systematic differentials.

2.6. Estimation

[Add Paragraph: Empirical Implications and methods]

2.7. Data

The calibration of the the location measures requires a number of specific data sets. These are a location's population, the total volume of mail, the additional communication data used to determine the split into business and private mail and the distance matrix between the locations as the basis

for transportation costs. The postal and population data are taken from publications of the Postal service. In particular there are two sources, first the Post-Lexikon (cite) reporting the data for the complete set of location with postal offices for the year 1876 and second the annual reports of the Postal service (cite) which list a smaller set of data for the set of locations with a first class post office.

The postal data set for 1876 contains the total incoming and outgoing volume of mail, which is a combination of letters and other, similar items like post cards. Furthermore the total number of incoming and outgoing packets without value declaration as well as packets with value declaration is included as is the number and combined value of money orders, the number of collection on delivery items and the number of order letters, a postal service to collect bills of exchange payments.

The reported population data is based on the official censuses conducted by the Imperial statistical office in a five year rhythm. The numbers for the intermediate years between the census years are linearly interpolated from the two surrounding censuses. Additionally the information in the Post-Lexikon is used to identify locations and create geographic references, which allow the calculation of the great-circle distance matrix between them.

The second part of the analysis, the explanation of the derived index values with actual location characteristics, requires an additional set of data. These data can be grouped in three categories, namely geographic, institutional and cultural. The geographic data include elevation, measured in

meters above sea level, and a range of climate measures, in particular a number of temperature and rain values. Furthermore the proximity of a major river is included with a dummy as is the proximity to a major lake. Similarly proximity to the North sea coast as well as the Baltic sea one are included. Finally the major areas with coal deposits, split into hard and brown coal, are identified and included with a dummy if a location is within the specific general area. Institutional variables are a number of contemporary and historical institutional characteristics of the location. The first group is a set of distance to borders, in particular the external border of the German empire, the distance to the Prussian state border as well as distance to Bavaria or Wuerttemberg. More contemporary institutions are the presence of a university, split into general and technical institutions, as well as the presence of a deep sea port. Historical variables include a town's membership in the Hanse, the medieval association of trading towns, and a past as a free Imperial town at any time during the old empire until the inception of the new German empire in 1871. These last two can also be categorized with the included cultural variables, which are the share of Catholics in the location's population and the share of those who are native speakers of a foreign language.

[Add description of the Kreis level data to be used in the dynamic analysis]

[Add Appendix with Data sources]

3. Estimation

3.1. Mail Volume

As detailed above, the first empirical step is the prediction of business mail volume and the associated index of applied literacy. As discussed above the index is based on the residual from a regression of total per capital mail volume on other, business-related postal numbers. In particular I include the following numbers, the number of telegrams received, the number of collect on delivery items, the number of order letters, the number of packets with value declaration and the value of the incoming money orders. While the dependent variable, the number of mail items per head, is based on outgoing items, the independent variables are all indicators of incoming postal items. The choice of outgoing volume for the dependent variable is based on the idea that private mail is not as reciprocal as the included business measures. The dependent variables are however based on incoming variables since such an incoming item is also representative of an business transaction. Additionally this avoids outliers driven by the presence of certain sectors, that are heavy users of packets, etc to distribute their products as discussed by Hull (1892)

The formal specification is

$$TM_i = \alpha + \beta_t Tel_i + \beta_c CoD_i + \beta_o OL_i + \beta_v VP_i + \beta_m VMO_i + \epsilon_i$$

where TM_i is the total mail volume, Tel is the number of telegrams, CoD the number of collect on delivery items, OL the number of order letters, VP

the number of packets with value declaration, VMO the value of money orders and *epsilon* is the residual that will be taken as the index for applied literacy, M_i.

The results are shown in Table 1. The results show a clear positive correlation between all business items and total mail, and the magnitude of coefficients, substantially above one, implies that each of such an item is associated with a substantial larger number of mail items, fitting with mail's status as the cheapest way to transmit information.

Additionally if the intercept is taken as the average volume of private letters per head it allows an estimation of the relative volume of business and private mail for the complete system. The resulting numbers imply XX, which fits fairly well with the estimation of XX derived by Michalski (1937) for the interwar time period. Figures 1 and 2 give a graphical illustration of the geographic distribution of the derived local values.

The next step is to identify the determinants of the derived measure which is taken as the . This is done through estimating a specification that incorporates the derived measure as dependent variable and the afore mentioned location characteristics as independent variables. Formally the following specification is estimation with OLS and robust standard errors:

$$Index_i = \alpha + \rho Pop_i + \sum \beta_g Geo_i + \sum \gamma_{in} Ins_i + \sum \lambda_{cu} Cul_i + \epsilon_i$$

where $Index$ is the derived volume measure, Pop is the location popula-

tion size, Geo, Ins, and Cul are the respective included geographic, institutional and cultural characteristics and ϵ is the error term.

The first step is to use the applied literacy measure, M_i, as the dependent variable. Furthermore the independent variables include besides the afore described characteristics also the population size of the respective location as an independent variable. The regression results are reported in Table 2. There are a number of location characteristics that influence the predicted private mail volume. One is the population size of a location, the larger the town the lower the per capita volume[9].

Geographic and climatic factors do not seem to have influenced applied literacy. One effect related to geography is the negative impact of proximity to the North Sea. Locations close to the shoreline sent about 2.7 less items, an effect that is in stark contrast to the eastern counterpart, proximity to the Baltic Sea. Locations close to that shoreline have a substantially increased number of items, though the effect is not statistically significant. Combined with the statistically significant and negative effect of deep sea harbours the results indicate that the proximity to this shore line had a substantially negative impact on applied literacy.

Railroads had a positive effect, growing stronger the longer a town had been connected. The median time to establishment implies an impact of about 1.4 items per head.

[9]Further research might clarify whether this is due to substitution, close personal contacts rather than private mail, or actual literacy differences.

The included controls for proximity to various borders show two effects, first a negative impact of proximity to foreign borders and second a positive impact of proximity to Bavaria and Wuerttemberg. The first follows expectations, the closer to the boundary a location is the lower the number of items mailed is. The second is different, proximity to the states of Bavaria and Wuerttemberg leads to a higher number of items. In connection with the point that the other internal border variables show no statistically significant effect this is likely more of a regional effect than a border effect. The results for the regional effects between postal districts indicate no real structural differences between the included regions with the exception of the Berlin metropolis. The district, which includes the capital and a small number of places around it, had a substantially higher number of items per head.

Cultural characteristics show that the presence of a native language other than German has no statistically significant effect, the sign however indicates a strongly positive impact. More importantly however the coefficient on the share of Catholics does show a statistically significant negative effect, people in catholic towns write more than one letter less than their counterparts in Protestant towns. This fits well with the results by Becker and Woessmann (2009). Historical town characteristics, more explicitly the status of a Hanse or Imperial town, do not seem to matter for applied literacy.

Another interesting result is the impact of universities, which is statistically significant and positive for general universities and insignificant for technical institutions. At the median concerning time since establishment

the impact of a university is over 3.3 items per head, demonstrating the substantial impact universities had.

For comparison purposes the estimation is repeated with the predicted business mail volume as independent variable and the identical set of independent variables. The results are reported in Table 3. The results show a number of similarities and contrasts to the results for private mail. There is again a difference based on location size, though here larger locations show a higher business mail volume. However the region around the by far largest town, Berlin, now has a structurally lower number of business items.

Catholic locations have again less volume than Protestant ones, while foreign languages again have positive impact, only marginally not statistically significant. Universities retained their positive effect while the effect of technical universities is still statistically insignificant. In contrast to private items, the Hanse legacy of a location had a substantially positive effect, a history as such a trading town led to significantly more items.

There is now an effect of average temperature, more importantly there is also a statistically significant impact of proximity to a river. The presence of such a natural transportation system was connected with a higher level of commercial transactions. This is also confirmed by the positive impact of railroads. In contrast to their influence private mail their effect however seems to fade out over time, it is weaker the longer a location is already connected to the system. Harbours similarly change their impact, they had statistically significant, postive effect on business mail volume.

3.2. Determinants of Geography

The following section continues with the calculation of the index for trade ability and the implied location amenity values which illustrates the spatial distribution of the two mechanisms, agglomeration forces and endowments, that shape the population and thereby economic landscape. This is combined with the estimation of the influence of location characteristics on measures, linking actual characteristics with the mechanisms through which they influence the spatial population distribution.

3.2.1. Trade Ability and Amenity

First the predicted business volume is used to calculate a value indicating the ability to trade. More precisely this is achieved by linking this mail volume to the market potential of each location. Under the assumptions that market potential translates in commercial transactions and that each transaction causes the same amount of mail the standard market potential measure is taken as the predicted amount of transactions. The ability to trade is then introduced as an adjustment factor for market potential such that the implied transaction volumes equal the predicted business mail values of each location. As introduced above this adjustment factor is a location specific multiplicative factor b_i that can be calculated based on market potential $\frac{Pop_j}{d_{ij}^2}$ and predicted business mail volume BM_I

Figure 3 provides a graphical representation of the resulting values.

The second step is to use the derived ability values to determine values

for the endowment index in each location. As described above the use of a given population distribution and a trade cost matrix allows the calculation of implied endowment values for all locations. The methodology follows Ploeckl (2012), where it is applied to investigate the urban, as well as rural, system of the state of Saxony. The use of the distance matrix adjusted for the ability to trade improves the estimation of agglomeration effects and thereby also that of the implied endowment values.

Figure 4 provides a graphical representation of the resulting values for the amenity index.

3.2.2. Empirical Determinants

The two index values for the ability to trade and the location amenity are directly associated with the two mechanisms underlying the spatial population distribution, namely agglomeration forces and location endowments. These however are also shaped by the characteristics of the actual locations. To identify the impact of these characteristics I estimate the following regression:

$$Index_i = \alpha + \sum \beta_g Geo_i + \sum \gamma_{in} Ins_i + \sum \lambda_{cu} Cul_i + \epsilon_i$$

where $Index$ is the either the ability to trade or the amenity level, Geo, Ins, and Cul are the respective included geographic, institutional and cultural characteristics and ϵ is an error term.. The main difference in terms of independent variables in comparison to the above specifications involving

the mail volumes as dependent variables is the exclusion of population as an explanatory factor.

The results for the two regressions are shown in Tables 4 and 5. The first noticeable point is that the set of factors with a statistically significant impact on the ability to trade does differ somewhat from the set of of factors important for commercial transactions, though there is of course considerable overlap. Additionally there are strong parallels between the results for the specifications explaining the ability to trade and the amenity values.

One, statistically significant, factor are hard coal reserves, which raise the amenity value but also trade costs. This is also in contrast to regions with brown coal reserves, which did not see any differential effect. A major factor is the the railroad, which has the expected effect of lower trade costs. The pattern of coefficients however indicates that this effect on trade costs was fading away over time, while the effect on the amenity level was reversing from the initial, negative shock.

While general universities only raised amenity values, technical universities combined a similar effect with higher trade costs. A similar effect is visible for the historical status of locations, a town‘s past as a Hanse town increases the amenity, but does not change trade costs, while Imperial towns exhibit a stronger, again positive, impact on the amenity level, but also a negative impact on trade costs. Finally deep sea harbours had a positive effect on the amenity but did not impact trade costs as well.

3.2.3. Counterfactuals

The previous section identifies which characteristics influence the ability to trade and the amenity value, but does not quantify their impact on location population. This section utilizes these results to calculate counterfactual population distributions for changes in these factors.The New Economic Geography model used to determine has a unique population equilibrium given transaction costs and amenity values. This implies that solving the system with counterfactual transaction costs and amenity values results in a counterfactual population distribution. This approach allows the calculation of the impact of specific factors in terms of population. Although this analysis has a different metric than the usual social savings approach pioneered by Fogel (1964) it nevertheless has the substantial advantage that this approach can quantify the impact out of spatial rather than temporal information.

The central equation of the model furthermore implies that the first-order effect of changes to the amenity is simply the ratio of the original and counterfactual amenity index values, so a ten percent increase in the amenity value translates into a ten percent higher population. This implies that the total difference in population can be separated into a direct endowment effect and a market access effect. The latter combines the direct effect of transportation cost changes and the impact of market access changes due to the changes in the amenity values.

In particular I look at the the impact of three specific factors, namely the railroad system and the legacy of the Hanse and Imperial township. In

each case the direct effect of the change in amenity values and the total counterfactual population is calculated

Removing the railroad system causes a drop of total population by 24.6%, where the direct amenity effect alone is 16.3%. The effect of the Hanse is substantially smaller with a total effect of 9.8% lower population and the direct amenity effect of 4.4%. Similar the Imperial town status is connected with a downside effect of 9.1% and a direct amenity effect of 7.2%

4. Dynamics

[Solve Panel of First Class offices]

[Decompose Panel into three effects]

5. Conclusion

The spatial distribution of people is strongly related to the equivalent distribution of economic activity. The later requires the exchange of information, which gave rise to the establishment of institutions to facilitate this. The central service used to coordinate and facilitate economic transactions over space at the time of the industrial revolution and the onset of modern economic growth was the postal service. The spread of this service, especially in the 19th century driven by the idea of universal access, not only provided a channel for economic transactions reaching most of the population, it also substantially touched personal lives and people‘s methods of communication. This reach, the homogeneity and the combination of commercial and private

motives allow postal data to be an excellent source to analyze the spatial shape of economic and human capital questions.

Paragraph: Summarize Results for Geography of the Empire

Paragraph: Summarize Results for developments over time

Postal data cannot only be used to analyze literacy and the spatial distribution of economic activity. The short analysis of the spread of the postal system points towards the diffusion of technology, the development of market structures like monopolies and the impact of the government interaction with the economy through the provision of important public services. Economic activity requires communication and the exchange of information, incorporating the postal system in the analysis helps therefore to understand better where, when and why economic activity occurs.

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Tables

Table 1: Relationship between Mail and other postal service items

	Estimate	Std. Error	t value	p-value
(Intercept)	3.8586	0.2674	14.43	0.0000
Telegrams	11.7840	0.6634	17.76	0.0000
CoD	18.0047	0.8302	21.69	0.0000
Order Letters	19.6034	1.7047	11.50	0.0000
Value Packets	3.5892	0.6061	5.92	0.0000
Money Orders	0.0942	0.0050	18.70	0.0000

Table 2: Applied Literacy on Location Characteristics

	Coefficient	SE	t-value	p-value	Sig
Intercept	-43.86	54.68	-0.80	0.42	
log(Population)	-1.74	0.23	-7.58	0.00	***
Longitude	0.10	0.54	0.19	0.85	
Latitude	0.88	0.88	1.00	0.32	
Catholics	-1.12	0.49	-2.26	0.02	**
Foreign Language	8.11	6.50	1.25	0.21	
Brown coal	-0.12	0.77	-0.16	0.87	
Hard coal	-0.50	0.57	-0.89	0.37	
Railroad dummy	0.60	0.72	0.83	0.41	
log(Railroad years)	0.47	0.26	1.79	0.07	*
Elevation	-0.00	0.01	-0.28	0.78	
River	-0.37	0.44	-0.83	0.41	
Lake	2.15	1.73	1.24	0.21	
Canal	0.54	1.20	0.45	0.65	
Baltic Sea	4.99	3.33	1.50	0.13	
North Sea	-2.72	1.54	-1.76	0.08	*
log(dist to Border)	0.61	0.26	2.34	0.02	**
log(dist to Ba & Wu)	-0.42	0.19	-2.22	0.03	**
log(dist to Other States)	0.25	0.17	1.45	0.15	
log(dist to Prussia)	0.03	0.23	0.14	0.89	
Rain	0.00	0.00	0.35	0.72	
Rain StDev	0.00	0.08	0.01	0.99	
Temperature Mean	0.13	0.08	1.51	0.13	
Temperature StDev	-0.00	0.00	-0.13	0.89	
University	31.32	16.13	1.94	0.05	*
log(University age)	-5.01	2.86	-1.75	0.08	*
Tech. University	12.78	10.32	1.24	0.22	
log(Tech. Uni age)	-1.24	2.44	-0.51	0.61	
Imperial Town	0.53	1.71	0.31	0.76	
Hanse	0.82	0.62	1.31	0.19	
Harbor	-3.03	1.24	-2.45	0.01	**
Arnsberg	-2.76	1.36	-2.03	0.04	**
Berlin	8.52	4.03	2.11	0.03	**
Braunschweig	0.08	2.08	0.04	0.97	
Bremen	-2.23	2.17	-1.03	0.31	
Cassel	-3.08	1.83	-1.68	0.09	*
Coblenz	-1.61	1.84	-0.87	0.38	
Coeln	0.82	1.57	0.52	0.60	
Constanz	-1.93	2.95	-0.65	0.51	
Darmstadt	-2.08	1.76	-1.18	0.24	
Dresden	3.67	2.73	1.34	0.18	
Duesseldorf	-2.71	1.01	-2.68	0.01	***
Erfurt	-1.07	2.26	-0.47	0.64	
FrankfurtMain	2.14	1.93	1.11	0.27	
Halle	-0.55	2.51	-0.22	0.83	
Hamburg	3.63	2.82	1.29	0.20	
Hannover	-1.17	2.05	-0.57	0.57	
Kiel	1.18	2.81	0.42	0.68	
Leipzig	0.97	2.46	0.40	0.69	
Magdeburg	-1.48	2.49	-0.59	0.55	
Minden	-1.59	1.81	-0.88	0.38	
Muenster	-2.71	1.36	-1.99	0.05	**
Oldenburg	-1.67	1.69	-0.98	0.33	
Potsdam	-0.01	2.96	-0.00	1.00	
Schwerin	-2.57	2.96	-0.87	0.39	
Trier	-1.36	1.55	-0.88	0.38	

Table 3: Commercial Activity on Location Characteristics

	Coefficient	SE	t-value	p-value	Sig
Intercept	-203.86	86.26	-2.36	0.02	**
log(Population)	3.54	0.42	8.36	0.00	***
Longitude	0.59	0.88	0.67	0.51	
Latitude	4.08	1.40	2.92	0.00	***
Catholics	-3.82	0.89	-4.28	0.00	***
Foreign Language	13.75	8.66	1.59	0.11	
Brown coal	-1.76	2.10	-0.84	0.40	
Hard coal	-1.08	1.54	-0.70	0.48	
Railroad dummy	5.48	1.20	4.58	0.00	***
log(Railroad years)	-1.06	0.44	-2.40	0.02	**
Elevation	-0.00	0.01	-0.57	0.57	
River	2.05	0.82	2.52	0.01	**
Lake	-3.20	2.99	-1.07	0.29	
Canal	0.89	2.27	0.39	0.70	
Baltic Sea	-4.40	2.48	-1.78	0.08	*
North Sea	1.53	2.76	0.56	0.58	
log(dist to Border)	0.92	0.47	1.94	0.05	*
log(dist to Ba & Wu)	-0.67	0.28	-2.35	0.02	**
log(dist to Other States)	-0.30	0.32	-0.94	0.34	
log(dist to Prussia)	-0.65	0.36	-1.81	0.07	*
Rain	0.00	0.01	0.53	0.60	
Rain StDev	0.10	0.14	0.75	0.45	
Temperature Mean	-0.21	0.13	-1.67	0.09	*
Temperature StDev	0.00	0.00	0.16	0.88	
University	40.09	16.27	2.46	0.01	**
log(University age)	-6.12	3.06	-2.00	0.05	**
Tech. University	1.10	11.61	0.10	0.92	
log(Tech. Uni age)	-0.33	2.76	-0.12	0.90	
Imperial Town	2.85	2.19	1.30	0.19	
Hanse	5.93	1.05	5.66	0.00	***
Harbor	3.26	1.80	1.81	0.07	*
Arnsberg	-5.73	3.03	-1.89	0.06	*
Berlin	-31.38	5.69	-5.51	0.00	***
Braunschweig	-17.45	3.91	-4.47	0.00	***
Bremen	-18.71	4.19	-4.46	0.00	***
Cassel	-8.51	3.59	-2.37	0.02	**
Coblenz	1.04	3.31	0.31	0.75	
Coeln	0.50	2.91	0.17	0.86	
Constanz	14.16	7.45	1.90	0.06	*
Darmstadt	-6.88	3.40	-2.03	0.04	**
Dresden	-12.71	5.05	-2.52	0.01	**
Duesseldorf	-9.58	2.43	-3.94	0.00	***
Erfurt	-12.36	4.22	-2.93	0.00	***
FrankfurtMain	0.77	3.65	0.21	0.83	
Halle	-15.46	4.56	-3.39	0.00	***
Hamburg	-20.17	5.14	-3.92	0.00	***
Hannover	-15.33	3.81	-4.02	0.00	***
Kiel	-22.08	5.02	-4.40	0.00	***
Leipzig	-14.81	4.55	-3.26	0.00	***
Magdeburg	-22.97	4.53	-5.07	0.00	***
Minden	-10.45	3.35	-3.12	0.00	***
Muenster	-9.30	2.96	-3.14	0.00	***
Oldenburg	-8.46	3.48	-2.43	0.02	**
Potsdam	-23.21	5.37	-4.32	0.00	***
Schwerin	-16.67	5.33	-3.13	0.00	***
Trier	5.87	3.33	1.76	0.08	*

Table 4: Ability to Trade on Location Characteristics

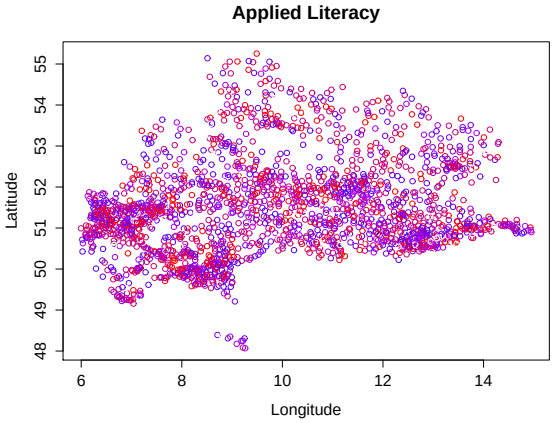
	Coefficient	SE	t-value	p-value	Sig
Intercept	-9.12	5.99	-1.52	0.13	
Longitude	0.04	0.07	0.66	0.51	
Latitude	0.21	0.10	2.13	0.03	**
Catholics	-0.07	0.07	-1.03	0.30	
Foreign Language	0.66	0.61	1.09	0.28	
Brown coal	-0.00	0.15	-0.03	0.98	
Hard coal	-0.29	0.11	-2.66	0.01	***
Railroad dummy	0.58	0.08	6.99	0.00	***
log(Railroad years)	-0.26	0.03	-8.08	0.00	***
Elevation	-0.00	0.00	-0.54	0.59	
River	0.07	0.06	1.11	0.27	
Lake	-0.34	0.24	-1.41	0.16	
Canal	0.11	0.17	0.64	0.52	
Baltic Sea	-0.10	0.25	-0.40	0.69	
North Sea	-0.01	0.23	-0.04	0.97	
log(dist to Border)	0.04	0.04	1.08	0.28	
log(dist to Ba & Wu)	-0.02	0.02	-1.12	0.26	
log(dist to Other States)	-0.02	0.03	-0.73	0.46	
log(dist to Prussia)	-0.04	0.03	-1.66	0.10	*
Rain	-0.00	0.00	-0.21	0.83	
Rain StDev	-0.00	0.01	-0.19	0.85	
Temperature Mean	-0.02	0.01	-2.28	0.02	**
Temperature StDev	-0.00	0.00	-1.17	0.24	
University	-1.23	1.50	-0.82	0.41	
log(University age)	0.10	0.28	0.35	0.73	
Tech. University	-1.21	0.54	-2.23	0.03	**
log(Tech. Uni age)	-0.02	0.13	-0.19	0.85	
Imperial Town	-0.65	0.18	-3.71	0.00	***
Hanse	0.06	0.07	0.87	0.39	
Harbor	-0.00	0.15	-0.01	0.99	
Arnsberg	-0.24	0.22	-1.11	0.27	
Berlin	-3.59	0.49	-7.35	0.00	***
Braunschweig	-0.69	0.29	-2.37	0.02	**
Bremen	-0.96	0.31	-3.07	0.00	***
Cassel	-0.13	0.27	-0.47	0.64	
Coblenz	0.10	0.24	0.41	0.68	
Coeln	0.08	0.21	0.35	0.72	
Constanz	0.98	0.40	2.47	0.01	**
Darmstadt	-0.05	0.25	-0.20	0.84	
Dresden	-0.64	0.39	-1.65	0.10	*
Duesseldorf	-0.92	0.19	-4.76	0.00	***
Erfurt	-0.40	0.31	-1.30	0.19	
FrankfurtMain	0.12	0.26	0.48	0.63	
Halle	-0.51	0.34	-1.52	0.13	
Hamburg	-1.18	0.38	-3.12	0.00	***
Hannover	-0.55	0.28	-1.96	0.05	*
Kiel	-1.07	0.34	-3.10	0.00	***
Leipzig	-0.68	0.34	-2.00	0.05	**
Magdeburg	-1.18	0.33	-3.53	0.00	***
Minden	-0.37	0.25	-1.49	0.14	
Muenster	-0.32	0.23	-1.41	0.16	
Oldenburg	-0.22	0.25	-0.86	0.39	
Potsdam	-0.97	0.38	-2.56	0.01	**
Schwerin	-0.56	0.37	-1.51	0.13	
Trier	0.67	0.25	2.70	0.01	***

Table 5: Amenity level on Location Characteristics

	Coefficient	SE	t-value	p-value	Sig
Intercept	4.94	4.66	1.06	0.29	
Longitude	0.01	0.05	0.12	0.90	
Latitude	-0.08	0.08	-1.09	0.28	
Catholics	-0.03	0.05	-0.57	0.57	
Foreign Language	-0.26	0.50	-0.52	0.60	
Brown coal	-0.06	0.12	-0.56	0.57	
Hard coal	0.24	0.09	2.74	0.01	***
Railroad dummy	-0.41	0.07	-6.26	0.00	***
log(Railroad years)	0.24	0.03	9.15	0.00	***
Elevation	0.00	0.00	0.49	0.63	
River	-0.05	0.05	-1.20	0.23	
Lake	0.30	0.25	1.22	0.22	
Canal	-0.08	0.12	-0.66	0.51	
Baltic Sea	0.03	0.21	0.13	0.90	
North Sea	-0.00	0.19	-0.03	0.98	
log(dist to Border)	-0.06	0.03	-2.05	0.04	**
log(dist to Ba & Wu)	-0.00	0.01	-0.12	0.90	
log(dist to Other States)	-0.00	0.02	-0.21	0.83	
log(dist to Prussia)	0.02	0.02	0.76	0.44	
Rain	0.00	0.00	0.57	0.57	
Rain StDev	0.00	0.01	0.04	0.97	
Temperature Mean	0.02	0.01	2.43	0.01	**
Temperature StDev	0.00	0.00	1.69	0.09	*
University	4.78	2.69	1.78	0.08	*
log(University age)	-0.66	0.47	-1.40	0.16	
Tech. University	1.70	0.48	3.58	0.00	***
log(Tech. Uni age)	-0.00	0.11	-0.00	1.00	
Imperial Town	1.00	0.16	6.36	0.00	***
Hanse	0.27	0.07	3.94	0.00	***
Harbor	0.24	0.13	1.84	0.07	*
Arnsberg	0.26	0.16	1.63	0.10	
Berlin	1.82	0.40	4.51	0.00	***
Braunschweig	0.46	0.22	2.08	0.04	**
Bremen	0.71	0.23	3.07	0.00	***
Cassel	0.11	0.20	0.53	0.60	
Coblenz	-0.01	0.17	-0.08	0.94	
Coeln	0.09	0.15	0.58	0.56	
Constanz	-0.40	0.28	-1.42	0.15	
Darmstadt	0.10	0.19	0.55	0.58	
Dresden	0.32	0.29	1.11	0.27	
Duesseldorf	0.82	0.14	5.90	0.00	***
Erfurt	0.31	0.23	1.33	0.19	
FrankfurtMain	0.02	0.18	0.11	0.91	
Halle	0.31	0.26	1.21	0.23	
Hamburg	0.78	0.29	2.72	0.01	***
Hannover	0.33	0.21	1.55	0.12	
Kiel	0.70	0.27	2.65	0.01	***
Leipzig	0.46	0.26	1.76	0.08	*
Magdeburg	0.80	0.25	3.17	0.00	***
Minden	0.27	0.18	1.46	0.14	
Muenster	0.32	0.17	1.88	0.06	*
Oldenburg	0.27	0.19	1.43	0.15	
Potsdam	0.56	0.29	1.92	0.05	*
Schwerin	0.41	0.29	1.42	0.16	
Trier	-0.19	0.18	-1.08	0.28	

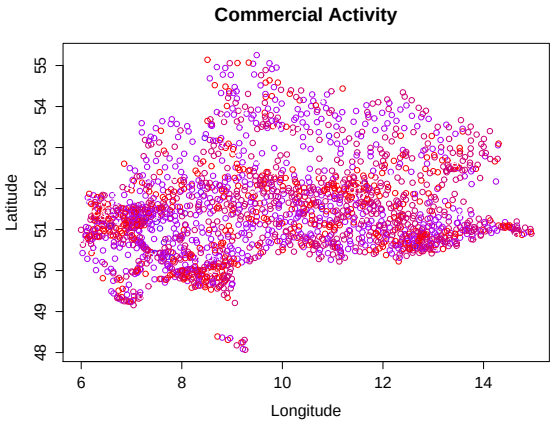
Figures

Figure 1: Amenity Levels



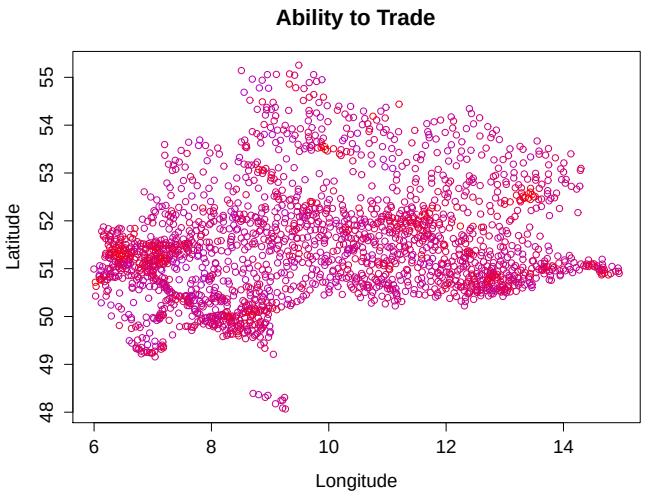
The graph plots the Applied Literacy levels from red to blue.

Figure 2: Amenity Levels



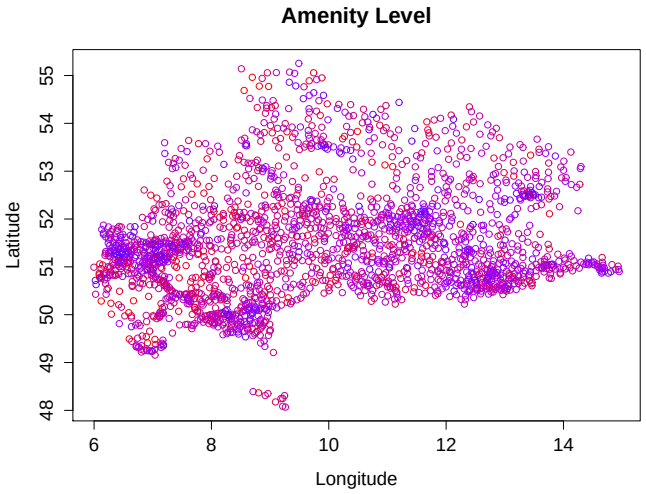
The graph plots the log of the calculated Commercial Activity levels from red to blue.

Figure 3: Amenity Levels



The graph plots the log of the calculated Ability levels from red to blue.

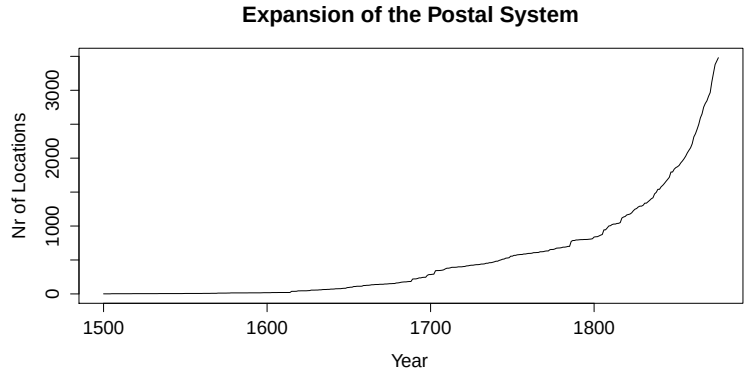
Figure 4: Amenity Levels



The graph plots the log of the calculated Amenity levels from red to blue.

Appendix

Establishment date



The graph plots the expansion of the number of locations served by the postal systems.

As described above the establishment of the postal system started at the turn of the 16th century. Initially connecting a single route the system began to be expanded wider and wider. The data set contains information about the year in which each town saw the establishment of its first post office. This allows to estimate the factors driving the expansion of the system. Formally I estimate a survival analysis with the years since the opening of the first office in the sample in 1500 as dependent variable and a series of independent variables. In particular these are many of the geographic ones, longitude and latitude, elevation, proximity to a river, lake, the North or Baltic sea, as well as mean and standard deviation of rain and temperature. Furthermore I include a town's history as an imperial or a Hanse town, a designation

which most of the affected towns had received prior to the establishment of the postal system. While all of these are clearly exogeneous, I additionally include a town's modern population as a proxy for its historic population. This variable would be endogeneous if the current size is differentially influenced, i.e if towns that received a post office earlier had a systematically larger size effect through said post office. Since these two assumptions, first a substantial influence on population and second that said influence actually was growing over time, are rather strong I do not believe this to be a substantial issue affecting the results.

I estimate empirically the factors influencing the hazard rate, which describes the likelihood that a town gets a post office at a particular point in time. Formally the rate is

$$h(t) = pt^{p-1}[exp(x(t)'\beta]$$

where t is time starting in the year 1500, x is the set of location characteristics, p a parameter of the underlying distribution and β a vector of parameters for the influence of covariates on the hazard rate. I use a Weibull distribution as the underlying distributional form.

The following table shows the results of this regression. As is clearly visible larger towns did receive post offices earlier. This points to two possible explanations for this result, first is a political motive, larger towns were more likely to be politically important, so they got connected earlier, and second an

economic motive, larger towns are likely to see a stronger demand for postal services, therefore provide higher revenues for the service provider. These two motives can be complementary, richer towns might be more important politically, and they can vary over time, political importance might have been a stronger motive early on while in the later stage economic motives prevailed. Additionally the motive of universal service provision, the intent of expanding the service to as many people possible, might be reflected in this result. The explanatory factors of economic and political importance are also reflected by the strong significance of the Hanse and Imperial town variables. Since these two variables capture these effects beyond what is done through simple differential population size, this points to substantial political and economic motives in the early expansion of the system.

Table 6: Survival analysis of Establishment of Post Offices

	Hazard Ratio	Std. Err.	z	p-value
Population	1.000009	4.61e-07	18.52	0.000
Hanse	3.996606	.3690894	15.00	0.000
Imperial town	26.90537	5.474196	16.18	0.000
Catholics	.9754499	.0546501	-0.44	0.657
Language	1.396679	1.91271	0.24	0.807
Latitude	1.072085	.0689079	1.08	0.279
Longitude	.9989454	.0240362	-0.04	0.965
Lake	1.41225	.4304285	1.13	0.257
Rain	.9995618	.0003143	-1.39	0.163
Rain Sd	.9907408	.0066323	-1.39	0.165
Temp Mean	.9994406	.0075633	-0.07	0.941
Temp Sd	.9999717	.0000938	-0.30	0.763
Elevation	.9998136	.0005083	-0.37	0.714
Hard Coal	.9390683	.0782386	-0.75	0.451
Brown Coal	.8443089	.1104173	-1.29	0.196
Baltic Sea	.8702337	.1502863	-0.80	0.421
North Sea	.9185801	.113095	-0.69	0.490
River	1.090286	.0599229	1.57	0.116
Foreign border	.9994562	.0004029	-1.35	0.177
Ba & Wu border	.9995595	.0003237	-1.36	0.174
ln(p)	2.042781	.0150672	135.58	0.000
p	7.712028	.1161985		
1/p	.1296676	.0019537		