Dynamics of Overlapping Clusters: Industrial and Institutional Revolution in the Industrial District of Aachen, 1800-1860

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Abstract:

The economic transition characterizing the process of European industrialization in the 19th century was concentrated on regions rather than on states. In the first half of the 19th century, the region of Aachen (in the west of Prussia) pioneered on the territory of the German states and developed to a powerful industrial district. The implementation and diffusion of the factory system and the economic impact of adapted and new institutions make the core of this paper. Reciprocal interconnections between firms of different clusters shaped the region and created economic dynamics. Investments transgressed the boundaries of single industries and new industries emerged. One important feature of the regional production system was cross-sectional knowledge transfer; a second was institutions supportive to this process.

Keywords:

Germany, Industrialization, Factory System, Joint-Stock-Companies, Development

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Introduction[1]

The economic transition characterizing European industrialisation in the 19th century was concentrated in regions rather than states.[2] Within the territory of the German states, the Aachen district was a pioneering region as measured by the implementation and diffusion of the factory system and by industrial production. In the mid-19th-century a powerful industrial district had emerged. Competition and cooperation together with reciprocal interconnections between firms and industries shaped the districts' economic dynamic. In economic terms, the district combined characteristics of the so-called Marshall-Arrow-Romer externalities (produced and consumed in a given sector) and of Jacobs' externalities (defined as flows between firms in all sectors).[3] Of course, each industrial sector had specific dynamics in terms of competition and new, production cost reducing technology. Yet regional development was based on technological linkages between industries and on joined ownership and governance, which allowed for knowledge spill-over between firms and branches. Development was facilitated by supportive institutional arrangements. Firms within an industry continued to compete on product markets and labour, just like cluster theory would predict; yet between different industries a cooperative pattern emerged with entrepreneurs of different branches increasingly investing in new, common industrial projects. The dynamics of regional economic development in connection with new collective institutions make the core of this paper.

The ideas used in this article are borrowed from traditional[4] and modern[5] literature on industrial districts and on Porters idea of cluster advantages, which to certain extend are compatible. In general, literature on industrial districts puts emphasize on regional concentration of a large number of firms within an industry and small firm size. It assumes, and has demonstrated, that horizontal specialization of a large number of small firms, due to external econo-

1 I wish to thank the participants of the session "The rise and decline of industrial districts, 18th-21st centuries" on the World Economic History Conference in Stellenbosch, 2012, for fruitful comments and suggestions. Special thanks to the organizer of the session, Jordi Catalan.

2 Pollard (1981).

3 Capello (2002).

4 Marshall (1879) and Marshall (1920).

5 See e.g. Becattini (1990); Becattini (2002); Dei Ottati (2003).

mies, might be a viable alternative to vertical integration and large scale production. It allows for a division of labour between firms (economies of specialization) and for learning and knowledge sharing despite of competition. One of Becattini's arguments is that industrial districts form a "socio-territorial entity" in which "community and firms tend to merge" because of the active presence of people and the firms in the respective district.[6] While literature on industrial district stresses regional concentrations of small firms, the cluster concept is perhaps better prepared to also reflect large and vertically integrated firms that may be a constitutive element of a cluster, which is characterized as a "geographically proximate group of interconnected companies and associated institutions in a particular field". In this concept the cluster is also an alternative to horizontal and vertical integration because within the cluster specialized suppliers of component and services, and firms in related industries offer specific advantages that, in combination with high competition of the companies central to the industry constituting the cluster, increase competitiveness and create dynamic advantages.[7] The two concepts thus want to explain different phenomena; the literature on industrial districts aims at an explanation of regional and local concentration of small and medium sized firms constituting an alternative to large scale production (also in mass production industries), the cluster concept wants to explain geographical concentration of very successful firms (often world market leaders) competing in one industry. Both concepts do not form a theory in the sense that it would allow for predictions, they rather provide a highly contextualized interpretation of economically successful environments not explained by mainstream microeconomics.

The argument presented in this article borrows on both concepts in an undogmatic way in that it combines the dominant ideas. It deals with the industrial region of Aachen in the first half of the 19th century, which was a small dynamic economic region in the West of the Prussian Rhineland. Within the region several traditional (woollen cloth, needles, paper, coal) and new industries (steel, zinc, machinery) advanced modern factory production and modern industrial organizations; the business men (and women) in the region also created modern institutions supporting economic development. In contrast to the modern view of industrial districts, the firms where yet not 'small'. About 1850 the industries of woollen cloth, coal mining, iron and steel, machinery, railway wagons, zinc, lead, glass, paper and needles produced on large scale with modern factory equipment. Approximately 2/3 of the districts' total workforce was working in manufacturing and mining; half of them in 'large' factories with more

6 Becattini (1990), p.38.

7 For a concise overview see Porter (2000), quote from p.254.

than 100 workers.[8] Traditional branches dominating the regional 18th century export industries, particularly the woollen cloth industry (based on artisanry and the putting-out system), had organized production in factories with power engines and machinery; coal mining developed to an industrial scale; and the industrialisation of iron and steel in the larger area went hand in hand with a concentration of production to the industrial district, whereas the traditional sites in the hills of the Eifel, distant from coal and from the railway, lost importance. New industries related to changing industrial demand, such as machinery, or related to raw materials emerged. This article deals mainly with three industries each of which formed a cluster, woollen cloth, coal mining, and iron and steel; it wants to provide an explanation of why these industries clustered within a relatively small district and how they created dynamic interconnections and spill-over. In order to avoid misunderstandings, the term 'industrial district' is referring to an industrial region, not to one geographically concentrated industry, for which the word 'cluster' is used.

The transition from commercial to industrial capitalism had been influenced by supportive institutional arrangements partly based on French law:[9] After the Revolutionary Wars in 1798, the Rhineland had become French with the district of Aachen forming the *Département de la Roer*; and after the French defeat in 1814, the region was integrated into the Prussian State. Yet with few exceptions the French legal system continued. The *code civil* and the *code de commerce* rather than Prussian civil law[10] constituted the norms of commercial activities. Not only property rights and civil rights, also other institutions of French origin (chambers of trade and commerce, commercial courts, or arbitration boards for work related conflicts) shaped economic behaviour.[11] In general, new Prussian laws did not dramatically influence regional economic development.[12] However important French institutions were for regional economic development, [13] the transition towards a "modern" economy had started long before in the 18th century; the guilds of Aachen had no longer been able to enforce their rules, and

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8 Reckendrees (2010), p.63; data: Reinick, 1865-1867, vol.I, pp.152-153.

9 Code civile; code de procédure civile; code de commerce; code d'instruction criminelle; code pénal.

10 Allgemeines Landrecht für die Preußischen Staaten. On legal institutions in the Rhineprovince and the continuation of French law: Conrad (1969); Faber (1970); Fehrenbach (1974); Schubert (1977); Bernert (1982, Strauch (1982).

11 Reckendrees (2010).

12 The integration of the Rhineland did, of course, also induce some economically relevant change; this regards e.g. the introduction of the Prussian currency or the Prussian trade union. More important was the Railroad Law (1838) and the Joint-Stock-Company Law (1843) based on French ideas. The latter perhaps helped developing the eastern parts of Prussia towards a capitalistic economy; for the industry of Aachen it introduced more oversight from the Prussian State.

13 In general Acemoglu's et al. argument is possibly correct; Acemoglu, et al. (2011). Yet concerning the Rhineland the authors overlook the transition that had already happened before the French Revolution. The guilds had no longer been able to enforce their norms and rules, and capitalist firms had emerged; farming was based on leasing and contracts could be bequeathed to hires.

capitalist firms had started to emerge; farming was already liberated from feudal regimes, landownership and inheritable leasing contracts dominated in agriculture.[14] The French Revolution made this process irreversible and fully implemented private property and bourgeois law.

In the analytical framework of this study a region is an economic entity, rather than a political territory. It has been constructed in terms of economic activity (level of industrial and factory employment; use of power engines).[15] Yet, also the border between Prussia and the Low Countries (and later Belgium) defines the district because, after the Rhineprovince became Prussian, the new border and respective tariffs hindered exchange across the border regarding raw materials, prefabricated goods, and labour. It had a paradox function[16] in that it connected independently developing regions for instance by Belgian investments to the Aachen district.

The scope of this paper does not allow for an analysis of all industrial branches; it predominantly focuses on the largest industries and on the interconnections between them; other industries involved in the respective processes will not be analysed specifically. Chapter two provides a brief overview of the general development with focus on three major industries: Firstly, woollen cloth as an example of a successful transition from artisanry and putting-out to modern factory production; secondly, coal mining experiencing an industrial reorganisation based on ideas of rationalization and economies of scale; and thirdly, iron and steel. The developments in coal and iron and steel are only briefly sketched; they are central in chapter three that analyzes interconnections between the industries. These interconnections regard knowledge transfer between industries, exploitation of raw materials, construction of railways, corporate finance, and development of commercial and organisational know-how. Most of the regional industries lost their pioneering role in the 1860s due to the improved transportation system that increased the districts relative distance to the markets, to new coal resources on the Ruhr, and to the limited size of the region. Now regional entrepreneurs invested mostly outside of the Aachen district. The final chapter provides a summarizing discussion.[17]

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14 See Reckendrees (2010), p.54-55 with further literature.

15 Fremdling, et al. (1979) and Banken (2000) on concepts of constructing economic regions.

16 On the border paradox, see Knotter (2002/03).

17 A regional economic history does not exist, for a brief outline see: Eyll (1980), I mainly refer to papers on woollen cloth and coal mining, Reckendrees (2006); Reckendrees (2012b); Reckendrees (2012a) and articles on regional institutional change, Reckendrees (2010); Reckendrees (2012c).

2 Three clusters of the industrial district

2.1 Woollen cloth

In the 18th century the region of Aachen had become the dominant woollen cloth region in the German cloth trade;[18] in the early 19th century it pioneered the introduction of spinning and carding machines in the woollen cloth industry. The traditional industry was based on lime-free water indispensable for finest cloth qualities, the typical product of the region; furthermore, warm springs close to Aachen provided excellent means for finishing and dying the cloth. Traditional production was organised as a combination of artisan production and putting-out. The putting-out system using domestic spinners and weavers had been established at the end of the 17th century in the gild-free towns of Eupen, Montjoie, Burtscheid, and Vaals. In cities of Aachen and Düren, cloth-maker and shearer gilds could maintain artisan manufacturing. Artisan workshops however also integrated putting-out work; artisans e.g. employed domestic spinners as well as journeymen and apprentices.[19]

In the first two decades of the 19th century the regional production system changed dramatically. About 1830, the large clothiers in Aachen, Burtscheid, Düren, and Eupen operated centralised factories and they owned vertically integrated firms; some of them, however, still connected to specialised suppliers. Power machines drove all kinds of machinery (scribbling, carding, slubbing or roving, spinning, raising, shearing, fulling, pressing etc.). Only weaving was later mechanized as fine cloth production required improved looms.[20] Different from English cloth districts, where spinning machines were used in the cottage industry,[21] comprehensive sets of machinery were introduced in Aachen combining scribbling, carding, and spinning machines, which required and allowed for factory establishments.[22] Within a few years they had erased home spinning and mechanisation had been extended to raising, shearing, and finishing. Now vertically integrated firms controlled almost the whole process of cloth production from scouring the wool to finishing and selling the cloth.[23] Vertical integration into one firm does however not mean centralised production in a single establishment. Fulling, for example, required much water and the mills were usually established on small rivers; dyeing

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18 Viebahn (1846), p.37; Viebahn (1868), pp.915.

19 For literature: Reckendrees (2006), pp.15-17.

20 Reckendrees (2006), pp.19-30.

21 Hudson (1975, Hudson (1986); Hudson (1986).

22 Reckendrees (2006); Reckendrees (2012a).

23 Reckendrees (2006), pp.22, 25, 28, 35. Not for all purposes machinery was used; early models did not allow finishing superfine cloth, even with improved cylinder shearing machines hand shearing dominated production of top quality cloth.

mills were usually operating outside of the towns because of water pollution, sometime it was subcontracted.

The efficient exploitation of machinery required power engines (steam engines, water wheels or, some years later, water turbines); it depended on access to resources (water and coal), on institutional arrangements (accession rights), and on an efficient transportation system. Thus, different patterns emerged within the larger cloth region. In the towns of Aachen and Düren water power was insufficient for the developing industry, furthermore were accession rights limited and different branches and the citizens of the towns competed on the use of water. Steam engines, however, provided a flexible source of power that did not depend so much on location, they freed production from climatic uncertainties, and they allowed for a more continuous utilisation of fixed capital. Thus from 1815 onwards, cloth industrialists in Aachen, even if they owned water wheels and accession rights increasingly operated steam engines. In later decades a substitution for more powerful and especially more efficient machines can be observed.[24] In the German context, Aachen's woollen cloth industry pioneered the implementation of steam engines in factory production. The new technology increased labour productivity and reduced production costs dramatically. It is estimated that combined implementation of spinning, scribbling, and carding machines and the gig mill increased labour productivity by about 50%.[25]

Only power looms have not early been introduced. Only two industrialists opted for a relevant number of power looms (85 and 53 until the end of the 1850s, the total number was 380).[26] Slow implementation of new weaving technology was an economically 'rational' decision as adapting the power loom to fine-cloth weaving was a difficult task and, if there were productivity gains, they were small. Wage expenses did not seriously decrease because of high investment costs and because weavers operating automatic looms had to receive higher wages.[27] Thus, incentives for new investments were very week.

Since the 1820s, the average size of integrated firms increased steadily. Unfortunately, the statistical data is not comprehensive and partly contradicting. Based on a relatively comprehensive overview of a sample constructed by the Aachen county administrator and chief di-

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24 Reckendrees (2006), pp.27-28.

25 Reckendrees (2006), p.29.

26 Düsseldorf State Archives (HSAD) BR2116-55: Gewerbetabelle der Fabrikations-Anstalten und Fabrik-Unternehmungen aller Art des Regierungs-Bezirks Aachen [1858]; HSAD BR2116-53: Spezielle Nachweisung der in der Gewerbe-Tabelle der Fabrikations-Anstalten und Fabrik-Unternehmungen [1858].

27 See also Schmoller (1870), p.496.

rector of police (table x),[28] in the city of Aachen 19 cloth factories employed more than 8.200 workers of which 13% were children. 1.150 workers were occupied in wool preparation and spinning; yet it is unknown how many weavers were working domestically. Assuming that the factory employees are thus overestimated by 30%, the 19 factories would have occupied 5.750 workers in their establishments; which gives an average size of 300 workers in a cloth factory. Vertical integration, the size of the factories, and the average number of workers indicates that by 1850 the transition to industrial capitalism was accomplished in Aachen.

Yet, outside of Aachen different organizational patterns of cloth production evolved. The city of Eupen (20km from Aachen) housed relatively more specialised spinning and finishing firms and less vertically integrated producers,[29] whereas the putting-out system with centralised dressing workshops survived in Montjoie (40mk from Aachen) until the cloth manufacture finally collapsed in the 1860s. The diverging local patterns can be explained by the local labour markets and by access to the railway system: (1.) The only relevant industry in Eupen and Montjoie offering wage labour was textiles, in Aachen qualified workers could find occupation in machine factories, less qualified workers e.g. in the steel industry, and children and young women in tobacco manufactures. (2.) The railway station in Aachen connecting the city to Antwerp, Liege and Cologne, reduced relative transportation costs; increasing distance to the railway increase the sales price of the products. This aspect will be further developed in the following chapters.

A reconstruction of how worked competition and cooperation in the cloth cluster exactly worked is not possible due to lack of sources allowing for such conclusions. However, institutions like the Chamber of Commerce, and also local government distributed knowledge among industrialists by, e.g. by circulating blueprints of new machines and establishing contact to the Prussian Trade Institute (*Gewerbeinstitut zu Berlin*[30]); the Chamber of Commerce and also the Casino Society, a social club, provided international newspapers and business journals.[31] The Prussian Trade Institute also offered new machines to the cloth producers (especially models from France and the United States), but industrialists were often reluctant to accept the Institute's condition that the firms getting the new machines for free had to give other producers access o their operations. The relevance of state institutions should thus not

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28 HSAD BR2116-48: Gewerbetabelle der Fabrikations-Anstalten und Fabrik-Unternehmungen [1849]; Reckendrees (2006), 33.

29 HSAD BR2116-49: Nachweisung derjenigen Fabrikationszweige, welche zusammen eine Anstalt bilden, in der Gewerbe-Tabelle [1849]; HSAD BR2116-48: Gewerbe-Tabelle der Fabrikations-Anstalten und Fabrik-Unternehmungen [1849].

30 See: Mieck (1965).

31 Sobania (1991); Thomes (2004); Reckendrees (2010), pp.58-61.

be overestimated because industrialists did not necessarily want to share production knowledge.[32] It seems as if the industrialists did not cooperate in cloth production, rather in new industries, which will be shown in chapter 3.

Two other important trades of the 17th and 18th century experienced a different industrialization process starting about 15 years later in needle production and lagging much behind in copper and brass. The specific reasons cannot be discussed here; I rather focus on the two two major industries next to woollen cloth, coal mining and iron and steel.

2.2 Coal mining

Since the 13th century, the region's two mining areas, the coal fields on the *Inde* and on the *Wurm*, produced hard coal. Up until the early 19th century, when coal mining industrialized, the two areas had developed due to geological and institutional factors quite different production systems:[33] (1.) The *Wurm* coal fields touched five states with different legal systems; ownership was thus dispersed and mines were smaller and less productive; (2.) for geological reasons and complex property rights water handling was more difficult on the *Wurm*; and (3.) the *Wurm* fields provided anthracite coal, whereas the *Inde* fields provided bituminous coal.[34]

Since the 30 Years War, the *Inde* coal fields were owned by the Duke of Jülich, whose administration rented out mineral coal extraction.[35] When in the second half of the 18th century mining required deeper pits and more sophisticated water handling systems, the extraction rights for most mines were leased to a coordinating consortium, which allowed for coordination and economies of scale. By and by the Wültgens-Englerth family concentrated most of the property rights; when the region became French, the family was able to contract a long term lease with the new government, and with the new mining law of 1810, it became the owner of the two most important mines.[36] Regional specific institutional arrangements thus resulted in early capitalist entrepreneurship allowing for consolidating the mines and long-term investments.

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32 HSAD RA1636, different cases.

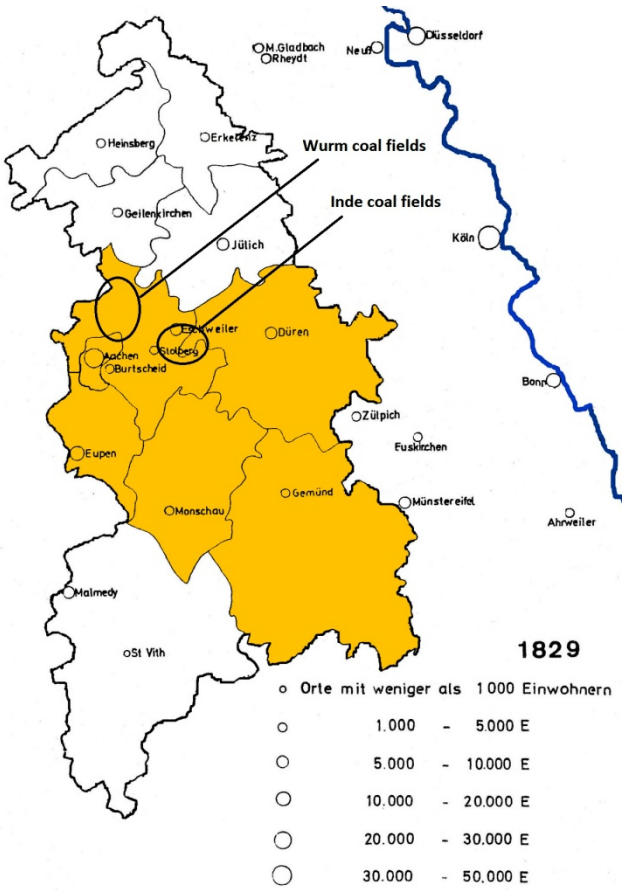
33 For a detailed description of pre-industrial regional coal mining see: Reckendrees (2012b), pp.4-32.

34 Reckendrees (2012b), pp.18-23; Willms (1923); Hinzen (1929); Schunder (1968); Wiesemann (1995).

35 Stegemann (1910b); Schunder (1968), pp.26-31.

36 Stegemann (1910a), pp.14-15; Reckendrees (2012b), pp.108-17.

Map 1: District of Aachen, coal mining areas (approximately)



Source: own construction.

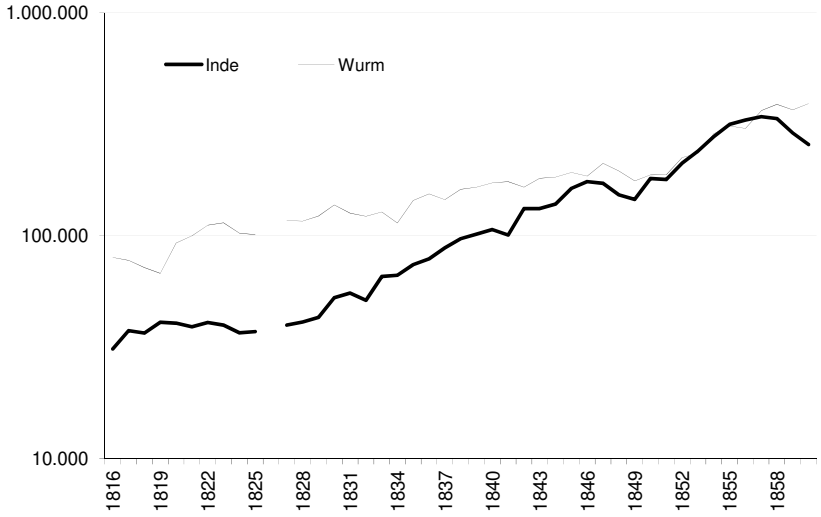
The technology driven transition towards 'industrial' production came much later in the *Wurm* fields, mainly in the 1820s. Then, all mines introduced modern steam engines increasing water handling capacities and allowing for more continuous and safer production. Furthermore were pumping systems of different mines connected to each other. However, the advantages were limited, until in the 1830s, ownership concentration allowed for rationalization of production and rapid industrialization. An important factor in this process has been newly formed joint stock companies, in which a broad set of regional industries cooperated; the argument is developed in the following chapter.

Both mining areas, the *Wurm* and the *Inde* coal fields prospered during the 1840s and the 1850s due to increasing industrial demand for coal and to the Rhenish railway giving access to more distant markets.[37] Production and sales data for the *Wurm* shows an upward but volatile development from 1820 to 1835. From then on, the concentration of of mines allowed for a rationalization of production aiming at scale economies and higher productivity, combined

[37] Yet the railway also allowed competitors from other mining districts to expand their markets, after a decade or so the disputed markets were even closer to the Wurm and Inde coal fields than before.

with increasing demand, sales increased. Growth was only briefly interrupted from 1847 until 1849 because of the crisis of 1847 and the 1848 revolutionary conflicts.

Figure 1: Inde and Wurm. Coal production (in metric tons, log) 1814-60



Sources: Reckendrees (2012b), pp.38, 116, 181, 187. Detailed description of the data: ibid. pp.167-173.

The centralised coal mines on the *Inde* (mining company *Eschweiler Bergwerksverein*), however, performed relatively better. The reasons are not only related to favourable institutional arrangements in the 18th century and early ownership concentration, with increasing regional industrial production the market for *Inde* coal grew much faster than the market for *Wurm* coal. The *Inde's* product, bituminous coal was preferred for steam engines, puddling works, or glass- and zinc production, the *Wurm's* product, anthracite coal, was used for household consumption. Production growth on the *Wurm* thus accelerated in the 1850s, when steam engines and production were adjusted to anthracite coal.

2.3 Iron and steel

The developments in iron and steel are only briefly described. Literature[38] does not provide reliable comprehensive data and my own data collection, based on reconstructions of (not fully reliable) plant level information, is not yet completed. Reliable estimates are difficult to undertake and are still in work; the general tendencies in iron and steel are however quite clear.[39]

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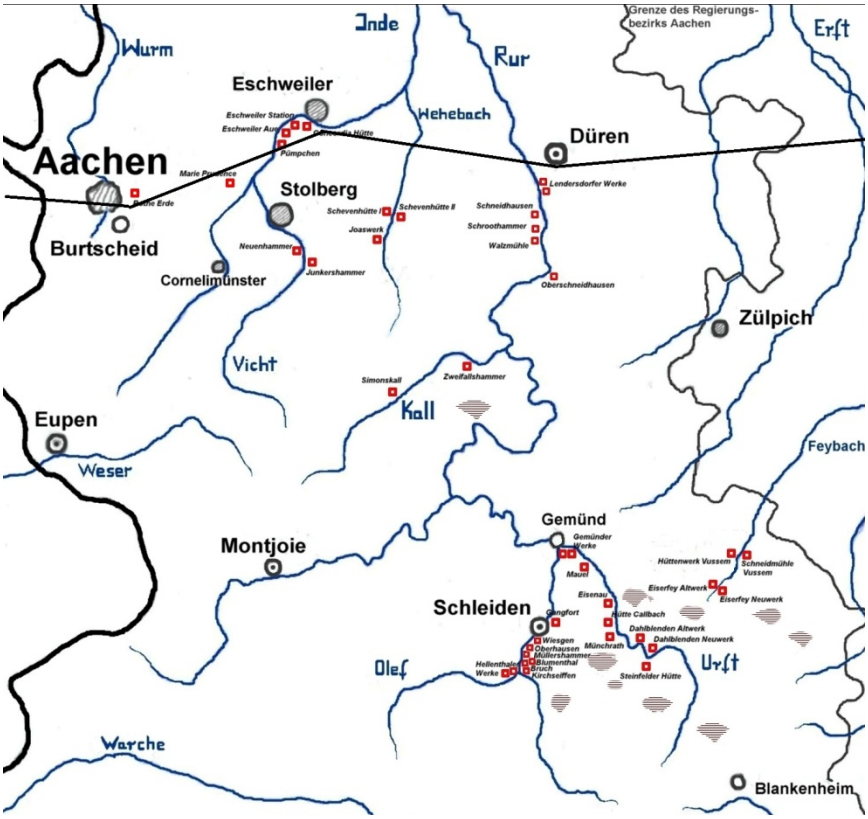
38 Best overview: Schainberg (1997); Bömmels (1925); Neu (1989).

39 Difficulties result from incomplete data series, especially regarding prices, reporting of capacities instead of production; sometimes unspecific weight and volume measurements, double counting of pig iron, cast iron, and wrought iron. Furthermore, the constructed industrial region (see introduction) does not fully overlap with the administrative districts of the Mining Authority ('Bergamt Düren'); thus aggregate data does not serve as a control measurement.

Traditionally, pig iron and wrought iron were produced in the hilly Eifel (county Gemünd/Schleiden; map 2) with plenty water and charcoal supply. During industrialization the traditional area lost its competitive advantage and the industrial district of Aachen attracted a new iron and steel cluster. Starting in the mid 1820s, wrought iron production moved away from the traditional area, when Eberhard Hoesch introduced the puddling process in his plant close to the city of Düren.[40] With the decision to build a railway from Cologne to Antwerp in 1834 (see below) the relocation of the iron industry gained full momentum. Now, puddling works and rolling mills were set on top of the *Inde* coal with direct access to the railway in Eschweiler. Due to lower transportation costs the new works increasingly substituted Eifel iron for Belgium iron.[41] Finally in the 1850s, also new coke blast furnaces were constructed near Eschweiler. From then on traditional (charcoal) iron production contributed only special quality iron. It did not yet fully decline, but it did no longer grow (see figure 2).

Map 2: Industrial district of Aachen. Location of iron and steel production, 1850s



Source: Annuschat (2007), p.6; own adaptation. Square dots indicate blast furnaces and steel works. The line indicates the railway from Cologne to Antwerp.

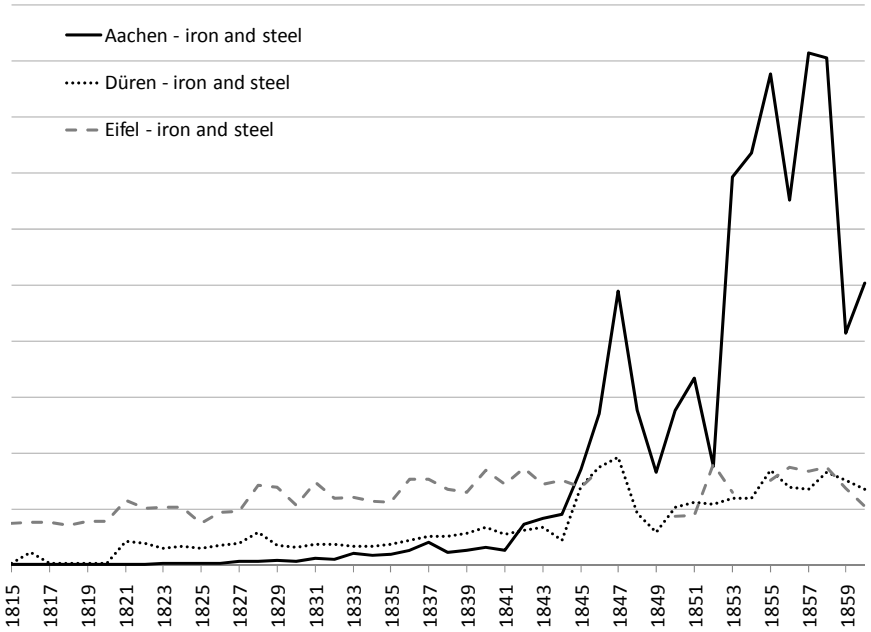
Early industrial development of the iron and steel industry was thus technologically driven. Especially the introduction of the puddling process (in 1825) and of new rolling mills, both

40 Beck (1899), p.703.

41 Fremdling (1986), p.134; Leboutte (1988); Pasleau (1993); Fremdling and Gales (1994); Schainberg (1997).

dependent on foreign technical experts, has been very crucial.[42] Yet from the 1840s onwards, development is better described as a demand pull process. Hoesch for example, owner of puddling works and rolling mills in Düren, established his new plant in Eschweiler in 1847 because of *'increasing demand for rails and considering that [… Michiels, a competitor in Eschweiler] due to the nearby coal mines […] has an advantage of almost 2,000 Thaler a year'*.[43] Increasing machinery production in Aachen and Eschweiler had already created a new, but still small market for wrought iron, and it had encouraged the establishment of new puddling works in the 1830s.[44] With the construction of the Rhenish railway in the late 1830s (see below), the market expanded rapidly requiring large amounts of standardized iron products (rails, wagon material) and attracting new factories.[45]

Figure 2: Industrial district of Aachen. Estimate of iron and steel production 1815-60 (Aachen-Stolberg-Eschweiler; Düren; Eifel)



Source: own data collection. The ordinate is not given because data is not yet completely consolidated; the final reconstruction will not have a strong impact on relations.

The districts' producers, first movers in their respective industries, were among the largest German rail and wagon suppliers and soon exported mass produced goods to other German and Austrian regions.[46] The establishment of coke blast furnaces in the 1850s was both technologically and demand driven. The knowledge of coke iron production had been systemised

42 Fremdling (1984); Fremdling (1991).

43 Hashagen and Brüggemann (1916), p.559.

44 KG Englerth & Cünzer 1832.

45 T. Michiels & Cie. 1842; 'Rothe Erde' Piedboeuf & Co. 1846; Hoesch plant 'Eschweiler Station' 1847.

46 Wagenblass (1973); Seeling (1983); HSAD RA1599: The authorized representatives of Collectiv Gesellschaft T. Michiels & Cie. to Royal Government Aachen, A.W. Hüffer, St. Beissel, 1.10.1846.

and codified allowing for knowledge transfer from Belgium to the major iron regions in Germany.[47] The growing puddling works and rolling mills in Eschweiler, Stolberg, and Düren demanded increasing amounts of pig iron so that import substitution seemed to be an economically reasonable strategy.

2.4 Workforce and labour markets

In the early 19th century, workforce was cheaply available. In the 1810s and 1820s, new textile machinery had set free very many workers. Coal miners had sideline agriculture or were smallholders living close to the mines, who worked in mines after harvest was brought in, supplemented by day labourers from adjunct regions.[48] The district's steel industry was still rather small. There was thus no labour shortage until the 1830s: natural population increase and migrants from the rural hinterland, if necessary also from Limburg or Belgium, supplied additional workforce. Around 1830 some hundred Belgian migrant workers worked in the Aachen cloth factories and machinery industry; they had industrial experience and they were easily disposable, as they would be sent back home, if there was no work.[49] Yet with increasing production in the late 1830s and especially during the 1850s, the labour market changed dramatically.

Data on wages indicating the change in the labour market is spurious. Other observations, however, allow for this conclusion. For example, in 1839 the mines of the *Wurm* coal fields started to provide health and accident insurance (*Knappschaft*) like those existing in the neighbouring *Inde* district.[50] The mines on the *Inde* were furthermore competing on labour with new zinc and iron and steel plants established on top of the coal, and also with the Rhenish railway looking for construction workers. The *Inde* mines thus started providing housing for workers.[51] The woollen cloth industry, in which many young women were occupied, was challenged by newly set-up tobacco manufactories offering less exhausting and relatively well paid work to girls and young women.[52]

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47 Behrens (1960); Fremdling (1983). The argument corresponds to Mokyr (2002).

48 Reckendrees (2012b).

49 Althammer (2002), p.376; Schainberg (1997); Reckendrees (2010), p.75.

50 The mining districts did not fall under the Prussian mining law, rather the French law set the standards where Knappschaften were not mandatory; Reckendrees (2013, forthcoming).

51 Reckendrees (2012b), pp.57, 92, 128, 138-42, 152; Reckendrees (2010), p.79.

52 HSAD RA1542: Chamber of Commerce top Royal Government, Aachen, 24.4.1857.

3. Interconnections

3.1 Machinery production: A bridge between industries

Textile machinery was the root of the district's *machinery industry* interconnecting all sectors. First machines were imported from Belgium (Cockerill's workshops in Verviers and Liége), but local supply was soon built up. A crucial step was the decision of the cloth merchant Kelleter in 1816/17 to build a spinning factory using a steam engine and to employ two British mechanics, *'very dextrous artists'*[53], to construct the factory. One of the *'dextrous artists'*, Samuel Dobbs settled in Aachen/Eschweiler. In 1819, when the textile factory was set-up, Dobbs founded the machine factory *Englerth, Reuleaux & Dobbs* in cooperation with a family member and an engineer of the Englerth coal mines on the *Inde*. The first engines were produced for the family's own mines, but soon other mines, cloth factories, and distant customers wanted to buy the engines that could compete with Cockerill's and others' machines.[54] Dobbs later set-up a wire factory in Eschweiler (1822), constructed the puddling works of *Hoesch* in Düren,[55] and was engaged in several new firms in the Aachen district (*Dobbs & Nellessen* 1833-36; *Poensgen & Dobbs* 1837-40). Everything *'that comes from the hands of this man is beautiful'*, wrote the District President to the Ministry in Berlin.[56] Dobbs was not the first in the region to produce steam engines, but his cooperation with the mine owning family made him the first to have commercial success.[57]

In the following two decades a number of machinery, steam engine, and boiler factories were set up. In 1820s, woollen cloth and coal mining companies founded machinery workshops (e.g. *G. Startz*) and also specialized textile machinery producers emerged (*Regnier Poncelet & Desoer*). The sector connected woollen cloth industry, coal mining, and steel industry; backward linkages and diversification thus provide an explanation of the development. The new factories also created a new market (forward linkages) for the iron and steel industry, especially steam engines, steam boilers (*J. Piedbeuf*), railway material required more and more rolling mill and casted products. In 1832, ten firms employed approximately 280 workers, seven years later it had been 600 in twelve factories; most have been modest with 10-30 workers, the four larger ones employed between 70 and 250. *Englerth & Reuleaux* continued

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53 Prussian State Archives, Berlin (GStA-PK) I.HA120D XIII2 no.9: Chief-President Reimann, Aachen, to the Royal State Minister and Minister of Trade and Commerce, 19.12.1822.

54 Severin (1826), pp.320, 321, 325; Schainberg (1997), pp.237-42; Reckendrees (2012b), p.111.

55 Beck (1899), p.703.

56 GStA-PK I.HA120D XIII2 no.9: Chief-President Reimann, Aachen, to the Royal State Minister and Minister of Trade and Commerce, 19.12.1822.

57 Wilhelm Dinnendahl was the first, due to high prices he leased his engines, Behrens (1970), p.9; Behrens (1974), p.374.

to be a large producer. With the Rhenish railway opened in 1841, and with the increasing number of large factories for steel and zinc (see below) the structure of the machinery industry changed. Now the machine factories were no longer appendixes to other industries. The largest belonged to the most advanced of their kind in Prussia. About 1860, almost 1.000 people worked in machinery.[58]

3.2 Joint-stock-companies: Cross industrial cooperation

The large number of companies within the clusters of woollen cloth, iron and steel, and coal mining (and also in the needle industry in Aachen and in the paper industry in Düren[59]) created a competitive environment, as all companies in the respective industry were aiming at similar markets. The industrial district allowed them to closely observe different practices and technology used (especially when the *Gewerbeinstitut* had provided the machines); yet it seems they did not cooperate within their industries and tried to keep control of production knowledge. Firms did however cooperate in cross-industry activities. For this purpose they set-up new joint-stock-companies (JSC), which was a little bit easier under French commercial law than under Prussian law, though a royal charter was necessary, too.

Before 1870, 15%-20% of all Prussian industrial JSC were founded in the Aachen district (with only 2.5% of the population), but in general the Rhineprovince pioneered JSC in Prussia, though the total number was small.[60] The institution of the JSC encompassed shared ownership and legal personality of the firm; another important feature under French law was limited liability.[61] There have been only few projects; they were, however, crucial for the district's dynamic as they created connections between the clusters of woollen cloth, needles, coal mining, iron and steel, and zinc. The institution of the JSC allowed for diversification of capital accumulated in traditional industries (especially woollen cloth and needles) and for knowledge sharing between industries. Regional industrialists, merchants, bankers, rentier-capitalists, and enlightened Government officials jointly invested in regional industrial and insurance projects. I briefly describe some exemplary JSC projects:

(1) The *'Wire Company, Inc. Eschweiler'* (1822), *Drath Fabrick-Compagnie, anonyme Gesellschaft auf Aktien*, was one of 13 industrial JSC founded in Prussia in the 1820s and

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58 See HSAD BR2116 (no. 45-53): Gewerbetabelle der Fabrikations-Anstalten und Fabrik-Unternehmungen; Anhang zur Gewerbe-Tabelle [1837, 1840, 1843, 1846, 1849, 1852, 1855, 1858]; Reckendrees (2010), p.63.

59 Geuenich (1959); Girkes (1921); Schaumann (1977); Saldern (2009).

60 Details on Prussian JSC 1800-1870 and an analysis of regional and branch composition: Reckendrees (2012c); a list of the companies, ibid., p.157, tab. 9.

61 In this regard Prussian and French JSC differed from British JSC; Freedeman (1979); Harris (2000).

1830s.[62] The founding aimed at import substitution of expensive raw materials, producing *'fine English steel'* and *'drawing English iron and steel wire'* in order to supply the regional needle producers with quality raw materials; with the cost advantage of locally produced wire the industry should become more internationally competitive. The expectation could not be fulfilled; the founding nevertheless demonstrated relevant functions of JSC in the process of industrialization.[63] The initiators were a heterogeneous group of needle producers (wanting raw materials), owners of coal mines (wanting a large customer), and cloth producers (wanting to diversify risk); in order to politically safeguard the new venture members of the District's government and of the Prussian State bureaucracy were included. The factory and its machines were constructed by aforementioned engineer Samuel Dobbs, indicating firstly that available technical expertise was used in different sectors, and secondly, how crucial few experts have been for industrial development. The company was managed by a salaried manager, Friedrich Thyssen, who also played a role in other JSC.[64]

(2) In the 1820s, several initiatives to concentrate the coal mines on the *Wurm* had failed. The aim was combining water handling systems, reducing the number of pits, and connecting the tunnels; but the mine owners could not agree on close cooperation as they wanted to keep control and property. In the mid 1830s, an investors' group similar to the one that set-up the *Wire Company* joint for a JSC paying out numerous mine owners. With an initial share capital of 250.000 Prussian Thaler *United Coal Mines on the Wurm* (*Vereinigungs-Gesellschaft für Steinkohlenbau im Wurm Revier*, 1836) was one of the largest industrial corporations at that time.[65] The founders were described as *'respectable industrialist, public servants, and respectable capitalists'*.[66] Most of them wanted cheap coal for their factories; yet they also wanted to monopolize regional house coal trade by uniting *'all anthracite mines of the Wurm and [eliminating] the harmful competition in order to achieve higher prices and to reduce the production costs by more rational production methods'*.[67] They succeeded after having been able to convince James Cockerill, a large coal mine owner, and the private bank *Sal. Oppen-*

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62 Reckendrees (2010), pp.63-66; Reckendrees (2012c); Gilson (2005).

63 GStA-PK I.HA74K, IX Niederrhein no. 6: Concession application, 19.3.1822; Founding contract, 9.1.1822. On the results of the first decades: Gilson (2005).

64 GStA-PK I.HA120D, XIII2 no.9: Chief President Reimann to the Royal State Minister and Minister for Trade and Commerce, Count von Bülow in Berlin, Aachen, 19.12.1822.

65 Reckendrees (2010), pp.66-69; Reckendrees (2012b), pp. 49-76.

66 GStA-PK I.HA120A XII7 no.113: Royal Concession for the 'Vereinigungs-Gesellschaft für Steinkohlenbau im Wurm Revier', Royal Government Aachen, 11.7.1836. List of shareholders in Reckendrees (2010), p.68.

67 Hilt (1886), p.3.

heim jr. & Cie. in Cologne.[68] The prospects of coal mining promised high future return, but rationalization and technical combination was a prerequisite of profitable mining. The JSC bought and merged coal mines and connected production sites above and below ground-level. The company should also invest in new coal fields and railways in order to create new markets.[69] A competing corporation, *Pannesheider Mining Association* (*Pannesheider Bergwerksverein*), founded in 1842 had a similar structure and approach, but it was less successful and taken over by *United Coal Mines* in 1858.[70]

United Coal Mines had modest success for the first 25 years giving its shareholders 5-10% dividends.[71] Yet the project was ambitious with regard to technical and commercial problems. Concentration of operating sites and improvement of water handling was difficult and required huge investments. The new railway to the Rhine (1841) was ambiguous: It increased the market, but it also provided access to competitors from the Ruhr. Thus disputed markets, where the sum of production and transportation costs of two mining areas was equal, were newly defined; for *United Coal Mines*, the railway did not relevantly enlarge the undisputed market.[72] However, regarding regional dynamics it is relevant that *United Coal Mines* offered industrialists opportunities to regionally invest accumulated capital in a new venture. It induced long term cooperation of entrepreneurs from different branches; it intensified and interconnected regional activities. Industrialists did not only invest money, they actively engaged in managing the company and knowledge sharing. The executive board consisted of a high civil servant (administration), the prosecutor of Aachen –a lawyer with excellent political contacts–, a mining engineer, and two cloth industrialists taking responsibility for accounting, financial administration, sales, and workforce management.[73] Their engagement was possibly result of lacking salaried expertise; yet it contributed to knowledge creation within the district.

(3) A similar group of capitalist *'from Cologne, Bonn, and Aachen'*, joined for the development of a new industry in the region, zinc; among them were James and John Cockerill[74], *Sal. Oppenheim*, and Friedrich Thyssen, director of the *Wire Company*.[75] The *Société Métallurgique de Stolberg, Aix-la-Chapelle* (1836) should operate rolling mills for zinc, copper, and brass plates, increase zinc capacities by three times, operate own coal mines, and –if iron ore

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68 On Oppenheim and the Aachen district: Teichmann (1995).

69 HSAD RA7951: Statutes of United coal mines, 1836.

70 Reckendrees (2012b), pp.77-92.

71 Hilt (1886), p.6.

72 Reckendrees (2012b), pp.92-102.

73 Reckendrees (2010), p.68, tab.2.

74 John Cockerill (1790-1840) had built the largest European blast furnace, steel and rolling mills in Seraing: Mahaim (1905); Hodges (1960); Fremdling (1981); Pasleau (1993).

75 HSAD RA7957: Mining Authority Bonn to Royal Government Aachen, 7.9.1836; Klass (1957), p.39.

was found– also blast furnaces, steel works, and rolling mills for boiler sheets, rails, and steel products.[76] The plan to invest in iron and steel production was given up after the death of the two Cockerills in 1837 and 1840.[77]

This JSC had similarities with other regional projects (see below on iron and steel) concerning ownership, governance, and the regional context of the project; yet, it was a far more risky investment transgressing the region. When it became too risky, most regional shareholders decided to leave, and left the project to more speculative investors. In this regard, the project indirectly confirms the regional pattern of industrial projects.[78] The zinc furnaces were leased to a Belgian-French group as regional investors wanted to leave this expensive and risky undertaking; instead, they contracted raw zinc supply from the Belgian-French group and focused on rolling mills. The demand for zinc products, however, was increasing in the cities of Paris and Brussels and soon observers talked about *'a general rage to go into the zinc business now'*.[79] Yet *Société Métallurgique* could no longer compete with its vertically integrated competitor; in order to focus on ore explorations it sold manufacturing to the Belgian-French group, that founded *Société Anonyme des Mines et Fonderies de Zinc de Stolberg* (1.6mio. Thaler) bringing in all assets and all its debt (0.56mio. Thaler) making it possibly the largest German IPO speculation of the 1840s. More than 50% of the shares were now owned by French and German banks.[80]

(4) In the iron and steel industry family companies and partnerships contributed more to the industry's rapid development in the late 1830s and 1840s than JSC. But when necessary investment for the minimum efficient plant size dramatically increased due to the possibility (and need) of coke blast furnaces, the JSC became the dominant type of firm. Three of the four iron and steel JSCs followed the presented 'regional pattern': *Eschweiler Society for Mining and Ironworks (Eschweiler Gesellschaft für Bergbau und Eisenerzeugung*, 1848), *Concordia Corp., Eschweiler Association for Mining and Ironworks* (*Concordia, Eschweiler Verein für Bergbau und Hüttenbetrieb,* 1853), *Aachen Ironworks Corp.* (*Aachener Hütten-Actien-Verein,* 1854). But the forth JSC, the large and vertically integrated *Phoenix Mining*

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76 HSAD RA7957: Cockerill, Pierlot, Preston & Lambion to Royal Government Aachen, 31.8.1837. GStA-PK I.HA120A XII7 no.58: Statutes of Société Métallurgique de Stolberg, Aix-la-Chapelle.

77 HSAD RA7957: Mining Authority Bonn to Royal Government Aachen, 11.12.1841; HSAD BAD57: Annual Report on the Inde mining region 1841.

78 Regional industrialists also strategically expanded their business to other parts of Europe and invested in bonds or commercial papers; yet the question here is how joint projects contributed to regional development.

79 HSAD BAD59: Annual Report on the Inde mining region 1843.

80 HSAD RA7957: Royal Government Aachen, 18.11.1845; Société Métallurgique to Royal Government Aachen, 27.11.1845; Klass (1957), pp.46, 49-51.

and Ironworks Corporation (*Phoenix anonyme Gesellschaft für Bergbau und Hüttenbetrieb,* 1852), followed a different pattern. Its origin was a rolling mill, the partnership of *T. Michiels & Cie.*, founded 1841 in Eschweiler by two Belgians and cloth industrialists from Eupen. They met heavy resistance from Prussian authorities, the reasons of which cannot be detailed here, and it took them six years to get the concession. It had been a project of outsiders not being able to find support from the local business elite; even the District Government, usually supportive to JSCs, was reluctant.[81]

It is not fully clear if lack of 'social capital' has been decisive for extraordinary difficulties, yet the three other JSC projects did not have to face these problems. In these firms, industrialists and capitalists belonging to regional elites joined forces. *Concordia's* founders came from the *'cycle of most wealthy mining and steel industrialists of the district and the best families of Aachen and Cologne'*, the mining company *EBV*, owners of blast furnaces, the bank *A. Schaaffhausen* from Cologne, and merchants and industrialists.[82] In the case of *Concordia*, the basic requirements for a JSC concession were not fulfilled: it was no new industry and the company did not need very high capital investments. The Districts Government instead argued that due to the crisis years (1847-50), it was *'very pleasing if mining and iron and steel on the Inde would get new dynamics and be able to successfully compete with the industry on the Ruhr.'*[83] The directors of the company, however, explained that the major rational was import substitution; pig iron should be produced close to the puddling and rolling mills, and not in Belgium which would result in uncertain supply –what was a market opportunity, was rephrased as a national task.[84]

It seems as if regional origin, but also cultural and social 'closeness' mattered for industrialists cooperation, which was much easier to achieve within the industrial district.

3.3 Infrastructure and the Rhenish railway

Improvements of infrastructure, especially for the transport of heavy goods were a prerequisite of industrial development. Hand in hand with industrialization regional companies and entrepreneurs engaged in improving transportation systems. In the 1820, this concerned mainly turnpikes, in the 1830s regional industrialists bargained for a railway connecting Aachen and Cologne, and thus the regional industry to ship routes on the river Rhine (and

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81 Details in Reckendrees (2012c).

82 Quote from: GStA-PK I.HA120A XII7 no.69: Opinion of the Royal Government Aachen, 21.3.1853. HSAD RA7990: First general assembly and list of shareholders, 28.5.1853.

83 GStA-PK I.HA120A XII7 no.69: Opinion of the Royal Government Aachen, 21.3.1853.

84 HSAD RA7990: Appeal for the concession of a joint stock company for the construction and operation of blast furnaces in Eschweiler, 28.2.1853.

later to Liége and Antwerp). The turnpikes mostly connected coal mines with the centres of consumption. They have not been economically successful, but the roads from Eschweiler to Düren, from Weiden to Eschweiler, from Düren to Cologne and from Aachen to Eupen connected commercial centres closely and contributed to increases in regional trade.[85] The Prussian State was engaged in long-distance roads, especially important was the road from Aachen to Duisburg.

Of major economic importance was however the *Rhenish Railway,* originally projected in 1833 as a railway from Cologne to Antwerp bypassing Aachen in the north. The Aachen Chamber of Commerce, however, under its chairman David Hansemann did engage in persistent negotiations with the Prussian Government and was finally able to attract the railway to the industrial district. It thus connected Aachen, the coal mines around Eschweiler, and Düren with Cologne and the Rhine ports, the steel industry of Liége, and the harbour of Antwerp. There is a detailed account of the negotiations which together with contemporary documentation allows concluding that it was the industrial district and the expected transports of goods and people that made the relocation of the planned railway possible.[86] The railway was opened in 1841 and had an ambiguous impact on different industries and even on the two mining areas. It connected Aachen, Düren, the *Inde* mines and the new iron and steel producers to both Cologne and Antwerp reducing transportation costs and enlarging the markets. Yet, it had a negative impact on the *Wurm* mines being relatively far away from the railway.[87] In the late 1830s and early 1840s, however, the railway created high expectations. Thus, new iron and steel factories were set-up on the *Inde* coal and close to the railway (between the cities of Eschweiler and Stolberg). The regional industry hoped for new markets for some of its major products (coal, iron and steel, and machinery).

The regional development confirms the forward and backward linkages of the railways, which Fremdling has analysed in detail.[88] In the Aachen region, the railway created a huge increase in demand for iron and steel and for machinery, which again created new demand for coal. The railway did not so much allow for a geographic expansion of the coal markets, and it thus did not fulfil all expectations. The reason is rather trivial: the further development of the railway system re-connected the Ruhr mines to the newly conquered markets and moved the disputed markets almost back to the previous 'equilibrium' that existed before the railway. The impact of the railway was thus reduced to the railway consumption of coal and to addi-

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85 Reimann (1834), pp.48-50.

86 Kumpmann (1910); Hansemann (1835); Hansemann (1837a); Hansemann (1837b); Hansemann (1838).

87 HSAD BAD60: Annual report on the Wurm mines, 1844.

88 Fremdling (1975).

tional demand for coal from industries that benefitted from the railway, like iron and steel, zinc, and machinery.

A further implication of the railway from Antwerp to Cologne was regional concentration of major industries in the small area between Aachen, Stolberg, and Eschweiler, that has already been described for iron and steel. Location of cloth factories was similarly affected by new means of transportation. Aachen, Eupen, and Montjoie had been the centres of early modern cloth production, but only Aachen got direct access to the railway. Already in the early 19th century, larger distance to coal mines and better access to water had created diverging industrial patterns in Montjoie and Eupen. While firms in Aachen centralised production and operated machines driven by steam engines, water wheels continued to be the main driving power in Montjoie (and to a certain level in Eupen that was closer to the mines), which had implications for expanding production and new investments. Aachen's access to the railway further increased the relative costs of coal supply to Montjoie and Eupen and worsened their competitive position.

The railway and other infrastructure improvements created new business opportunities. It is yet difficult to establish a causality allowing for separating industrial agglomeration effects and increase in labour supply on the one hand and infrastructure effects on the other hand. A good example is the tobacco manufacture soon employing more than 1,000 people; artisan workshops, food production, and services might also serve as indicators. In the case of tobacco, which means pipe tobacco and cigars, the decision to set up the manufacture in Aachen was probably labour related. Usually were tobacco manufactures in the German states located in agricultural regions, close to tobacco fields or with access to intercontinental shipping (e.g. in the hinterland of Bremen). It is exceptional for this branch to locate in an industrial district; but many children and women working in the textile or needle industries suffered from heavy, unhealthy, and low paid work. There is yet no proof that such considerations were crucial for the location of tobacco manufactures in the 1840s and 1850s.

3.4 Legal and social institutions

The institutional arrangement had been supportive to the district's economic development. Much of it can be attributed to French commercial law and institutions, which continued to regulate regional actors and transactions, despite the district became a part of Prussia. The substitution of French law for new Prussian laws was a slow process and new Prussian laws were much inspired by the French example (Railway Act 1838, Joint-Stock-Company Act

1843, General German Trade Law 1861). Some of the implications have already been discussed.

Other institutions of French origin have possibly been even more important for the districts economic development. They have been creatively adapted by the regions industry, especially the *Chamber of Commerce* (1804),[89] the *Commercial Court* (1805) and the *Trade Court* (1808). In Prussia, the *Chamber of Commerce* had administrative functions (providing information on industry and trade to the Prussian ministries; and providing ministerial information to the local industry), but the *Chamber* consisted of industrialists elected by industry representatives. From the existing archival material it can be concluded that the *Chamber* acclaimed a double function: it fulfilled its administrative tasks, but it also represented the industrial interests towards the Districts Government and the State. Representation of economic interests was not the 'idea' of the chambers, but the regional industry used the institution for these purposes, which can be shown in regard to the projected Rhenish railway or to tariffs.[90] With the *Chamber* lobbying, the industry of Aachen was much more successful than neighbouring districts where this institution was not available.

The judges of the *Commercial Court* (*Handelsgericht*, existing until 1879)[91] and the *Trade Court* (*Gewerbegericht*)[92] were also elected representatives from commerce, trade and industry; both were beneficial to economic development in different ways. The *Commercial Court* smoothed or decided on conflicts between firms and between merchants; the trade court decided on labour related conflicts. These institutions were flexible instruments within the only slowly changing civil law system, because case based development of legal practices was part of the jurisdiction in trade and commerce.[93] They created a framework allowing for the articulation of diverging interests, which could perhaps not always be mitigated but negotiated, which supported trust-based relationships and thus a more stable institutional environment.[94]

Another example of new social institutions is the *Aachen Fire Insurance Comp.* (*Aachener Feuer-Versicherungs-Gesellschaft*, 1825). It did not directly contribute to industrial develop-

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89 Chambre consultatives de manufacture, fabriques, arts et métiers, Zeyss (1907); Thomes (2004), pp.20-33.

90 Reckendrees (2010), 56-58, with some more examples.

91 Zeyss (1907), pp.1-18; Bernert (1982), pp.126-128, 144.

92 There are differences between the Trade Court in Aachen and the Factory Courts established in the 1840s, Bernert (1982), p.147; yet they fulfilled similar functions: Willoweit (1982); Schöttler (1985); Mieck (1997).

93 For more details: Reckendrees (2010). The observation supports the legal-origins hypothesis in the economics of law literature. Usually, France and Prussia are regarded civil law systems; yet, in the early period of industrialization case oriented decision processes were part of the judicial practices in trade and commerce. Cf. Mahoney (2001); Glaeser and Shleifer (2002); Glaeser and Shleifer (2002, La Porta, et al. (2007).

94 On the importance of networks for trust in institutions see e.g.: Granovetter (1985).

ment, but it helped integrating the working class into the capitalist system and moderating the existential problems of unemployment and illness. 90% of initial shareholders came from the region; most important were factory owners as the company insured houses and industrial property against fire.[95]

In order to be accepted by authorities, an insurance JSC (after sufficient reserves had been accumulated) was to spend 50% of its net-income on social purposes. The main instrument of the *Fire Insurance* was a savings bank for the working class established in 1834 in reaction to a violent revolt in 1830.[96] It served as an instrument to ideologically integrate workers into the capitalist system, which in the view of farsighted industrialists depended on social systems safeguarding the workers from the risks of wage labour: Savings should allow workers to survive in times of unemployment or illness, as most workers did not have any other means like side-agriculture. Savings accounts were subsidized by funds from the insurance and interest rates attractively high to those, who earned a little bit more then they needed for survival. Yet, high interest rates were dependent on well behaviour: Considering the clients' *'industriousness, order, and well conduct'*, banks officials decided on the premium paid. Workers, who continuously saved for three years and accumulated 20 Thaler (corresponding to the wage of 50 working days), could get a premium of three Thaler. The bank was extremely successful; in the 1850s, it advanced to the largest Prussian savings bank.[97] While the *Fire Insurance* perhaps had not direct influence on economic growth, it contributed to the industrial districts social stability that had been challenged in the revolt of 1830.[98]

4 Summary and outlook on the decline of the industrial district

Each of the three briefly described clusters had its own historical routes and followed specific patterns of development, but they did not develop independently from each other.

Geographical concentration in *coal mining* is determined by natural resources. The comparison of developments on the *Inde* and the *Wurm* show the importance of economies of scale for profitable production. Two factors seem to be most relevant for the regions general economic development: Firstly, the mines' huge demand for steam engines for water pumping and coal production created a market for local producers that soon employed some thousand

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95 HSAD BA16058: List of shareholders. GStA-PK I.HA120D XXII9 no.4: statutes. Masius (1846), pp.116-124; Berndt (1884); Aachener Verein zur Beförderung der Arbeitsamkeit (1909).

96 For details and literature: Reckendrees (2010), pp.75-77; Reckendrees (2012c).

97 HSAD RA16058: Direktion der Aachener Feuerversicherungs-Gesellschaft als provisorischer Ausschuss des Vereins zur Beförderung der Arbeitsamkeit (Pastor, Hansemann, Seyffart), 25.10.1833. Pohl (1999); Thomes (1999).

98 On further attempts of social inclusion see Reckendrees (2010), pp.71-80.

workers and soon went beyond the regional market; secondly, capital diversification and commercial knowledge transfer has been a crucial factor for the industries development as rationalization and economic concentration required other capitalists investing in coal mining.

Iron and steel production is also relatively dependent on resources; yet not only the price of raw material (charcoal, coke, iron ore) and labour costs determine output, transportation costs of raw material and access costs to markets are also factors of competitiveness, location thus depends on resources and on infrastructure. Furthermore, the combination of raw materials depends on technology used. From the 1830s until the 1850s, a new iron and steel cluster developed in the industrial district of Aachen that comprised all levels of iron and steel production including finished goods. The reasons to concentrate close to Aachen–Eschweiler were availability of coal and coke, railway infrastructure, and the regional market for steel products (machinery industry, steam engines and boilers, railways, wagon industry, etc.). The traditional industry in the Eifel did no longer supply pig iron to steel works and rolling mills as they did when high transportation costs and the fragility of charcoal prohibited long-distance transports. Relatively, charcoal iron from the Eifel not allowing for similar economies of scale became more expensive; it was then mainly used for goods requiring high quality inputs.

In *woollen cloth*, the transition from artisan workshops and putting-out systems to industrial production followed a different path. Availability of labour saving technology and – compared to the surrounding countryside relatively high labour costs– induced integration of production in vertically integrated firms operating power machines and an increasing amount of fixed capital (especially for buildings). 40km from Aachen the putting-out system continued to exist; with a large rural hinterland there was no incentive to save on labour costs and invest into fixed capital.[99] The cloth merchants in Montjoie, who in the 18th century, had been the first to establish shearing manufactures had however not become technology adverse; they used new technology if it reduced total cost (carding and spinning) and continued putting-out if transactions costs were lower than investments in centralized production.[100] Yet, over time they lost competitiveness against integrated factory production.

Textile machinery had been the root of the district's *machinery industry* interconnecting all sectors. While first machines were imported from Belgium, local supply was soon built up. From a production perspective machinery connected the different industries by supplying industrial equipment, but also by creating a market for steel products (and to a lesser extent for

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99 The development in woollen cloth supports to a certain extent the argument of Allen (2009).

100 Reckendrees (2012a), 18-19; HSAD RA1567, Major, Aachen City, 22.10.1816.

coal). This observation is further supported by the fact that the respective firms were build up as partnerships of engineers on the one hand, and owners of coal mines, textile factories, or rolling mills, on the other hand.

Since the 1820s, the institution of joint-stock-companies was used to engage in new industries and in large scale project. The new institution allowed for limited liability, share ownership and diversification of capital. This encouraged cross industrial connections and intersector cooperation; it allowed for attracting capital to new ventures and industries and contributed to diffusion of the scarce resources of entrepreneurial, organizational, commercial expertise and technical knowledge. The social composition in the respective firms represents core businesses and successful entrepreneurs from different clusters

Based on efficient institutional arrangements that supported political representation of common industrial ideas and that enforced communication and compromising among industrialists, they were able to bargain for substantial investments in infrastructure that further reallocated firms, capabilities and financial resources to the industrial district. Social institutions dealing with potential conflict resulting from wage labour were also discussed within the elite networks.[101]

It is not possible to establish any causality between the briefly mentioned institutions and, e.g., the establishment of JSCs, but it seems to be plausible to assume that social and communicative structures had a positive impact on observed cooperation. Each of the industrial projects can, of course, be explained by economic self-interest and profit expectations, which are probably crucial. The argument presented here is that the institutional environment developed within the industrial district encouraged cooperative approaches to reach the respective economic aims.

In regard to the concept of industrial districts and clusters it has not been the aim of this article to 'show' that they are fully applicable to the development in the early 19th century; they have rather been used to frame this study. The intention has been to creatively use some of the basic ideas in order to provide a contextual explanation for rapid industrial development in a small pioneering region within the relatively backward state of Prussia.

[101] This idea could not be developed, see Reckendrees (2013).

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