The Dynamics of Overlapping Clusters

Industrial and Institutional Revolution in the District of Aachen, 1800-1860

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Dynamics of "Overlapping Clusters": Economic Development in the Industrial Region 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 region. 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.

1. Introduction*

European early industrialisation was concentrated in regions rather than states.[1] In the case of the German states, the region of Aachen (Prussian Rhine province) was pioneering as measured by the diffusion of the factory system, by employment and industrial production. In the first decades of the 19th century, traditional branches that had dominated the export industries based on artisanry and the putting-out system in the early modern period, particularly woollen cloth, introduced modern factory production with power engines and sophisticated machinery. Coal mining developed to industrial scale, and industrialisation of iron and steel led to spatial concentration of production. New industries emerged within the region reflecting changes in industrial demand and new raw materials. Supportive institutional arrangements advanced rapid transition to industrial capitalism. By 1860, two thirds of the regional workforce was employed by industry. This article takes a regional and industry based approach in order to

* 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 comments and suggestions; special thank goes to the session organizer, Jordi Catalan.

1 Pollard (1981); Fremdling, et al. (1979); Hudson (1989); Wilson and Popp (2003a); Pierenkemper (2004). For an overview of regional approaches to economic development, see: Scott (2000).

analyse economic development in the region of Aachen and in order to explain how and why different clustered industries created interconnections allowing for cross-sector learning, knowledge sharing, and technical and entrepreneurial spill-over. The framing ideas of the analysis are borrowed from traditional and modern literature on industrial districts (ID)[2] and on clusters.[3]

The two concepts share similarities, but they have distinct perspectives.[4] The (neo-) Marshallian ID is defined as a local concentration of a large number of small and medium sized firms within a *dominant* industry (usually light manufacturing) involving both horizontally competing and related vertically specialised firms as well as companies providing specialised services. The ID constitutes an economic system functioning as a viable alternative to vertical integration and large scale production (even in mass production industries). To a certain extent, other industries 'may be localised in the district […] for example the nuclei of new industries, or the remains of old industries'.[5] Due to its "industrial atmosphere" (Marshall), the people in an ID share belief systems and develop social institutions that support collective interests, they form a "socio-territorial entity" (Becattini), in which 'community and firms tend to merge'.[6] IDs allow for (vertical) division of labour between firms, for learning and knowledge sharing despite of competition; they create economic advantages external to the firm, yet internal to the district ("Marshall-Arrow-Romer externalities", produced and consumed in a given sector): economies of scale, cost reduction and increased returns.[7]

Whereas the ID literature stresses local concentrations of small manufacturing firms, a cluster may encompass different configurations, including coexistence of few very large companies with many small and medium sized companies. According to Porter cluster is defined as a 'geographically proximate group of interconnected companies, service providers and associated institutions in a particular field, linked by externalities of various types.' Like an ID it is supposed to create advantages external to the firm, for example because firms in related industries (specialized suppliers of components and services) offer advantages to the firms of the cluster. In combination with strong competition among the companies central to the clustered industry leading to higher levels of specialization, this increases overall competitiveness and innovation capacities. Porter emphasized that 'the industry may not be the appropriate

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2 Marshall (1919), (1920); for the modern (neo-) Marshallian concept see Piore and Sabel (1984); Becattini (1990), (2002); Dei Ottati (2003); Becattini, et al. (2009b).

3 Porter (1990), (2000), (2003); Porter and Ketels (2009); for a historical perspective on regional clusters Wilson and Popp (2003b).

4 Zeitlin (2008); Porter and Ketels (2009).

5 Becattini, et al. (2009a), p.xviii.

6 Becattini (1990), p.38.

7 Bellandi (2007); Becattini, et al. (2009a).

unit of analysis […] specialization in clusters of related industries, not in industries *per se*, should lead to better regional performance.' He then introduces related and "overlapping clusters" that should be associated with higher performance than unrelated clusters.[8]

Both concepts share the spatial approach and provide contextualized interpretations of economically successful environments not explained by mainstream microeconomics. They are similar but want to explain partly different phenomena. In Porter's perspective 'IDs are one type of a cluster' achieving 'their advantages primarily through local outsourcing on the local level'[9] and social embeddedness. Cluster research draws more on industrial economics, company strategy, and formal institutions. In a historical perspective, however, some of these differences disappear. First, industrial regions encompassing different industries very often emerged from (proto-) industrial districts.[10] And second, formal institutions supportive to modern clusters (like trade associations, standard setting agencies, quality centres, technology networks) did not yet exist in the late 18th and early 19th century or they disappeared when the guild system was dissolved. At the time, social embedded economic activity was probably more important than slowly developing new formal institutions. A third approach focusing on spatial dimensions of economic development, "regional industrialisation", is less specific than the concepts of IDs and clusters. It mainly focuses on input-output analysis and forward and backward linkages of industries[11] (corresponding to "related industries" in the cluster and "specialised suppliers" in the ID concept. The differences of the approaches mainly result from the units of analysis: In the case of ID it is an industry and its organisation; the cluster approach analysis related firms within their network and surrounding institutions; the concern of regional industrialisation is the respective region that may be host to clusters or may include an ID. This paper aims at analysing regional economic development just like "regional industrialisation", but it uses analytical ideas from the concepts of IDs and clusters for analysing and explaining regional economic dynamics.

If narrowly defined, both concepts (IDs and clusters) overlook important factors for historically observable economic development, what has been stressed for English early industrialisation, too.[12] In the early modern period the region of Aachen might well be described as encompassing a pre-industrial woollen cloth districts and a pre-industrial needle district (with brass as an additional, less important sectors). In the 19th century, the industrial region of Aa-

8 Porter (2003), p.562.

9 Porter and Ketels (2009), p.181.

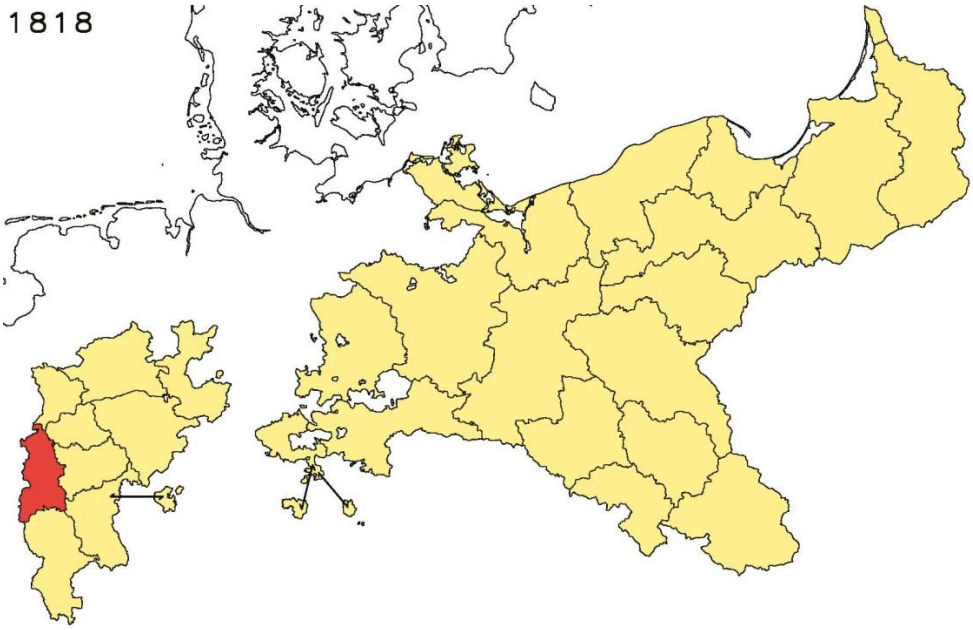
10 Wilson and Popp (2003b); Hudson (1989).

11 Fremdling, et al. (1979); Pollard (1980), Pollard (1981); Kiesewetter and Fremdling (1985); Kiesewetter (1988), (2007); Banken (2000); Pierenkemper (2002), Pierenkemper (2004).

12 Popp and Wilson (2009).

chen does no longer fit to the ID concept. About 1850 the major industries of the region, 'old' ones like woollen cloth, coal mining, paper, and needles and also 'new' industries such as iron and steel, machinery, railway wagons, zinc produced on large scale with modern factory equipment. In contrast to the (neo-) Marshallian ID, these firms were yet not 'small'; approximately 2/3 of the districts' total workforce was working in manufacturing and mining; half of them in factories with more than 100 workers.[13] Most important have been woollen cloth, coal mining, and iron and steel, each of them showing strong tendencies of vertical integration. Yet, reciprocal interconnections between different industries constituted an important feature of the regional economy. It was thus characterized by both 'Marshall-Arrow-Romer externalities' and 'Jacobs externalities' (defined as flows between firms in all sectors).[14] The cluster concept would not be a sufficient substitute for the ID concept, as it would tend to neglect important socio-economic factors such as locality and social embeddedness. It would also assume positive effects of *related* industries, but not flows across all sectors.

Map 1: Prussia, administrative districts. District of Aachen (dark).



Source: © IEG Mainz, A. Kunz (2001), own adaption.

The development in Aachen is interesting because reciprocal interactions of unrelated industries have been important for regional economic development (woollen cloth, for example, is unrelated to needle making or heavy industry). The different clusters were embedded in a social structure that corresponds to an ID, and they were partly overlapping especially in regard

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

[14] Capello (2002).

to developing new industries. Identifying these dynamics of "overlapping clusters" is the purpose of this article.

The transition from commercial to industrial capitalism had been influenced by supportive institutional arrangements partly based on French law:[15] In 1798, after the Revolutionary Wars the Rhineland became French and the district of Aachen became the *Département de la Roer*. After the French defeat in 1814, the region was integrated into Prussia, yet with few exceptions the French legal system continued. The *code civil* and the *code de commerce* rather than Prussian civil law[16] constituted the norms of commercial activities. Also other institutions of French origin, like chambers of commerce, commercial courts, or arbitration boards for work related conflicts, helped shaping economic behaviour. New Prussian laws in general did not dramatically influence regional economic development.[17] However important French institutions have been for regional economic development, it must be noted that the transition towards a "modern" economy had started long before. Already during the 18th century, the guilds lost capacity to enforce their norms and rules. Capitalist firms emerged and for already about two hundred years farming had not been subject to a feudal regime, instead landownership and inheritable leasing dominated. The French Revolution made this process irreversible and fully implemented private property and bourgeois law.[18]

In the analytical framework of this study the 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).[19] Yet, also territory (the border between Prussia and the Low Countries, and later Belgium) defines the region because trade restrictions negatively impacted cross-border exchange of raw materials, prefabricated goods, and labour when the Rhine province became Prussian in 1814. The border had a paradox function[20] in that it connected independently developing regions for instance by attracting Belgian investments to Aachen.

German economic historical research on the 19th century has mainly focused on the emergent nation state and the second industrial revolution and less on the formative period of industrial capitalism, the early 19th century. The period is covered in edited volumes presenting

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

16 On legal institutions in the Rhine province and the continuation of French law: Conrad (1969); Fehrenbach (1974); Bernert (1982); Strauch (1982)

17 The integration of the Rhineland also induced economically relevant changes like the introduction of the Prussian currency and the Prussian trade union. Important were the Railroad Law (1838) and the Joint-Stock-Company Law (1843) based on French ideas. Yet, the latter predominantly helped capitalist development in the East of Prussia, for the industry of Aachen it increased State oversight.

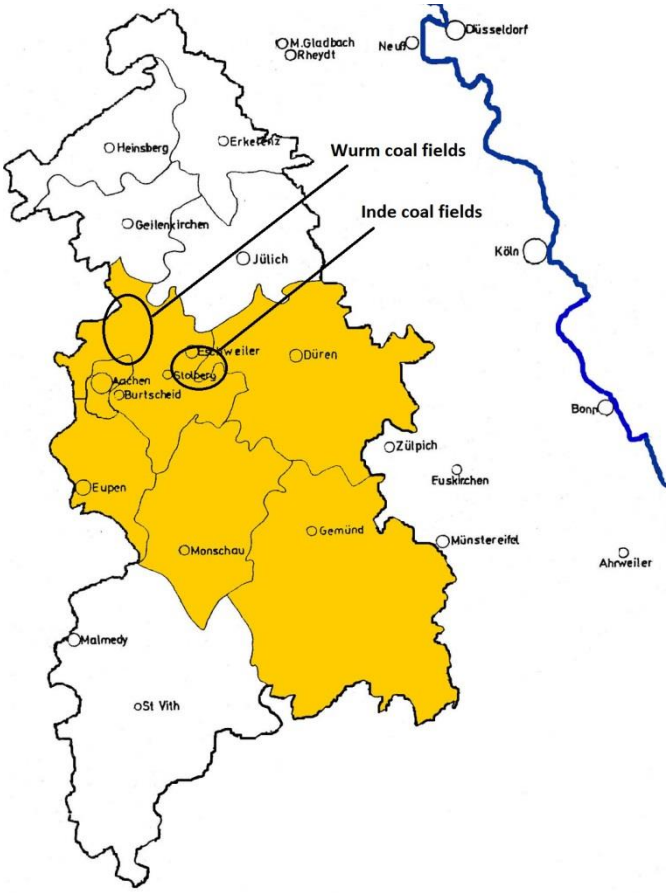
18 See Reckendrees (2010), p.54-55 with further literature. Acemoglu, et al. (2011) overlook the institutional change that had happened already before the French Revolution.

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

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

the regional approach,[21] yet substantial new research has been published only on a few regions like the Saar[22] and Saxonia[23] or it is limited to a local level.[24] The industrial region of Aachen, despite of considerable research on proto-industrialisation in the region[25] (though not covering the transition to industrial capitalism), has not been studied accordingly.[26] This article is part of a project on a comprehensive regional economic history of Aachen; the material used comes from public archives, contemporary publications, and also from early 20th century publications that was based on archival sources destroyed in the two world wars.

Map 2: Administrative district (Regierungsbezirk) of Aachen. Industrial region (dark) and coal mining areas (approximately).



Source: Own construction.

[21] Pollard (1980); Kiesewetter and Fremdling (1985); Pierenkemper (2002).

[22] Banken (2000).

[23] Kiesewetter (1988), (2007).

[24] See e.g. Flik (1990); Kriedte (2003); Berger (2009).

[25] See e.g. Ebeling (1997), (2000); Schmidt (2000), (2004); Pfister (2004).

[26] A brief outline, Eyll (1980), and a PhD thesis on Belgian influence on the steel industry, Schainberg (1997). Furthermore, von Saldern (2009) published a major study on the family network of the Schöller family in Düren.

The scope of this paper does not allow for an analysis of all industrial branches; it focuses on the largest industries (woollen cloth, coal mining, and iron and steel) and on the interconnections between them; other industries involved in the respective processes will not be analysed specifically. The dynamics of regional economic development in connection with new collective institutions make the core of this paper. It wants to provide an explanation of why different industries clustered within a relatively small region and how they created dynamic interconnections and spill-over.

Chapter II provides a brief overview of the industrial cluster; firstly, woollen cloth as an example of a successful transition from artisanry and putting-out to modern factory production; secondly, coal mining that experienced an industrial reorganisation based on ideas of rationalization and economies of scale; and thirdly, iron and steel. The developments in coal and steel are only briefly sketched. They are central to chapter III analysing interconnections between industries. They regard knowledge transfer between industries, general supply industries, development of commercial and organisational know-how, corporate finance, and transportation infrastructure. Chapter IV provides a summarizing discussion.

2. Three clusters of the industrial region

2.1. Woollen cloth

In the 18th century Aachen had become the dominant region in the German woollen cloth trade;[27] it pioneered the introduction of spinning and carding machines in woollen cloth in the early 19th century. Traditional production was based on lime-free water indispensable for finest cloth qualities, the typical product of the region; warm springs close to Aachen provided excellent means for finishing and dying the cloth. Production was organised as a combination of artisan production and putting-out. The putting-out system employing 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. Yet, artisan workshops also integrated putting-out work and employed domestic spinners as well as journeymen and apprentices.[28]

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 owned vertically integrated firms; some of them still connected to specialised suppliers (spinning, dyeing). Power machines drove all kinds of machinery (scrib-

[27] Viebahn (1846), p.37.
[28] Reckendrees (2006), pp.15-17.

bling, carding, roving, spinning, raising, shearing, fulling, pressing etc.). Only weaving was mechanized late as fine cloth production required improved looms. Different from English cloth districts, where spinning machines were used in the cottage industry,[29] in Aachen from the beginning comprehensive sets of machinery combining scribbling, carding, and spinning machines were introduced, which required factory establishments. Within a few years home spinning had been erased 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.[30] Yet, vertical integration into one firm does not necessarily mean centralised production in a single establishment. Fulling mills, for example, requiring much water were usually established on small rivers; dyeing mills usually operated outside the towns because of water pollution; both processes were also subcontracted.

Efficient exploitation of machinery required power engines (steam engines, water wheels or, some years later, water turbines); access to resources (water and coal), institutions (accession rights), and an efficient transportation system were increasingly important. Thus, different patterns emerged within the larger cloth region. In the towns of Aachen and Düren water power was insufficient for the growing industry, accession rights to water were limited and different branches and the citizens of the towns competed on the use of water. Especially here, steam engines provided a flexible source of power not dependent on location; they also freed production from climatic uncertainties and allowed for a 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 substitution with more powerful and more efficient machines can be observed. In the German context, the woollen cloth industry in Aachen pioneered the implementation of steam engines in factory production. 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%. Only power looms have not been introduced early; until the end of the 1850s just two industrialists opted for larger numbers (85 and 53, the total was 380).[31] Yet, slow implementation of new weaving technology was economically ‘rational’ as adapting the power loom to fine-cloth weaving was a difficult task and if there were any, productivity gains were small. Expenses did not serious-

[29] Hudson (1975), (1986).

[30] Reckendrees (2006). Machinery was not used for all purposes; early models did not fit superfine cloth, even with improved cylinder shearing machines hand shearing dominated production of top quality cloth.

[31] Reckendrees (2006), pp.27-31.

ly decrease because of high investment costs and because automatic looms weavers had to receive higher wages.[32] Thus, incentives for new investments were very week.

Since the 1820s, the average size of integrated firms increased steadily. Comprehensive handwritten reports informed on factory establishments; though they are incomplete they allow for some quantitative estimates.[33] The city of Aachen and its local surroundings hosted more than 120 firms with more than 10 employees (the number of firms with less employees is uncounted). For 1846, 1849 and 1852 about 13,000 workers in cloth factories are reported and 1,600 in spinning mills. In 1849, 19 large integrated cloth factories in the city of Aachen employed more than 8.200 workers.[34] Some firms employed a substantial number of domestic weavers, but this number is not reported.[35] Assuming that the reports overestimate factory employees by 30%, those 19 large factories would have employed 5,740 workers within their establishments; which gives an average size of 300 workers in such a factory. Vertical integration, size of the factories, and the average number of workers indicates that by 1850 the transition to industrial production was accomplished in Aachen.

Outside of Aachen different organizational patterns evolved. In the city of Eupen (20km from Aachen) specialised spinning and finishing factories have been more common and vertically integrated firms less dominant. 40km from Aachen, in the pre-industrial ID of Montjoie the putting-out system with centralised dressing manufactures and high vertical specialization survived until the 1860s; with a large rural hinterland there was no incentive to save on labour costs and invest into fixed capital.[36] The cloth merchants in Montjoie, who in the 18th century had been the first establishing manufactures had not become technology adverse; they used new technology if it reduced total cost (e.g. spinning) and continued putting-out if transactions costs were lower than centralized production.[37] Yet, they lost competitiveness against integrated factory production. Diverging local patterns and sustained putting-out can be explained by local labour markets and by access to the railway: (1.) In Eupen and Montjoie, textiles was the only industry supplying wage labour, whereas in Aachen qualified and unqualified workers could find alternative occupation (machinery, needles, tobacco, coal, steel,

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[32] See also Schmoller (1870), p.496.

[33] For each third year from 1837-59 the tables report on workers, spinning machines, and steam engines in factories. HSAD BR2116 (vol. 46-53): Table on commerce and trade and factories; Supplement to the table on commerce and trade.

[34] HSAD BR2116 vol. 48.

[35] In 1855, firms employing domestic workers had about 45% of the workforce outside of the city, HSAD BR 2116 vol. 54, f.173 pp.

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

[37] HSAD RA1567: The Major of Aachen, 22.10.1816.

zinc etc.). Thus lower wages for both towns are reported,[38] and the incentive to substitute machinery for labour was smaller. (2.) The railway connecting Aachen to Antwerp, Liege and Cologne, increased relative transportation costs for producers from Eupen and Montjoie. This aspect will be further developed in the following chapters.

A reconstruction of how competition exactly worked in the cloth cluster is not possible due to lack of sources allowing for such conclusions (e.g. product portfolio, prices and wages). Because of its substantial export ratio (see: Appendix A) it must be assumed that the regions cloth industry was internationally competitive. Qualitative information gives further evidence: Regional institutions were used to get access to technical knowledge; f.e. the chamber of commerce and the local government circulated blueprints of new machines; the chamber of commerce and the Casino Society, a social club, also provided international newspapers and business journals.[39] In terms of competition the response to the *Prussian Trade Institute* (*Gewerbeinstitut zu Berlin*[40]) offering new machines to cloth producers (new models from France, the United States, and Britain) is interesting. Very often those to whom they were offered were reluctant to agree to the *Trade Institute's* condition of giving open access to their operations.[41] Keeping production knowledge a secret clearly indicates competition on product markets. The observations also suggest not to overestimate state support during early industrialisation. Though cloth industrialists did not horizontally cooperate in cloth production, vertical cooperation was usual as specialisation of production indicates. They also cooperatively invested into new industries, which will be shown in chapter 3.

The size of the woollen cloth cluster induced independent supply industries that cannot be further discussed here. This regards especially the carding industry, which developed to the largest on the German territory.[42] Other trades important in the early modern period experienced different industrialization patterns. In needles and paper it started about 20-30 years later; and in brass transition to industrial production took not place.[43] The reasons cannot be discussed here; I rather focus on the two large industries next to woollen cloth, coal mining and iron and steel.

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38 HSAD RA 1542, f.46: Landrat von Eupen an Regierung Aachen, 20.4.1857.

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

40 See: Mieck (1965).

41 Different cases are reported in HSAD RA1636.

42 Weinberg (1931), p.48

43 On the needle industry: Vogelsang (1913); Weinberg (1931), pp.49-53, on paper: Geuenich (1959); on brass: Becker (1913); Roderburg (1924).

2.2. Coal mining

Since the middle ages, the region's two mining areas on the rivers *Inde* and *Wurm* (see map 2, above) produced hard coal, but due to geological and institutional factors they developed quite different production systems: (1.) The coal fields on the *Wurm* touched five states with different legal systems; ownership was thus dispersed and mines were small and less productive; (2.) for geological reasons and because of property rights collective water handling was impossible on the *Wurm*; (3.) the *Wurm* fields provided anthracite coal, the *Inde* fields provided bituminous coal.[44]

Since the 30 Years War, the *Inde* fields were owned by the Duke of Jülich, whose administration leased out coal extraction.[45] When in the second half of the 18th century mining required deeper pits and sophisticated water handling systems, the extraction rights for most mines were leased to one single consortium allowing for coordination and scale economies. By and by the Wültgens-Englerth family concentrated most of the licenses. Under the new French government, the family was able to contract a long term lease and with the mining law of 1810 it became the owner of the two most important mines.[46] Region specific institutional arrangements thus promoted early capitalist entrepreneurship allowing for consolidation and long-term investments.

The technology driven transition towards 'industrial' production came much later in the *Wurm* area, mainly in the 1820s. Then, all mines introduced modern steam engines, which increased water handling capacities and allowed for more continuous and safer production. Furthermore, different mines connected their water pumping to each other. The effects were yet limited before, in the 1830s, ownership concentration allowed for rationalization of production. An important factor in this process has been the new institution of joint stock companies, in which a broad set of regional industries cooperated; the argument is developed in the following chapter.

From the 1830s onwards, the mines of both *Wurm* and *Inde* prospered due to increasing industrial demand for coal and to the Rhenish railway giving access to more distant markets.[47] Production and sales data for the *Wurm* shows a volatile upward tendency from 1820 to 1835.

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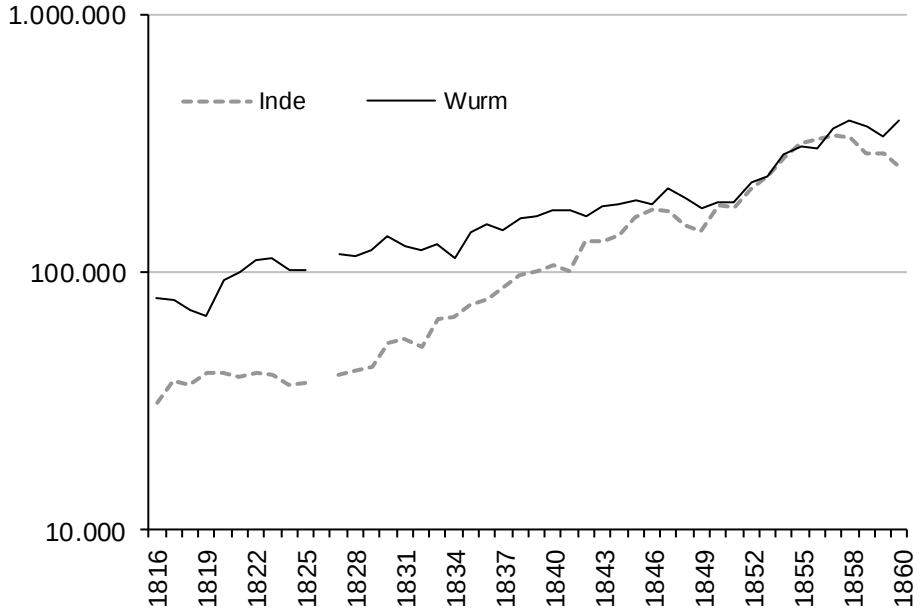
44 Willms (1923); Hinzen (1929); Schunder (1968); Wiesemann (1995); for a detailed analysis of pre-industrial regional coal mining see: Reckendrees (2014a), pp.12-30.

45 Schunder (1968), pp.26-31.

46 Stegemann (1910), pp.14-15; Reckendrees (2014a), pp.16-18, 28, 102-111.

47 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.

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



Source: Reckendrees (2014a), pp.176 (description of the data, ibid. pp.156-161).

From then on, with concentrated ownership rationalisation allowing for scale economies and productivity increase, and combined with growing demand sales increased. Yet, the centralised mines on the *Inde* (mining company *Eschweiler Bergwerksverein, EBV*) performed relatively better. The reasons are partly path dependence (favourable institutional arrangements in the 18th century resulting in early concentration) but more importantly, with increasing regional industrial production the market for the *Inde's* product, bituminous coal, grew much faster than the market for anthracite coal from the *Wurm.* Bituminous coal was chosen for steam engines, steel and zinc production and so on. Anthracite coal was used for household consumption. When steam engines were adjusted to anthracite coal in the 1850s, production growth on the *Wurm* accelerated due to substantially lower prices.

2.3. Iron and steel

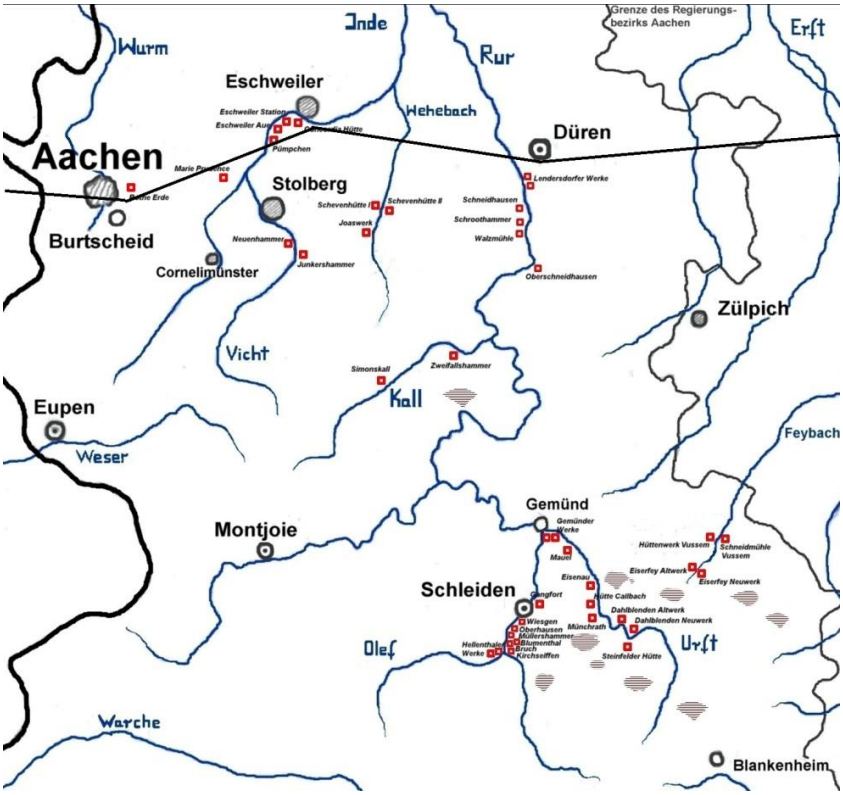
The developments in iron and steel are also only briefly described. Literature[48] does not provide reliable comprehensive data and own data collection, based on reconstructions of plant level information, is not yet completed. Reliable estimates are difficult to undertake; the general tendencies in iron and steel are however quite clear.[49]

[48] Best overview: Schainberg (1997); Bömmels (1925); Neu (1989).

[49] Difficulties result from incomplete data (prices), reporting of capacities instead of production; unspecific measurements, possible double counting of pig iron, cast iron, and wrought iron.

Historically, pig iron and wrought iron were produced in the hilly Eifel around Schleiden (map 3) with plenty water and charcoal supply. Yet with early industrialization the traditional area lost its competitive advantage and the region of Aachen attracted a new steel cluster.

Map 3: Industrial Region of Aachen. Location of Iron and Steel Production, 1850s.



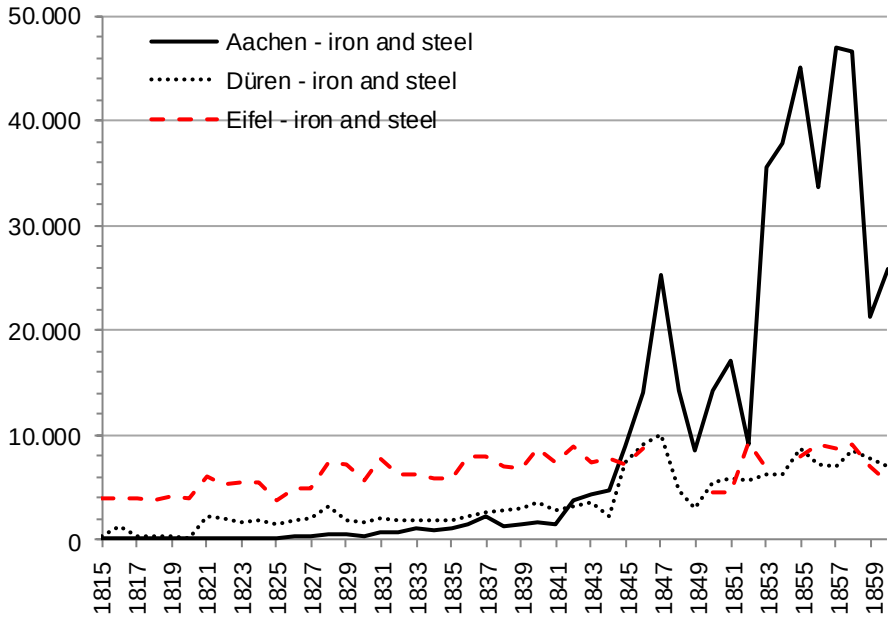
Source: Annuschat (2007), p.6; own adaptation. Square dots indicate blast furnaces and steel works. The line indicates the railway from Cologne to Antwerp.

Since the 1820s, wrought iron production tended to move away from the traditional area to Düren, where Eberhard Hoesch introduced the puddling process in his new plant.[50] With the decision to build a railway from Cologne to Antwerp in 1834 (see below) the relocation of the iron industry gained full momentum. Puddling steel works and rolling mills were now set up on top of the *Inde* coal with direct access to the railway. Due to lower transportation costs these works increasingly substituted imported Belgium iron for Eifel iron.[51] In the 1850s, new coke blast furnaces were established near Eschweiler, from then on traditional (charcoal) iron production in the Eifel focused exclusively on special qualities and production stagnated.

[50] Beck (1899), p.703.

[51] Fremdling (1986), p.134; Leboutte (1988); Pasleau (1993); Schainberg (1997).

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



Source: Own data collection, not yet consolidated but the relations between the sub-areas are presented correctly.

Early industrial development of iron and steel was technologically driven. Particularly important were the introduction of the puddling process (1825) and new rolling mills, both dependent on foreign technical experts.[52] From the 1840s onwards, development is better described as a demand-pull process. For example Hoesch, owner of steel works and rolling mills in Düren, in 1847 set up a new plant in Eschweiler because of *'increasing demand for rails and considering that due to the nearby coal mines […] Michiels [a competitor in Eschweiler] has an advantage of almost 2,000 Thaler a year'*.[53] Increasing machinery production in Aachen and Eschweiler had created a new, still small market for wrought iron in the 1830s, and encouraged the establishment of new puddling works (*Englerth & Cünzer* 1832). 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.[54]

The districts' producers, first movers in their respective industries, were among the largest German railway suppliers and soon exported mass produced goods to other German and Aus-

[52] Fremdling (1984); Fremdling (1991).
[53] Hashagen and Brüggemann (1916), p.559.
[54] T. Michiels & Cie. 1842; 'Rothe Erde' Piedboeuf & Co. 1846; Hoesch plant 'Eschweiler Station' 1847.

trian regions.[55] The establishment of coke blast furnaces in the 1850s was both technologically and demand driven. The knowledge of coke iron process had been systemised and codified allowing for knowledge transfer from Belgium to Germany;[56] equally important were the new steel works and rolling mills who demanded increasing amounts of pig iron so that import substitution seemed to be a reasonable strategy.

2.4. Workforce and labour markets

In the 1810s and 1820s, new textile machinery had set free very many workers and work was cheaply available. Miners had side-line agriculture or were smallholders working in mines only when harvest was brought in, they were supplemented by temporary migrant labourers from adjunct regions. The region's steel industry was still small. There was thus no labour shortage until the 1830s: 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 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.[57] Yet, with increasing industrial production since the late 1830s and especially in the 1850s, the labour market changed dramatically.

Wage data indicating the change in the labour market is spurious, yet adaptive company policies allow the conclusion of emerging labour markets. For example, when the *Wurm* mines in 1839 established a health and accident insurance (*Knappschaft*)[58] like the one the neighbouring *Inde* mines had introduced three decades before, the *Inde* mines started providing housing for workers. They were not only competing with the other coal mines (Appendix B on wages in coal mining), but also with the new zinc and steel plants established on top of the coal and with the Rhenish railway looking for construction workers.[59] The woollen cloth industry, in which many young women were occupied, was for example challenged by newly set-up tobacco manufactories offering less exhausting and relatively well paid work to girls and young women.[60] The reports of the chambers of commerce for the 1850s inform about rising wages and wage competition, yet not about the wage levels.[61]

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55 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.

56 The argument corresponds to Mokyr (2002).

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

58 Due to French law, Knappschaften were not yet mandatory; Reckendrees (2015, forthcoming).

59 HSAD RA 7960, folio 398pp: "Complaint about scarcity of coal […]", 20.5.1842.

60 HSAD RA1542: Chamber of Commerce to Royal Government, Aachen, 24.4.1857.

61 For example, Handelskammer zu Stolberg (1854), p.17.

3. Interconnections

3.1. Machinery production: A bridge between industries

Textile machinery was the root of Aachen'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 in 1816/17 was the decision of Kelleter, a cloth merchant, to build a spinning factory using a steam engine; he employed two British mechanics, *'very dextrous artists'*[62], to construct the factory. One of the *'artists'*, Samuel Dobbs, came from Cockerill, settled in Eschweiler and founded the machine factory *Englerth, Reuleaux & Dobbs* (1819) in cooperation with a family member and an engineer of the Englerth coal mines (*Inde*). He was not the first to produce steam engines, but his cooperation with the mine owning family made him the first to have commercial success.[63] The first engines were produced for the family mines, but soon other mines, cloth factories, and other customers wanted to buy the engines that could compete with Cockerill's and others' machines.[64] Dobbs later set-up a wire factory in Eschweiler (1822), constructed the already mentioned puddling works of *Hoesch* in Düren,[65] and was engaged in several new firms in Aachen (*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.[66]

In the following two decades the number of machinery, steam engine, and boiler factories increased. Woollen cloth firms founded machinery workshops (e.g. *G. Startz*), specialized textile machinery producers emerged and Belgian firms set up factories (*Regnier Poncelet & Desoer, J. Piedbeuf*). The machinery sector served as a specialised supplier for the woollen cloth and the steel industry and for coal mining. In the terms of the regional industrialization approach backward linkages provide an explanation of the development, from the firm perspective also diversification played a role. These new factories at the same time created a new market (forward linkages) for the steel industry, as steam engines, boilers, and railway material required more and more rolling mill and casted products. In 1832, ten machinery factories employed approximately 280 workers, seven years later there were twelve with 600 workers. Most of them had a modest size of 10-30 workers, the four larger firms employed between 70 and 250 workers. With the Rhenish railway starting its operations in 1841 and the increasing

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62 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.

63 The first producer, Wilhelm Dinnendahl, leased his engines due to high prices, Behrens (1974), p.374.

64 See price list 1826, Appendix B.

65 Beck (1899), p.703.

66 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.

number of large factories for steel and zinc (see below) the structure of the machinery industry changed. Now the 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.[67]

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 (in the needle industry in Aachen and in the paper industry in Düren) created a competitive environment, as the firms in the respective industry aimed at similar product markets. Product specification and price competition seem to have been the most important strategies, though resilient data is not available. Spatial concentration allowed them to closely observe practices and technology used (especially when the *Trade Institute* had provided the machines). Yet, beyond supply relationships industrialists within one sector did not "cooperate" they rather aimed at controlling production specific knowledge. Firms (though not all of them) 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.

Indirectly the importance of these JSCs can be concluded from Prussian statistics: Though the region of Aachen hosted only 2.5% of the Prussian population, more than 15% of all Prussian industrial JSCs founded before 1870 were operating in this region. In fact, the total number was small yet the Rhine Province pioneered JSC in Prussia. The important features of the new institution were shared ownership, legal personality of the firm, and limited liability.[68] There have been only few projects but they were crucial for economic dynamics as they created connections between the clusters of woollen cloth, needles, coal mining, iron and steel, and zinc. The JSC facilitated diversification of capital accumulated in traditional industries (woollen cloth and needles) and knowledge sharing between industries. Regional industrialists, merchants, bankers, rentier-capitalists, and enlightened Government officials jointly invested in regional projects. I briefly describe some exemplary JSC projects.

(1.) The *'Wire Company, Inc.'* 1822 (*Drath Fabrick-Compagnie, anonyme Gesellschaft auf Aktien*), was one of 13 industrial JSC founded in Prussia in the 1820s and 30s.[69] The cluster created its own supply industry producing *'fine English steel'* and *'drawing English iron and steel wire'* and aiming at import substitution of expensive raw material supply for the regional

[67] HSAD BR2116 (no. 45-53): Table on commerce and trade and factories; Supplement to the table on commerce and trade 1837, 1840, 1843, 1846, 1849, 1852, 1855, 1858; Reckendrees (2010), p.63.

[68] On Prussian JSC between 1800 and 1870, see Reckendrees (2012); a list of JSCs, ibid., p.157, tab. 9.

[69] Reckendrees (2010), pp.63-66; Gilson (2005).

needle producers.[70] Locally produced wire was expected to be cheap and should improve the needle companies' international competitiveness. The expectation was not immediately fulfilled, but the establishment demonstrates how the institution of the JSC enabled cooperation: The initiators were a heterogeneous group of needle producers (supply motives), owners of coal mines (sales motives), and cloth producers (diversification motives); the new venture also included officials of the District's government in order to politically safeguard the project. The factory and its machines were constructed by aforementioned engineer Dobbs, indicating that available technical expertise was used across different sectors, and that few experts have been crucial for industrial development. The company was the first to be managed by a salaried manager, Friedrich Thyssen, who also played a role in other JSC.[71]

(2.) The *United Coal Mines on the Wurm* 1836 (*Vereinigungs-Gesellschaft für Steinkohlenbau im Wurm Revier*). In the 1820s, several attempts to concentrate the small mines on the *Wurm* failed. The aim was combining water handling systems, reducing the number of pits, and connecting the tunnels; but the owners wanted to keep control and property and could not agree on collective property. In the mid-1830s, an investors' group similar to the one that setup the *Wire Company* joined for a JSC that should buy the Wurm mines. After having convinced James Cockerill (owner of a large coal mine) and the private bank *Sal. Oppenheim jr. & Cie*. in Cologne to become project partners, the founding succeeded.[72] With an initial share capital of 250.000 Prussian Thaler *UCM* was one of the largest industrial corporations at that time.[73] The founders were described as *'respectable industrialist, public servants, and respectable capitalists'*.[74] Most of them wanted cheap coal supply for their factories; yet they also aimed at monopolizing the 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'*.[75] The prospects of coal mining promised high return, but profitability required technical combination and rationalization. The JSC bought and merged several coal mines and connected production sites above and below ground-level. It should also invest in new coal fields and in railways in order to create new

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70 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).

71 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.

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

73 Reckendrees (2014a), pp. 49-76.

74 GStA-PK I.HA120A XII7 no.113: Royal Concession for the United Coal Mines, Royal Government Aachen, 11.7.1836. List of shareholders in Reckendrees (2010), p.68.

75 Hilt (1886), p.3.

markets.[76] A competing corporation, *Pannesheider Mining Association* (1842), had a similar ownership structure and approach, but it was not successful and taken over by *UCM* in 1858.[77]

UCM had modest success for the first 25 years giving its shareholders 5-10% dividends.[78] The project was ambitious with regard to technical and commercial problems, because concentration of operations and water handling required huge investments. Yet, it offered an opportunity to invest regionally accumulated capital in a new venture within the region. It induced long term cooperation of entrepreneurs from different branches and intensified and interconnected regional activities. Industrialists did not only invest money, they engaged in managing the company and by doing this in knowledge sharing. The executive board (administration) consisted of a lawyer with excellent political contacts, the prosecutor of Aachen, a mining engineer (technical expert), and two cloth industrialists who brought in commercial expertise (responsibility for accounting, financial administration, sales, and workforce management).[79] This engagement contributed to knowledge diffusion (and creation) within the regional industry, because they helped educating administrative employees.

(3.) The *Société Métallurgique de Stolberg* (1836). This JSC should operate rolling mills for zinc and brass plates, threefold raw zinc capacities, operate coal mines, and (if iron ore was found) also blast furnaces, steel works, and rolling mills for e.g. boiler sheets and rails.[80] A similar regional group of capitalists from different industries joined with Belgian capitalists for setting up a new industry in the region, among others James and John Cockerill, the private bank *Sal. Oppenheim*, and Friedrich Thyssen, director of the *Wire Company*.[81]

Concerning ownership, governance, and the regional context, the project had similarities with other regional projects (see below on iron and steel); yet, it was also a far more risky investment. When it became too risky, regional shareholders decided to partly sell-off to more speculative investors. In this regard, the project indirectly confirms the regional pattern of industrial projects.[82] The expensive and risky undertaking of ore extraction and raw zinc production was leased to a Belgian-French group; the *Société Métallurgique* contracted raw zinc

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

77 Reckendrees (2014a), pp.77-92.

78 Hilt (1886), p.6.

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

80 HSAD RA7957: Cockerill, Pierlot, Preston & Lambion to Royal Government Aachen, 31.8.1837; GStA-PK I.HA120A XII7 no.58: Statutes of Société Métallurgique.

81 HSAD RA7957: Mining Authority Bonn to Royal Government Aachen, 7.9.1836; Klass (1957), p.39. In Seraing, John Cockerill (1790-1840) had built the largest blast furnaces, steel and rolling mills in Europe: Hodges (1960); Fremdling (1981); Pasleau (1993). – The plan to invest in iron and steel was given up after the death of the two Cockerills in 1837 and 1840; HSAD RA7957: Mining Authority Bonn to Royal Government Aachen, 11.12.1841; HSAD BAD57: Annual Report on the Inde mining region 1841.

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

supply from this group and focused on rolling mills. However, demand for zinc products in Paris and Brussels was increasing and observers started talking about *'a general rage to go into the zinc business now'*.[83] The rolling mills of *Société Métallurgique* could no longer compete with its (self-created) vertically integrated competitor and sold the company sold its rolling mills to the Belgian-French group that now founded *SA 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 owned by French and German banks.[84]

(4) In the steel industry, family firms and partnerships had been sufficient for the industry's rapid growth in the late 1830s and 1840s. Yet, when with the new technology of coke blast furnaces the necessary investment for the minimum efficient plant size dramatically increased, and the JSC became the dominant type of firm. Three of the four regional iron and steel JSCs followed 'regional pattern' of collaboration of capitalists from different industries, regional elites and a regional bank already presented: *Eschweiler Mining and Iron Production Corp.* 1848 (*Eschweiler Gesellschaft für Bergbau und Eisenerzeugung*), *Concordia, Eschweiler Mining and Ironworks Corp.* 1853 (*Concordia, Eschweiler Verein für Bergbau und Hüttenbetrieb*), and *Aachen Ironworks Corp.* 1854 (*Aachener Hütten-Actien-Verein*). Only the vertically integrated *Phoenix Mining and Ironworks Corp.* 1852 (*Phoenix, anonyme Gesellschaft für Bergbau und Hüttenbetrieb*) followed a different pattern. Its origin was the partnership of *T. Michiels & Cie.* a rolling mill founded 1841 in Eschweiler by two Belgians and cloth industrialists from Eupen. They met heavy resistance from Prussian authorities and needed six years to get the concession. It seems as if lack of 'social capital' has been decisive for extraordinary difficulties, because none of the three other projects had to face similar problems. *Phoenix*, however, was a project of outsiders not belonging to the Aachen network without support from the local business elite (Chamber of Commerce) and even the District Government, usually supportive to new JSCs, was reluctant.[85]

It seems as if regional origin as well as cultural and social 'closeness' mattered for cooperation, which was much easier to achieve within the core of the regional industrial network. The other three projects had no difficulties founding a JSC. Here, capitalists belonging to the 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

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

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

85 Details in Reckendrees (2012).

mining company *EBV*, owners of blast furnaces, the bank *A. Schaaffhausen* from Cologne, merchants and industrialists. In this case not even the basic requirements for a concession were fulfilled (because the industry was not new and the investments not particularly high) but due to the crisis years (1847-50) the Districts Government found it *'very pleasing if mining and iron and steel on the Inde would get new dynamics and would be able to successfully compete with the industry on the Ruhr.'*[86] The directors of the company argued more in a nationalist perspective and explained that the rational was import substitution of pig iron from Belgium; uncertain foreign supply to the puddling and rolling mills should be substituted with local production.[87]

3.3. Infrastructure and the Rhenish railway

Infrastructure is not the most discussed factor of industrial clusters and ID, perhaps because the IDs of the 1970s already had access to transportation and communication infrastructure; yet it is implicitly, and sometimes explicitly part of the argument, particularly in cluster theory where transportations systems are seen as crucial complementarities to the clustered industry.[88] During early industrialization improvement of infrastructure, especially for the transport of heavy goods, was a prerequisite of industrial development. So was it in Aachen, where regional companies and entrepreneurs, and also the state, continuously engaged in improving transportation systems (beneficial to all cluster participants). In the 1820, this mainly concerned paved roads, in the 1830s regional industrialists bargained for a railway. It should connect Aachen and Cologne and Aachen (via Liége) and Antwerp, and thus the regional industry to shipping routes and to supply industries in Belgium. The network of paved roads increased from 159km (1816) to 250km (1831) and 375km (1846), many of them private financed turnpikes. Especially the new roads from Eschweiler to Düren and to Weiden, from Düren to Cologne and from Aachen to Eupen connected the commercial centres more closely and contributed to increase in inner-regional trade.[89]

Of major importance was the *Rhenish Railway*, originally projected in 1833 as a railway from Cologne to Antwerp bypassing Aachen some kilometres north. The Aachen chamber of commerce, however, under its chairman David Hansemann, and the city administration engaged in persistent negotiations with the Prussian Government, they made feasibility studies

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86 Quotes 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.

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

88 Becattini (1989), p.132; Porter (2000), pp.257, 260; Zaratiegui (2004), p.82.

89 Reimann (1834), pp.48-50; Wirminghaus (1917).

for a new route including Aachen, Eschweiler and Düren and finally attracted the railway to the city of Aachen and the industrial locations. It connected Aachen and the industrial region with Cologne and the Rhine ports, with the steel industry of Liége, and the harbour of Antwerp. A detailed account of the negotiations together with contemporary documentation[90] allows the conclusion that it was industry and the expected additional transports of goods and people that made the relocation of the planned railway possible. Lobbying did not negatively impact other interest groups, the new plan made the railway a few kilometres longer, and tunnel and a bridge were necessary, yet from the late 1840s onwards the increased costs were more than fully covered by additional transportation of goods and people. The railway opened in 1841 had an ambiguous impact on different industries. It connected Aachen, Düren, the *Inde* mines and the new steel producers to Cologne, Liége, and Antwerp both reducing transportation costs and enlarging the markets, but it had a negative impact on the *Wurm* mines being relatively far away from the railway.[91] However, more important for economic dynamics was that the railway created high expectations and in the early 1840s, new iron and steel factories were set-up on the *Inde* coal close to the railway.

Regional development confirms the forward and backward linkages of the railways, which Fremdling has analysed in detail.[92] In the region of Aachen, the railway created a massive increase in demand for steel and for machinery, which again created new demand for coal of industries that benefitted from the railway, like iron and steel, zinc, and machinery. Improved infrastructure had a strong effect on spatial concentration of industry around cities with railway access (Aachen, Stolberg, and Eschweiler). Even location of woollen cloth factories was affected by new means of transportation. Aachen, Eupen, and Montjoie had been centres of early modern cloth production. Already in the beginning of the 19th century, larger distances to coal and easier access to water had created a diverging production patterns in Montjoie and Eupen with less vertical integration than in Aachen (see above). When Aachen got direct access to the railway, the relative costs of coal supply for producers in Montjoie and Eupen and worsened their competitive position.

3.4. Legal and social institutions

Institutional arrangements have been supportive to economic development. Some of it can be attributed to French commercial law and institutions, which continued to regulate regional actors and transactions, despite the region became a part of Prussia. Substitution of French

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90 Kumpmann (1910), p.109-169 (with information on contemporary reports).

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

92 Fremdling (1975).

law for Prussian laws was a slow process and new laws were 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 region. They have been creatively adapted, especially the *Chamber of Commerce* (1804),[93] the *Commercial Court* (1805) and the *Trade Court* (1808). In Prussia, *Chambers of Commerce* had administrative functions (providing information on industry and trade to the Prussian ministries and ministerial information to the local industry), but they were formed by elected industry representatives. In practice, the chamber of Aachen acclaimed a double function: it fulfilled administrative tasks *and* it represented industrial interests towards the Government. Though representation of economic interests was not the "idea" of the chambers, the regional industry used the institution for this purpose, which can be shown for example in regard to the projected Rhenish railway or to tariffs. With the chamber lobbying, it seems as if industrialists from Aachen had a stronger voice than industrialists from neighbouring regions, who had no institutional form to articulate collective interests.

Also the judges of the *Commercial Court*[94] and the *Trade Court*[95] were elected representatives from commerce, trade and industry. The *Commercial Court* smoothed or decided on conflicts between firms and between merchants; the *Trade Court* decided on labour related conflicts. Both institutions were beneficial to economic development; while the civil law was changing only slowly, they allowed for more flexible case based decisions[96] adapting commercial law to the needs of the changing economy. The courts also created a framework for the articulation of diverging industrial interests that were not always mitigated but at least negotiated; this processes supported trust and thus a more stable institutional environment.[97]

Another example of new institutions is the *Aachen Fire Insurance Corp.* (1825, *Aachener Feuer-Versicherungs-Gesellschaft*). 90% of initial shareholders came from the region, many of which were factory owners as the company insured industrial property against fire.[98] It did not directly contribute to industrial development, but it helped pacifying the working class

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93 Chambre consultatives de manufacture, fabriques, arts et métiers, Zeyss (1907); Thomes (2004), pp.20-33; Reckendrees (2010), pp.56-58.

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

95 The Prussian Factory Courts established in the 1840s fulfilled similar functions: Willoweit (1982); Schöttler (1985).

96 Reckendrees (2010). The observation supports the legal-origins hypothesis; the economics of law literature [see e.g.: Glaeser and Shleifer (2002); La Porta, et al. (2007)] usually regards France and Prussia as civil law systems; yet, in the early 19th century case law was an important feature of commercial law.

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

98 HSAD BA16058: List of shareholders. GStA-PK I.HA120D XXII9 no.4: Statutes. Masius (1846), pp.116-124; Berndt (1884).

and moderating the existential problems of unemployment and illness. The main instrument was a savings bank for the working class established in reaction to a violent revolt in 1830. Business elites obviously perceived limited social inclusion and stability as an important condition for the reproduction of the socio-economic system.[99]

In order to get license an insurance JSC was to spend 50% of its net-income on social purposes (after reserves had been accumulated). In the case of the *Fire Insurance* this was mainly the savings bank (*Association for the Advancement of Industriousness*, 1834). It served as an instrument to ideologically integrate workers into the capitalist system that in the view of farsighted industrialists depended on social systems safeguarding the workers from the risk of wage labour: Savings should allow survival in times of unemployment or illness, as most workers did not have any other means like side-agriculture. The insurance subsidized savings accounts with attractive interest rates. Yet, these premiums depended on well behaviour: Bank officials decided on the premium based on the savers *'industriousness, order, and well conduct'*. Workers, who continuously saved for three years and accumulated 20 Thaler (the wage of 50 days), could receive a premium of three Thaler. The bank was extremely successful; in the 1840s and 50s, it advanced to the largest Prussian savings bank.[100]

4. Summary

Each of the three briefly described clusters followed its own historical path and sector specific dynamics in terms of new technology used and competition. It has been shown that additional to what the cluster- (and also the ID-) concept would focus at technological linkages and knowledge spill-over between unrelated industries were important features of regional economic development. The three industrial clusters "overlapped" and they have been connected (1.) by machinery production (at that time almost a general purpose supply industry), (2.) by the institution of the JSC allowing for capital diversification as well as commercial and technical knowledge transfer between unrelated industries and towards new industries, (3.) by favourable institutions that helped shaping an "industrial atmosphere" (A. Marshall) and cross-industrial cooperation; furthermore, complementarities like the transportation infrastructure reinforced spatial concentration and increased cluster advantages.

The existence of pre-industrial spatial concentrations of firms as well as location of natural resources (coal) allowed for a regional machinery industry and encouraged improvements of transportation infrastructure, which then attracted new industries into the region. In *woollen*

[99] On the revolt and on further attempts of social inclusion Reckendrees (2014b).

[100] HSAD RA16058: Direction of the Aachen Fire Insurance Comp, 25.10.1833; Anonymous (1861), p.94; Thomes (1999).

cloth, the transition to industrial production started with the French Revolution. In the formerly guilded cities of Aachen (also in Burtscheid and Düren) availability of labour saving machinery and high labour costs compared to the countryside induced vertically integrated production in firms allocating increasing amounts of fixed capital. Vertical specialisation (a characteristic of an ID) did not fully disappear, but it became less important. Firms did however use the regional labour pool to temporarily outsource and expand production. They competed on product markets and for labour, but some of them also joined for new industrial projects. At the same time, the pre-industrial ID of Montjoie where putting-out and vertical specialization continued to exist declined.

New textile machines was the root cause for the regional *machinery industry;* first, machinery was imported from Belgium but soon local supply was built up due to the demands of the textile industry, but also due to the mines with their huge demand for energy. The machinery industry, soon employing hundreds of workers and stretching beyond the regional market, supplied industrial equipment to all industries. It also created a market for steel products (to a lesser extent for coal). Its experts were employed in all industries improving production and setting up new factories. The inter-connections created by the machinery industry is also reflected by the fact that respective firms were established as partnerships of engineers on the one hand, and owners of coal mines, textile factories, or rolling mills, on the other hand.

After 1830, a steel cluster emerged with iron and steel production and finished goods. Its location depended on resources *and* infrastructure reducing access costs to markets. The reasons to concentrate close to Eschweiler were availability of coal and coke, streets and railways, and the regional market for steel products (like machinery industry, steam engines and boilers, railways, wagon industry). *Coal mining* where resources determine followed a well know growth pattern of scale economics; yet it served also as a market for machinery and as an opportunity for investments.

Firms within an industry predominantly competed; yet firms of different industries joined to engage in new industries and in large scale projects, this is interpreted as a cooperative pattern of (parts of) the social elites of the industrial region; “locality” and social closeness mattered just like in a (neo-) Marshallian ID. “Locality” was further deepened by collective institutions (chamber of commerce, commercial court, trade court) enforcing communication and compromising among industrialists. Though it is not possible to establish causality between those social institutions and cross-industrial new ventures, it seems to be plausible to assume social and communicative structures having a positive impact on observed cooperation. These common projects mainly took the form of a JSC. This new institution allowed for limited lia-

bility, shared ownership and diversification of capital, it enabled inter-sector cooperation, attracted capital to new ventures and industries, and perhaps even more crucial, it helped diffusing the scarce resources of entrepreneurial, organizational, and commercial expertise as well as technical knowledge. The social composition of the respective firms represents core businesses and successful entrepreneurs with different cluster backgrounds. Of course, each of the industrial projects can be explained by self-interest and profit expectations. The argument presented here is that the institutional environment developed within the region encouraged cooperative approaches to reach the respective economic aims.

In regard to the concepts of IDs and clusters it was the aim of this article to 'show' that they are fully applicable to early regional industrialization in the first half of the 19th century, the intention was rather to creatively use some of the basic ideas in order to analyse a small pioneering region within the relatively backward state of Prussia. Combining the industry approach and the regional perspective has helped identifying important factors of dynamic economic change that else might have been overlooked.

The region lost its pioneering role in the 1860s. With the German railway network completed increasing the relative price of market access, with the coal resources on the Ruhr attracting modern iron and steel works, and due to limited size of the region it became less attractive to new invest within the region. The region did not decline but it grew slower than other industrialising German regions. Regional entrepreneurs who increasingly invested in other parts of Germany and in Europe (especially at the Ruhr and in Austria and Poland) contributed to this development. For them, "locality" became less important than expected earnings.

Appendix A: Sales of the cloth industry of Aachen and Burtscheid 1837-1848

	pieces produced	Prussian tariff union	South of Germany	North of Germany	Nether-lands	Belgium	Switzer-land	Italy, Napoli, Sicilia	Spain	Levante	China	North America
Aachen												
1838	67.650	**10,6%**	10,3%	8,9%	13,3%	3,0%	6,7%	31,0%	4,4%	4,4%		7,4%
1840	62.100	**12,9%**	6,4%	4,8%	12,1%	1,6%	8,1%	28,3%	5,6%	6,4%	6,8%	7,2%
1844	65.280	**12,9%**	13,0%	8,7%	8,0%		10,4%	29,9%		1,5%	2,6%	7,7%
1847	70.100	**9,6%**	8,8%	7,7%	7,4%		8,0%	27,4%		2,1%		25,4%
Burtscheid												
1838	16.500	**18,2%**	15,2%	18,2%	12,1%	3,0%	6,1%	24,2%		3,0%		
1840	16.500	**24,2%**	15,2%	18,2%	12,1%		9,1%	16,4%		4,8%		
1844	17.100	**24,6%**	18,7%	19,9%	8,8%		11,7%	16,4%				
1847	18.720	**13,9%**	16,0%	16,0%	13,4%		11,8%	9,6%				19,3%
totals												
1838	84.150	**12,1%**	11,3%	10,7%	13,1%	3,0%	6,5%	29,7%	3,6%	4,2%		5,9%
1840	78.600	**15,3%**	8,3%	7,6%	12,1%	1,3%	8,3%	25,8%	4,5%	6,1%	5,3%	5,7%
1844	82.380	**15,3%**	14,2%	11,0%	8,1%		10,7%	27,1%		1,2%	2,1%	6,1%
1847	88.820	**10,5%**	10,4%	9,5%	8,7%		8,8%	23,6%		1,7%		24,1%

Source: Wichterich (1922), p.191 (citing Archiv der Handelskammer Acta IV/18, destroyed)

Appendix B: Wages in coal mining, in "Silbergroschen" per shift, 1837-60

	Inde and Wurm	Eschweiler Coal Mining Comp.	
	average	coal hewer	carrier
1837	15		
1838			
1839	16,3		
1840	16		
1841	15,4		
1842	15,1		
1843	14,9		
1844	14,6		
1845	14,6		
1846	16		
1847	16,3		
1848	14,6		
1849	13,7		
1850	15,4	16,58	14,17
1851	15,2	16,92	14,17
1852	15,3	16,75	14,25
1853	14,9	17,58	15,17
1854	19,8	19,17	16,17
1855	20,1	19,08	16,33
1856	19,8	21,33	17,00
1857	20,1	21,25	18,75
1858	20,1	21,33	17,92
1859		20,92	16,92
1860		20,00	16,00

Sources: Arlt (1921), p.146, Huyssen (1861), pp.19-20.

Appendix C: The Prices of Steam Engines. Rhine Province, 1826

producer	machine	HP	use of coal, in tons per 12h	coal / hp	price in Thaler	
Englerth, Reuleaux u. Dobbs	no. 29	12,0	4,000	0,333	3.400	double impact
Englerth, Reuleaux u. Dobbs	no. 41	8,5	3,000	0,352	4.000	double impact
Englerth, Reuleaux u. Dobbs	no. 47	8,5	2,000	0,234	4.000	double impact
Englerth, Reuleaux u. Dobbs	no. 48	8,5	2,000	0,234	4.000	double impact
Englerth, Reuleaux u. Dobbs	list price, 1826	10,0	3,750	0,375	4.200	**
Freund, Berlin	no. 08	8,0	0,956	0,120	4.448	double impact
Joh. Dinnendahl	no. 27	10,8	4,500	0,417	4.600	double impact
Cockerill	list price, 1822*	10,0			4.730	low pressure
Cockerill	no. 44	10,8	4,500	0,417	5.690	double impact
W. Dinnendahl	no. 38	18,9	9,000	0,477	6.000	single impact
Cockerill	list price, 1822*	10,0			6.170	high pressure
Englerth, Reuleaux u. Dobbs	list price, 1826	20,0	6,250	0,313	6.670	**
Cockerill	no. 36	16,0	3,000	0,188	7.300	double impact
Englerth, Reuleaux u. Dobbs	no. 34	13,5	3,333	0,247	7.300	double impact
Cockerill	list price, 1825*	20,0			7.974	low pressure
Cockerill	no. 39	10,8	4,500	0,417	8.000	double impact
Joh. Dinnendahl	no. 21	19,8	7,250	0,366	8.000	single impact
W. Dinnendahl	no. 46	16,1	4,500	0,279	8.000	double impact
Cockerill	list price, 1825*	20,0			8.190	high pressure
Englerth, Reuleaux u. Dobbs	list price, 1826	30,0			8.460	**
Englerth, Reuleaux u. Dobbs	no. 40	17,6	6,750	0,383	9.000	double impact
Englerth, Reuleaux u. Dobbs	no. 50	21,6	5,000	0,231	9.000	single impact
Cockerill	list price, 1825*	30,0			9.995	high pressure
Joh. Dinnendahl	no. 20	27,9	7,500	0,269	10.000	single impact
W. Dinnendahl	no. 42	16,9	3,750	0,222	10.000	double impact
Englerth, Reuleaux u. Dobbs	no. 43	26,7	13,250	0,497	10.500	single impact
Englerth, Reuleaux u. Dobbs	list price, 1826	40,0			10.510	**
Cockerill	list price, 1825*	30,0			11.011	low pressure
Cockerill	no. 25	38,5	6,500	0,169	11.500	double impact
Franz Dinnendahl	no. 22	30,0			11.500	double impact
Englerth, Reuleaux u. Dobbs	no. 45	28,0	9,000	0,321	11.900	double impact
Englerth, Reuleaux u. Dobbs	no. 33	30,0	5,333	0,178	11.925	double impact
Joh. Dinnendahl	no. 26	32,2	8,750	0,271	12.000	single impact
Cockerill	no. 37	35,0	3,000	0,086	15.000	double impact

* in franc: 3,89 franc = 1 Thaler ** fob Cologne

Sources: Severin (1826), pp.320-326; Van Neck (1979), p.410 (on Cockerill).

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