Testing for Industrial Agglomeration using Micro-Geographic Data in China (Hunan) and the Netherlands (ca. 1900 – 2010)

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1. Introduction

The tendency of industries to cluster in some areas is well-known since the publication of Alfred Marshall's (1890) *Principles of Economics*. As Marshall (1890) pointed out, benefits of agglomeration accruing from the transport of goods, labour and ideas were crucial to shaping the location of industries as firms tended to locate near their centres of suppliers and/or clients. In the course of time, these primitive location areas could develop certain advantages such as the development of local skills and subsidiary trades which makes them develop in what Marshall termed "industrial districts" (Belussi and Caldari 2009). By being in such districts, small or medium size industries could enjoy similar benefits as large, vertically integrated, firms. Marshall pointed at the end of the 19th century to the clustering of the "knitted/worsted textile manufacture" and the "cutlery manufacturing" in England as examples from such clustering.

This distinction between initial clustering, which in time advances to proper industrial districts, can also be found back in the literature. For example, Crafts and Wolf (2014) show that initial conditions such as access to water power were crucial for the clustering of cotton textiles in the UK in 1838. Meyer (1998) showed that also for New England 1790-1820 initial conditions mattered at first, but that different factors such as subsidiary economic sectors increased in importance over time. Studies on present day examples of such clusters are plentiful, although most focus on Europe and the USA (Combes and Overman 2004). Yet, increasingly, studies on other parts of the world are emerging such as on China (e.g. Brakman et al. 2016), which often find different patterns due to e.g. differences in institutions or government policy.

Yet, since most studies focus mainly on (a small sample of) recent years, it is only possible to analyse the "initial" conditions such as education or types of ownership while time-specific factors, such as the rise of subsidiary industries or changes in government policy only receive limited attention. Therefore, in order to study the location patterns of manufacturing firms over time, and particularly the tendency for certain industry sectors to cluster, we use distance-based tests of localization (Duranton and Overman 2005; 2008). These tests are applied to 4 datasets: two of Dutch manufacturing firms in 1896 and 2010 and two of manufacturing firms in the Chinese province of Hunan in 1954 and 2004. This allows us to empirically test both the static and the dynamic part of the agglomeration theories of Marshall (1890) on two samples of the late 19th or early 20th century as well as two samples of the 21st century.

The paper is organized as follows. In section 2, we will discuss the data and method. In section 3 and 4 we turn to the spread of manufacturing firms in the Netherlands and China (Hunan) respectively. In section 5, we discuss the importance of the fall of transport costs, to end with a brief conclusion in section 6.

2. Data and Method

Measuring agglomeration is heavily influenced by the choice of methodology. In recent years, two divergent methodologies of controlling for industrial concentration have gained importance. First, the dartboard approach(Ellison and Glaeser 1997) used largely by spatial economists (e.g. Maurel and Sédillot 1999; Devereux, Griffith and Simpson 2004). Essentially, this method controls for the agglomeration of an industry sector in specific spatial units (county, province, country, etc.) as darts thrown randomly on a map. Second, you have the distance-based method (Duranton and Overman 2005; 2009), preferred by economic geographers (e.g. Puga 2010; Delgado, Porter and Stern 2014), which uses distances between establishments to study agglomeration of industries. Essentially, this method uses latitudes and longitudes to calculate inter-firm distances as a proxy of agglomeration at varying distances.

Evidently, both methods have advantages, but also disadvantages. The disadvantages of the Duranton-Overman method, is twofold. Not only is it computational intensive (Kosfeld et al 2011; Scholl & Brenner 2011), it also determines a general level of clustering without making clear in which region, city, … the clustering is highest. The approach of Ellison-Glaeser (1997), on the other hand, uses aggregated data, as it allocates manufacturing companies to aggregated spatial units, such as countries, counties, prefectures, municipalities, or others. However, this in turn leads to a possible Modifiable Areal Unit Problem (MAUP), since the aggregate value varies by region size (Yule and Kendall 1950; Cressie 1993).

As it is easier to obtain data for spatial units rather than to obtain micro-geographic coordinate data in older time periods, it is no surprise that most publications in economic history have opted for the dartboard method. However, in economic geography the Duranton and Overman method (2005) method is widely recognized to be better in terms of quality, as it allows calculating distances between real firms and aggregate these distances into a density. Rather than looking at aggregated units of analysis, this method thus presents a more detailed direct measurement of agglomeration while avoiding zoning and scaling issues, which are especially important when studying earlier time periods. Additionally, this method is independent of political motivated boundaries that changed strongly over the course of time both in the Netherlands and China. Therefore, we opted for the second method.

Besides the model, we faced the decision of which industrial sectors to select. Again, following Duranton and Overman (2005; 2008), many studies have selected four sectors for analysis. Duranton and Overman claimed they based their choice of four selected sectors based on “illustrative purposes” (Duranton & Overman 2005: 5). More specifically, Duranton & Overman (2005) used the manufacture of diary, ceramic, hinges and locks and electric domestic products while Duranton & Overman (2008) used pharmaceutical, derived pharmaceutical, agricultural machinery, and textile machinery products.

Other authors decided to verify the claims of Marshall (1890), thus to study the sectors which he described as highly clustered. For instance, examples of cluster identified by Marshall (1890: 155) - cutlery in Sheffield, furniture in Wycombe, pottery in Staffordshire - were tested for agglomeration by e.g. Duranton and Overman (2005).

Given the complexity of historical data collection, we decided to follow a pragmatic approach, in choosing 4 sectors that link to Marshall, provide both intermediate and final consumer industries, and have enough observations, based on the ISIC Revision 4 classification system: manufacture of bakery products (ISIC 1071), manufacture of carpets and rugs (ISIC 1393), manufacture of casting of iron and steel (ISIC 2431), and manufacture of cutlery, hand tools and general hardware (ISIC 2593).

For the two samples on China, individual modern factories were defined as either using power tools or having above 10 employees. This choice is partly based on the better availability of data, partly on the premise that modernization is to a large extent driven by modern factories, and partly because handicraft (also including family labour) may follow different colocation rules.

Table 1. Concordance of Chinese manufacturing sectors to ISIC Rev 4

ISIC Revision 4 Sector	China 2002 Classification
1071, Manufacture of Bakery Products	1411, Manufacture of Pastry and Bread 1419, Manufacture of Biscuit and Other Baked Foods
1393, Manufacture of Carpets and Rugs	1759, Other Textile Made-Ups Manufacturing
2431, Casting of Iron and Steel	3210, Iron Making 3220, Steelmaking 3230, Rolling Steel Processing 3240, Ferroalloy Smelting
2593, Manufacture of Cutlery, Hand Tools and General Hardware	3422, Hand Tools Manufacturing 3429, Other Metal Tools Manufacturing

Given this choice of modern factories in these four sectors, it becomes important, before turning to the actual analysis, to provide an impression about the share of modern industry in total industry as that changes over time. Indeed, as pointed out, within those 4 sectors, the share of modern industry in both the Netherlands (1896, 2010) and Hunan (1954, 2004) was limited.

Calculating the coverage of modern factories in total industry in Hunan of 1954 is complicated since we do not have complete sectoral data and the sectors do not 100% match the 2002 or ISIC classifications. As regards to the classification, since we have individual factory data for 1954, we can match them directly with the ISIC classification. Yet, calculating that share in total factories and total labourers in each sector is impossible since (a) the sectors of the data not in our sample do not match ISIC completely, and (b) the handicraft industry is not completely subdivided in sectors. To solve the change in sectoral composition, we took the sector that resembled closest the sectors of interest from Hunan Provincial Archives, i.e. for ISIC sector 1071 we took the rice and wheat grinding sector, for ISIC sector 1393 we took the daily cotton textile industry (日用棉纺), for ISIC sector 2431 we took the iron and steel smelting industry (钢铁冶炼) and for sector 2593 we took the metal products for daily life industry (日用金属制品). To solve the second problem, that is the lack of information on the spread of handicraft industry over sectors, we used the distribution by sector of workshops under individual ownership in our sample as a proxy. For 2004 we use the 2004 economic census, which covers all factories, excluding self-employed, even though that is relatively small.

Table 2. Share of modern factories and labourers in total number of factories and labourers by sector in Hunan, China[1]

	% in our sample			
	1954		2004	
	Labourers	Factories	Labourers	Factories
1071, Manufacture of Bakery Products	45.8%	12.5%	91.5%	53.1%
1393, Manufacture of Carpets and Rugs	23.1%	0.5%	99.6%	78.3%
2431, Casting of Iron and Steel	9.5%	0.5%	99.1%	47.1%
2593, Manufacture of Cutlery, Hand Tools and General Hardware	28.0%	0.6%	99.4%	49.0%

For the Netherlands, we did compose a similar dataset for two different benchmark years. For 1896, we relied on the Dutch municipal reports, reports composed by the municipal government and which reported e.g. on the number of larger factories operating within its municipal borders. Large factories in these reports were defined as an establishment which employed at least 20 employees. By a comparison of this dataset with the occupational records in the population census of 1899, it appears that these reports adequately captured most of the larger factories in the Netherlands. By individually attributing each of the larger factories' their description in these reports to the most fitting sector in the 4th revision of the ISIC classification, we were left with a total number of observations of 189.

Furthermore, since the company names were provided in the municipal reports, we were able to retrieve the addresses and coordinates of these companies by matching them with a multitude of historical sources such as address books, private company archives, advertisements in local newspapers, and others. All in all, our sample of the Netherlands around 1896 compromised an equal or higher share of modern companies in its total employment than Hunan in 1954 (see table 3), with the exception of

[1] *Notes*: For 1954, we selected the following sectors: 1071 or bakery products (rice & wheat grinding), 1393 or daily cotton textile industry (日用棉纺), 2431 or iron and steel smelting (钢铁冶炼), 2593 or the manufacture of metal products for daily life (日用金属制品). Additionally, the sample of 2004 excludes self-employed employment. *Sources:* Hunan Provincial Archives, File No:187-1-108, The statistic of State-owned, Local government-owned, joint public-private and private industrial enterprise of Hunan in 1954 (湖南1954年国营、地方国营、公私合营、私营工业统计). For 2004, we used the Economic Census.

bakery products as in the Netherlands the manufacturing of bread was more dominated by smaller bakers and, contrary to the Netherlands, bakery products were a luxury product in Hunan.

Table 3. Share of modern factories and labourers in total number of factories and labourers by sector in the Netherlands

	% in our sample			
	1896		2010	
	Labourers	Factories	Labourers	Factories
1071, Manufacture of Bakery Products	3.69%	0.54%	55.49%	12.53%
1393, Manufacture of Carpets and Rugs	20.17%	11.11%	89.53%	82.35%
2431, Casting of Iron and Steel	32.55%	27.17%	93.90%	19.74%
2593, Manufacture of Cutlery, Hand Tools and General Hardware	22.97%	7.46%	66.03%	14.89%

For 2010, we relied on the extensive LISA dataset of 2010. This privately-composed dataset documented on the establishment level, rather than the Dutch Statistical Office data which document exclusively on the company level. Although this survey did not cover all businesses in the Netherlands, it did succeed in capturing the majority of the larger establishments, especially for the manufacturing sector, including their location.[2] To make a comparison between the sample of 1896 possible, we only included all establishments where at least 20 employees were registered. For classifying these companies in sectors, the LISA dataset used the *Standaard Bedrijfsindeling* or SBI which is a specific Dutch classification system but did not diverge much from the ISIC classification system. Therefore, attributing the most fitting SBI sectors which matched the ISIC sectors as close as possible did not meet much issues of conversion, as reported in table 4. Thus, we were left with our sample of the Netherlands in 2010 at 149 observations.

Table 4. Attribution of Dutch manufacturing sectors to ISIC Rev 4

ISIC Revision 4 Sector	Dutch SBI 2008 Classification
1071, Manufacture of Bakery Products	1061, Manufacture of Grain Mill Products 1062, Manufacture of Starches and Starch Products
1393, Manufacture of Carpets and Rugs	1393, Manufacture of Carpets and Rugs
2431, Casting of Iron and Steel	2451, Casting of Iron 2452, Casting of Steel
2593, Manufacture of Cutlery, Hand Tools and General Hardware	2571, Manufacture of Cutlery 2572, Manufacture of Locks and Hinges 2573, Manufacture of Tools

[2] See the general guidelines and information regarding the LISA dataset, or *LISA-HANDBOEK Definities, protocollen en achtergronden van LISA (edition March 2015),* pages 6 – 7.

Using our four samples of factories in the Netherlands and Hunan in each of these four sectors, we apply the Duranton and Overman (2005) method. First, we select the relevant observations. We consider all the establishments in each industry and distinguish between new entrants and existing establishments. Second, to assess the concentration of new entrants with respect to their industry, we calculate the Euclidian distance between every pair of entrants. For an industry with n entrants, there are $n\ (n - 1)$ unique bilateral distances between entrants. Third, because these Euclidian distances are only a proxy for true physical distances, we kernel-smooth to estimate the distribution of bilateral distances. More specifically, denote by di,j , the Euclidian distance between establishments i and j. With n entrants, the estimator of the density of bilateral distances (henceforth K-density) at any distance d is:

$$(1) \qquad \hat{K}(d) = \frac{1}{n(n-1)h} \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} f\left(\frac{d - d_{i,j}}{h}\right)$$

where h is the bandwidth and f is the kernel function. All densities are calculated using a Gaussian kernel with optimal bandwidth (Silverman 1986).[3] The histograms represented in Figures 3 - 6 and 9 - 12 plot these densities for our four illustrative industries.

3. Measuring Agglomeration in the Netherlands

Figures 1 - 2 map the location information for the four selected industries in 1896 and 2010 respectively, where each dot represents a manufacturing establishment in the Netherlands. The first observation we can make when comparing figure 1 and 2, is how the dots are more spatially dispersed in 2010 compared to 1896. Clearly, agglomeration seems to have played a larger role in 1896 compared to 2010. This statement seems to hold even more ground, when taking into account the lower number of observations in 1900 (n = 189) compared to the number of observations in 2010 (n = 149).

However, when we take a look at the sector level, it seems there was a large variation over sectors. In 1896, carpets & rugs sectors (1393), iron & steel (2431), and cutlery (2593) seem to have been more concentrated while the bakery products sector (1071) seems to have been highly dispersed over the territory of the Netherlands. Iron & steel (2431) and cutlery (2593) seem to be located in different clusters, mainly around the IJssel river in the east and the Maas river in the west. In contrast, we can find how bakery was highly dispersed, mostly concentrating around the larger Dutch cities. In 2010, we find how all four selected sectors appear more dispersed over the Dutch territory. Based on both maps, it thus appears that that agglomeration was stronger in the Netherlands in 1896 than in 2010. In order to confirm this, we calculated the k-densities of each sector and compare the results of 1896 and 2010 over sectors.

[3] More specifically, following Section 3.4.2 of Silverman (1986).

Figure 1. Location of Factories in the Selected Sectors in the Netherlands (1896)

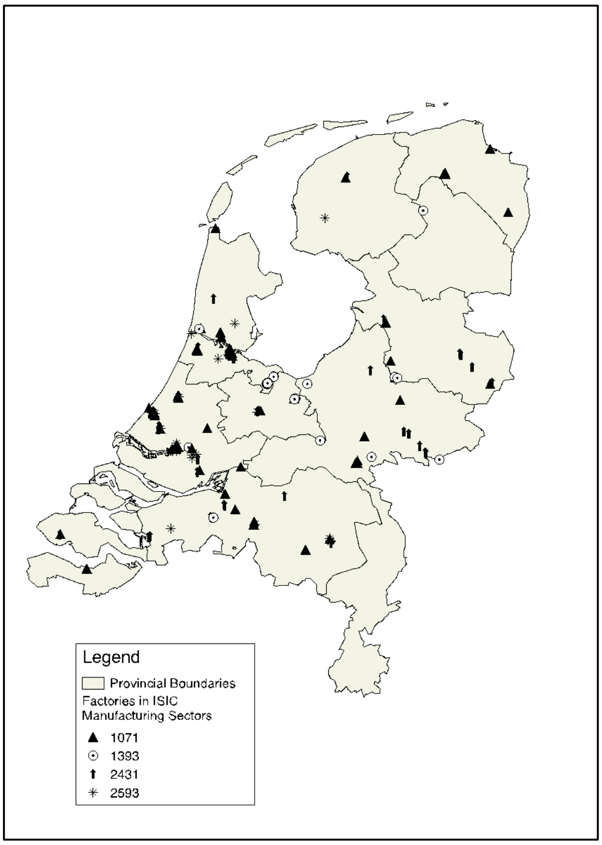


Figure 2. Location of Factories in the Selected Sectors in the Netherlands (2010)

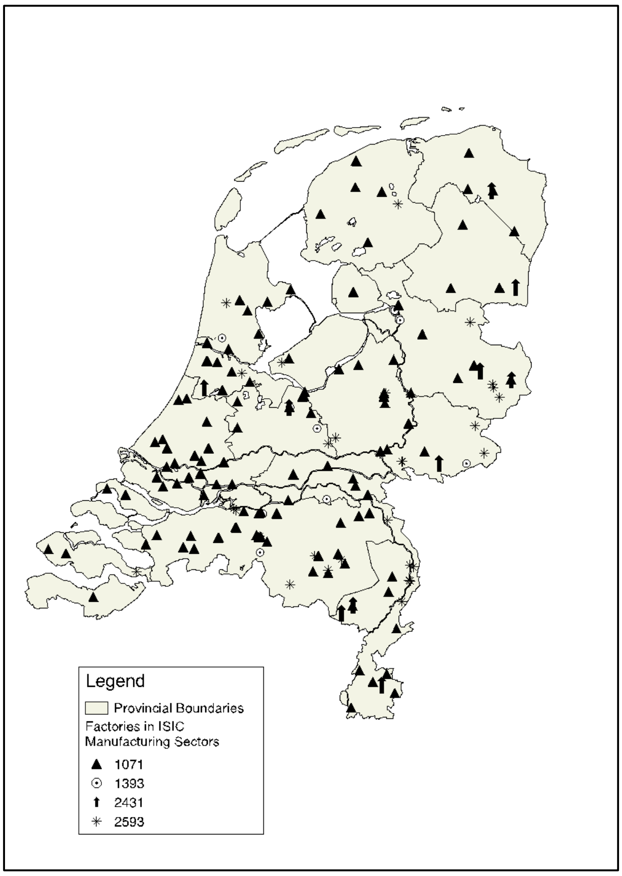
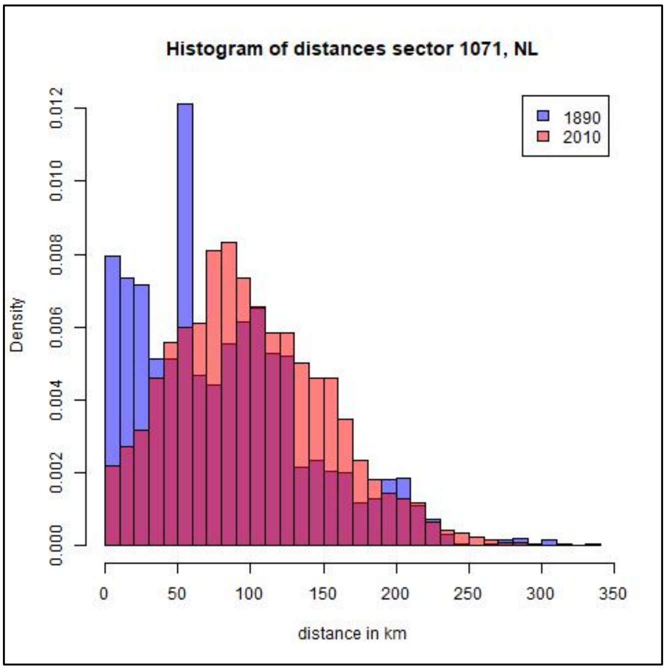


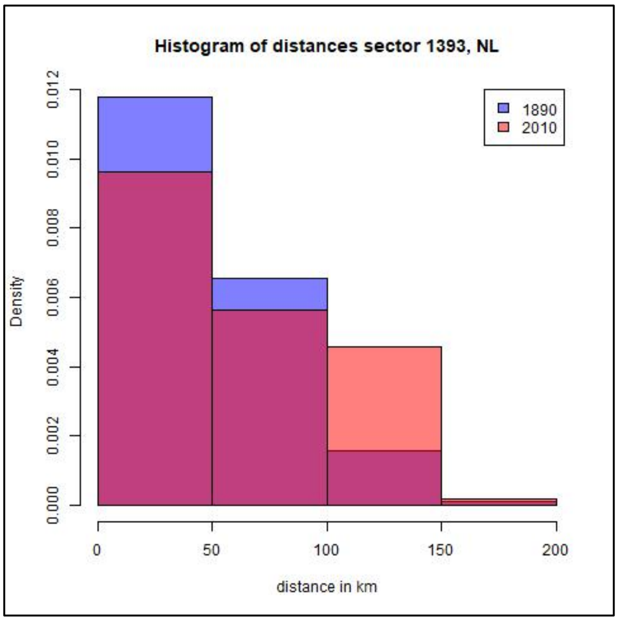
Figure 3. Agglomeration in the Manufacture of Bakery Products (ISIC 1071) in the Netherlands



First, we reported in figure 3 the k-densities of bakery products (ISIC sector 1071). De Jonge (1968: 218 - 219) and Van Zanden (1996: 82) described how the market for bread (the most purchased bakery product at that time) in the 19th century Netherlands, was highly fragmentized over regional markets. Retail trade was supplied by small local producers and a real market for bread was small to non-existent, due to high transportation costs for flour and thus less open for economics of scale. One of the larger factories of our dataset, compromised a bakery within military barracks, as the Dutch navy and army was one few bulk purchasers of bread. This explains not only the low market share of factories in table 4 by 1896, but also why we find so much bread factories dispersed over the map of 1896. Although no real clusters existed in this market, we still find the majority of factories located close to each other in figure 3 since the larger factories mostly operated in the urbanized, populous, western part of the country within a small selection of large cities such as Rotterdam, Amsterdam, Haarlem, and the Hague.

Due to the fall of transport costs during the 20th century, we do find a more integrated, larger market for bread both larger and smaller manufacturing companies in 2010 in general. But mainly for the larger companies, the bread market became more specialized over the 20th century, where next to bread other products rose in importance, creating a less homogenous market. Indeed, the market share of larger companies went up from 0,5 % of the total market to 12,5 % of the total market in 2010. We can observe in figure 3 that this evolution led to a lower share of closely located enterprises (companies located within less than 50 kilometres) and a higher share of more dispersed enterprises (companies located further than 50 kilometres). Due to a fall in transport costs and a lower advantage of moving its business operations close to a city centre, establishments in this sector thus became less agglomerated over the 20th century.

Figure 4. Agglomeration in the Manufacture of Carpets and Rugs (ISIC 1393) in the Netherlands



By 1896, the Netherlands was still in the middle of its industrialization process (De Jonge 1968; Jansen 1999), with increasing numbers of operating steam engines and a continuous specialization and scale expansion. The manufacture of carpets and rugs were still performed by smaller handicraft companies or even by domestic producers, although larger factories took increasingly over their market share. By 1896, one cluster emerged in the outskirts of Hilversum, a minor city in the vicinity of Amsterdam: 13 of the 29 carpet factories were located in this city while an additional 4 factories operated in its direct neighbourhood, in the smaller, nearby villages of Naarden en Laren. In local historical journals, this small city was even dubbed as the Dutch 'carpet city' (Van Mensch 1979; Pelgrim 1997), although both publications did not verify how large the city's share was relative to the total carpet industry.

Therefore, it is no surprise to find a far larger k-density of this sector in figure 4, compared to the bakery manufacturing sector. A smaller nearby cluster was the city of Amersfoort and the city of Deventer, in the Eastern Netherlands where the textiles sector was of great importance to the regional economy (e.g. Hendrickx 1993). By 2010, this Hilversum cluster had completely disappeared from the map with not a single carpet factory being active within its boundaries. While at present, another cluster has emerged in Genemuiden, with 5 out of a total of 15 factories it failed to reach the relative height that Hilversum once took. Therefore, it is no surprise that we again find an increasing dispersion in this sector, just as with the manufacturing of bakery products.

Figure 5. Agglomeration in the Casting Iron and Steel (ISIC 2431) in the Netherlands

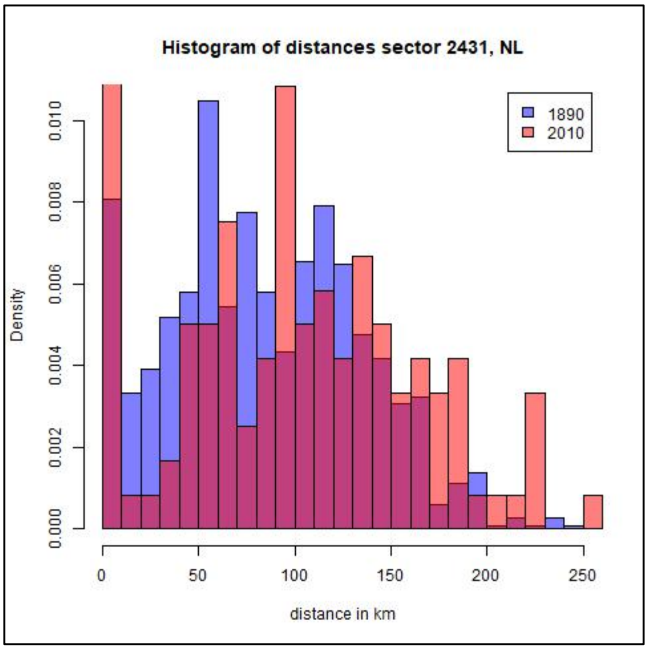
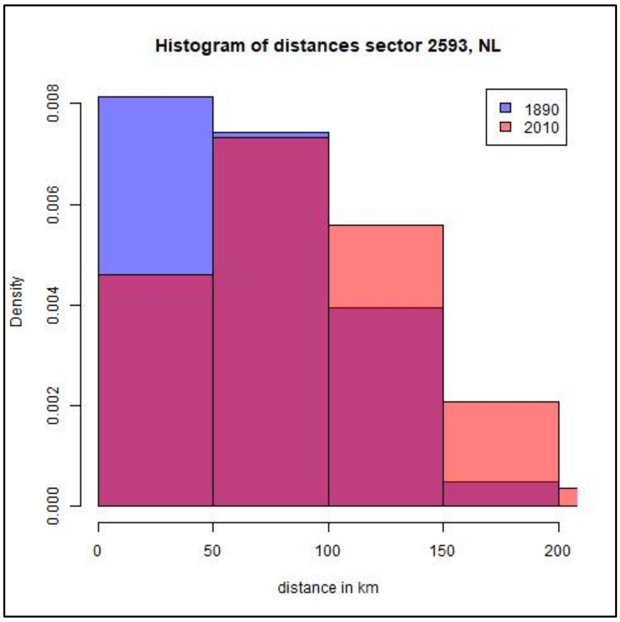


Figure 6. Agglomeration in the Manufacture of Cutlery, Hand Tools and General Hardware (ISIC 2593) in the Netherlands



Lastly, the metallurgy sectors of 2431 (casting or iron and steel) and 2593 (manufacture of cutlery, hand tools, and general hardware) seem to have endured a highly comparable evolution. In iron & steel, two cluster emerged around the middle of the 19th century: one near the IJssel river in the east of the country (Smit and Straalen 2007) and one in the outskirts of the city of Amsterdam. Similarly, in cutlery, a cluster emerged around Rotterdam and its nearby regions of Ridderkerk and Nieuw-Lekkerland. While 8 of the 28 factories in cutlery were located in the Rotterdam cluster, 8 of the 46 factories of the iron&steel sector were located in the IJssel cluster. Since the size of both clusters influenced greatly the agglomeration as measured by the k-densities of the left parts of figures 5 and 6, it appears that iron&steel was more agglomerated than cutlery by 1896. Moreover, both clusters were ideally located near water, as this was required for the production process of both sectors, and a transport facility of either a navigable waterway or a railway. Somewhat dispersed over the rest of the country, we find companies of both sectors in other regions as well.

However, by 2010, the agglomeration within the sectors seemed to have decreased, just as with bakery sector or the carpets and rugs sector. Rather than the result of an increasing dispersion as in the bakery sector, this was the result – just as with carpets and rugs – of a disappearance of the clusters in 1896. In Rotterdam and Amsterdam, not a single iron casting or hardware manufacturing company remains today, while in the IJssel cluster only one iron casting company remains: *Lovink Technocast B.V.* in Terborg which houses at present 201 employees. But contrary to the carpets and rugs sector, no recent cluster emerged in neither iron and steel casting or cutlery.

4. Measuring Agglomeration in Hunan

Much alike the Netherlands at the start of the twentieth century, Hunan was at the middle of the 20th century at the start of its industrialization process, with increasingly extracting labour from the agricultural sector into the industrial sector. Being a closed off area, surrounded on three sides by mountains and facing a large lake on the north, its economy was mainly based agricultural cultivation and on the utilization of its wide distribution of small iron ore deposits. This lead to the indigenous rise of handicraft industries mainly on food processing, cotton and ramie textiles, and metal utensils industry. During the Westernization Movement in the 19th century, rich nonferrous metal deposits were discovered and mined in Hunan and metallurgy became the earliest developed modern industry.

After the beginning of the war of resistance against Japan in 1937, due to the already existing metal industry and its sheltered location, some sectors of a strategic importance, such as machinery, were moved to Hunan by the central government. During this period the urban region with cities like Changsha and Xiangtan (actually the birthplace of Mao Zedong) developed local industry and commerce while in Hengyang and Zhuzhou became manufacturing centres of the most important strategic goods. Especially, Hengyang experienced a rapid development in manufacturing caused by the westward shift of the political, economic and cultural centre of the central government due to the war. In 1943, Hengyang had even developed into the second large industrial city in China with a population of around 1 million.

After a decline during the period of the Chinese civil war (1945-1949), during Mao's times, with Mao being born in this province, the industrial development in Hunan obtained further political significance. For instance, in the 1st 5-year plan, Zhuzhou was listed as one of the 8 most important industrial cities in China, 4 key projects built by the Soviet Union, and more than 20 enterprises directly under the central ministries or provincial enterprises were arranged to be built there. Being a focus in the 5-year plans, added with significant backing by the central government, caused a rapid recovery from the depression of the war years and was the basis of subsequent growth. Indeed, the first set of 4 5-year plans focused on the past strengths of Hunan, i.e. self–sufficiency and supplying the possible front line with civil and military products. This was advanced by restarting factories that once stopped production due to the wars, establishing some new factories and moving factories from other provinces to Hunan. This complete industrial system, which covered 39 out of 40 industrial sectors recorded by the national statistics, has maintained by and large until today.

Figure 7. Location of factories in the selected sectors in Hunan, China (1954)

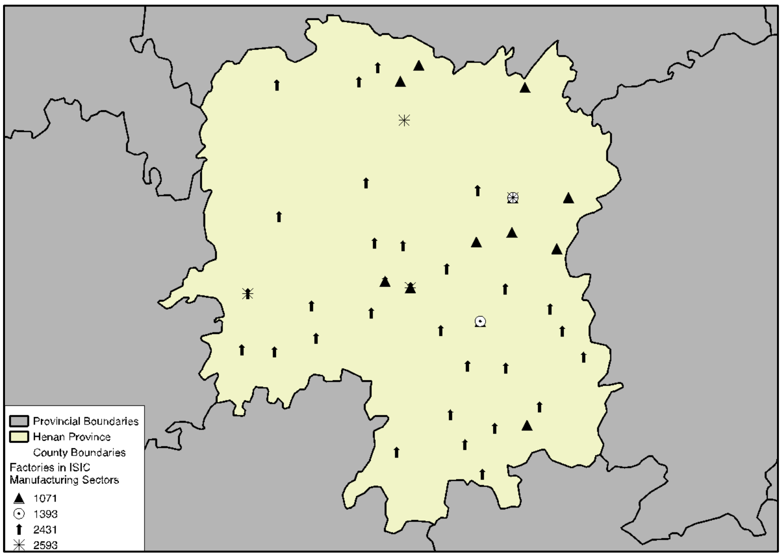
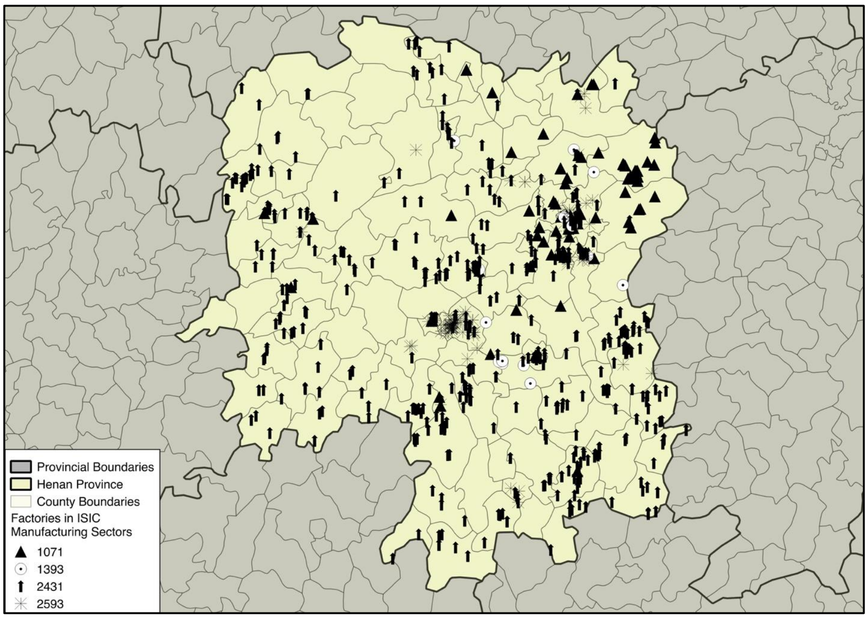
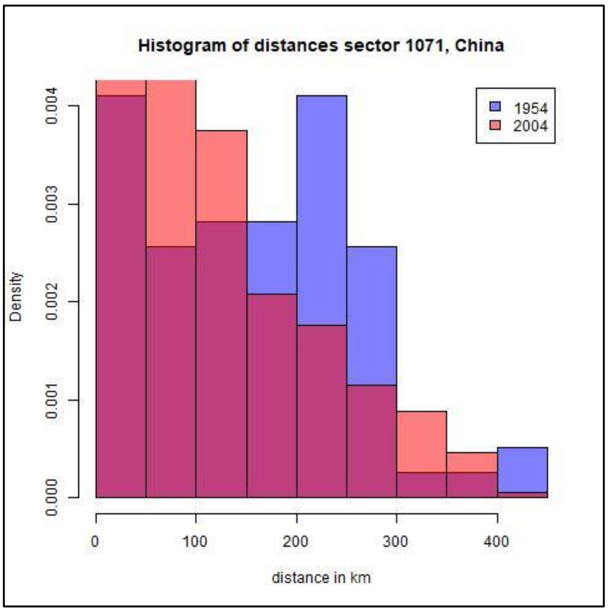


Figure 8. Location of factories in the selected sectors in Hunan, China (2004)



Indeed, looking at figures 7 and 8, we can witness quite some persistency over time. First, figure 7 of our earliest sample, 1954, was only the second year of the first 5-year plan and, consequently, it shows largely the inheritance of the Westernization movement and he Nanjing government. Indeed, one way of looking at it is the ownership type, which was close to 65% pure private in modern industry in 1954, which was a bit high compared to the nevertheless ca. 40% in 2004. Second, the Changsha-Zhuzhou-Xiangtan Economic Zone and Hengyang-Loudi-Shaoyang triangle had the highest densities of industrial factories in both years. This becomes also clear when looking at the individual sectors where the main producing areas did not change that much either.

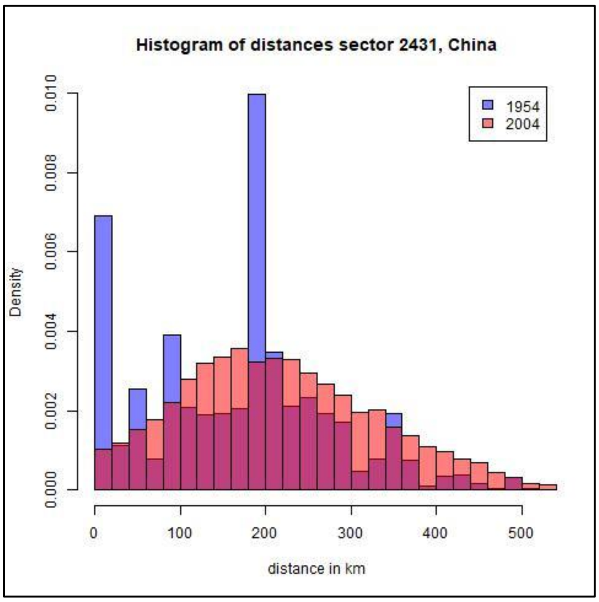
Figure 9. Agglomeration in the Manufacture of Bakery Products (ISIC 1071) in Hunan, China



As for the bakery sector, it was located mainly in two clusters with one being alongside the Dongting Lake Area including Changde, Yiyang and Yueyang, which was (and still is) a producing area of grains. The other cluster is the Changsha-Zhuzhou-Xiangtan Economic Zone, which was the most prosperous urban area of Hunan. In these cities, a large, and relatively prosperous population amounted to a large market for bakery products. In addition, many surplus rural labourers that went to large cities to make a living functioned as labour resources. This dual pattern can to some extent be observed in figure 9, which shows for 1954 a dual peak around 0-50 km and around 200 km.

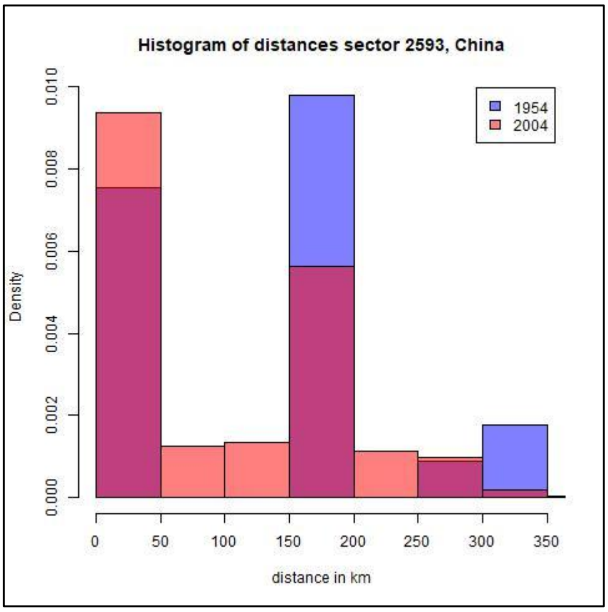
This pattern with two producing areas stayed in existence until today, but their relative importance changed. Over time, increasingly factories were built close to Changsha-Zhuzhou-Xiangtan Economic Zone while growth around the Dongting Lake Area stagnated thus removing the dual peak structure (around 200-250 km). An explanation may be that today the benefit of proximity to raw materials is increasingly exceeded by other advantages such as investments, demand markets, management, and technology. First, because of lowering transport costs. Second, with the relatively fast improvement of urban living standard, big cities with a larger market and abundant labourers attracted more investment in a wide range of industrial sectors, including bakery industry. Third, for bakery industry, it is also important to guarantee the freshness of products and increase value added by leading the fashion trend by product innovation and exquisite product designs.

Figure 10. Agglomeration in the Casting Iron and Steel (ISIC 2431) in Hunan, China



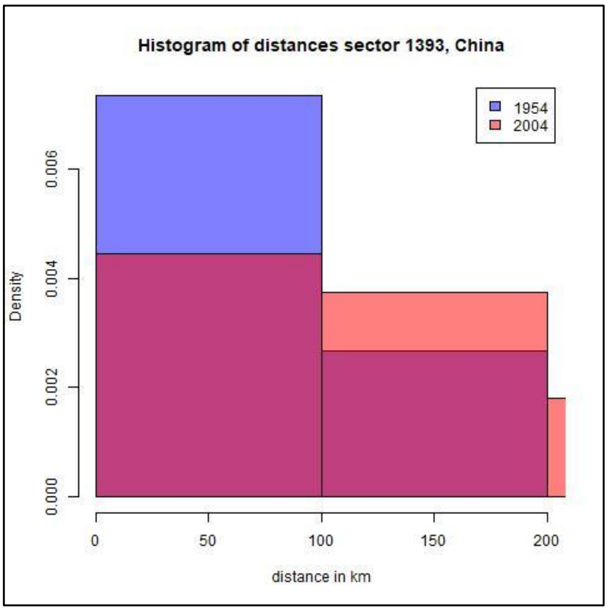
As pointed out, before, Hunan had a history in basic metals, especially nonferrous (i.e. other than iron and steel). Iron and steel smelting factories were thus scattered all over the province but modern industry was mainly concentrated in Changsha-Zhuzhou-Xiangtan Economic Zone and Hengyang to supply materials for other industries (such as machinery, auto and auto parts) and Loudi area due to the abundant coal, iron ore and limestone which were important raw materials for iron and steel melting. Furthermore, these regions had convenient railway transport conditions as well as access to skilled workers, something that had accumulated during their long history with iron smelting industry. In the 12th five-year plan (2011-2015), the high-quality steel processing industry cluster was still located in Xiangtan, Loudi and Hengyang. Using the supply of the iron and steel smelting industry, the main producing area of metal products for daily life overlapped with the core production base of iron and steel smelting industry (see figures 10 & 11).

Figure 11. Agglomeration in the Manufacture of Cutlery, Hand Tools and General Hardware (ISIC 2593) in Hunan, China



As pointed out, this patterns hardly changed up to the present. Indeed, current leading enterprises were all established in the early stages of New China. But we need to notice that according to the histogram of distances, the distribution of iron and steel factories becomes more and more uniform because in 1950s a large percentage of small iron works were handicraft workshops and were not included in statistics (only 9.5% of all labourers were working in modern factories in this sector according to Table 2) and gradually they grew into small factories today.

Figure 12. Agglomeration in the Manufacture of Carpets and Rugs (ISIC 1393) in Hunan, China



The most dispersed sector in the 1950s was textiles with many small companies and only a handful modern ones located mainly in the Changsha-Zhuzhou-Xiangtan Economic Zone. Yet, over time, more and more home cotton textile companies went to grow into core enterprises such as Mengjie, Duohia, and Wan'an. Part of this process of increasing textiles may be explained by the modernization of industrial structure in nearby province of Guangdong thus pushing textiles to its more rural hinterland, i.e. southeast counties of Hunan. This trend is clearly reflected in Figure 12 with distances among factories increasing substantially since the 1950s.

From above discussion about Hunan, it becomes clear that, even though certain changes occurred, the basic pattern of 1954, and hence of the pre-New China period, persisted to some extent. But how could this have occurred even though a change to a state-led system occurred in the 1950s and another transition back to a market economy in the 1980s? As mentioned, Hunan's modern industrial foundation and framework were built in the early stage of New China and most of the enterprises started and operated under the strong support from the government. The only thing that companies needed to think about was production. The sale, the cost, the price, raw materials and human capital were what the government should plan for. Yet, after government planning was reduced, economic rationality became once more a prime concern for these enterprises. So, the explanation for the path dependency should be that, to some extent, economic rules about industrial distribution were taken into account when the government made a decision about the establishment of a company. The matching between the government's decisions about the location with economic rules created potential for their survival after the reforms.

Perhaps the clearest example is provided by the iron smelting industry where the government motivation to build new factories was undeniably strategic. For example, the establishment of the Henyang steel factory in Henyang was, besides for the supply of steel to other key industries such as machinery, auto parts, and electric equipment, also aimed at the amongst others 12 state-owned nuclear industry factories that were moved there. Another example is the Xiangtan Iron and Steel Company, which was planned under the national strategy to improve the industrial production in hinterlands and shift the economic centre of the country from the coast to the hinterland.

Yet the strategic reasons for setting up these plants did not deter the government of taking a more economic-pragmatic approach to their location. For example, the Xiangtan Iron and Steel Company was located in Xiangtan for having sufficient water and electric power that were necessities for iron and steel smelting, as well as a geographical advantage for the transport of raw materials and final products as one of the most important railway lines connecting Beijing and Guangzhou had a stop there. Moreover, located in Changsha-Zhuzhou-Xiangtan capital economic zone, it had access to resources such as human capital and infrastructure. From the perspective of demand side, there was a huge demand of steel caused by an industrial cluster of auto and auto parts in nearby Changsha and the biggest national production base for rail and electric locomotive equipment in Zhuzhou. Likewise, the establishment of Lianyuan Iron and Steel company was aimed to cater to local demands and was decided by the provincial government based on the comparison of related natural resources with other four alternative places including Youxian, Shaoshan, Laodaohe (Changsha) and Dajiangkou (Xupu). According to the investigation, the other four options failed to be chosen because of the lack of either coal, iron, water or inconvenient transportation. But economic pragmatism did not always stretch very far. The Henyang steel Company, for example, was built to supply iron and steel to nearby industry despite there was a lack of resources. A large amount of raw materials was transported to Hengyang via railway for example, coal from Shanxi, billet from Tangshan, Anshan and Xiangtan while large steel enterprises in Anshan and Shanghai offered training service for its workers.

It has also been argued that at all times Hunan's industry has been small scale and scattered. Whether this scattered nature is the cause or consequence of being small scale is uncertain but it is clear that the government policy, implemented since the 6th 5-year plan (1981-85), of focusing on productivity rather than scale met with limited success in Hunan. Obviously, the government pursued various policies such as using profit contracts instead of direct administrative control, and encouraging enterprises to combine with declining and newly rising companies to adjust the production mix based on new demand thus enhancing their capability to join in market competition. Yet, government-enacted large companies remained low productive facing, compared to other provinces, limited resource endowments and imperfect transportation. Later, some of them were purchased by individuals or introduced private investment during the Reform of State-owned Enterprises. This development led Liu to argue that the dispersed allocation of resources of Hunan since 1950s was responsible for the current industrial dispersion.

5. The Role of Transportation Costs

As pointed out, this pattern of dispersion over time can obviously be linked to a great many initial factors such s education, presence to raw materials etc. Likewise, it may be linked to intermediate variables such as the creation of specialised skills. Yet, in this paper we will look at the indicator that links all explanatory variables together, i.e. transportation costs. Indeed, transportation costs play a central role in location theory, since its inception by Von Thünen (1826) and Weber (1929). Both models are based on the assumption of a static situation with given transport costs, given transport technology and given transport networks. Dynamics in the interaction between location and transport costs was introduced by Krugman (1991), who modelled the interaction between forces of agglomeration and dispersion and often referred to as a core-periphery model. Agglomeration is strengthened by different sources of increasing returns to scale caused by the effects of high fixed costs, technology spill-overs and pools of skilled labour, while dispersion is motivated by lower wages and different proximities to markets. Krugman (1991) found that at low transport costs, firms that enjoy economies of scale will be concentrated in one place, since no dispersion factors are in action. In the opposite situation, with high transport costs, that may counterbalance the effects of economies of scale and lead to an even dispersion of industries.

Krugman's core-periphery model is especially applicable to the problem discussed in this paper for two reasons. First, we compare different periods in both geographical regions, hence transport costs cannot be assumed constant. Second, we compare industries with different degree of possible economies of scale. Sectors 2431 (Casting of Iron and Steel) and 2593 (Manufacture of Cutlery, Hand Tools, and General Hardware) have higher fixed costs in comparison to sectors 1071 (Manufacture of Bakery Products) and 1393 (Manufacture of Carpets and Rugs). Possibly, the first mentioned sectors also enjoy more benefits from a common labour pool. Hence, the core-periphery model suggests that as transport costs decrease, agglomeration had to be stronger in the former than in the latter sectors.

In order to test these theoretical assumptions, we decided to calculate the averages and standard deviations of distances to both factories of the same sector and nearest transport networks. For the average distances of companies of the same sectors, we calculated both the average and standard deviation of the geographical distance of a manufacturing establishment to the nearest other manufacturing establishment of the same sector. We repeated this calculation over the four manufacturing sectors. Based on the topographic maps of both China and the Netherlands, we calculated the average distance to the nearest transport facility, to proxy the effect of transport networks over our samples. This process was repeated for the following six transport networks: railroad, primary road, secondary road, navigable waterway, and non-navigable waterway. Lastly, we attempted to proxy centres of economic activity, by calculating the distance to the nearest municipality city centre in the Netherlands and the nearest county capital city centre of China.

Table 5. Average Distance (in kilometres) to Nearest Transport Facilities of Factories in the Netherlands

	1896		2010	
	Mean	**Standard Dev.**	**Mean**	**Standard Dev.**
Average distance to nearest factory in sector 1071	81,32228	58,46535	100,08404	52,82788
Average distance to nearest factory in sector 1393	40,58296	39,54054	57,50176	48,97241
Average distance to nearest factory in sector 2431	84,07123	50,11001	100,35734	62,48203
Average distance to nearest factory in sector 2593	63,42791	44,43014	89,74787	49,27996
Average distance to nearest railroad	2,12346	3,90440	5,65992	6,40616
Average distance to nearest primary road	1,53820	3,47505	1,65176	1,69204
Average distance to nearest secondary road	0,53695	0,68342	0,26656	0,25163
Average distance to nearest navigable waterway	4,40365	4,90239	7,86544	7,19499
Average distance to nearest non-navigable waterway	0,82858	1,16403	3,48656	5,03520
Average distance to nearest municipality city centre	1,63047	1,67099	3,38576	2,03182

As discussed in section 3, it appears that the inter-firm distances have increased in the Netherlands over the 20th century based on our results in table 5. There appear to be large regional differences in this dispersion pattern. As sector the bakery sector (1071) was already quite dispersed in the Netherlands in 1896, here the relative difference appears to have been low. In sector 2431, 1393, and 2593, we have seen that the clusters in these sectors disappeared over the 20th century. Hence, agglomeration, proxied by the inter-firm distances, seem to have been decreased during 1896 – 2010 in these four sectors. Scale expansion seem to have been a major reason for this, as in all four manufacturing sectors a small number of larger firms took the manufacturing activities over what in the 19th century has been done by many small and medium enterprises (see section 2).

However, transport costs seem to explain a great deal of this pattern as well. From table 5, it appears that the distance to the nearest transport facility was the distance to the secondary and primary road. It stands without doubt that at the end of the 19th century, the most common used way of transporting manufacturing goods, especially non-bulk goods, were roads in the Netherlands. This was the result of a well-intended economic policy of the Dutch government: until the middle of the 18th century, the Dutch government mostly invested in larger transport infrastructure, using most of its assets for financing the construction of large canals and maintaining access to the sea from its ports in Amsterdam and Rotterdam (Van Der Voort 1994: 173). However, during the 19th century, increasingly more of the public finance was provided for the smaller municipal governments, intended to construct and maintain these smaller, secondary roads for raising local economic development.

For bulk goods, navigable waterways in the Netherlands were the most preferred, given the well-maintained system of canals of minor rivers. After the late 1830s, when the first railroad between Amsterdam and Haarlem railway was opened in 1839, it faced more and more competition from the bulk rail transport. Although the railway construction process would peak after the 1860s – 1870s, railroads were still used more for passenger transport than bulk transport in 1994 (Van Der Voort 1994: 155). Especially for sectors 2431 and 2593, transport of railroads and larger waterways were important for transporting the goods while railroads were also often used for transporting the employees. Therefore, it is no surprise that the average distance of the factories in these sectors were located closer to the railroads and waterways than the other sectors. Additionally, since the production process of metal products required the use of water, the distance to waterways was a handy to necessary bonus as well. Most exemplary in this perspective is probably the iron casting cluster around the Ijssel river, where all factories were located very close to the nearby railroad and Ijssel river (Smit and Van Straalen 2007). Similarly, sectors 1071 and 1393 were located closer to the municipality centre than sectors 2431 and 2593, as the factories in these sectors benefitted more from the closeness to an establishment of retail trade.

Comparing the nearest distances from firms to transport facilities in 1900 to 2010, it seems that the average distances to almost all facilities decreased. The distance to waterways, both navigable and non-navigable – decreased most spectacular, and the distance to railways as well. In contrast, the distance to primary roads increased not as drastically as railroads and waterways, with the distance to secondary roads even decreasing. Thus, it seems that the fall of transport costs, as argued by Krugman (1991) is confirmed: while the relative cost of railway and waterway transportation remained constant, the relative cost of road transportation caused a shift during 1890 – 2010 in the location of industry in the Netherlands. In addition, it seems that the distance to municipality city centres decreased as well: while enterprises preferred to locate near city centres for an easy accessibility to both input goods and retail trade, due to easy transportation from its labourers in 2010 this doesn't seem to matter anymore. To summarize: while in 1890, industry companies preferred a location near waterways, roads and railroads depending on the manufacturing sector, while in 2010 the location of an industrial company depends solely on the accessibility of roads.

Table 6. Average Distance (in kilometres) to Nearest Transport Facilities Factories in Hunan (China)

	1954		2010	
	Mean	**Standard Dev.**	**Mean**	**Standard Dev.**
Average distance to nearest factory in sector 1071	155,85685	107,07773	125,39766	95,12594
Average distance to nearest factory in sector 1393	40,10955	68,84869	111,60895	83,60503
Average distance to nearest factory in sector 2431	167,07239	109,7525	216,84391	113,11886
Average distance to nearest factory in sector 2593	123,6375	109,18804	99,65899	91,35985
Average distance to nearest railroad	64,72749	66,16277	21,60298	25,36910
Average distance to nearest primary road	12,47876	16,78422	13,38859	15,94803
Average distance to nearest secondary road	5,13344	3,35398	3,93608	4,94078
Average distance to nearest navigable waterway	35,80850	33,00732	14,83183	12,50518
Average distance to nearest non-navigable waterway	10,84617	8,89935	4,55811	4,79953
Average distance to nearest county city centre	19,48994	18,85012	15,12388	11,39469

The decision of the location of an enterprise is the result of the comprehensive cost comparison including the transport cost for raw materials and final products, labour cost, land price, and other transaction cost caused by institutions or for information seeking. Among all of these factors, during the start stage of New China, the most significant difference of each area lied on the transport cost for raw materials and final products because there were huge gaps in transport facilities between several transports centres and a wide area of inconvenient traffic as is shown in table 6 with the average distance to the nearest railroad being 64.7 km. Yet, besides national strategy playing an important role in making an industrial location plan, the government also took transportation into account. For large companies, either a new railways or roads were built to solve the transportation problems in target cities or, alternatively, industrial factories would be located in such cities that already had a certain access to transportation facilities explaining the over-all reduction in distance to transport facilities observed in Table 6. Yet, the caveat remained that the many small factories or manual workshops without enough influence on the government's planning of the construction of transport facilities, they had to make their own decisions according to the existing transport conditions. Some of them produced based on local materials and distance to sales markets while others tended to choose those areas with a convenient traffic that offered good connections among raw materials, production and consumer. As a result, there was a relatively high density of factories in major traffic arteries, no matter it was natural formed or planed due to strategic purpose. With the economic development, the clustering of factories spread along the traffic lines.

Currently, the gap in transport facilities among different areas has narrowed, mostly in terms of railways and main roads. Indeed, in China the adagio is widely accepted that "Want to be rich? Build roads first!". As a main method to help undeveloped areas out of poverty and to promote economic growth through investment, both country roads and expressways were extended at a rapid speed and became the most important logistics channel. In 2016, road transport accounted for more than 78% of the total freight volume. In hinterlands like Hunan, road transport carried much higher a proportion of freight traffic than this average level. In 2006, the proportion was around 85%, a figure that rose to 86,6% in 2009. Today, expressways have connected 115 counties and cities and it is expected that every county will be connected by expressway in 2020. Given the traffic conditions improved everywhere, if the transport cost is low enough, the transport cost will not be a factor that influence the location of factories any more as pointed out by Krugman. But the fact is despite that almost in the vast majority of areas there has been a convenient access to road transport, the transport cost is still high due to more institutional and organizational reasons such as expensive tolls and the underdeveloped logistics. Indeed, even though the ratio of total logistics cost to GDP showed a downward tendency from 17.8% in 2010 to 14.6% in 2016, it is still over twice that of developed countries such as US, Japan and Germany. For industrial enterprises, the average proportion of the logistics expenses of to the main business income was more than 8%, which was also much higher than the average level of the whole world.

Table 7. Turnover of freight traffic by means of transport (in 100 million ton/km)

	Hunan		**China**	
Year	**1950**	**2010**	**1954**	**2010**
By railroad	7.93	1068.12	932.48	27644.10
By road	0.10	1539.36	39.88	43005.40
By waterway	5.50	350.93	269.73	64305.30

The indirect costs of tolls, added with the congestions in traffic arteries, may explain why in Hunan the distance of a factory to roads hardly declined over time the way it did in the Netherlands while that the railroads and waterways (available in Hunan) remained their importance. Even today there is still a tendency for companies to remain closer to transportation lines. Indeed, based on an observation about the influence of traffic facilities such as railway and highway on the economy after the Reform and Opening-up, Banerjee et al. (2012) found that there was a higher density of industrial factories and a higher average benefit rate in those areas closer to the traditional traffic network in China which is what we also observed in Table 6. Consequently, high transport cost even today reduces the possibility for undeveloped areas to attract enterprises by offering low cost labour, land, and improved traffic conditions.[4]

In Hunan, it is obvious that in those traditional clusters of industrial factories such as Changsha, Zhuzhou, Xiangtan, Loudi and Hengyang had more comparative advantages as regards the trade-off of costs. These cities were close to raw material market or sale market that meant a relative low transport cost for enterprises. During a long period of development in certain industries, they had labour accumulations and due to the brand effect and scale effect, enterprises only needed to spend a relatively low information seeking cost. The convenient traffic strengthened their comparative advantages so it is very difficult for other places to attract industrial agglomeration unless they had other comparative advantages that could bring more benefits than the loss caused by the increasing transport cost, transaction expenditure etc.

6. Conclusion

Agglomeration and clustering of industries is important for both factory management as well as government policy. Various studies have analysed this topic in detail, even though most focused on the recent decade and on Western Europe and the USA. In this paper, we made an attempt to broaden our temporal and geographic scope. The temporal aspect is introduced by comparing the early and late 20th century together, allowing us to test if agglomeration did indeed decrease over time and what the role of transportation costs was in this process (Krugman 1991). Our geographic scope, covering both the Netherlands and China, allowed us to add test what the effect of other institutions and government policies were on this process of dispersion. Nonetheless, we must acknowledge that due to limitations in data availability, we exclusively made tests on four specific manufacturing sectors: manufacture of bakery products (ISIC 1071), manufacture of carpets and rugs (ISIC 1393), manufacture of casting of iron and steel (ISIC 2431), and manufacture of cutlery, hand tools and general hardware (ISIC 2593).

[4] Obviously, this also depends on other factors. Indeed, Jin (2012) showed that both developed areas and undeveloped areas benefited from the improvement of transport facilities, but enterprises still tended to gather in developed areas and an increasing gap between regions appeared.

Our results found indeed evidence for a process of dispersion over all sectors. Nonetheless, we found large differences over sectors: the effect of dispersion was notably lower in those sectors with the lowest economies of scale, more specifically in our results the manufacture of bakery products and the manufacture of carpets & rugs. This dispersion was caused partly by lower transportation costs, although partly the increasing returns to scale, as pointed out in the introduction, might have been multiplied by the positive effect of clustering as well. In the Netherlands, this dispersion process was caused due to the shift of the location of factories from railroad, road and waterway facilities to road facilities thanks to the improved road network over the 20th century. Instead, China did experience a similar process, though muted by government intervention combined with relatively high indirect transportation costs.

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