Urbanization and Transportation in Finland, 1880–1970

The history of railways and roads is studied extensively in a number of fields because of its relevance to social development. Nonetheless, even though the importance of transport infrastructure is widely recognized, only recently have historical researchers attempted to investigate how transport systems affect society. Most of this research, however, focuses on the transportation infrastructure solely as a means of connecting people, markets, and resources, not on the differential effects of its accessibility. Since accessibility is a spatial concept referring to distance in terms of travel cost, typically measured either by physical distance or by time, it is fully amenable to analysis with geographical information systems (GIS). By combining the trends of population change and measured accessibility with statistical analysis, it is possible to scrutinize simultaneously the effect of road and railway accessibility on population change. The concrete research questions adopted in this study are (1) What was the effect of railway accessibility on population change? (2) What was the effect of potential accessibility by road and railway network on population change?


Harri Antikainen is GIS Analyst, Department of Geography, University of Oulu. He is the author of “Terrain Path Optimization Using the Connectivity Graph Approach Applied to GIS Data Structures,” Nordia Geographical Publications, XXXVIII (2009), 1–85.


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How did population density, as a measure of local accessibility, relate to population change?¹

The issue of accessibility has received particular attention in the field of transport geography, as well as in the context of economic development and population dynamics. Generally, population distribution comes under the influence of several factors, including natural constraints and resources, changes in economy, and political/institutional factors involving subsidy and taxation. However, accessibility is also important for economic competition. Yet, in spite of its apparently strong relevance on a number of fronts, accessibility is not a major factor in traditional models of economic geography that explain the distributional patterns of population. There have been surprisingly few attempts to incorporate accessibility within such economic models. Arguably, the most significant contribution in this regard comes from Krugman, who explains the emergence of a core–periphery pattern by the interaction of increasing returns, transportation costs, and demand. According to Krugman’s theory, in a pre-railroad and pre-industrial society, most of the population is engaged in agriculture, and population concentration is limited due to low demand. In such a situation, only a small fraction of the population works in manufacturing, and high transportation costs ensure weak economies of scale.²


Societies with mass consumption and production, however, in which transport costs are low due to transport innovations, display economies of scale, and concentration begins because of the location and re-location of production and people. Although the reasoning behind the relationship between accessibility and population concentration makes intuitive sense, and although it offers a persuasive alternative to the traditional models, quantitative historical research with strong datasets showing the relationship of population change and urbanization to developing transportation networks and modes, such as railways, is almost completely nonexistent.

This article traces the relationship between railway and road infrastructure and population change in Finland from the early stages of railway development in the 1880s to 1970, by which time the national railway network had reached, with only minor exceptions, its current extent. Finland is an interesting case for research about population concentration and urbanization for a number of reasons. First, the Finnish population was almost evenly distributed before the inception of the large-scale transportation infrastructure. Second, because of its remote northern location and its border with the Baltic Sea to the south and west, Finland has had only limited connections with other countries, especially in comparison with the norm in Western and Central Europe. Thus, in spite of Finland’s need to concentrate activities in the southern regions of the country—the better to reach both overseas and domestic markets—the effect of international connections on Finnish regional structure was weak. 3

Finally, urbanization in Finland lagged behind that in most other developed countries. The relationship between population change and urbanization in Finland and the accessibility of railways and roads is an unstudied field. The case of Finland represents an opportunity for understanding urbanization in sparsely

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populated and peripheral countries, which differs from the typical setting of urbanization in Western Europe and America.

The analysis of population change in this study required the creation of historical GIS (hGIS) databases about population at the municipal level and about the railway network. The general purpose of the study is to scrutinize the case of Finland through relating the municipal-level population data, at ten-year intervals, to the measures of accessibility by railway and road.

Notwithstanding its status as an interesting subject with considerable research potential, the role of railways has been marginal in the writing of Finnish history, except in explaining the extreme transformation of a few small towns into cities because of their position at railway junctions. Quantitative historical research about the regional structure of population distribution and the long-term process of population concentration in Finland is rare, although the bare characteristics of this process have seen substantial coverage during recent decades.4

In the early nineteenth century, Finnish society was almost completely agrarian, immobile, and staid. The industrialization that began during the latter half of the century occurred first in the most densely populated areas. At this point, Finland had cheaper energy and labor than its neighboring countries. In 1880, the Finnish population of 2 million people was almost evenly distributed, with a mean density of five inhabitants per square kilometer. The primary source of livelihood was agriculture (75 percent); industry’s share was only 5 percent. During the last decades of the nineteenth century, migration to the population centers in the southern parts of the country began to gain momentum. Around the turn of the century, and especially during the 1910s, a remarkable number of the surplus rural population, amounting to about 400,000 people, migrated to the United States and Canada.

During and after World War II, more than 400,000 people

from areas seized by the Soviet Union re-settled in a wide range of regional municipalities. Not until the 1960s did immigration toward cities per se accelerate to the level of the vaunted “Great Migration.” In 1970, the population of 4.6 million, with a mean population density of 13.5 inhabitants per square kilometer, was mainly employed in construction, commerce, transportation, and services (41 percent), as well as the industrial sector (23 percent); the share of workers in agriculture decreased to 18 percent.5

The emergence of railways may well be the most dramatic change in the domestic transportation history of Finland. In contrast to the traditional shipping by waterway and canal, shipping by railway was relatively free from natural constraints. Railways connected inland places in a completely new way and increased their accessibility remarkably in comparison with the navigable inland waterways. Railways both challenged and complemented other modes of transport. The most important parts of the Finnish railway system opened in the late nineteenth century, mainly subsidized by the state but with some privately owned railways to serve local and feeder traffic. Railways were relatively easy to construct in Finland on a large scale because of the absence of such major natural impediments as mountains. However, numerous lakes, rivers, and swamps hampered construction on a local scale.

The position of railways as a mode of transportation changed during the period considered herein. By being the only serviceable mechanical form of land transport during the nineteenth century, railways achieved dominance until the mid-twentieth century when motor vehicles gradually surpassed them. The state-owned railway company has shown a loss since 1955. The enlargement of the network is the main reason for the increasing accessibility of railways. Since railway access is possible only at particular points, the presence of stations at the local level is critical. The Finnish railway network was intended to serve various purposes, but Rautatiehallitus (the Finnish Railway Administration) and Sep-pinen report that the most important motivation was to connect

the principal population centers. However, many smaller places also increased their accessibility in the process. 6

The first railway link was between the state capital of Helsinki and inland waterways through the provincial town of Hämeenlinna in 1862. Because Finland was a grand duchy of Russia at the time, the next link was between Helsinki and the then-Russian capital St. Petersburg in 1870. The expansion of the railway network continued with two coastal harbor links in 1873/74. From 1876 to 1894, three north–south-directed trunk lines opened for traffic. The first of them was the westernmost line that connected the second and third largest cities of the country to the network. The central line was also supposed to bring other large municipalities in central and eastern Finland into the system. The easternmost line, which also served important population centers, does not enter this study due to lack of data; the Soviet Union seized the area served by the line during World War II.

In the early twentieth century, the state continued to extend the trunk-line network while a few privately owned and operated lines opened for local traffic, extending outreach and introducing regional branches. Until World War II, the construction focused mainly on the east–west-directed junction lines, which made the network more cohesive. The connection to Sweden opened in 1919, but the different gauge used on the Swedish side of the border (the Finnish rail gauge complied with the wider Russian variety) continues to impair railway traffic between the two countries. After the war, interest in expanding the railway network waned; the focus shifted toward the construction of secondary lines, mainly because of regional subsidization policies. Since the 1960s, the primary objective for constructing new railway has been to facilitate long-haul connections. During this decade, Finland finally replaced its steam-powered locomotive engines with diesel engines. By 1970, the Finnish railway network had almost achieved saturation. Figure 1 shows the peripheral location of Finland, the development of its railway network between 1880 and 1960, as

Fig. 1 Finland’s Railway Network in 1880 and 1960 and Ten Biggest Municipalities in 1880 and 1970

Sources: Statistics Finland and the Finnish Rail Administration.
well as its major municipalities, located mainly in the southwest, in 1880 and especially 1970.⁷

Accessibility by road is difficult to define precisely before the automobile era due to the lack of a historical model of the road network and information about the transport modes and conditions. The road network certainly maintained its role as connector at the local level, however, even after the emergence of railways. The significance of the road network began to rise again in the 1930s, when more flexible coach traffic began to compete seriously with railways. The motorization of passenger vehicles started to gain momentum after World War II, escalating especially during the 1960s. At the beginning of the 1930s, Finland had about 20,000 automobiles on the road; in 1950, the number was closer to 27,000. By 1960, it had increased to around 183,000, and in 1970, about 711,000. As a reaction to increased competition, rail transportation had to shift its focus toward long-haul traffic and local traffic within the capital-city area. Hence, accessibility by railway must be understood in the context of its competition with flexible land and waterway transportation that had a higher carrying capacity.⁸

This study employs GIS and an advanced, semiparametric regressive method—generalized additive models (GAMS)—to analyze the relationship between population change and accessibility in Finland throughout a ninety-year-long time series covering the entire country in a temporally comparable form. This study has also produced a historical database of the Finnish railway network that extends to 1970. Given the aforementioned absence of a historical model of the road network, the present road-network geometry is used but with historically relevant attributes. The long-term historical datasets and advanced analyses permit us to trace increasing accessibility relative to the process of population concentration from the early days to the era of urbanized and industrialized society. Roughly from 1970 onward, the transportation needs of society were almost solely met by automotive traffic. To the best of our knowledge, no previous historical studies

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of transportation combine potential accessibility with regressive approaches.9

GIS data about population and transport networks Two GIS-based databases had to be constructed for this study. The first involves describing population change within a consistent format, ensuring the spatial uniformity of the municipal boundaries over the entire study period. The second database captures the construction process of the railway network. In order to avoid the ecological fallacy, our aim was to use the most accurate census data available. In practice, the municipal division turned out to be the most reasonable choice, providing the best detail for the entire period from 1880 to 1970. Figure 2 illustrates the geographical accuracy of the datasets.10

Because the municipal structure of Finland has been subject to change throughout the research period, the population figures had to undergo manipulation for the sake of temporal consistency. The municipal structure of the year 2007 became the standard since it was the most recent available spatial reference. The source for population numbers and changes in the municipal structure were statistics in decadal tables, which also carried descriptive notes about particular territorial changes in the municipal structure affecting population amounts. Given that accurate information regarding municipal boundaries in the past was unavailable, the database was constructed along the lines of areal interpolation, except that the population numbers were calculated using a spreadsheet instead of spatial attributes.11

The work of constructing the municipal database entailed three stages—(1) conversion of the literal hardcopy data into a digital database, (2) elimination of the inconsistencies caused by merges and dissolutions of municipalities, and (3) the joining of

10 Longley et al., Geographical Information Systems and Science (Chichester, 2005; orig. pub. 2001), 49–50;
the population data with the 2007 municipal database containing
the current boundaries and centers of each municipality. In the sec-
second stage of the process, the population numbers were calculated
for each municipality by multiplying the original population num-
bers at each point in time by ratios calculated from statistical litera-
ture with information about the population changes associated with
the municipal mergers and divisions during the entire period. The
calculation procedure to achieve historical population estimates for
one municipality before a specified moment of time is

\[ P_{t-\Delta t} = p_{t-\Delta t} \left( 1 + \sum_{i=1}^{n} \frac{P_{part_i}}{P_{tot_i}} \right) - \left( \sum_{j=1}^{n} \frac{P_{div_j}}{P_{tot_j}} \right) + \sum_{k=1}^{n} P_{merg_{k-\Delta t}} \]
where \( P_{t-t'\Delta t} \) is the municipal population estimate of the point of time \( t-t'\Delta t \) fitted to the boundaries at the point of time \( t \); \( P_{t-t\Delta t} \) is the original population of a municipality at the point of time \( t-t'\Delta t \); \( P_{tot,t} \) is the total population of a municipality at the point of time \( t \); \( P_{part,t} \) is the added population of a partial municipal merge at the point of time \( t \), when \( i \) is the number referring to mergers; \( P_{div,t} \) is the subtracted population of partial municipal dissolution at the point of time \( t \), when \( j \) is the number referring to dissolutions; \( P_{merg,t} \) is the added population of a merged municipality at the point of time \( t-t'\Delta k \) when \( k \) is the number referring to the merged municipality. To construct a temporally consistent database covering several decades, the calculation was necessary for all of the municipalities affected by the structural changes.

In 2007, Finland had 416 municipalities; the number of municipalities had been as high as 580 (in 1940). In the course of Finnish history, 93 new municipalities have emerged via the division of existing municipalities, and 188 consolidations have occurred. Exact population numbers were available for 206 municipalities that remained stable from 1880 to 2007. Changes in municipal boundaries without explicitly reported spatial arrangements had to be excluded from the calculations because of missing or inadequate data. Nonetheless, the municipal estimates are accurate insofar as analysis involving the entire country is concerned.

The railway network model was devised to represent spatial and temporal development. Its construction involved the attachment of relevant information (primarily the opening dates of links, estimated travel times, and rail classifications) to the railway-network geometry, maintained by the Finnish Rail Administration, by means of linear referencing (the model does not include narrow-gauge railways, which have had only a local role in the Finnish history). Using linear referencing was possible by virtue of the temporal permanency of the network and the positioning system used by the Finnish railways from the outset. Railway stations, stops, and halts in use at different times had to be located as well to establish the connection points within the network. The location of stations was determined from engine-driver timetables in a linear framework based on railway kilometers. Stations thus identified could be joined to the railway network by linear referencing. Information about the usage of railway stations in differ-
ent eras derived from a historical atlas about the Finnish railway stations.\textsuperscript{12}

The model representing the road network came from the Digiroad database, maintained by the Finnish Road Administration. Unfortunately, the database represents the current situation only, without information regarding the construction dates of individual road links. This information was also impossible to extract from other sources with adequate accuracy. However, the travel-time attributes associated with the road links were modified to reflect the assumed travel conditions in different eras, providing a rough estimate of historical accessibility by road network.

\textbf{METHODS TO ANALYZE ACCESSIBILITY} This study analyzes the accessibility of municipalities in three different ways. First, municipal-level population density stands as a measure of local accessibility. This indirect measure is the best available, unambiguous way of comparing average accessibility inside municipalities. Second, the distance from the municipality center to the nearest railway station stands as a measure of railway network access or accessibility at the municipal level. Third, because access to a road network is ubiquitous at the municipal level, and measuring access to a road network itself is not meaningful, measurement of all other municipalities’ accessibility and of their population along a road network involves potential-accessibility analysis, which is a common but advanced method in transport geography.\textsuperscript{13}

The idea behind potential accessibility is to describe how the population of other locations can be accessed from each location involved in the analysis. In the case of the municipalities, the potential-accessibility value of any municipality is calculated by dividing the population numbers of other municipalities by the distance and summarizing these values. Distance does not always refer to a spatial interval; it can also denote time or interaction cost. In other words, potential accessibility to any location is a sum of accessed populations related to the travel friction. The basic form of potential accessibility is


where $A(P)$ is the potential-accessibility matrix; $d_{ij}$ is the distance between locations $i$ and $j$; $P_j$ is the population attribute of the destination $j$; $n$ is the number of origin locations; and $\alpha$ is the parameter for the transport friction related to the efficiency of the transport system and the interest to move. The resulting potential-accessibility values can be controlled by adjusting the parameter $\alpha$. Increase in $\alpha$ will cause a greater distinction between nearby and distant destinations. Obviously, the value of $\alpha$ is highly dependent on the scale of analysis and the type of activity modeled. On a national and international scale, $\alpha$ typically takes the value 1. This study ran experiments with values 1 and 2 in order to take into account a wider potential accessibility with linear friction increase and more local potential accessibility with quadratic friction increase.\footnote{Vickerman, “Accessibility and Economic Development,” 10; Gutiérrez, “Location, Economic Potential and Daily Accessibility.”}

The benefit of potential-accessibility analysis is its ability to differentiate between clustered population concentrations and isolated concentrations, as well as peripheries. Although potential-accessibility analysis is highly rated in theoretical terms, it rarely comes into practice, arguably because of the requirements associated with GIS techniques. Indeed, software for carrying out potential-accessibility analyses is not widely available. Even in this study, the application for calculating potential accessibility had to be devised and programmed on the ArcGIS software platform. The potential-accessibility measurement is based on the fastest travel times between municipalities, calculated separately for each decade of the period under study.

\gamsid{2613}

\gamsid{2614} were employed to analyze the relationship between population change and potential accessibility. In contrast with classical regressive approaches, in which the supposed functional form is pre-selected and fitted to relate a response variable to explanatory variables, \gamsid{2614} can capture the shape of the relationship between variables without pre-judgments about a particular parametric form. Thus, \gamsid{2614} are based much more on data than on the suppositions of a researcher, thereby avoiding loss of informa-
tion and identifying complex relations. Relations can be estab-
lished with smooth functions, and response distributions can be
other than normal. In this study, the so-called spline smoothers
have one to four degrees of freedom by default. Response shapes
of smoothed predictor variables are plotted to show the effect of
potential accessibility to population change. Confidence intervals
of 95 percent, explained deviance, and $p$-values also support the
analysis.\textsuperscript{15}

THE EFFECT OF ACCESSIBILITY ON THE PROCESS OF POPULATION CON-
CEN TRATION The progressive concentration of the Finnish pop-
ulation in large population centers, which occurred during the re-
search period, is evident in Figure 3. As the large population
centers connected to the railway network, an increasing share of
the population started to migrate to them. The concentration pro-
cess can be illustrated even more precisely with descriptive statis-
tics. Table 1 reveals that the number of municipalities with popu-
lation on the rise was decreasing toward the end of the research
period. When the extending coverage of railways is related to mu-
nicipal population change, the share of municipalities with in-
creasing population is greater in municipalities covered by rail-
ways, especially in the early and latter parts of the research period.
A notable exception is the post–World War II era, when re-
settling led to the growth of population in a number of municipal-
ities regardless of their position in the regional structure.

GAMS can reveal the potentially nonlinear relationships be-
tween accessibility and population change. This study employed
hundreds of GAMS to inspect alternative relationships between the
variables. For final models, variables were selected according to
the statistical significance level of $p < 0.01$. The role and impor-
tance of variables between and during decades were assessed in
terms of explained deviance. In addition to explained deviance of
the joint model involving all statistically significant variables and
explained deviance of each variable alone, the drop in explained
deviance when removing a variable from the joint model was also
calculated. The population–change variable was treated as relative,
but because the population–change values measured in percent-

\textsuperscript{15} Michael J. Crawley, \textit{The R Book} (Chichester, 2007); Thomas Yee and Neil D. Mitchell,
ages were overdispersed for GAMS, the logarithmic function of the relative population change had to be used instead. The equation can be written as

$$\Delta \text{Pop} = \ln\left(\frac{\text{Pop}_t}{\text{Pop}_{t-1}}\right)$$

where $\Delta \text{Pop}$ is the population change, $\text{Pop}_t$ and $\text{Pop}_{t-1}$ are the population at the end of a period and at the beginning of it, respectively.

In general, the study indicates that the population increase at the municipal level is strongly related to high potential accessibility.
Table 1  Descriptive Statistics about the Population Concentration at the Municipal Level as Related to the Railway Network

<table>
<thead>
<tr>
<th>DECADE</th>
<th>MUNICIPALITIES WITH INCREASING/DECREASING POPULATION (%)</th>
<th>RAILWAY KILOMETERS</th>
<th>MUNICIPALITIES COVERED BY RAILWAYS (%)</th>
<th>MUNICIPALITIES COVERED BY RAILWAYS WITH INCREASING/DECREASING POPULATION (%)</th>
<th>MUNICIPALITIES NOT COVERED BY RAILWAYS WITH INCREASING/DECREASING POPULATION (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1880–1890</td>
<td>96.5 / 3.5</td>
<td>720</td>
<td>12.1</td>
<td>12.1 / 0.0</td>
<td>84.3 / 3.5</td>
</tr>
<tr>
<td>1890–1900</td>
<td>96.7 / 3.3</td>
<td>1,724</td>
<td>23.2</td>
<td>23.2 / 0.0</td>
<td>73.5 / 3.3</td>
</tr>
<tr>
<td>1900–1910</td>
<td>66.4 / 33.6</td>
<td>2,357</td>
<td>31.3</td>
<td>23.5 / 7.8</td>
<td>42.9 / 25.8</td>
</tr>
<tr>
<td>1910–1920</td>
<td>71.5 / 28.5</td>
<td>3,004</td>
<td>36.1</td>
<td>26.3 / 9.8</td>
<td>45.2 / 18.7</td>
</tr>
<tr>
<td>1920–1930</td>
<td>72.2 / 27.8</td>
<td>3,392</td>
<td>39.6</td>
<td>29.5 / 10.1</td>
<td>42.7 / 17.7</td>
</tr>
<tr>
<td>1930–1940</td>
<td>59.1 / 40.9</td>
<td>4,048</td>
<td>46.5</td>
<td>31.1 / 15.4</td>
<td>28.0 / 25.5</td>
</tr>
<tr>
<td>1940–1950</td>
<td>94.2 / 5.8</td>
<td>4,620</td>
<td>51.0</td>
<td>47.7 / 3.3</td>
<td>40.5 / 2.5</td>
</tr>
<tr>
<td>1950–1960</td>
<td>42.4 / 57.6</td>
<td>4,773</td>
<td>51.3</td>
<td>26.5 / 24.7</td>
<td>15.9 / 32.8</td>
</tr>
<tr>
<td>1960–1970</td>
<td>23.2 / 76.8</td>
<td>5,195</td>
<td>54.3</td>
<td>19.7 / 34.6</td>
<td>3.5 / 42.2</td>
</tr>
</tbody>
</table>
to other municipalities by road network, to high population density in the municipality, and to nearness of railways during the latter part of the research period, as shown by the response curves in Figure 4. High population density as a local factor is associated with population increase throughout the research period, particularly during the first, the second, and the last decade (see Table 2). The only exception is the 1940s when people re-settled after the war. High potential accessibility appears to be an important factor that attracted population from 1890 onward, especially during the 1920s and from the 1940s to the 1960s. The proximity of railways is highly significant during these decades, but otherwise, railways do not have any statistical significance in the models when population density and potential accessibility are involved.

Another highly important conclusion about the role of railways in the models is based on the drop in explained deviance when removing a variable from the joint model. The deviance ex-
plained by railway accessibility alone is relatively high for the 1920s, the 1950s, and the 1960s, implying a significant effect of railway accessibility on population increase. However, the low drop values from 1950 to 1970 show that the role of railways is much less significant when population density and potential-accessibility variables enter the account. This finding underpins the caution needed when determining causality via quantitative analysis. Furthermore, the discovered multidimensionality in the phenomenon questions the ability of cartographical techniques per se to enable inferences from complicated dynamics without the support of statistical analyses.

The GAMS also have the best explanatory power for each of the decades, particularly the 1960s, for which the model explains 57.7 percent of the population change. The accessibility of railways, tested in combination with the road network, did not produce any significant change to the models. Nor did an emphasis on locality in the potential-accessibility measure by adjusting the value of $\alpha$ have any remarkable effect on the models.

One of the most curious findings about the role of railways concerns the 1920s and the 1930s. According to the models, the railway-accessibility variable has strong explanatory power regarding the population increase during the 1920s, but it is not a statistically significant variable for the 1930s. A likely reason for this discrepancy is that the strong economic growth and industrialization of the 1920s also caused railway transports to increase rapidly, whereas railway transports decreased at the beginning of the 1930s due to a recession. Again, the considerable explanatory power of railway accessibility during the 1920s relative to subsequent decades can be attributed to the decreasing role of railways when motorcar transport emerged.16

Overall, the role of accessibilities on different spatial scales, including local population, potential accessibility with respect to other municipalities, and access to the state-level railway network, is an interesting, yet challenging issue. Population density is the most unambiguous way of measuring local accessibility; municipalities with concentrated populations stand to benefit most from

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Table 2  The Effect of Potential Accessibility, Distance to the Railway Network, and Municipal Population Density on Population Change, according to gams

<table>
<thead>
<tr>
<th>DECADE</th>
<th>EXPLAINED DEVIANE</th>
<th>POTENTIAL ACCESSIBILITY—ALONE / DROP P</th>
<th>DISTANCE TO NEAREST STATION—ALONE / DROP P</th>
<th>POPULATION DENSITY—ALONE / DROP P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1880–1890</td>
<td>11.6</td>
<td>—</td>
<td>—</td>
<td>11.6 / 11.6 ***</td>
</tr>
<tr>
<td>1890–1900</td>
<td>23.2</td>
<td>7.0 / 3.2 ***</td>
<td>—</td>
<td>20.0 / 16.1 ***</td>
</tr>
<tr>
<td>1900–1910</td>
<td>15.6</td>
<td>9.1 / 6.4 ***</td>
<td>—</td>
<td>9.2 / 6.5 ***</td>
</tr>
<tr>
<td>1910–1920</td>
<td>9.9</td>
<td>5.6 / 2.0 *</td>
<td>—</td>
<td>7.9 / 4.2 **</td>
</tr>
<tr>
<td>1920–1930</td>
<td>30.5</td>
<td>17.1 / 7.9 ***</td>
<td>16.3 / 7.8 ***</td>
<td>13.1 / 3.5 **</td>
</tr>
<tr>
<td>1930–1940</td>
<td>15.0</td>
<td>8.0 / 4.2 ***</td>
<td>—</td>
<td>10.8 / 7.1 ***</td>
</tr>
<tr>
<td>1940–1950</td>
<td>22.9</td>
<td>18.5 / 14.5 ***</td>
<td>8.4 / 4.4 ***</td>
<td>—</td>
</tr>
<tr>
<td>1950–1960</td>
<td>31.5</td>
<td>19.2 / 8.8 ***</td>
<td>12.6 / 3.2 ***</td>
<td>16.4 / 5.6 ***</td>
</tr>
<tr>
<td>1960–1970</td>
<td>57.5</td>
<td>31.0 / 7.7 ***</td>
<td>22.3 / 4.7 ***</td>
<td>43.7 / 11.9 ***</td>
</tr>
</tbody>
</table>

Notes: “Alone” means the percentage of deviance that the variable explains; “drop” refers to the decrease in the explained deviance in percentage units when the variable is taken away from the model. The statistical significance (p) is presented in the following way: *** p < 0.001, ** p < 0.05, * p < 0.01. The empty cells mean that the explanatory variable has not been found to possess any significant explanatory potential.
economies of scale. Potential accessibility is the potential to access population elsewhere. According to our analysis, municipalities located close to growth centers clearly benefited from this proximity since the 1890s. That railways became significant after the 1920s only for municipalities in their immediate vicinity shows the “dualistic” role of the railway in Finnish transport history: The effects of accessibility are noticeable at the local level, even though the connectivity of railways involves the scale of the whole state. Because railways have high loading and reloading freight expenses in terms of ton-kilometer costs, the connectivity provided by the railway network was economically effective only for the locations close to the railway, especially during the period before highly developed logistics.

Before the arrival of industry and the railroad, the population of Finland was almost evenly distributed. When the industrializing cities began to grow during the late nineteenth century, the potential accessibility of other municipalities began to matter. The heavy concentration of people in regional centers, coinciding with the major wave of urbanization—often called the Great Migration—occurred mostly during the 1960s, when Finland rapidly motorized. These trends are associated with the widening scale of the Finnish economy from the local to the regional level and then from the regional to the interregional level, covering the state. However, the most notable process behind this development was the cumulative concentration of population in highly accessible municipalities or municipal clusters. Since these emergent cities had more to offer than rural areas did during the late nineteenth century, population continued to migrate toward them. Meanwhile, the developing transportation system brought places closer to each other in time as well as in cost, making them even more attractive to people and investment.

Although this study focuses on a single country, the methodology presented is applicable to any other country where population and transport network data are available at a reasonable level of accuracy. The findings and procedures herein clearly underpin the need for accessibility analyses in historical research, especially in the field of historical geography and transport history. Potential-accessibility analysis and network-accessibility analysis, combined with such advanced statistical techniques as generalized additive
models, show considerable promise for historical transport research. The significance of this analysis is not so much in establishing direct causal relationships between social phenomena as in offering means to reveal geographical patterns and trends in society that may be hidden visually but can be measured using appropriate variables and models with the help of GIS.