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Accessibility
long term perspectives

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**Accessibility: Long term perspectives**

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Arbeitsbericht Verkehrs- und Raumplanung

Erreichbarkeiten: Eine historische Perspektive

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Kurzfassung

Die Diskussion um Erreichbarkeit findet oft ohne Bezug zur weiteren Diskussion um die gesellschaftlichen Veränderungen statt. Dieses Kapitel versucht drei Themen aufzugreifen: die Logik der Investitionen in den Verkehr, die Verkleinerung der Welt als Ergebnis dieser Investitionen am Beispiel der Schweiz und zum Schluss, wie sich die sozialen Netzwerke an diese kleine Welt angepasst haben. Das Kapitel schliesst mit einer Diskussion der sich aus diesen Themenergebenden Forschungsfragen.

Schlagworte

Erreichbarkeit, Soziale Netze, Verkehrspolitik, Verkehrsnetze

Zitierungs vorschlag

Abstract

Improved accessibility and its correlate lower generalized cost of contact, travel and transport have been sought by dynamic human societies for their economic and social benefits throughout recorded history. The paper will reflect about this process at a number of different spatial and temporal scales based on a conceptual model. Looking back at European history, it will trace the interaction between Christaller’s logic of local market areas and the idea of (low contact cost) network cities. Focusing on Switzerland since 1950 it will show how network investment changed the relative distribution of population and employment and how this interacted with changes in the preferences of the travelers. Using a recent snapshot of how a substantial sample of Swiss maintain their social networks over often very large areas, it will try to answer the question of what will happen in the future, if the current trend of ever lower costs of contact will persist.

Keywords

Accessibility, policy, network growth, social network geography

Preferred citation style

Transport policy and planning are increasingly asked to improve, optimise accessibility, a term often left undefined or unmeasured. It is not the task of this chapter to reflect why policy has shifted in this direction. The political economy of the term and the intentions behind it are out of the scope here. Its aims are much more limited. In three brief sections the paper will sketch three issues, which relate to this discussion and will hopefully provide some useful background to it. In the first section, it will discuss the two logics of organising cities across space, Christaller’s logic of autarkic production and the logic of long-distance trade. This will lead to a conceptual model of accessibility production in modern societies, where it is driven by the ongoing wish and need to provide increasing incomes for increasing populations. The second section will illustrate this process with a review of the Swiss experience during the last 150 years. It will also show, that this policy has started to run its course, as the marginal gains of further accessibility increases are decreasing. Shrinking Switzerland further is becoming an increasingly costly way of supporting economic growth. The final substantial section reports the results of a survey of the globalisation of social contacts and networks. The ego-centric networks of the Zürich respondents make use of the fallen cost of travel and contact and include both local and (inter)-national friends. The travellers have reconstructed the spatial structure of their social capital. The chapter closes with some ideas of what this new reality means to transport policy and where the research challenges lie.

1 Undifferentiated plane and network city

There are four different viewpoints under which one can choose the location of a city: production of goods and services, longer-distance trade, rule and consumption. A different view of accessibility is relevant for each. For trade and consumption accessibility is used as a synonym for market size or area, which can be served or reached from any given point. Here the preferred formal measure of accessibility is the summed number of potential customers (employees, employers, activity opportunities) weighted by the inverse of the generalised cost of travel to reach them (Rietveld and Bruinsma, 1998). In the context of a discrete choice random utility model of destination choice, this measure is equivalent to the log sum of a model which only considers two arguments in the utility function: the log of the number of customers at j and the generalised cost of travel between i and j. For rule and for certain services it is number of points which can be reached in a certain maximum time, e.g. emergency rooms for the heart attack patient or border defence installations for a military unit. For production it is the provision of the required suppliers for a given average cost.
In Christaller’s classic model of city location under conditions of autarkic production cities of different rank are positioned at the appropriate points of maximum accessibility. The resulting pattern of hexagonal market areas has always been disrupted by foundations motivated by the other three reasons given above. Historically cities founded for extractive rule and for shear (luxury) consumption have never grown large. Cities set up for long-distance trade were able to grow larger than any of autarkic “production” cities. Historic examples of government cities and its associated (luxury) consumption are Jerusalem, Rome, Kyoto, Peking or Versailles; note that only the capitals of empires grew to any size, as they were able to command the required food supplies. Still, as rule, cities associated with local rule followed the system of autarkic production. Only with state formation were the higher levels of government able to free themselves of these constraints. Still, path dependency normally led to the adoption of prior locations.

The system of cities engendered by trade and its associated value-added production is ruled by a different logic than the hexagonal system of autarkic production, which aims to cover a whole territory exhaustively. Trading cities locate where the technology of the time requires a change in the mode of transport, in particular from a faster, more efficient and cheaper mode to a less efficient mode: harbours intermediating between ocean shipping and rivers; between lakes and rivers; between rivers and carts; or between carts and sleds (e.g. Chur at the bottom of the alpine passes Julier, Abula, Majola, Septimer, St. Bernhard, Splügen and Lukmanier). Later, in addition, government privileges of enforced bulk-braking achieved the same effect, as for examples cities as Nürnberg, Leipzig or Frankfurt attest. For most of history water-carried vessels were faster, had larger carrying capacities and were cheaper favouring them where ever a navigable water course was available, which in a time before river regulation was not as often as we would think today. Trading cities were able to escape the constraints of their cart-accessed hinterlands and to grow as far as their water-accessible hinterlands would allow. The geography of these break points is random and overlays the logic of the hexagons and transforms them, as the trading cities were normally the stronger party. Historically, the boom and bust – towns of resource extraction (e.g. mining of ores and salt) added further randomness to the overall pattern. While the logic of the trading cities does not follow the logic of exhaustive rule and autarkic production, they depend on them for custom. One would expect, that trading cities only exit separately down to a certain level of the central place hierarchy, as it is not worth to establish separate locations for the final, area-wide distribution of the trade goods. In addition, the traders would not expect to find customers for their higher value goods at the lower levels of the central place hierarchy in any case.
Historically, trade goods tended to have very high value densities to justify their cost of transport; or they were able to walk themselves, such as cattle, sheep, horses or slaves. Such luxury demand was driven by the wish of the local elites for prestige and differentiation and was therefore relatively price insensitive. Under those conditions investment in accessibility was therefore mostly driven by military considerations, as the Roman road system shows. The demand of concentrated military populations supported a certain amount of long distance trade in everyday goods, as is well attested for the Roman empire and its legions.\(^1\)

Investment in accessibility for trade in everyday goods and services becomes an issue, when a mass demand begins to materialise and when the producers want to gain economies of scale. This starts to happen, when for the given technology any local population surplus cannot be absorbed anymore through further intensification of agriculture, i.e. adding layers to the central place hierarchy, or by converting hitherto marginal land into albeit less productive farmed land (forest, swamp, heath, mountain valleys), or finally by emigration.

It is unclear to this author, when the logic of the three-way interdependency, virtuous cycle, between the growth in income, achievement of economies of scale and scope and the increase in market area via lowering of the generalized costs of travel was first fully understood. By the late 18\(^{th}\) century most of the elements had been formulated (Smith, 1776; Ricardo, 1817 Still, European states had started to behave, as if they had understood this earlier (de Vries and Van der Woude 1997; Spufford, 2002): e.g. Florentine road investment in the 14\(^{th}\) and 15\(^{th}\) century, Dutch canal investment from the 17\(^{th}\) century onwards, British canal and turnpike investment in the 18\(^{th}\)). In the 19\(^{th}\) century programmes of canal, road and railway investment became one core activity of the new nation states, as they aimed to mobilise their populations and their economies. In the liberal climate of that time, the nation states fully understood that the lowering of the cost of travel threatens local monopolies, as effectively as the official abolition of restrictive guild practises, or of local bridge tolls and imposts (See Figure 1 for the Swiss conditions in 1825).

The anxiety, which is caused by the anticipated loss of secure local monopoly production, is even today a central reason for local resistance to improved accessibility. Still, most nation

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1 Feeding Rome and Constantinople was a different matter, which required substantial fleets and even larger tax incomes.

2 A good example is the Japanese adoption of wet paddy rice cultivation in the Edo period, including the development of a steady fertilizer supply from urban areas (night soil)

3 17\(^{th}\) and 18\(^{th}\) century French road building is still very much guided by military considerations.
states adopt policies to destroy those monopolies inside national space, as they know that they are likely to hinder innovation and increase prices and therefore suppress demand. Nevertheless, the long and torturous history of the EU internal market or of trade liberalisation shows how reluctant the nation states are to adopt these policies at international scales.

In the 19th century there was little concern about to whom the benefits of increased accessibility would accrue, which is an issue today. In principle, it is impossible to say, which end of a new connection will gain most, as one cannot predict with certainty which firm will invest first, or will provide the innovative good or service which can only flourish given the new market size. One would assume, that the side relatively stronger in terms of population, capital, or innovation ability is more likely to win in those domains for which its resource endowments predispose it. The other end will gain in those areas, for which it has the relative advantage.

Figure 1  Swiss network of lake-side tolling stations in 1825

Source: Fritzsche, Frey, Rey and Romer (2001); there was in addition a rich network of road and bridge-based toll stations, as well (Legend: empty squares: cantonal capitals; filled squares: toll stations)
Within the framework of the virtuous cycle outlined above Figure 2 identifies the mechanisms through which the generalised cost of travel are lowered and adds the feed-back loop of congestion and unreliability which can temporarily dampen the fall in generalised costs. The increased incomes are used by individuals and governments to build more and faster slots, i.e. physical infrastructures and their management systems, which provide the time-space paths for travellers and their vehicles. They also acquire larger, more comfortable and faster vehicles trading up-front capital expenditures for lower generalised costs of travel⁴.

In addition, one would expect that the level of out-of-home activity increases, especially through the entry of females into the out-of-home labour market and through an increasing ability to purchase services delivered out of home (restaurants, holidays, hair cuts, cinema, theatre, concerts etc.). Generally, it is assumed, that this demand elasticity is small, but there is no strong empirical evidence. Stronger empirical evidence is available for income elasticity of the value of travel time savings (Fosgerau, 2005 for review and new results) show that the assumption of a unit elasticity is reasonable. This increasing impatience favours the further expansion of the transport system. The fall in generalised cost is translated into larger market areas and therefore increases in person and ton-miles. In conjunction with the increases in the vehicle fleet, this increases the vehicle-miles more then proportionately and leads to congestion as long as the number of slots lags current demand. Congestion causes both increases in the average cost of travel, but equally important increases the variance in the cost of travel as the system becomes more sensitive to small fluctuations in demand.

⁴ Frei (2005) and Raff and Trajtenberg (1985) show, how dramatically the quality adjusted prices of cars have dropped since 1900 supporting the increased uptake of car ownership.
2 The case of Switzerland since 1950

The model sketched above says nothing about the speed and strength of the changes induced by accessibility change. Much of the literature has looked at relatively short time periods (10 to 15 years) which makes it difficult to assess this question, or the question, if saturation effects might set in over time (Aschauer, 1989; Kesselring, Halbherr and Maggi, 1982 or Shirley and Winston, 2004 provide a good starting point). As explained above, the derivation of the preferred accessibility measure as the log sum term of a destination choice model implies saturation, as substantial change become very difficult to achieve when the base value is already high. A series of research projects at ETH resulting in two PhD dissertations (Fröhlich; Tschopp) have overcome these limitations by analyzing Swiss accessibility change over the last 150 years, but especially during the last 50 years resolving the changes at the level of the about 2900 Swiss local authorities. Based on assignment-ready network models for road traffic and public transport for each decade since 1950, accessibilities were calculated for each municipality. For the period since 1850 this calculation was performed for the 184 Be-
zirke or districts, based on less detailed travel time calculations for the time before 1950 (Figure 3).

Figure 3  Accessibility change since 1850: Box plots of the values of the 184 Bezirke

The accessibilities only considered the contributions of other districts. Given the larger spatial resolution the generalised cost (travel time) parameter was chosen to be 0.01. Please note, that the accessibilities are logarithmic.

The saturation of the accessibilities is clearly visible in Figure 3 in spite of on-going investment in road capacity and public transport frequencies. The road-based accessibilities overtake the public transport based-ones only in the 1950s, when car-based travel is becoming the default mode for road travel. The improvements in speed of the ever larger car fleet supplemented by motorway construction have maintained this advantage since. Public transport in Switzerland has manly benefited from improved scheduling, as very little new capacity has been built since the war. The impact of the improved frequencies is not included in this figures, which would reduce the differences between the two systems. An intuitive way of visualising the changes brought by the on-going investment is to produce time-scaled maps of the
country, as in Figure 4. Here, the distances in the map are proportional to the travel time between any two points. The effective shrinkage of the country is obvious. Road-based Switzerland has been halved, whereas the factor is somewhat smaller for public transport-based Switzerland.

Figure 4  Road travel time - scaled maps of Switzerland (same scale for both year)

Source: Axhausen, Dolci, Fröhlich, Scherer and Carosio (2006)

The population has adapted to this change, as the steady increase in the commuting distances shows (Figure 5), which are being travelled with steadily increasing speeds.

Fröhlich shows in his thesis that the implied values of travel time savings rise in line with real incomes for public transport users and more then real income for car users. The logit models were estimated using the commuter matrices and the associated network models for time since 1970. They include the best possible estimate of travel costs and control for type of commute, average incomes and car ownership in the origin municipality.
Figure 5  Swiss commuting distance distributions since 1970

Data: Swiss Census 1970-2000

Figure 6  Values of travel time savings for Swiss commuting since 1970

Source: Fröhlich; estimated using census information and the IVT network models

In his further modelling, he can show, that further improvements in overall accessibility
measured with the log sum term of a combined destination and mode choice model for commuting have decreasing impacts on the willingness to commute. Its elasticity nearly halves between 1970 and 2000. It is reasonable to assume, that this saturation is also noticeable in its effect on relative population growth.

In his analysis, Tschopp could show that accessibility change has an impact on the relative population growth (Table 1). Municipalities, which benefit from accessibility increases, grow faster then the national average even after correcting for employment growth in the municipality. Still, over the five decade that impact becomes smaller for road based accessibility and the explanatory power of the models decreases. Both trends indicate saturation effects at the national level.

<table>
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<tr>
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<tbody>
<tr>
<td>Adj. R²</td>
<td>0.383</td>
<td>0.715</td>
<td>0.309</td>
</tr>
<tr>
<td>Constant</td>
<td>0.190</td>
<td>0.001</td>
<td>-0.007</td>
</tr>
<tr>
<td>Employment growth (2. Sector)</td>
<td>-0.025</td>
<td>0.013</td>
<td>0.014</td>
</tr>
<tr>
<td>Employment growth (3. Sector)</td>
<td>0.089</td>
<td>0.000</td>
<td>0.011</td>
</tr>
<tr>
<td>Change in car-based accessibility</td>
<td>0.246</td>
<td>0.082</td>
<td>0.150</td>
</tr>
<tr>
<td>Change in public transport-based accessibility</td>
<td>0.267</td>
<td>0.000</td>
<td>0.430</td>
</tr>
<tr>
<td>Spatial error correlation</td>
<td>0.555</td>
<td>0.464</td>
<td>0.412</td>
</tr>
</tbody>
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Source: Tschopp (forthcoming); the SEM weight matrix includes 8 neighbours, which was shown to be the optimal number; indicating that the immediate vicinity has an impact on the local growth pattern

Breaking the results down by canton in a multi-level regression framework Tschopp showed, that these saturation effects are most pronounced in those parts of the country, which started with high levels of accessibility. In the peripheral cantons 2nd tier cities can still benefit
strongly from accessibility gains, but more at the expense of the periphery of the periphery than off the mayor centres.

In summary, the Swiss case demonstrates how radically the generalised costs of travel have been reduced, but also the decreasing marginal contributions of further investment in a well established network. The impacts on residential choice and travel behaviour are also tapering off. While accessibility improvement was able to mobilize the population strongly in the 1950 to 1970s, they have become much less important in the last decade. Still, away from the core of the country, accessibility change has above average impacts, but mostly at the expense of the immediate environments of the growth pole.

3 Friends in a shrunken world

Leisure travel has been consistently the fastest growing segment of the transport market for some time. Shares of 40% of travel and 40% of mileage travelled are common in industrialized countries. Leisure travel is to the largest extent travel to be with other persons (e.g. Bundesamt für Statistik, 2000 or Bureau of Transportation Statistics, 1995 (See Figure 7). It is therefore necessary to establish how those persons are distributed over space, if one wants to explain leisure travel and its further growth. Are friends, relatives and contacts mostly local or are they now spread across larger areas? The shrunken world shown above would suggest the latter, as the first would imply trip rate increases which we have not observed. While further accessibility gains might not shift the residential population anymore, they might continue to have large impacts on the geographies of the social networks, in particular as the generalised costs of long distance travel and communication continue to fall quite quickly due to low cost (intercontinental) airlines, zero-marginal cost voice-over-internet-protocol telephony, commodity-pricing of mobile telephony and zero-marginal cost emailing. They should increase the distances and the associated spread of the friendship networks.

Unfortunately, sociologists and geographers have not addressed this issue in their research into social networks and neighbouring, as their focus of attention lies elsewhere. In recent surveys, the IVT has started to fill this gap in our knowledge by measuring the distances be-

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5 See Mok and Wellman, 2007; Carrasco, 2006 for two recent exceptions.
between the home locations of respondents and their contacts and by asking about the contact frequencies by main modes of contact (face to face, telephone, texting (SMS) and email).
After a series of pre-tests and qualitative interviews the main survey involved 300 Zürich respondents, which participated in a 60-70 minute face-to-face interview and who returned a self-completion questionnaire of about the same duration (247 of these are used in these first analyses). The key items for the discussion here were the name generator and name interpreter questions. Respondents were asked to identify first those people, who are emotionally and socially important for them, and second those, with whom they spend leisure time; assuming, that these will also be friends. The respondents reported on average 12 contacts (median of 10), for which they indicated the frequency of face-to-face meetings, phone calls, SMS messages and emails.

The key results can be summarised by three graphs. Figure 8 shows the distribution of the distances between the respondents and their contacts. Half of the contacts live locally, i.e. within the same zip code, which covers in Zürich on average addresses for 6’500 residents. The remaining distances seem to follow a lognormal distribution. Their mean is 500km and their median 60km. This mixture of the local and regional and international is typical and was observed in our earlier work, as well.

Figure 8 Great circle distances between the respondents and their contacts

The great circle distance accounts for the spherical shape of earth. Distances between local contacts, i.e. with the same zip codes for the home addresses, were coded as 1 km.

The importance of the mix of the local and non-local is visible in Figure 9. It shows the distribution of the shares of local contacts among all reported contacts. About 10% of the respondents have only local friends, while the share of those with no local contacts is slightly
smaller with 6%. The bulk has a ratio of about 50%, as implied in the share of local distances. Respondents need both for their daily life. The effort they are willing to accept falls with the frequency of meeting their friends face to face. The rare, once or twice a year meeting on the other hand involves hundreds of kilometres of travel.

Figure 9  Share of respondents with a given share of contacts among all contacts within their residential postal code

The frequency of face-to-face contacts follows an exponential decay process (Figure 10), as does the frequency of phoning. The asynchronous messages (email and SMS messaging) are independent of distance. The three modes reinforce each other, especially as the asynchronous messages are mostly about the co-ordination of meetings for friends living close. The phone and the face-to-face meeting do not replace each other, but complement each other.

In the absence of previous measurements we do not know how fast the spread of social network geographies has been in the last 50 years. As discussions about a supposed or real lack of neighbourly contact are common in the literature since the 1970’s, it is reasonable to assume that the process had already started then (See for references in Campell, 1990; Campell and Lee, 1992; Day, 2006 or Lloyd, 1984). In the absence of low cost flying and low cost phoning, one would assume that the range was decidedly more regional than it is today. This would imply relatively strong generalised cost elasticities in the past and therefore further growth in the future.
Asynchronous messages comprise here SMS or texting (short message service) and email

In summary, today’s travellers have chosen to mix local with distant friends. Distance still matters for the frequency of the interactions, but those rare visits involve very considerable distances and time costs. These patterns have implications for transport policy, as the current levels of social capitals are tied to these spatially spread patterns of friendship and contact.

4 Policy implications: Dimensions of decoupling

The globalisation of the economy and of friendship patterns seems set to continue. China, India and the other developing countries are investing heavily in the lowering of the generalised costs of travel and transport inside their countries. The industrialised countries are also pursuing capacity expansion, but not at the same rate as they did in the 1960’s and 70’s. The ongoing growth in world trade and tourism is providing the demand which is driving the investment into its infrastructures: harbour expansions, widening of the Panama canal, new and
enlarged airports, and increases in vehicle size (e.g. A380, Post-Panamax containerships\(^7\)). At the same time, world society has become aware of its constraints through global warming, but also by the demands of global migration. In addition, at the national scale, there is the requirement for regional equity, while the consideration of global equity is increasingly important, as well. Both favour further investment in the transport systems. Transport policy, as part of economic and social policy, has to find ways of meeting both challenges: increase and more equally spread wealth, while decreasing energy consumption per unit of wealth created, or more urgently decreasing the \( \text{CO}_2 \) emissions per unit of wealth created.

Given the long-distance lives currently lived, transport policy will have to look beyond the transport system proper, as a simple minded policy of \( \text{CO}_2 \) reduction will destroy the social capital of the travellers and the firms. Transport policy will have to identify ways, in which travellers and firms can be supported in the reshuffling and rebuilding of their social capital. They will need help in the development of technologies, which can benefit from increases in scale and scope, without necessarily increasing market size. It will not be enough to rely on the increasing share of service production to decouple economic growth and energy consumption.

These larger questions have to be kept in mind, but the immediate research questions are less ambitious in scope, but they are ambitious in comparison with what has been done so far. It is essential that the work undertaken for Switzerland is replicated elsewhere. While it seems reasonable to assume, that other countries have shrunk as much as Switzerland, it would be important to know so. Given its importance, any new study should address the freight sector as well, and include the changes in freight costs, which have been dramatic (See for example Levinson, 2006). The scale should be changed as well, as many of these processes are now fastest at the global scale. How much smaller has the world become for passengers and freight since 1950.

This need for replication is also present for the social network analysis. Ideally such new studies would be comparative to avoid the trap of the national focus. It might be that the networks of the Indian farmers are as large, as those of the American farmers, maybe larger, as they invest more heavily in the educational success of their children. Finally, there is the special challenge of tracing the changes over time and to reconstruct them. New survey methods will be needed for the retrospective work, but also for the on-going benchmarking, so as to make

\(^7\) The Emma Maersk, currently the largest container ship can carry 11’000 standard containers (www.maersk.com/NR/rdonlyres/)
the process easier for the respondents.

5 Acknowledgements

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Mr. Frei, IVT, ETH Zürich, has been in charge of the social network survey discussed above.

7 Literature


[http://www.are.admin.ch/imperia/md/content/are/gesamtverkehr/verkehrsforschung2/25.xls](http://www.are.admin.ch/imperia/md/content/are/gesamtverkehr/verkehrsforschung2/25.xls)

[http://www.transtats.bts.gov/DL_SelectFields.asp?Table_ID=1036&DB_Short_Name=NPTS](http://www.transtats.bts.gov/DL_SelectFields.asp?Table_ID=1036&DB_Short_Name=NPTS)


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