

## Semester paper : Building railways in the XIXth century

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Semester paper

## **Building railways in the XIXth century**

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### **Summary**

The second half of the XIXth century is the theatre of the quick development of a wide and dense railway network. This article focuses on the logic of this development, from the point of view of a railway company. Is it possible to make a line profitable, and how? How was railway business understood at that time? Which methods were used to analyse the economic potential of each path? Are they similar to the current ones? Was the railway sector supply or demand led?

To address these questions, we first extract the elements of the general context of that time. We then focus on two particular cases. The Zürich-Bodensee line is an example of an early key line which needed analysis to be built in the right way. The Lausanne-Le Pont line, and especially the Vallorbe-Le Pont section represents a small line built to respond to a precise issue. We eventually sketch general answers to the previous questions.

## **Gratitude**

This study would not have been possible without the help of several people who needed to be thanked.

To Professor Axhausen for the taste he has given to me for the transportation science field, for the choice of this particularly interesting subject as well as for his guidelines to structure this work.

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## I Purpose, aims and methodology

The following work analyses the methods used to build railway lines in the middle of the XIXth century in Switzerland. By the global term ‘method’, we mean three distinct aspects. The first component is the analysis of the relevance of the construction of a line between two distinct places – not necessarily cities, for instance the necessity to link Zürich with the Bodensee was prior to the decision of the city which would be the other endpoint. The second one is the question of the exact path of this line. The third one concerns the estimations of the costs and benefits associated with this path. These three aspects are of course linked with each other and cannot be considered only on their own. For instance, it seems clear that the pertinence of a line depends on its expected profitability.

This study is based on documents by the archives of the predecessors of the SBB (schweizerische Bundesbahnen – Swiss federal railways), mainly the Nordostbahn for the Zurich-Bodensee and the Jura-Simplon for Lausanne-Le Pont part. These archives can be found at the ‘SBB Historic’ building in Brugg (Argovie). Besides general material on the railway business, the main documents consulted include acts of the foundation of these companies, reports of general assemblies, reports from engineers on the expected costs and profitability. Aside that, several statistical facts are extracted from the large database ‘histstat’ from the university of Zürich ([7]).

Throughout this study, several questions will serve as guidelines. The point is not to address them one after another, but to keep them in mind and give global answers in the end. Here is a non-exhaustive list of these points of attention:

- Are there significant differences in the pre-construction analysis between a major (Zurich-Bodensee) and a minor (Vallorbe-Le Pont) line?
- To what extent are the methods used in the middle of the XIXth century different from the current ones?
- Is the expansion of the railway network in the XIXth century led by the supply of the private companies or by the demand of the customers (freight and passengers)?

## II The early railways business

### *1) Public wills, but private constructions*

As it is known, the first trains' tracks in Switzerland were built in 1844 by a French company between Saint-Louis and Basel. One had to wait three more years to see the first Swiss line between Zürich and Baden (P. Kammerer, Historical statistics of Switzerland online).

Building railways had revealed itself to be a highly political issue, as well as a strategical business, two facts that bankers and investors of the time had well understood. That is why there was a global disappointment for the businessmen when one noticed that the constitution of 1848 contained almost no mention of the transportation matter, as J. Jung stated in 'der Aufbruch zur modernen Schweiz 'Allerdings überrascht, dass die Bundesverfassung, mit welcher die Architektur einer neuen und modernen Schweiz entworfen wurde, zum Bau und zum Betrieb von Eisenbahnen kein einziges Wort verlor'. The only mention of railways is indeed in the article 28, about contracts on transit charges by customs.

The increasing excitement for the railways construction in the neighbouring countries naturally led to an interest also in Switzerland. Among the different actors, the cantons were the first to see the advantages of a local network linking the very young industry centres to the major cities. Due to the Sonderbund troubles, the realisation was delayed and it is only in 1849 that emerged a federal political strategy concerning the future network from the federal government. The method used was to convey a study made by two English experts – Mr Stephenson and Mr Swinburne, on the needs of the Swiss territory in transports so that they give general directions on the train network to satisfy these needs.

This political lack of interest was filled in 1852 with a law on the construction and exploitation of railways. It was the result of the confrontation between advocates of a public control of the railway system and partisans of private constructions with Alfred Escher at their head. In the end, the scales tipped in favour of the latter ones and the 1852 law stated that private companies should build the lines and that the cantons were to sell the concessions, and set the conditions for their exploitation, like pricing policies. The confederation did not make any prescription for a network at national scale. At that point, we already see that even if companies might have been inspired one by another, there is a priori no reason why the two cases considered (Zürich-Bodensee and Vallorbe-Le Pont) would have the same characteristics, since they were located in different cantons (Zürich, Thurgau, Saint-Gallen for the first one and Vaud for the second).

## 2) *Different companies, different methods?*

Any company had mainly two alternatives to build its business plan. On the one hand, it could search the smallest construction costs, and thus prefer direct routes, avoiding possibly nodes with potential, and waiting for first successes to expand the network, as the railway business was still hazardous. On the other hand, it could look for the biggest long-term profitability, and try to link as many strategic nodes (industry centres, major and minor cities, foreign countries) as possible (R. Stephenson, Swinburn, Bericht der vom Bundesrathe einberufenen Experten). One illustration of this duality is the will to build either a single or a double track line. This choice had also an influence on the type of transport a line planned to make. A shorter route – in most of the cases with lesser cost, would indeed favour freight transportation, especially in the case of exchanges with foreign countries. However, passengers would favour a less direct route through several nodes this case following the concept of a public service.

As the cantons and to a lesser extend the cities were major investors, the argument of building a public service was often put forward, leading companies to prefer the second option, or at least to consider it, even if a more direct route was already in construction. An example for that is the Zürich-Bodensee line as we will see later in this study. As a result of the risky choice of making more expensive paths, it has been estimated that in 1861, about three quarters to four fifth of the railway companies were facing serious financial troubles. These troubles were less the result of a bad exploitation, than of the fact that huge costs were involved in the construction of a line, and that the optimistic wave concerning railways had led to an overestimation of the number of passengers potentially interested (J. Jung, “der Aufbruch zur modernen Schweiz”). Another factor was the underestimation of the costs before the construction. As several companies often made offers concerning a section, the competition led them to undervalue the costs to get the concession. This phenomenon created deficits even in the rare case of absence of unexpected events in the construction.

Furthermore, most of the spared companies were healthier because of foreign capital. This was often the case in border regions where the bordering country (mainly Germany and France) had few interests in the construction of a Swiss public service, and then to strongly prefer the minimal cost option. This was in particular due to the fact that the freight transport was much more important than the passengers transport. This led them to choose the minimal cost option, which made the finances healthier at short term.

Moreover, the option of building at minimal cost was also the one urged by the English experts Swinburne and Stephenson sent by the federal government. They made a strong emphasis on the necessity to make the most out of natural topography, which is mainly to say to build along rivers and to avoid precipitous terrain (R. Stephenson, Swinburn (1850) Bericht der vom Bundesrathe einberufenen Experten). These advices could seem obvious at first sight, but the underlying opinion is that these recommendations are more important than the start and end points of the cities. A few criticisms emerged after the publication of their report, concerning notably the fact that Bern would only be on a minor line, and more generally that this new network would be strongly similar to the already existing links. At that time, trains are indeed competing with carts on road and especially steamboats on the rivers. One of the weaknesses of the steamboat's network is that it has obviously to follow rivers, and building railways along the same watercourses would indeed not make the most of its potential power to link different places in an efficient way.

### *3) A recurrent question: demand or supply led?*

As it is the case currently, supply and demand are two main levers of the economy and especially of the launch of new product, which was the case of railways at that time. However, these terms have to be understood in a slightly different way. 'Supply led' refers to a situation where companies assumed -- with arguments, that building a line would lead passengers to use it, even if they had not planned it before. On the other hand, 'demand led' implies that the demand pre-existed and that it was the main reason why a company decided to build a line or ask for a concession. The difference is that the public actors, like cantons or towns, had a strong weight in the impulse to build lines – to open up certain regions for instance, whereas they were not future users as such. That being said, we will still include this case under the global name 'demand led'.

A first idea is that the eastern part of Switzerland, being more developed, especially around Zürich, had more potential to fund railways companies. That led them to build a tighter network, or at least with more lines and thus to anticipate the needs of the population. In this sense it is an example of a supply led process. Another general idea is that main lines are rather supply-led; even if few passengers or businesses had expressed needs for this kind of line, railway companies are confident that this axes would be used and thus profitable for them (J. Jung, Alfred Escher ; der Aufbruch zur modernen Schweiz). On the other hand, minor lines are a more hazardous business, so without explicit demand a railway company is not keen to study this kind of project.

One of the strategic decisions concerning the railway business is naturally the pricing for both passengers and freight. The pricing process also indicates the lever that was used to build a specific line. As a matter of fact, the higher the price, the more confident the company is that customers would still be interested, which is characteristic of a demand-led process with inelastic demand. The modern idea behind is that a company afford to instore a high price only if it is sure that customers would still be interested. That being said, it is not sure that the logic was the same at that time. A lower price would on the contrary be the reflection that a company needs the price argument to attract customer (both passengers and freight) on its line, which is a supply-led process. The question of demand or supply led is in this sense intimately related to the question of pricing, which is why it will be a major point of attention in the case studies.

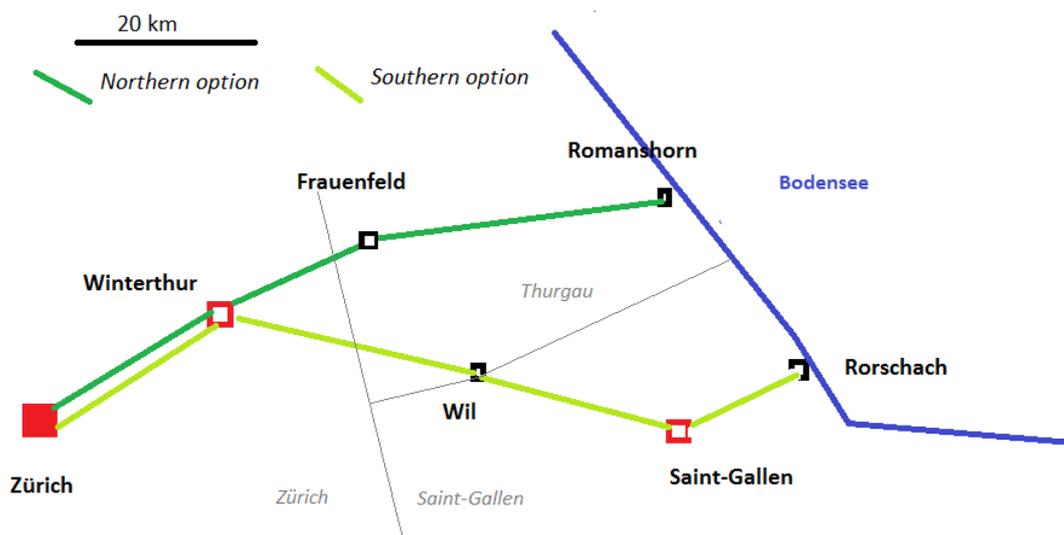
To understand better the pricing issue, it is essential to keep the prices in their context. Here are a few landmarks concerning prices in the second half of the XIXth century. They have all been taken from the historical database of the UZH ([6]). A daily salary for a worker on the worksite for the 'Le Pont-Vallorbe' line was 4 Francs a day. As a comparison, the salary in the building and construction sector in the region of Zürich was around 4.8 Francs a day (11 hours). For food, the price for a kilogram bread varied between 0.4 and 0.5 Franc on the period covered (1855-1890), a kilogram pork meat increased from 1.2 to 1.7 Franc. The rent for a flat with three rooms and a kitchen in Oerlikon was about 260 francs a year in 1900. The following study also came across the weight measure of the XIXth century, the 'Zentner'. One Zentner represents 100 pounds, around 50 kilograms.

### III A main line : Zurich-Bodensee

#### 1) A political competition

The biggest challenge of the Zurich-Bodensee line was probably to reach an agreement among the various actors on the path of this highly political and economically vital line. Although the connexion with Winterthur was an evidence for all, there were still two main options to decide among.

Figure 1 : Main alternatives for the Zürich-Bodensee line



Source : Own representation

On the first hand, the path considered goes to Romanshorn through Frauenfeld. This is the quickest option, and the one recommended by the English expert Stephenson. As stated before, the overall length is around 80 kilometres for an estimated cost of 16 million Swiss francs as double track. The main part of this track goes through Thurgau, what resulted in a serious advocate from this canton.

The other path considered was to Rorschach through Wil and Saint-Gallen. It had the drawback of being longer and much more expensive as the countryside it had to go through

was harder to build on. The total length is 100 kilometres and the estimated cost 33 million Swiss francs also double track. The cost is thus twice for only a quarter more distance. However, one of the main advantages was to connect Zürich to Saint-Gallen, which had a developed industrial centre, as well as a population structure close to Zurich's. Even if this line was shortly traversing the canton Thurgau, the main defender of this option was obviously the canton Saint-Gallen.

Before going more into detail, we can already see that this Zürich-Bodensee line is an example of the tension we mentioned in the first part between building at minimal cost (shortest path to reach the lake), or with potential better long term profitability (through a region with more inhabitants).

As soon as the law was released, there was a rush to make an offer on this line. Thurgau was not willing to make any concession, arguing that its track was recommended by the objective foreign expert. There were however strong criticisms from the other part against Stephenson's work, based on the assumption that a foreigner could not understand well the needs of the Swiss people, and thus using implicitly the argument that railways had to be a public service.

## *2) Cost and revenues expectation methods*

Although it is not done in the same way as it would today, studies were still made to forecast the use of this line. Our main source is the report called 'Über die Rentabilität' (about profitability) led by Dr B. Hilderbrand in 1852 to the general assembly of the Nordostbahn, which tried to address three issues. The first one is the estimated number of people which would use one of the projected lines (either to Romanshorn, or to Rorschach through Saint Gallen). The second one is about the total costs, and the question of whether a single or a double track line should be built in each case. The third one concerns the profitability in each case, with prices as an input.

The first question is the expected number of passengers on the line. Two methods were used: a survey was conducted at the border, and the numbers of travellers on the roads given by the department of customs were studied.

During six months (1851), a sample of randomly taken people entering Switzerland from Germany were asked the question 'If there were a train line connecting the Bodensee to Zürich through Frauenfeld and Winterthur, would you be interested in taking it, and if yes, until where?'. The results showed that 5% would use it to go to Frauenfeld, 25% to go to Winter-

thur, 40% to go to Zürich, and 20% to go further west in Switzerland. Only 10% of people stated that they would not be interested in such a line, and that is maybe the biggest lesson of this survey. This was surely a positive sign for the company; it is thus important to note that it was not an argument in favour of either of the paths. It is also interesting to note that the method of a survey proposing alternatives to a customer in a potential situation was already used, as it is a reference nowadays.

Another way to estimate the number of people travelling in a more systematic way was the counts made by the department of posts along the paths. Hilderbrand used the average on the numbers between 1850 and 1852. He relied for instance on the counting in Schwamendingen to estimate the number of persons travelling between Zürich and Winterthur, which was 260 000 in average over these three years, and thus estimated that around 300 000 passengers would use the 'Zürich-Winterthur' section in one year. This overestimation was justified by an observation he made while analysing Prussian railways, where he saw that the number of passengers on the line Berlin-Potsdam in 1839 was 150% the number of travellers on this road two years before. That is a reason why Hilderbrand considered the estimation of 300 000 passengers as safe; another reason is that trains were at first also seen as a new attraction, and thus might been used by people who want less to arrive at the other endpoint than to travel by train.

The figures of the department of customs were also used by Hilderbrand to compute the expected freight travelling from Germany, potentially by train. He made the assumption that within five years, almost all the freight would pass through train. This might seem a bit optimistic, but the future would give him right. In his analysis, he looked at the amount of freight carried to Switzerland through the Bodensee, which was around 1 million 'Zentner' (50 000 tons) in Rorschach and 900 000 'Zentner in Romanshorn ( 45 000 tons). He noticed that it was a large majority for importation – between 85% and 90%. That is why he focused mainly on the destination of this freight in the sense Germany towards Switzerland. The splitting is also important, and the department of customs reported that 2,5% went to Frauenfeld, 23% to Winterthur, 44% to Zürich and the remaining 30% to western Switzerland.

With these figures, Hilderbrand draws conclusions on the expected number of passengers and the amount of freight transported per year. Here is a table for the first option. The other ones can be found in the appendixes. We observe the figure of 300 000 passengers, which is deduced from the counting analysis. Moreover, it is interesting to note that Hilderbrand estimated that 50 000 more people would travel on the Frauenfeld-Romanshorn part than on the Winterthur-Frauenfeld one, which has no obvious explanation.

Table 1 Expected number of passengers and amount of freight on different sections of the line per year

Section	Zürich-Winterthur	Winterthur-Ffeld	Ffeld-Romanshorn
Passengers	300 000	100 000	150 000
Freight (Zentner)	1 200 000	850 000	900 000

Source : Hilderbrand, „Über die Rentabilität“

Another central data in this analysis is the number of inhabitants of each of the cities in 1850. It would be anachronistic to talk about the use of a gravity model, but the idea remains the same. These data were provided by the historical database of the University of Zürich and come from the census done each ten years in Switzerland in the XIXth century. We observe that the two harbour cities have a similar number of inhabitants, which is much smaller than the other cities'. Zürich is of course the city with the most inhabitants. The interesting figure is the population of Saint-Gallen, which is higher than the one in Winterthur. According to a gravity model, where only persons (and not freight) are considered, the demand for Zürich-Saint Gallen and Winterthur-Saint Gallen would entirely justify the construction of the second path.

Table 2 : Population in several Swiss cities in 1850

City	Zürich	Winterthur	Frauenfeld
Inhabitants	41 000	15 000	3 500
City	Romanshorn	Saint-Gallen	Rorschach
Inhabitants	1 400	18 000	1 700

Source : Patrick Kammerer, *Historical Statistics of Switzerland online*

The second point studied by Hilderbrand is the costs of each of the options. He divided these costs into three categories, which are the cost of construction, the upkeep cost and the cost for the transport of the passengers. He noticed that the first one was independent of the number of passengers; that the second one might be proportional but with an unknown law, and that the third one was linear with respect to the number of passengers. He then gathered different studies which detailed each of these subcosts. At that point, we have to recall the situation. Dr Hilderbrand was part of the Nordostbahn, which had decided to build a line between Zürich and the Bodensee, but had a priori no preference between either of the paths. On the other hand, the detailed cost studies he looked at were given by experts who happened to come from the canton Saint-Gallen, which had obviously interests in the final decision of the Nordostbahn. That is why Dr Hilderbrand was careful with the given costs of construction, which were of 16 million Swiss Francs for the Zurich-Romanshorn line and 31 million for the Zurich-Saint-Gallen-Rorschach line. However, the costs for exploitation and upkeep were more reliable, as they were computed in the same way for each of the paths.

The exploitation costs were then divided between the administrative costs and proper exploitation and upkeep costs. Administrative issues which were essential and did not depend on any of the section, but their cost was then split according to the number of kilometres. This is one of the reasons why the section 'Zürich-Winterthur', which has a relatively small distance and a high potential frequentation, has the smallest exploitation and upkeep cost in percentage – around 41 % with 255 000 Francs per year. The other sections have costs between 40% and 60% of their expected income. One question that remains is to know how the pricing

for freight and passengers was determined, as it is an essential data to compute the expected income, and thus the proportion used by the costs. This is the purpose of the next paragraph, and the costs have a high influence in this pricing.

The pricing is maybe the part of the analysis which differs the most with what would be nowadays. There is indeed no mention of the influence it may have on the number of travellers. The underlying assumption is thus that the number of passengers is not influenced by the price, which is maybe exaggerated, but one must recall that XXth century's reality was not the same, and that there were few options available. Hilderbrand computed indeed the prices after having the costs' estimation, so that these costs represent between 40% and 60% of the expected income depending on the section. The expected income was computed by multiplying each of the goods transported (freight or people) by its nominal price. Ensuring a profit seemed thus more important than trying to maximise it in a more risky way. Another interesting point is the fact that this resulting price is given per kilometre (5c per kilometre according to Hilderbrand's study), which means that no distinction is made according to the section, and that the price for a section only depended on the length of it. One could expect for instance the price per kilometre to be higher on the section Zürich-Winterthur, where the demand is higher. As a comparison, even if the situation is not the same anymore, a ticket with a Halb-tax card costs currently 6.30- to Winterthur and 15- to Romanshorn. The price proportion is then around 2/5 whereas the distance is only 1/4. To sum it up, we can say that the question of how much a passenger would be willing to pay is not taken into account. This matter might have risen later from a deeper analysis, but it is also a consequence of the fact that there was lesser competition on travelling means.

To conclude this part, it is clear now that the choice of the best path was not clear for the Nordostbahn. Beyond the Zürich-Romanshorn and Zürich-Saint Gallen-Rorschach competition, we can see the opposition between two conceptions of railways system. The Zürich-Romanshorn line had indeed the advantage of being shorter and with an easier topography, which made it much cheaper. On the other hand, the Zürich-Saint Gallen line would attract more passengers, produce a higher income and might have more development possibilities. The first one wants railways to be efficient at minimal cost and the second one includes the notion of public service and seek long term profitability with potentially a riskier situation.

The final argument used by Hilderbrand to decide was economical. He compared the pro rata of the initial (construction) costs that would be refunded by the expected incomes in the three following cases – including the option of building both lines. He wanted thus to put on the same level the strengths of each solution. This gave him around 8.5% for the Zürich-

Romanshorn line, 4.5% for the Zürich-Rorschach line, and 3.4% for both together. He concluded that the additional cost did not bring enough additional income, and urged the Nordostbahn to choose the Zürich-Romanshorn option, agreeing thus with the analysis made by the English experts. He however stated that, to him, the Zürich-Saint Gallen-Rorschach line was a reasonable project. Shortly after, the line would indeed also be built.

## IV A minor line : Lausanne- Le Pont

In this part, we will focus on the train line linking Lausanne and Le Pont (VD). The current density of the Swiss railway network must not make forget that it was quite odd to see before 1900 a link to a less than 1000 inhabitants' town. As mentioned before, the construction of the train lines were given to private entities, so this should lead to an effort on lines between major cities, where the profit is more interesting and less hazardous, even more since many minor companies had bankrupted between 1860 and 1880. The main questions leading our study will thus be: What lead investors to build this line? Did they manage to make it profitable, and if yes, how? Is this line representative for other small lines of this time period?

The line Lausanne-Le Pont is actually composed of two different sublines which have different histories and purposes.

The first part chronologically is Lausanne-Vallorbe, which started to be built in 1870. The geographic situation of Vallorbe explains rather well the statute of this line. It is located near the French border, and enables the connection between Lausanne and the French city of Besançon. This is another example of the trend that cross-border lines were ahead of time, thanks to the foreign capital of German states, France or Italy, which had more experience and a more developed railway network at that time, and were thus keen to connect it, even with small lines. This may strengthen also the idea according to which the development of eastern Switzerland network was earlier than the occidental one, although one must keep in mind that the conditions are not the same, since Zurich was a bigger economic centre than Lausanne, and that there were already links between France and Switzerland (through Geneva for instance). It is important to keep in mind the idea of lines being sooner developed in bordering regions, but from now, we will focus on the track linking Vallorbe to Le Pont.

This section is the perfect example of a demand-led construction. It is the 'Societe des Glaces', a company selling ice blocks found in the Joux lake to Lausanne, Lyon or Paris, which asked for a concession in 1882 to build this line. It is important to notice that the process was usually done the other way round, that is to say the canton informed that concessions were available, and companies made offers. The proposition was accepted by the Vaud Canton, which even gave a consequent subvention (360 000 Francs), and the 4 villages in the valley concerned by this line had also agreed on a subvention of 40 000 Francs each (R.Rochart, Cent ans d'histoire du chemin de fer Le Pont-Vallorbe), which is huge compared to their small population estimated to 5 000 inhabitants for the 4 villages (beside Vallorbe) concerned by this section. Even if it was not the original purpose of this line, the canton was favourable

to this initiative which would open up the Joux valley, which had been so far hardly reachable. The canton had offered the same subvention in the past to any company willing to build a road to the valley, but the great costs involved had repelled the investors. It is also important to note that these subventions were given without studies on the potential profitability of the line. One can already see the storyline: A private initiative leads to a significant improvement in public service.

The company 'Société des Glaces' bought the concession to the canton but soon realized they lacked the expertise and experience to do the construction works; in one report, an executing director indeed stated that although this line would significantly decrease their costs – which motivates their offer, it would still be too hazardous to launch this operation themselves, which cost was estimated to about half a million Swiss francs. That is why they sold it in 1885 to a syndicate of Genevian bankers who took the name 'Pont-Vallorbe' company. The sale was done with defiance from both parts, which led to the inclusion of an important condition. The 'Société des Glaces' committed itself to transport at least 20 000 ice tons per year – around 1500 coaches, which was the double of their sales in 1884. The 'Pont-Vallorbe' syndicate was also upset by the fact that their experts had estimated the construction costs to 1.5 million Swiss Francs, almost thrice what the 'Société des Glaces' had announced (Michel Dehanne, *Voies normales privées du Pays de Vaud*). It is however worthwhile to notice that these costs per kilometre (1.5 million for 8 km) are still similar to the ones for the Zürich-Romanshorn line (16 million for 80km), whereas the topology of the line is much steeper; racks had to be built on almost 2 kilometres. This fact remains odd, even if it can be partly explained by the fact that as this line was built around 30 years after the Zürich-Bodensee one, the construction techniques were more developed and thus cheaper.

It is also necessary to have a better understanding of the business plan of the 'Societe des Glaces'. Depending on the regions, the ice could be sold for between 8 and 10 cents the kilogram (P. Kammerer, *Historical statistics of Switzerland* online). The new train line connected Le Pont where the ice was stored to Vallorbe in 40 minutes, instead of the 5 hours previously needed because of topography and congestion on the small roads. From Vallorbe was Lausanne reachable in about 2 hours, and Geneva in around 4 hours (R. Rochart, *Cent ans d'histoire du chemin de fer Le Pont-Vallorbe*). We can roughly say that the time to reach Geneva was divided by 2, and that the amount of ice lost by melting by the same factor. Making the assumption that Geneva represented the half of the sales (we sadly have no indication for that although it seems a convincing estimation), we obtain that at least 5000 tons of ice were spared, which represents 50 000 Francs per year. We did not include the additional costs for the train, assuming that there were compensated by the costs of the carriers, even if there were

actually higher. Including the other sales destination, one can assume that the economy made by the Societe des Glaces would have been on the order of 80 000 Francs per year.

The pricing process for this line is also specific. In their first analysis sent to the canton in order to obtain the concession, the ‘Société des Glaces’ fixed the price for a one way ticket to 1 franc for a passenger for the section ‘Le Day-Le Pont. Le Day was a town neighbouring Vallorbe, which in the end became the endpoint of the line. Sadly, we have not managed to have access to the analysis which led to this pricing, but one could expect it to be similar to the Zurich-Bodensee one, that is to say based on the desired profitability more than on the willingness to pay. An interesting fact is that this price was modified and increased to 1Fr 20 – still for a single way ticket shortly after. One hypothesis for this is that the company was anticipating the sale of the exploitation and tried to make it look more profitable to make this sale more easily. As a result, the prices were exceptionally high: around 15 cents a kilometre, three times more than the Zürich-Bodensee line’s price, whereas we have noticed before that the costs per kilometre were similar. As a reminder, a worker salary was 4 Francs per day, which means that it was not enough to go to Lausanne and come back. This choice of high prices – maintained by the ‘Pont-Vallorbe’ syndicate afterwards clearly reminds that trains were also an attraction and a luxury good at their beginning, even if some actors, like the canton saw them as an effective tool to open up the Joux valley.

At that point, one could think that the syndicate ‘Pont-Vallorbe’ could rely on the incomes ensured by the transport of ice blocks, which was lower bounded by contract to 20 000 tons per year. However, the company ‘Société des Glaces’ was led into bankruptcy in 1887, probably due to emergence of artificial ice and some scandals which significantly decreased the demand for ice. One can also assume that the high prices policy – which they launched themselves, did not help them. The railway company was threatened to lose its main source of freight; it represented 3/5 of the goods transported in 1886 although the amount of 20 000 tons had not been attained in 1886 and that the penalties were not paid. They thus decided to buy back the ‘Société des Glaces’. After some tight years, which were marked by another buy-back by the ‘Jura-Simplon’ company, the section benefitted in 1899 of its extension to the lake’s other end, Le Brassus, which significantly increased tourism, and thus the line’s frequentation and help the finances, before the nationalisation in 1903.

## V Comparative analysis and answers

In this section, we will come back on the questions asked in the introduction, and understand to what extent these two case studies gave an answer to them

The first question was to know whether there were significant differences in the pre-construction analysis between a major and a minor line.

One cannot expect the Zürich-Bodensee and Le Pont-Le Brassus line to have the same characteristics since they were built at different time, in different regions, by different companies. The point of the following paragraphs is to highlight the main common points and differences.

Both lines were built for economic reasons at first, on top of which the public actors (cantons and towns) tried to add a public service matter. This had different outcomes; it led to tensions between the cantons Thurgau and Saint-Gallen in the first case, whereas it eased the process in the second one, especially thanks to subventions that the ‘Pont-Vallorbe’ company obtained rather easily. Even if they were both built for economic reasons, the central question of expected profitability was not dealt with in the same way. It was the major argument in the first case, which led to the construction of the Zürich-Romanshorn section, and the documents about it are numerous and detailed. In the other case, the profitability had also been studied, but the ‘Société des Glaces’ wanted the line to be built, implying maybe that it could cover the costs in any case with the benefits resulting from the time gained– and thus volume of ice spared. Although estimating the costs is a difficult exercise, one notices also that the error made was much bigger in the western case (underestimation by a factor of three), even if it was built 30 years after, so one could assume the experience had spread in the country.

The second question was to know to what extent the methods used differed from the current ones.

Several methods used nowadays had already been introduced then. Some of them have almost not changed, as it is the case for the cost estimation. Others are premises of current methods : the idea is the same, but its realisation has changed, notably because of the amount of data easily available. This is for instance the case for surveys with options in different potential futures in order to understand the population’s opinion towards a new alternative or a policy change. As it had been used in the Zürich-Bodensee line, which is quite early in this

half century of railways' construction, we can suppose that it was widespread and applied for a major construction. One drawback was indeed that the collection of data was much more difficult than it is now, which made it also costlier, and which might explain why it was not systematically used for smaller lines.

However, the pricing methods were dramatically different. We indeed saw in the case studies that the prices were 'cost-driven', that is to say computed after costs were determined, so that the profitability reaches a certain level. There were almost no research on the price a customer would be willing to pay for taking the train, or on the relation between the price applied and the number of passengers interested. This might seem a weakness at first sight, but is also an outcome of the situation at that time. There was much less competition for transportation means. Steamboat were also developing, but were subjected to watercourses, and carriages were slower as well as more expensive. In this situation, the optimism concerning the choice of the customer for the railway is already more justified. One can hypothesise that only the rise of a stronger competition – in transportation means as well as in other sectors, led the concept of willingness to pay to rise and to be studied. Still, this is a reflect of the fact that railways network were not understood in the same way as they are now. Indeed, in an industrious time, using a train meant to make previous constructions and to wear them, whereas in our current society of service, passengers only want to be transported from point A to point B. In this sense, it is understandable that companies in the XIXth century made customers pay for oil, tracks' or material construction and upkeep, whereas we pay now for a service.

The third question was whether the building of railways at that time was supply or demand led.

As it could be expected, it is difficult to give a global answer to it. Would the passengers come because a line was built, or is a line built, because people, or companies ask for it? The example of the Vallorbe-Le Pont line is clearly demand led. Even if there was a theoretical will to open up the valley, it is only because the 'Société des Glaces' asked for the concession for their personal benefit that it was built. It was almost the opposite problem, since after the bankruptcy; the 'Pont-Vallorbe' company struggled to find passengers and freight.

It seems logic to affirm that the first lines have mainly been supply-driven. So long railways were not widespread, it is difficult for the population to evaluate clearly its benefits, and thus to be demanding. This hypothesis is confirmed by the figures concerning passengers in Prussian railways, which Hilderbrand used for its study. It showed indeed that the amount of passengers on the Berlin-Potsdam line for instance had doubled in its four first years(1840-

1844), which is the sign of a supply driven good. The Zürich-Bodensee line appears thus as a mixture of both processes. Another intuition one could have is that the major lines were built on a supply-led analysis: people could already travel using other modes – even if they were less efficient, so there was no real demand, but experiences and examples had shown companies that if they built a line, people could change their habits. On the other hand, smaller lines are rather demand led, the demand coming either from the canton and other public actors to open up a certain region, or from a company in specific cases, as for Le Pont-Vallorbe.

## Conclusion

“Railways will be the transportation means of the XXIth century if they manage to survive the XXth century” stated the French railway businessman Louis Armand in the early XXth century. This concise idea could sum up the way the railway business was seen in the XIXth century. It showed indeed great potential, as the tremendous success of the supply-led lines is an example, but the optimistic wave among the population as well as among businessmen had also led to hazardous projects and a lot of bankruptcies among small railways companies. The Swiss state decided thus to nationalise the exploitation of the railway network in 1903 to prevent the possibility of a breakdown of a tool which had become vital in the business landscape. This turning point also converted the railways system from a product among others to fully a public service as we know it in 2016.

Although this study has produced interesting results, it might be improved and there are still directions it would be useful to dig into. First, some reports of the “Pont-Vallorbe” line . As it was a smaller company than the “Nordostbahn”, their archives are not as well centralised as the “Nordostbahn” ones which are almost all at the SBB historic building in Brugg. Some documents are for instance at the archives of Vallorbe or in the village of Le Lieu and could not be exploited for time matters. There could have provided this study with more figures and statistics concerning the western line. Throughout this study, the situation was often looked at from the railways company’s viewpoint. Another improvement could be to include other actors, for instance the cantons or other companies that may have benefit from the installation of train lines. Further study points could be to understand how public authorities allocate budgets for the subventions of different lines, or to quantify the financial benefits made by a precise company thanks to the opening of a line. To link both points, one could study the relevance of a new tax on benefits to finance further new line sections.

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## Appendix

Table 3 : Expected number of passengers on the southern option in different sections

Section	Zürich-Winterthur	Winterthur-Frauenfeld	Frauenfeld-Wil
Passengers	300 000	150 000	200 000
Freight (in Zentner)	1 200 000	1 200 000	1 200 000

Section	Wil-Saint Gallen	Saint-Gallen Rorschach
Passengers	300 000	300 000
Freight	1 850 000	1 850 000

Source : Hilderbrand, „Über die Rentabilität“