The Impact of a New Subway Line on Property Values in Helsinki Metropolitan Area

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Key words: subway, property valuation, housing price, property value

SUMMARY

The planning process of a new subway line started in 2007 in the Helsinki metropolitan area. The construction works were started in 2009 and the new subway line is planned to be opened by the end of 2015. As a result of the new subway line the travelling time to the city center decreases. The prediction of economic theory would be that housing prices near the subway stations would increase as a result of having better access and lower cost of traveling within the city. The empirical evidence on these predictions is however missing, at least in Finland.

The objective of this article is to illuminate whether this new subway line will have an impact on residential apartment values and on public revenues. The research questions are: how far does the effect of a new subway line reach (Q1); how big (%) is the average impact on apartment values (Q2) and; how big (€) is the total impact on apartment values (Q3). The article also discusses how the rail-induced value increases effect public revenues. The first question was analyzed and answered based on literature review. The second question was analyzed based on hedonic approach. The third question was answered based on the two previous questions.

The results showed that a new subway station has an impact that reaches in most surroundings at least to 400 meters. The impact that the new subway station had on residential apartment values was on average 11-15 percent in the studied area. The total impact in the studied area was approximately 122-193 million euros. It was estimated that the rail-induced value impact increased the city's revenues from property taxes for almost 10 percent.

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1 INTRODUCTION

The planning process of a new subway line started in 2007 in the Helsinki metropolitan area. The construction works begun in 2009. The new subway line is planned to be opened by the end of 2015. This study analyzes the value impact that the new subway line will have on one residential area. The case area called Matinkylä will have its own subway station by the end of 2015. Whether this new subway line will have an impact on apartment values and further more on public revenues is a question that will be illuminated in this article.

The prediction of economic theory would be that housing prices near the subway stations would increase as a result of having better access and lower cost of traveling within the city (Alonso 1968, p. 59; Mills 1967, p. 200; Muth 1970, p. 5-6). As a result of the new subway line the travelling time to the city center decreases. The decreased travelling time increases the wellbeing of the community which causes growth in the prices of residential apartments. The prices will keep increasing because of the higher demand until the wellbeing has been restored to its previous level due to the increased living expenses. The empirical evidence on these predictions is however missing, at least in Finland.

As regards funding for public transit, one should point out that possible public-transit induced premium on sales of residential apartments generates additional revenue from property taxes. This effect of public transport has been largely filtered out in the discussion of funding for public transit, which might be due to the lack of empirical evidence so far regarding the influence of rail infrastructure on house prices in Finland. This study is to help to close this gap by analyzing the contribution of rail-induced price increases to the funding of public transport.

Therefore the effect of the new subway line in the Helsinki metropolitan area becomes an empirical question. The goal of this study is to estimate is there such an impact. The research question regarding property prices is divided in three sub-questions:

1.) How far (meters) does the effect of a new subway line reach (Q1)?
2.) How big (%) is the average impact (Q2)?
3.) How big (€) is the total impact (Q3)?

The average impact means the percentage increase of real estate value and total impact the absolute increase of real estate value. The first question is analyzed and answered based on a literature review. The second question is analyzed based on a hedonic approach. The third question will be answered based on the two previous questions. The contribution of rail-induced price increases will be analyzed and discussed based on the third question.

The study contributes to an understanding of the hitherto little explored influence of income level on the connection between access to railway infrastructure and residential apartment prices. *Literature review* section provides an overview of the current literature on the subject. *Materials and methods* section describes the data that forms the basis of the study and illustrates the empirical models used. In the *Results* section the answers to the research questions are given based on the material and methods used. *Discussion and conclusions* are presented in last section.

2 LITERATURE REVIEW

There are two main questions that need to be reviewed when the total impact of a new subway line is analyzed. The first question is how far the impacts (positive or negative) reach. The second question is how strong the impact in the chosen or revealed area is.

The reach of the impact of a subway station has been analyzed in several studies. The studies show that the impact on property values can reach for almost five kilometers away (see Table 1). According to Dewees (1976) the impact area reaches to 1600 meters. McMillen and McDonald (2004) discovered that the impact reaches up to 2400 meters. Bowes and Ihanfeldt (2001, p. 15-18) show that the impact to the price is negative when located close to a subway station, but after 400 meters the impact turns positive. Brandt and Manning (2012, p. 1009-1011) estimated that the impact is the biggest when reaching a distance of 250 to 750 meters from a station. In every study that was reviewed in this study the impact area reached at least to 400 meters. This distance is considered to be the minimum distance for which the new subway station has at least impact. The different values in one row are those limits, where the impact changes.

Table 1. *Previous research on impact areas of subway.*

Research	Impact distance (m)	Research area
Dewees 1976	1600	Toronto, Canada
Laakso 1986	200, 400, over 400	Helsinki, Finland
Hellman 1987	400	Helsinki, Finland
Lahti 1989	200, 400, 800	Helsinki, Finland
Laakso 1997	250, 500, 750, 1000, over 1000	Helsinki, Finland
Bowes & Ihlanfeldt 2001	400, 800, 1600, 3200, 4800	Atlanta, United Sates
City of Espoo et al. 2002	600	Espoo and Helsinki, Finland
Lin & Hwang 2004	400	Taipei, Taiwan
McMillen & McDonald 2004	2400	Chicago, United Sates
Debrezion et al. 2007	400	Several locations
Brandt & Maenning 2012	250, 750, 1250, 1750, 2000	Hamburg, Germany
Pan 2013	400, 800, 1600, 3200, 4800	Houston, United States

When reviewing the previous studies, it has to be noted that in this case area the subway line is built to an area with no existing subway lines. This will most probably have an effect on how far the effect of the new subway line reach. If the research area has already several existing subway lines, the impact area of a new line may be smaller because the density of the stations is bigger and due to that, they collect less people from the surrounding area. Table 2 presents the existence of subway lines in the research areas of the previous researches. Based on the background information of the previous researches, the most similar areas compared to the studied area are those which concern the new subway line in Espoo (Lahti 1989; City of Espoo et al. 2002), the Helsinki subway (Laakso 1997), the Toronto subway (Dewees 1976) and Chicago subway (McMillen & McDonald 2004). In these studies the impact reaches from 600 meters to 2400 meters. The City of Espoo et al. (2002) examined the impact of the new subway line and found it to be 600 meters on average from each subway station. As the subway in the case area is being built in the City of Espoo, the estimate from last source can be seen as the most reliable one.

Table 2. *The existing subway lines in the previous research areas.*

Research	**Existing lines**
Dewees 1976	No other subway lines. The subway was built to replace the previous “street car service”.
Laakso 1986	No other lines.
Hellman 1987	No other lines.
Lahti 1989	No other lines in Espoo, subway line in Helsinki.
Laakso 1997	No other lines. The next line in Helsinki subway is completed in 1998.
Bowes & Ihlanfeldt 2001	Also other lines.
City of Espoo et al. 2002	No other lines in Espoo, subway line in Helsinki.
Lin & Hwang 2004	Three other lines.
McMillen & McDonald 2004	No other line in this area, elsewhere in Chicago subway line from the beginning of 20th century.
Debrezion et al. 2007	Study was made to collect information from other studies.
Brandt & Maenning 2012	A whole rail network surrounding the area.
Pan 2013	When building the line, no other lines. The subway was built to replace the previous “street car service”. When the research was done, two other lines at building stage and two at planning stage.

Based on the previous studies it can be stated that the impacts of a subway station reach almost certain to a distance of 400 meters. This is the minimum distance used in this study. The maximum distance chosen for this study is 800 meters since the density of stations of the new line is rather large. By choosing the maximum distance of impact to be 800 meters, the goal is to avoid overlapping estimation of impacts of several stations.

The previous Finnish studies show that the impact of building a subway has only positive effects. The price increases of residential properties near the subway station (< 400 m) varied from 7,5 to 16 percent (Laakso 1997; Laakso 1991; Laakso 1986). More variance can be detected in international studies where the impact near the subway stations varies from – 18,7 to 33 percent. The property value impacts form the reviewed articles are presented in Table 3.

Table 3. *The change in prices of residential properties.*

Research	**Distance from the station (m)**				
	0-400	400-800	800-1200	1200-1600	1600-2000
Laakso 1986	+ 16,0 %	-	-	- 8 %	
Laakso 1991	+ 7,5 %	+ 5,0 %	+ 2,5 %	-	
Laakso 1997	+ 9,2 %	+ 5,4 %	+ 2,1 %	- 2,3 %	
Bowes & Ihlanfeldt 2001	- 18,7 %	+ 2,4 %	+ 0,5 %	+ 0,5 %	+ 1,8 %
Bae et al. 2003	+ 4,4 %	-	-	-	-
Lin & Hwang 2004	+ 33,0 %				
McMillen & McDonald 2004	+ 6,9 %				-
Debrezion et al. 2007	+ 4,2 %	-	-	-	-
Agostini & Palmucci 2008, announcement of building the line	+ 8,6 %	+ 6,7 %	+ 1,4 %	-	-
Agostini & Palmucci 2008, announcement of location of the stations	+ 6,7 %	+ 4,7 %	+ 0,9 %	-	-
Brandt & Maenning 2012	+ 3,2 %	+ 3,4 %	+ 2,0 %	+ 1,2 %	+ 0,4 %
Pan 2013	decrease	no effect			increase
Average	**7,4 %**	**5,0 %**	**2,3 %**	**- 2,2 %**	**- 2,1 %**

The international studies show that the impacts of a metro station to the prices of residential properties vary strongly. A study made by Bowes and Ihlanfeldt (2001) reveals also a negative impact when examining the close surroundings of a metro station. A possible explanation for this may be that this particular study takes also the crime statistics into account. Overall, the variation in impact areas between different studies can be explained by variation in research data and methodology. Each of the studies needs to be carefully revised when comparing the impact areas.

3 MATERIALS AND METHODS

3.1 Study material

3.1.1 Apartment prices

Apartments are classified as private properties in the Finnish legislation. The Finnish purchase price register has information only concerning real property transactions. Only the Finnish tax officials have the full information on realized prices form apartment transactions and this information is not available, even for research purposes. The Finnish realtors have, however, their own price register on apartment prices which they publish online (www.asuntojen.hintatiedot.fi). The information is available only from the past 12 months. Transactions are presented only if there are three or more transactions in the same postcode. Only the major realtors are publishing transactions. These restrictions mean that on average, approximately half of the transactions are listed in this online price register. (Tuominen 2014, p. 37-39). Information that is this price register include: transaction price, postcode, number of bedrooms, area, construction year, floor, elevator (yes/no), balcony or yard (yes/no) and condition (poor/satisfactory/good).

Information for this study was collected from the mentioned price register in 21st February 2014. Transactions were selected from two cities, Helsinki and Espoo. Total 3 431 transaction were found and 11 from those were eliminated because they were most likely parking slots or similar utilities inside apartment buildings. Transactions were made in 177 different postcode areas. The construction years varied from 1 874 to 2 015. 5 percent of the apartments were in poor condition, 41 percent in satisfactory condition and 54 percent in good condition. 60 percent of the apartments had an elevator and 25 percent a balcony or a yard. The floors varied from 1 to 17 and the number of bedrooms from 1 to 4 (or bigger). The average price per square meter was 4 234 €.

Also an additional variable regarding travelling time to central business district (CBD) was added to the study material. The travelling time to CDB was defined by using the official route calculator (www.reittiopas.fi) that analyses travelling time (minutes) with the chosen transportation. Finally, the material was coded for hedonic approach.

3.1.2 Apartments

The information about apartments and their characteristics itself is widely available. In this study a public database (SeutuCD) was utilized to collect the information about apartment characteristics on the residential area (Matinkylä) that was chosen as the case area. By utilizing the answers to Q1, represented in *Literature review*, the information about apartment characteristics was collected. Figure 1 shows the study area and illustrates the surroundings on different distances (400 meters, 800 meters).

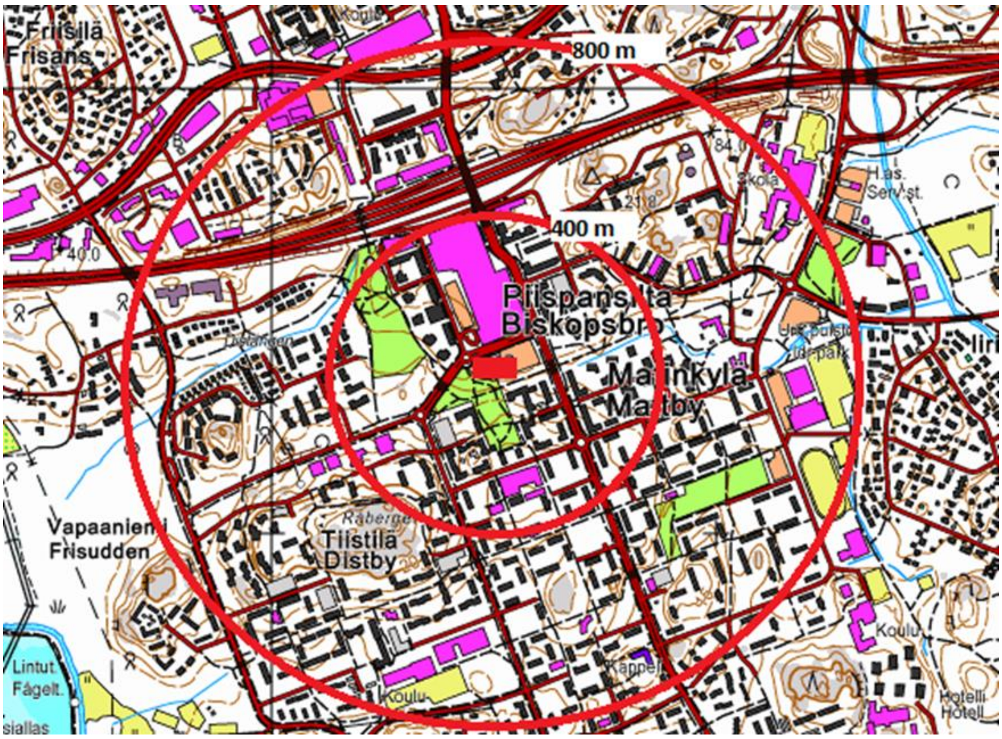

Figure 1: *Matinkylä resindential area. The information about apartment characteristics was collected by using two radius (either 400 or 800 metres) around the new subway station.*

Inside 400 meter radius there were 77 apartment houses and inside 800 meter radius 561 apartment houses. The age of the apartment houses varied from 1 to 55 years, average being 25.

Following information was collected concerning each apartment inside an apartment house: age, number of bedrooms and size of the apartment. Also two additional variables regarding travelling time to CBD were added to the study material. First of all, the current travelling time was added by utilizing the official route calculator. Then the future travelling time (after the subway is built) was added. This was done by calculating the travelling time as a sum of the time spent on the way to the subway station and on the subway itself. The route calculator was utilized to estimate the time spent between each apartment and the subway station and the timetables of the new subway (published already!) to estimate the time spent in the subway.

3.2 Methodology

The average price impact (Q2) is calculated with hedonic price functions. Econometrically, hedonic price models are estimated with the Ordinary Least Squares (OLS) method. The idea of hedonic pricing is to consider housing as a multi-dimensional differentiated good. Hedonic equations are used to decompose housing rent or value into measurable prices and quantities that can be used to estimate rents or values of different dwelling combinations. A hedonic estimation is simply a regression of expenditures on the housing characteristics. The regression coefficients may be transferred into implicit price estimates of these characteristics.

There are many features affecting housing prices, the most common categories being structural, neighborhood and locational characteristics. Malpezzi (2003) presents the fundamental hedonic equation simply as follows:

$P = f(S, N, L, C, T)$, where: [1]

P = price / value of the dwelling, S = structural characteristics, N = neighborhood characteristics, L = location, C = contract conditions or characteristics, and T = the time rent or value is observed.

There is no such thing as an established functional hedonic form in the literature of urban economics (see e.g. Halvorsen and Pollakowski 1981, Malpezzi 2003). Pioneering papers on hedonic analysis like Lancaster (1966) and Rosen (1974) provide little help for choosing the functional form. One of the most important findings of the hedonic pricing theory is the nonlinearity of the value function (Laakso 1997). Nonlinearity stems from the non-divisibility feature of housing. In practice, the nonlinearity is taken into account by using the natural logarithm of price as the dependent variables.

Different authors have tried different models to find the best fit. For instance, in his literature review on empirical studies on housing prices, rents and land prices, Laakso (1997) concludes that the most common functional forms are log-linear and semi-log forms. Flexible functional forms and the Box-Cox transformation are also common. Laakso concludes that when the size of the data set allows the use of dummy variables, dummy variable models are superior as compared with continuous variable models regarding R2 statistics and homoscedasticity. Furthermore, the results of dummy models are simple to interpret. After having reviewed a number of hedonic pricing studies, Sirmans et al. (2005) conclude that linear and semi-logarithmic specifications are the most common ones.

In this study, the data was analyzed using the ordinary least squares method. The general form of the linear regression model is as follows:

$$y = \beta_0 + \beta_1 x_1 + \ldots + \beta_n x_n + u \qquad [2]$$

where β_0 is the intercept, $\beta_{1\text{–}n}$ measure the change in y with respect to $x_{1\text{–}n}$, while holding all other factors fixed, and u is the error term. The estimated equation expresses the price per square meter as a function of the independent variables. An attempt was made to take a natural logarithm of the unit price, but the linear form was found to be a better fit.

After a number of iteration, the best equation that could be formed based on the data available is presented in Table 4. As seen in Table 4, only four variables were found statistically significant (at 1 percent level). The variables that were not included in the model were: floor, elevator (dummy), balcony (dummy), condition, municipality, and distance by private car. Even the condition of the apartment could not be included to the model because of its strong correlation between the ages of the buildings as was the correlation between distance by private car and distance to CBD. The model accounted for 48 percent (R^2) of the variance in the apartment prices which is not very good comparing price models in general. But in this case where the data is limited it was the best achievable result. The result could have been better if some proportion of the observations that didn't fit the model had been eliminated from the study material. But as we had no other evidence than the price to conclude if the observation was representative, practically all of the observations were included in the analyses.

Table 4: *The hedonic model from apartment transactions in Helsinki metropolitan area between 22.2.1013-21.2.2014.*

Model	**R**	**R Square**	**Std. Error of Estimate**
1	0,69	0,48	1073
Coefficients	**B**	**Std. Error**	**Sig.**
B_0 (constant)	15432	400	0,000
Age of the building (ln)	-401	26	0,000
Distance to CDB (ln)	-1963	42	0,000
Size of the apartment (ln)	-876	98	0,000
One bedroom (dummy)	0	-	0,000
Two bedroom (dummy)	-427	73	0,000
Three bedroom (dummy)	-281	105	0,007
Four or more bedroom (dummy)	-222	137	0,105

The model presented in Table 4 is used to analyze the answers to Q2 and Q3. For Q3, the formula is used to calculate a value estimate for every apartment in the study areas (400 meter, 800 meter), both before and after the new subway station is in use. The difference between these two values in both areas is considered to give an answer to the question how big (€) is the total impact (Q3). When the total impact is divided among single apartments, an estimate on how big (%) is the average impact (Q2) can be given.

If we would like to give an estimate for an expected price change for a single 80 square meter apartment that is built in 1967 (age 48), has 3 bedrooms and has now 35 minutes distance to CDB and afterwards 30 minutes distance to CDB, the formula can be formed as:

Price (before) = 15432 – 401 x ln(48) – 1963 x ln(35) – 876 x ln(80) – 282 x 1 = 2780 €/m2

➔ 80 meters x 2780 €/m2 = 222 400 €

Price (after) = 15432 – 401 x ln(48) – 1963 x ln(30) – 876 x ln(80) – 282 x 1 = 3082 €/m2

➔ 80 meters x 3082 €/m2 = 246 600 €

In this case the total impact would be 24 200 € and the average impact 11 percent.

To analyze the impact on public revenues the total impact (Q3) is multiplied with annual property tax (0,8 percent) and capitalized to 30 years with 5 percent interest rate. This discount rate and time period was chosen because they are generally used for cost-benefit analyses in public investment projects in Finland.

4 RESULTS

This study was set up to analyze the impact that the new subway line has on apartment prices and on public revenues. In the literature review it was observed that a new subway station has an impact that reaches in most surroundings at least to 400 meters. In the studied area, the reach of the impact regarding property prices was estimated to be somewhere between 400 and 800 meters. In the studied area other subway stations are located quite close to each other and after 800 meters it is difficult to estimate which station "makes" the impact.

The impact that the new subway station has on residential apartment prices is on average 15 percent in 0-400 meter radius and 11 percent in 0-800 meter radius. The total impact in the studied residential area Matinkylä was 122 million euros in 0-400 meter radius and 193 million euros in 0-800 meter radius.

When the impact is totally capitalized to apartment prices, the annual tax revenues will increase approximately 1,0-1,5 million euros. Therefore, the capitalized impact to the public revenues from the increased property taxes is approximately 15-24 million euros in the studied area. There are eight new subway stations in the city of Espoo. If the average revenue from each station is somewhere in the same range, the tax revenues increase ca 120-189 million euros in total. For the city of Espoo this means that the tax revenues from property taxes increase for almost 10 percent which a little bit more than what is found elsewhere. For example in Chile, the building of a new subway line was estimated to increase property taxes by 7,5 percent (Agostini and Palmucci 2012, p. 72). On the other hand, Brandt and Maenning (2012, p. 1014) noted that the property tax is not the only tax increasing, also the transfer taxes increase.

Whether or not the increase in the tax revenue is considered as a major benefit, the majority of the revenues go to private property owners. They have the actual possibility to collect the value increase by selling their properties. It has to be reminded as well that the increase in value does not happen overnight. The value increase has probably started several years ago when the first discussions about the new subway line were started. The benefits are not most probably yet totally capitalized in the values of the apartments. The long time period in the value creation makes it difficult to study if the study material does not include observations from several years.

The methodology utilized in this article does not observe the actual price changes that the new subway line creates. This study estimates only the impacts by analyzing the differences of distances. This methodology is chosen, not because it is the most reliable one but rather because it is the most suitable one with the material at hand. If there had been information about apartment prices more widely available, especially from several years, the methodology could have been altered. This methodology does not take into account that subway station most probably have adverse (noice, crimes etc.) effects as well (Brandt & Maenning 2012).

If the results of this study are compared to previous studies, it can be observed that the value increase estimated in this study is higher than in most studies. Most relevant studies that can be compared are the Finnish ones, in which the average value increase was 1-6 unit percent lower. This might be explained with the adverse effects that are excluded in the methodology applied in this study.

6 DISCUSSION AND CONCLUSIONS

The subway is one of the largest investments in the public infrastructure in the Helsinki metropolitan area. The construction of a new subway line has an impact on housing prices which is not negligible. The price tag for a new subway line was approximately 700 million euros. There has been a wide debate on whether this will be a profitable investment. A better question would have been, for who is it profitable. The result of this study showed that the apartment prices increase 122-193 million euros in just one residential area. As there are nine residential areas where the new subway will have an effect on, it is undeniable that the investment is profitable. However, most of the profits are collected by individual property owners and whether this should be included in the profitability analyses at all, is a political choice rather than an empirical question.

The construction of a new subway has also a lot of other impacts that are not in the scope of this study. But in the discussion part the most important ones cannot be forgotten. First of all, there is a lot of evidence that public-transit induced premium on sales does not concern only apartments houses but also other property types, especially office and retail spaces (Laakso 1986, p. 27; Lahti 1989, p. 66, 97; Debrezion et al. 2007, p. 161). A new subway also changes the land use near the subway station to a more efficient one which might have major impacts on employment. The economic boost that the new subway creates has increased at least retail and service business near the stations and on the other hand reduced industrial areas on the neighborhoods. (Bae et al. 2003, p. 92-93). This all fits well to Alonso's (1968) basic theory on location and land use.

The reasons why the subway is being built now and not earlier is the adverse effects that the citizens are afraid of. In some areas of Helsinki the surroundings of a subway station are not especially appealing. Will the surroundings change to an undesirable direction is a question that can only be speculated. The same concerns the public debate on drug problems that have been added to the list of adverse effects of a new subway. If the property values increase it does not seem probable that the surroundings will change for the worse. For us it does not seem very likely either that the increase in apartment prices will be used on drugs. One of the interesting implications of the positive impact of the new subway line on housing prices is the associated increase in property tax revenues. Our estimations imply a tax revenue increase ca 10 percent. This could potentially be earmarked either for the new investments in the subway lines or to the prevention of the adverse effects that the new subway might cause. Perhaps this would be the opening in the upcoming debates on whether or not to build more subway lines in the Helsinki metropolitan area.

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