Fiber-Broadband-Intenet and its regional impact - An empirical investigation*

Gordon Klein †

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Abstract

I analyze a quasi-natural experiment of fiber broadband rollout in a rural German area. The analysis particularly investigates the impact on real estate values. I find that there are strong and significant effects of fiber broadband deployment. These indicate that there are relevant personal benefits from broadband deployment for customers. Therefore, the findings add to the literature of evaluation of broadband infrastructure investment.

Key words: Broadband Internet, Real Estate Values, Quasi-natural experiment, Treatment Evaluation

*Corresponding Author: Gordon Klein, CAWM, Westfaelische Wilhelms-Universitaet Muenster, Germany gordon.klein@wiwi.uni-muenster.de. Jonathan Tuerk, CAWM Westfaelische Wilhelms-Universitaet Muenster; We are very grateful to Deutsche Glasfaser and Empirica Systems for providing us with data for the study. We thank Kathrin von Graevenitz and Jonathan Tuerk for work in an early stage of the study.

†CAWM, Westfaelische Wilhelms-Universitaet Muenster, Germany

1 Introduction

When discussing future growth and welfare in the area of digitization, it is commonplace in the political debate to demand an enhancement of the digital infrastructure and, in particular, of broadband internet access or even fiber broadband access.[1] One aspect, that is often taken for granted in this discussion, is a substantial positive impact on further economic development driven by fiber broadband. Given the vast amount of public subsidies, it is important to understand whether these proposition hold and how large the potential utility of fiber broadband is. Given that subsidies are typically focused on particular regions (Bundesministerium fuer Wirtschaft und Energie, 2017), it is also important to understand how this potential effect translates into a regional and individual impact.

A positive attitude regarding investment in telecommunication is backed, in general, by the literature. For instance, it has been shown by the landmark paper of Roeller and Waverman (2001) and confirmed for broadband infrastructure by Koutroumpis (2009) and Czernich et al. (2011).[2] Still, those studies treat mostly common broadband and do not differentiate for the broadband quality. A recent study by Briglauer and Gugler (2019) confirms this general pattern also for fiber broadband internet. Applying an instrumental variables approach, they estimate the impact of broadband adoption by different technologies, i.e., basic, FTTH/FTTB[3], as well as hybrid broadband. Thus, they are able to identify different aggregated effects of adopting broadband according to different kinds of technology. In particular, they show that adopting broadband has a positive effect on the GDP, but this additional gain is denoted to be decreasing with recent technologies, indicating a typical decreasing marginal utility pattern. This finding indicates that evaluating the utility of fiber broadband is a complex task and requires further evaluation.

[1] This in fact translated into various programs that intend to subsidize the rollout of such infrastructure (Bundesministerium fuer Wirtschaft und Energie, 2017; European Commission, 2019). For a discussion, see Klein (2020), which also refers to the results of this study.

[2] For similar discussion, see Bertschek et al. (2013).

[3] The acronyms FTTH and FTTB are for fiber-to-the-home and fiber-to-the-building

Recognizing how the usage and availability of broadband internet in general (not FTTH in particular) translates into economic performance has a long history. For instance, Bertschek et al. (2013) show how broadband availability translates into corporates innovation and to product and process transformation and not necessarily to short-run productivity growth that indicates the complexity of a process that has been analyzed by further economics' studies across different dimensions (for a survey, see Bertschek et al., 2015). A different and also broad approach measuring the individual utility of broadband has been provided by Ahlfeldt et al. (2017), who, using spatial data, investigate how broadband internet affects real estate prices. In particular, they claim this impact on real estate prices is a valid indicator for the individual benefit of broadband access on properties. Using data from the UK, they can confirm significant effects on real estate prices. However, the markup for ever faster broadband seems to be decreasing in such a way that one can note that the marginal utility of additional speed is decreasing as well. This study confirms, in general, a large individual benefit of broadband internet that is increasing with the broadband speed; however, they do not observe very recent broadband technology of which fiber technology is state of the art and, thus, the most capable infrastructure. Therefore, the question arises whether large individual benefits also exist for very recent technology or whether the increase in marginal utility due to a speed add on is decreasing so much that it will not cover additional investment costs.

This is where this study steps in. I analyze how large the individual benefit or investment in broadband infrastructure is by investigating the impact of FTTH Internet-availability on real estate prices. This is done to uncover, more disaggregated than Briglauer and Gugler (2019), how FTTH affects economic outcomes. In particular as in Ahlfeldt et al. (2017), it allows me to show how the individual utility of users is affected. This increase in utility can be easily interpreted as private benefits translating into willingness-to-pay and can be compared to the costs of the rollout.

The setting I investigate is a quasi-natural experimental situation in a German rural county consisting of several communities. An entrant, which is a firm specialized in the fiber rollout in rural areas, came to provide communities within this region with FTTH. The decision as to which communities to connect was determined by the decision made to choose only communities without cable internet (and cable TV), given that cable internet is the most capable outside option to FTTH. Since the decision to deploy cable TV (that has been upgraded for cable internet) was made almost 40 years ago, it can be denoted exogenously to our setting, because the initial decision was without any prior knowledge that FTTH would appear 40 years later. Thus, I can indicate control and treatment groups and apply a common difference-in-differences setting with treatment groups that receive an FTTH connection and a control group that consists of communities within the same county, but which have cable-broadband internet available. This setting allows me estimating a lower bound of the individual benefit of fiber internet compared to other broadband technology available.

I find significant and positive effects on real estate prices. Comparing those effects with the estimated costs for fiber deployment, I see that the benefits should typically outweigh the costs. This indicates that there are substantial regional benefits from the deployment of the most recent broadband technology. Still, one has to bear in mind that the found effects are conditioned on the particular region analyzed. Claiming that, at least for Germany, this region is not too untypical, one can carefully derive the hypothesis that there is a certain likelihood that results can be applied to other rural areas in developed countries.

The following study is structured as follows. Section 2 provides the empirical strategy, section 3 comprises the results, and section 4 concludes.

2 Empirical Strategy

The aim of this study is to identify the impact of fiber broadband internet rollout on consumer welfare. To identify this impact, I follow the work of Ahlfeldt et al. (2017), who base this argument on several other studies that try to capture, for instance, the impact of regional investment (e.g., football stadiums, Ahlfeldt et al., 2014) or environmental circumstances (e.g., air quality on real estate prices, Chay and Greenstone, 2005). Similar to Ahlfeldt et al. (2017), the study investigates the impact of broadband internet; however, contrary to them, and more similar to Briglauer and Gugler (2019), the particular interest lies in the impact of fiber broadband on real estate prices. As in Ahlfeldt et al. (2017), Ahlfeldt et al. (2014), Chay and Greenstone (2005), the underlying model to infer the impact on those real estate prices is a hedonic price model. Contrary to Ahlfeldt et al. (2017), the data is neither countrywide data, nor includes dedicated technical availability measures. Differently, but similar to Ahlfeldt et al. (2014), the study relies on a local quasi-natural experiment investigated by a difference-in-differences approach, taking into account a quasi-natural experimental situation.

The underlying situation is the fiber broadband rollout in a particular rural county in western Germany ("Kreis Warendorf"). In some communities (i.e., smaller cities as, for instance "Telgte" with approx. 20,000 inhabitants) of that county there was a rollout by a firm specialized in the roll-out of fiber-broadband (Deutsche Glasfaser). According to its own information, the firm specializes in broadband deployment in rural areas and actively tries to bundle demand before starting with the particular rollout. The firm states that, besides other typical profitability decisions, the investment decision depends on the area where it is deployed, and that no rollout of coaxial cable internet has yet occurred, there is no roll-out of coaxial cable internet, which is one of most capable non-FTTH technologies. Given that the initial decision to deploy coaxial cable was taken decades before its usage as a medium to access the internet, the decision can be taken as rather exogenous. Moreover, if there is any systematic bias between areas with and without cable, it should be dependent on the former decision of cable profitability, which may mean that those areas could generally be less profitable for the deployment of infrastructure.

Therefore, this situation can be considered as a quasi-natural experiment that allows the differentiation between treated and non-treated communities. Given that all communities are within one county and are of comparable size, are also subject to the same macro-economic shocks, and are furthermore comparable regarding socio-economic factors, the setting allows for typical difference-in-differences like treatment evaluation. Still, since the roll-out did not take place at a single point in time, but occured over a certain period, I thus use variation not only across treated and non-treated communities but also communities treated at different points in time. The information available regarding the rollout allows the activation of particular fiber broadband in each street/house to be identified, and this information is then linked with real estate data provided by Empirica Systems. The data is generated from online real estate platforms, where the sellers and landlords advertise their properties as either for sale or to rent. This, however, incorporates some bias since it does not include any transaction data. Given that renting relationships are typically repeated actions which differ from the sale of real estate (in particular from private sellers), it can be expected that the landlord collect some experience in the real estate prices over time such that it can be assumed that the bias should be smaller in the case of rented properties than of properties for sale. Therefore, the study focuses on rental properties to minimize this source of bias.

Combining these data sets allows to identify which properties already have fiber internet available. Still, the main information corresponds to the respective zip code level. However, I have additional data for different communities (villages/suburbs) within the zip code. That is, there are several treatments within a postal code. Moreover, there is no information on what kind of internet access had been available prior to the fiber rollout. This means, there is some uncertainty regarding the matching of treated and non-treated properties. This bias, however, is limited since the fiber provider actively tries to bundle demand such that a substantial part of the whole community and, thus the whole zip code is treated. Secondly, not knowing which kind of broadband was available till then makes it difficult to identify the particular fiber effect. Any analysis would need to assume the equally distributed broadband speeds to clearly identify the effect. Knowing that there was some selection, i.e., Deutsche Glasfaser did not roll-out fiber in municipalities where there was coaxial cable technology, which is the most capable infrastructure after fiber, indicates that any estimated effect will be some kind of lower bound of the fiber effect. It is compared to a rather capable infrastructure.

Given the data at hand, I apply a difference-in-differences-like setting where I compare a treatment group that has been fiber activated and a control group that has not. Both groups are in the rural county of Warendorf, in the state North-Rhine-Westphalia, Germany that is close to the city of Muenster. While a fraction of the municipalities is subject to the Federal Government's subsidy scheme for broadband internet and/or may have connections via coaxial cable, the other is not and may be subject to the fiber rollout of Deutsche Glasfaser.

Furthermore, since one of the key assumptions of the difference-in-differences setting is the common trend assumption, I observe the observations over time to check whether there is a particular time trend between the treatment and control group in the pre-treatment period that already differs. Figure (2) shows a lowless smoothed running average plot of real estate rent prices over time, indicating that in the time prior to the treatment the trend is almost the same, while it changes after the fiber rollout has been announced.[4]

The rollout, as said, takes into account a certain period of time with three rollout dates (September 2016, January 2017, April 2017). Therefore, I have a time-heterogeneous treatment. I formalize

[4]Lamentably, I do not have any information on when the rollout was announced. I assume a six-month lag before the first availability date. Still, if the rollout is attached to significant public works, it may require more time. If this is the case, this would mean that estimates would have a downward bias and be lower than stated.

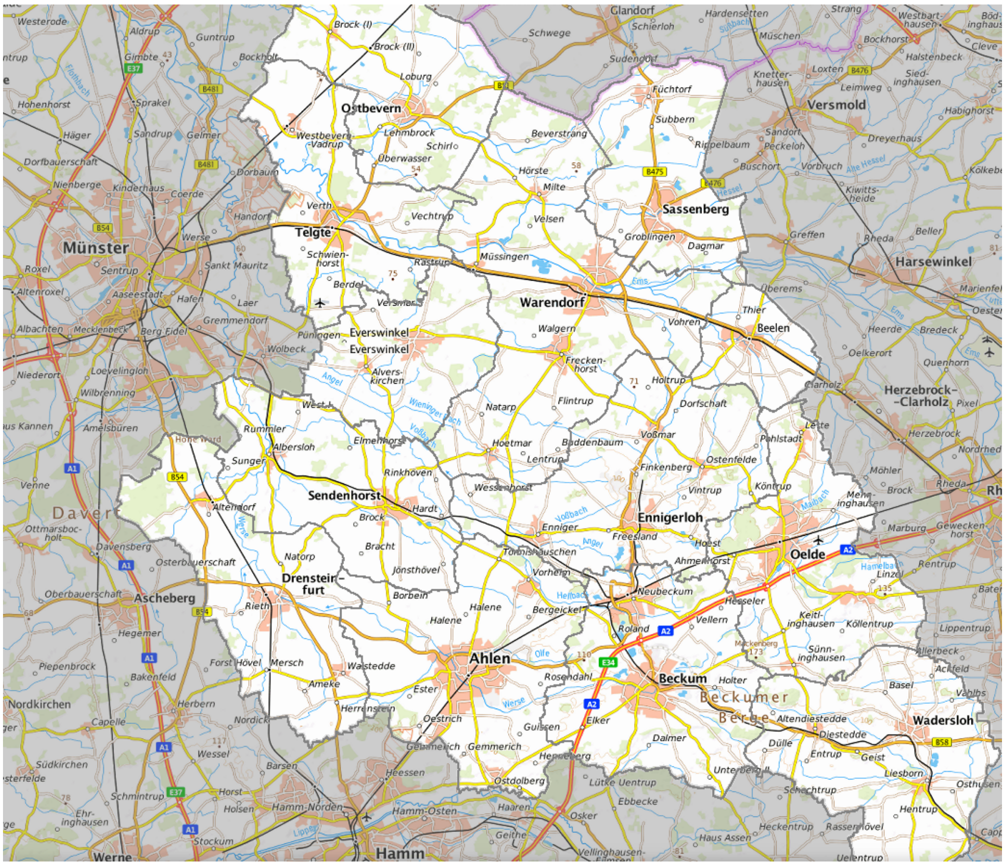

Figure 1: MAP: County (*Kreis*) Warendorf; Copyright: TopPlus Open© Bundesamt für Kartographie und Geodäsie 2020, Gemeindegrenzen © Kreis Warendorf.

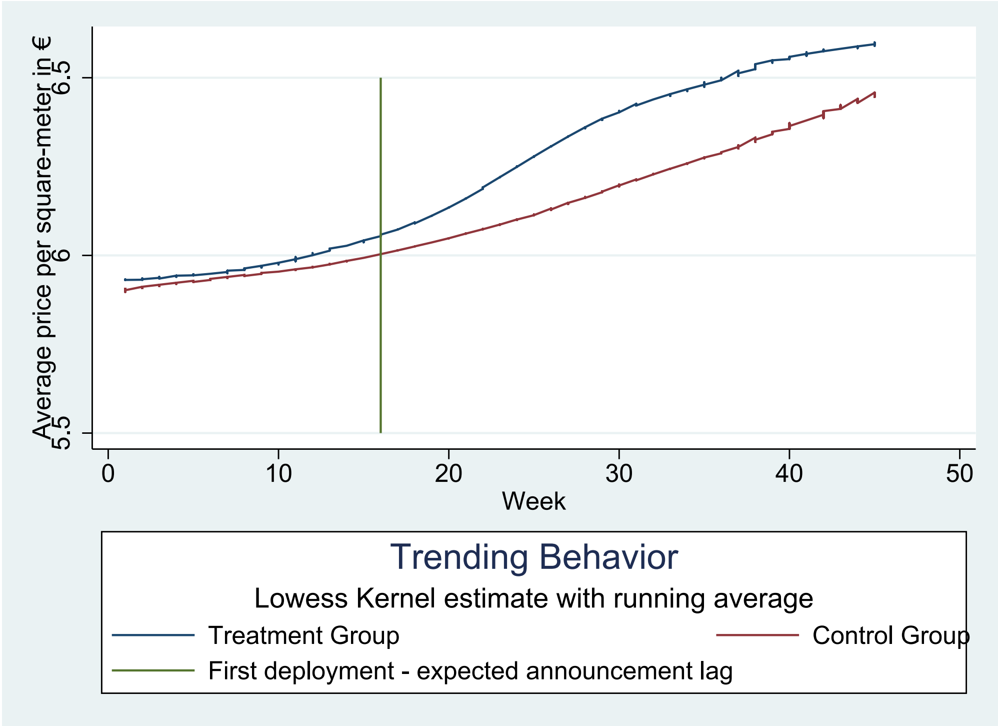

Figure 2: Common Trend

this in the setting

$$ln(Y_{i,t}) = \alpha rollout_{i,t} + \beta rollout_{i,t} * Group_{i,t} + \gamma_i Group_i + \sum \delta_t Time_t + \sum \theta_j * Location_j + \phi_i X_{i,t} + \epsilon \quad (1)$$

I use a logarithmic form of the dependent variable to reduce the impact of outliers and to interpret the coefficients as percentage changes. I use the price per square meter as the relevant indicator. This indicator is not used arbitrarily, but is a commonly used average indicator to evaluate rent levels in different communities as a rent index.

On the right-hand side, I implement the difference-in-differences setting consisting of the treatment, which is the rollout ($rollout_{i,t}$), the group effect ($Group_i$), and the treatment effect, being the interaction of the treatment and the group effect ($\beta rollout_{i,t} * Group_{i,t}$). To control for further heterogeneity, I implement a non-linear time effect ($Time_t$), i.e., time-fixed-effects, capturing potential general trends such as a steady increase of rent prices over time that might constitute an underlying general trend affecting both groups in the same manner.

Given that the product at hand, real estate let for lease, is rather heterogeneous, I control for any further differences. Although the regional focus is rather small with a particular county (*Kreis*) at hand, some differences may still exist between communities. To control for that I take into account community indicator variables ($Location_j$) indicating whether observation i is in a community j to take into account time-invariant differences among those communities. Furthermore, I consider real estate characteristics captured in the matrix $X_{i,t}$. This means that there may be some structural differences between flats and houses for rent. This is also captured by a dichotomous control variable. In addition, the matrix contains a measure for the standard of the real estate. This is captured via indicator variables, indicating either a low, medium or high standard.[5] As a final part of the above equation, the variable ϵ captures a normally distribute standard error.

In addition, to ensure that the time-span at hand might not indicate the particular problem of autocorrelation which could lead to biased standard errors, I use bootstrapped standard errors as suggested by Bertrand et al. (2004).

To summarize: I have discussed that the rollout does not seem to be driven too strongly by current decisions and short-run states of the treated area, but on decisions of the past (the rollout of cable 30–40 years ago). I have shown that the necessary common trend assumption is plausible. Furthermore, I have implemented a wide set of controls capturing further heterogeneity of the analyzed objectives. Finally, the common problem of autocorrelation has also been addressed. Thus, I am confident that the estimates can be interpreted causally and will not be subject to severe bias.

3 Econometric Analysis

3.1 Descriptive Analysis and Data

[5]These indicator variables are created by Empirica Systems on the basis of several indicators.

Table 1: Summary Statistics

Variable	Observations	Mean	SD	Min	Max
Price per m^2	8889	6.15	1.43	2.43	31.67
Treatment Group	8889	0.15	0.36	0	1
Treatment	8889	0.51	0.36	0	1
Size (m^2)	8889	81.31	32.13	10	700
House	8889	0.08	0.27	0	1
Flat	8889	0.92	0.27	0	1
Level of Equipment					
Simple	8889	0.07	0.25	0	1
Average	8889	0.57	0.21	0	1
Good	8889	0.31	0.46	0	1
Superior	8889	0.05	0.22	0	1

Sources: Deutsche Glasfaser, Empirica Systems

The data comprises two sets of data which are summarized in table (1).

The summary includes real estate characteristics for apartments. There are 8,889. First, the price per m^2 is provided. The mean price stated with approximately 6 euros however with a dispersion between approx. 2.43 euros and 31.67 euros. I see that approx. 15% are in the treatment group and around 51% of all observations are within in the treatment period. The average apartment size is around 81 m^2 and approximately 92% of all rentals are apartments. Still, around 8% are houses. To characterize the standard of the rental objects, I use four categories that are provided by Empirica Systems. These include four categories that range from simple (7%) and normal (57%) to good (31%) and superior (5%). These are formed according to information regarding bathtub, garden, floors, etc. by Empirica System. Its advantage is that it is available for all observations as information on single elements has not been provided for all objects. Moreover, it is rather complex to rebuild the general standard or quality directly.

Observing these data descriptive differences, table (2) provides first insights. While the differences in the before period are marginally small, with approximately 1 cent differences between the treatment and the control group, there is an increase to approximately 21 cents per m^2. Clearly, there may be other explanatory variables than the treatment explaining this change, but even so, those findings seem to back the hypothesis that the treatment of the treatment group is associated with an increase in the level of housing prices.

Table 2: Descriptive Information

	Treatment Group	
Treatment	0	1
0	5.96 (1.50)	5.97 (1.14)
1	6.29 (1.39)	6.50 (1.39)

Standard Deviations in Brackets

3.2 Econometric Analysis

The econometric analysis now controls for several further factors that may have an impact on the price building process. Thus, table (3) provides a more in-depth analysis of the relevant patterns.

Column (1) provides the base estimate. The impact of fiber broadband deployment leads to a clear and significant increase in the real estate prices. Still, the impact may be slightly overestimated since I only control for basic controls. The impact itself is highly significant. Given the standard errors being computed via 100 bootstrap replications, I also tackle the typical problem of autocorrelation as highlighted by Bertrand et al. (2004). The basic controls also behave as expected (price is decreasing in the size), apartment prices are slightly lower and the costs for the heating drive down the real estate valuation. Column (2) presents further time controls, i.e., a non-linear time trend. This means that we control for further time-specific impacts that happen jointly in both groups. Column (3) adds several control variables for the real estate values due to the equipment categories.

Table 3: Econometric Analysis

ln(price per m^2)	(1)	(2)	(3)	(4)
Treatment Group	0.011	0.013	0.037***	0.036***
	(0.007)	(0.008)	(0.012)	(0.010)
Treatment	0.055***	-0.042	-0.056	-0.054
	(0.004)	(0.045)	(0.045)	(0.034)
Treatment X Group	0.029**	0.029**	0.019*	0.021*
	(0.012)	(0.013)	(0.011)	(0.011)
Size	-0.002***	-0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
Flat	-0.133***	-0.135***	-0.110***	-0.107***
	(0.010)	(0.009)	(0.009)	(0.010)
Location Fixed Effects			x	x
Properties Standard			x	x
Time Fixed Effects		x	x	x
Constant	2.008***	1.988***	1.924***	1.912***
	(0.015)	(0.019)	(0.019)	(0.019)
R^2	0.065	0.078	0.228	0.225
N	8889	8889	8889	7552

* $p<0.05$, ** $p<0.01$, *** $p<0.001$. Bootstrapped Standard Errors (100 replications).

Specification (4) without county capital Warendorf.

Still, there is no significant change in the coefficient such that it seems plausible to conclude that the impact of fiber internet deployment significantly increases the value of real estate. Moreover, I take into account further location-specific impacts due to location fixed effects. This is, if there is any trending from cheaper to more expensive communities (or vice versa) within the mass of real estate properties in the data across either treatment or control group, this may cause some bias, which is tackled through this variable. In the last column (4), I test whether cities that may have a too good initial broadband service available being impacted. Thus, I exclude the counties' capital, which I assume to have a rather good broadband connection even without having fiber available. I see that there is hardly any change in the coefficient. This indicates that the control group is not affected too much by potential outliers of the counties municipalities. Summarizing the result across all specifications, I am able to identify a treatment effect of approximately between 2% and 3% of the housing prices, with however, 2% in the more elaborated settings. This means that for each 100,000 Euros of a rented apartment there is an estimated increase in value of 2,000 Euros. This means that there seems to be a strong impact on the values of houses that is substantial.

4 Conclusion

The study provides an analysis of a fiber broadband roll-out in a special situation in Germany that can be denoted as a quasi-natural experiment. This allows us to identify large treatment effects of the deployment and incorporate a rental increase of approximately 2%. The interpretation of increased rents as an increase of the real estate value of the same size leads to the conclusion that the increase due to the investment is substantial. The results are conditional on the particular situation observed and one has to be careful when transferring them unconditionally on other situations. Still, given that the structure of the county observed does not seem extraordinary, there is a likelihood that the values uncovered also roughly fit for comparable counties in developed countries.

The study focuses on the private value of fiber broadband development. This means that the benefits may be higher than those found. In particular, there may also be further economic development as well that has positive effects beyond an increase in real estate prices.

Given the mere size of the effects found, it is questionable why there is still limited investment in fiber broadband infrastructure in rural areas. Besides mere costs, it could be that there may be additional problems in the regulation of firms, informational asymmetries regarding the value of broadband, transaction cost problems in bundling demand for an efficient deployment of broadband cables or alternative explanations. To answer this would be out of the scope of this paper, but clearly a question for further research.

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