Enterprise Estimation of Broadband Performance

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***Abstract*—The worldwide broadband demand is increasing. However, often the research regards the demand for a better broadband availability and higher broadband connection speeds on the base of residential broadband demand, whereas the need for higher bandwidths and estimation of the broadband performance of enterprises are mostly unconsidered. Since only a few market analyses explicitly include the broadband requirements of companies, these requirements have been given little attention in Germany up to now. To deepen the research-based knowledge about the needs of enterprises regarding the usage of broadband connections, a survey of enterprises in Germany (with focus on the Rhein-Main area) has been performed. Based on the analysis, the broadband performance, which are available for enterprises, with special regard of the received broadband connection speeds and the price-performance ratio, this study, shows that the satisfaction of companies depends in particular on the extent to which broadband access covers their future needs and less on the current situation.**

Keywords-enterprise broadband demand; broadband connection speeds; broadband performance; price-performance ratio.

I. INTRODUCTION

On the base of the upcoming digitization of workflows and an increasing linkage between different enterprise locations and between enterprises and customers in the virtual world, the broadband provision and the availability of high broadband connection speeds get more and more important for enterprises in the business and industry sector [1]. Since the availability of broadband accesses is a key factor for enterprise and private household settlement, broadband accesses need to be stable, appropriate to the needs and comprehensively available [2]-[7].

Based on the economic significance of a sufficient broadband provision for enterprises, a situation analysis about the current broadband provision of enterprises is necessary. In this context, an online survey has been conducted to figure out how the enterprises in Germany (with focus on the Rhein-Main area) evaluate the performance and sufficiency of their current broadband provision. Here, information about the currently achieved broadband connection speeds, the perceived price-performance ratio and the satisfaction about the broadband performance has been also collected by the survey. The main intention was to identify how enterprises experience the performance of their current broadband access and if the performance will be sufficient for the future by satisfying the enterprise needs regarding the different kinds of business purposes and activities.

Therefore, the paper is structured as follows. After the introduction, the second section covers the literature review. Here, the first subsection contains an in-depth definition of broadband. The second subsection of the literature review regards the challenges by the consideration of the enterprise broadband demand. The following subsection compromises the conceptual model and the set hypotheses. Based on the structure of these three subsections, the next section presents the methodology and research approach of the study. Section 4 contains the data analysis and the main results of the survey. In the fifth section, the results will be briefly discussed.

II. LITERATURE REVIEW

A. Definition of Broadband

Broadband means an uninterrupted access to a great number of services, using fast connection speeds [7]. Since the access speeds and demand for Internet services are still increasing the definition of the speed at which a broadband connection is established must be adjusted from time to time, with this (lower) limit being adjusted from 0.5 Mbps to 4 Mbps in the period before 2011 [8]-[11]. This limit was increased to (up to) 25 Mbps downstream in the last update 2015 [12].

B. Challenges

In general, the studies and reports from the International Telecommunications Union (ITU) [13] and Organisation for Economic Cooperation and Development (OECD) [14][15] focus on the broadband provision of private households, whereas the broadband supply of enterprises is often unconsidered.

On the base that residential customers represent 80% of broadband users [16], the focus on the consideration of the broadband provision of private households is naturally. However, since companies, for example as employers, have a decisive influence on the (economic) importance of a region, the significance of broadband connections for business customers must be taken into account. In principle, it can be assumed that business customers have a higher demand for broadband and a higher willingness to pay than residential customers [17]. In Germany, for example, users

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of broadband access with at least 100 Mbps are mainly companies and a few private heavy users [18]. Generally, enterprises have a strong necessity to send and receive large amounts of data between different enterprise locations or in the enterprise-customer communication.

On the expectation that enterprises have a greater willingness to pay for higher broadband connection speeds (compared to private households), network operators believe that business customers have a significantly higher revenue potential per line (compared to residential customers).

However, the network operators can only benefit from the higher willingness to pay from the enterprises if they are able to satisfy the enterprises broadband needs. This study is intended to contribute to the question if the performance of the current broadband access is sufficient to satisfy the enterprise needs.

C. Conceptual Model

In this subsection, the conceptual model (see Figure 1) for the comprehension about the enterprise perceptions regarding the broadband access performance will be deepened.

The core problem is that enterprises see the own broadband access with connection speeds as one important economical location factor, which they need to keep their status in business competition [2]-[7]. From this point of view, the presence of high quality broadband infrastructures indicates a key factor for enterprises in their choice of location, economic success and future (international) competitiveness [19]. If the availability of broadband access in a specific region or area do not satisfy enterprise needs, the enterprises get directly limited by doing their business purposes and they may choose another location for doing their business activities. In this respect, a non-existent local broadband provision directly deters the enterprise productivity and service quality in the specific region.

In addition, the availability of broadband Internet builds the base for the collection of information and exploiting the potential of electronic markets in the digital world [10][20]. In this regard, a sufficient broadband access with high connection speeds is the base for the national competitiveness and profitability of enterprises [9][21]-[23].

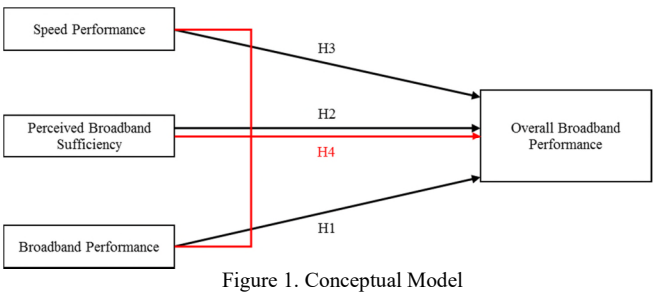

Figure 1. Conceptual Model

The technological progress of telecommunications infrastructures allows the achievement of broadband connection speeds of 100 Mbps and more. From the technological perspective, the network operators should be able to satisfy the bandwidth needs of the enterprises [24][25].

Besides the availability of a high quality broadband network, enterprises expect that the broadband access would be also cover the enterprise needs in future. Furthermore, the broadband access should have a (a) fair price-performance ratio, (b) availability in other enterprise locations, (c) guaranteed stable connections, and (d) appropriate lead times [26]-[28].

The evaluation of the performance of the current broadband access directly depends on the paid prices and the network availability [29]. For example, the evaluation of the perceived broadband access performance gives a direct feedback if the needs of the enterprise are fulfilled.

In this context, the authors assume that the overall broadband performance is rated as good if the broadband connection speeds are sufficient to meet companies' current and future broadband needs and if the price-performance ratio is perceived as fair.

Based on this, the hypotheses for this paper are:

H1: A positive assessment of the speed performance of the current broadband access by enterprises has a positive impact on the overall perceived broadband access performance.

H2: A positive assessment of the sufficiency of the current broadband access for future needs positively affects the overall perceived broadband access performance.

H3: A positive assessment of the price-performance-ratio of the current broadband access positively affects the overall perceived broadband access performance.

H4: A positive assessment of all the above-mentioned performance parameters positively affects the overall perceived broadband access performance.

III. METHODOLOGY

To verify appropriateness of the hypotheses, the authors have performed a survey about the current performance of enterprises' broadband accesses. Especially, the survey captures information regarding (a) the current broadband connection speeds in downstream and upstream, (b) the paid prices and the perceived price-performance ratio, (c) the level of Internet interruptions, as well as (d) the expected broadband demand. The main intention is here to figure out how the enterprises evaluate the total performance of the received broadband access and how the different indicators affect this evaluation.

As our university is located in the Rhein-Main area (Hesse) in Germany, the survey was mainly distributed via local multipliers located in the municipalities to reach all types of businesses (from micro to large). For the simplification of the data collection, a cross-sectional online-survey ("one-shot survey") have been prepared [30].

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Although an online survey can in principle reach a wide range of potential respondents, the absence of a high participation rate and the completeness and accuracy of the answers cannot be guaranteed for such online surveys. In addition, the questionnaire was designed in such a way that individual questions can be skipped without ending the survey. The survey was distributed during the period from May to July 2018 and 364 companies had opened the questionnaire. However, only 81 of the 364 companies have completely passed the questionnaire.

In the first part of the survey, the enterprises were asked about their industry, enterprise size and degree of Internet usage in general. The second part covers questions about the Internet provider, broadband technology, and the broadband connection speed in downstream and upstream. The third part include questions about the importance of different Internet services. The following fourth part of the survey deals with the question to what extent the current broadband situation satisfies the needs of the company. These are supplemented in the fifth part by questions on service quality and fault frequency. The last part regards questions about the price of the current broadband access and the willingness to pay for a better broadband access.

The collected data were analyzed using quantitative research methods and the Statistical Package for the Social Sciences (SPSS) statistical program. To examine the reliability and validity of the data, the estimation of the Cronbach's Alpha and the Exploratory Factor Analysis were performed.

The questions regarding the broadband performance are determined on the base of 5-Point-Likert-scale questions [31]. Here, the measurement of the broadband performance follows the scale from a very strong to a very weak evaluation of the performance. Furthermore, the scope of disturbances gives an overview about fault frequency of the used broadband access (5-Point-Likert-scale: very rarely to very often) [31]. Lastly, the price-performance-ratio (5-Point-Likert-scale: very strong to a very weak performance) and the willingness to pay (5-Point-Likert-scale: fully disagree to fully agree) for a better broadband connection are queried.

As introduced above, the used approach for assessment the hypotheses partly deviate from the original model of the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2).

IV. DATA ANALYSIS AND RESULTS

A. Result Conditions

The further analysis assumes that the participants of the survey will answer these from their position as business customers. In the following, first the descriptive results and the correlation analysis are presented. After a validation of the concepts used, the results of the validity and reliability analyses are briefly discussed. Finally, the results of the ordinary least square regressions of the hypothesis test are presented.

B. Descriptive Results

In the beginning of the analysis, the classification of the involved companies will be discussed. 23.5% of the responding enterprises are directed in the IT section, whereas 17.3% of the enterprises are situated in provision of services. The other participating companies are distributed almost evenly across the other 11 industrial sectors and each represents only a small proportion of the total distribution.

Regarding the classification of the enterprise size in Table I, it can be seen that micro enterprises and small enterprises take the biggest shares of the responding enterprises with 38.5% and 37.2%, respectively. On the base of the assumption that the distribution of the enterprises in Germany in regard to their size would be quite similar with the distribution of the enterprises in Hesse, it must be admitted that the shares of micro enterprises in the survey is underrepresented. Contrary, small, medium, and large enterprises are overrepresented.

Although the distribution of enterprises does not coincide with the distribution of enterprises in Germany and Hessen, the available data can provide detailed feedback on the broadband connections available to small, medium-sized and large enterprises.

It can be assumed that larger enterprises tend to require higher broadband connection speeds than small and medium-sized enterprises, in particular due to the connection of different business locations. On the base of evolving Internet services and applications and by linking these pieces of information in relation to the degree of Internet usage, it is not surprising that in over 60% of the companies surveyed, over 80% of employees have to use Internet connections to perform their daily business tasks (see Table II).

As shown in Table III, more than half of the companies surveyed have only one business location. The remaining approx. 45% of companies with more than one location depend on a good quality of links between these locations. Otherwise, problems could arise that lead, for example, to loss of information, longer work processes or a delay in processing business transactions.

The current broadband coverage of enterprises is described below. Figure 2 shows that 60% of companies use copper-based broadband connections. In second place are fiber optic lines with just over 20%. (In contrast, coax cable infrastructure is the second most important connectivity technology after copper for residential lines in Germany). Although fixed broadband connections are best able to secure stable broadband connections with a defined connection speed without frequency and weather interferences, 5.2% of the companies surveyed still access the Internet via mobile networks and 1.7% via satellite connections.

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TABLE I. SIZE OF THE ENTERPIRSES
(EM = Employees) [33]

Size	Percentages in the Survey	Percentages in Germany
Micro Enterprises (below 10 EM)	38.5%	89.5%
Small Enterprises (10-49 EM)	37.2%	8.3%
Medium Enterprises (50-249 EM)	17.9%	1.8%
Large Enterprises (250 EM and more)	6.4%	0.4%

TABLE II. PERCENTAGE OF EMPLOYEES USING THE INTERNET

Percentage of EM using the Internet	Percentages of Enterprises in the Survey
0% to 20%	8.6%
21% to 40%	9.9%
41% to 60%	9.9%
61% to 80%	11.1%
More than 80%	60.5%

TABLE III. NUMBER OF ENTERPRISE LOCATIONS

Number of Locations	Percentages in the Survey
1	55.1%
2 to 5	32.1%
6 to 10	5.1%
11 to 15	1.3%
More than 15	6.4%

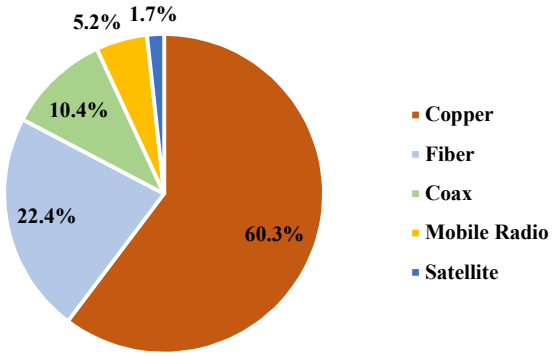

Figure 2. Distribution of the Broadband Access Technology

Only 20% of the companies have access speeds of 100 to 1,000 Mbps. Therefore, it is not surprising that about 70% of the queried enterprises companies assume that their current broadband connection speed will not be sufficient to provide the services and products of the future business life.

In this respect, 77.6% of the companies surveyed responded that they immediately needed higher bandwidths, which is in line with the previous studies [1].

Since, the main part of the copper infrastructures in Germany are provided by the incumbent, it is not wondering that 69.6% of the enterprises are connected to broadband Internet by the incumbent of the German broadband market.

As shown in Table IV, approx. 48% of the enterprises use broadband connection speeds of less than 30 Mbps in downstream. In earlier studies, for the German market, values of about 40% of companies with broadband connections of (up to) 16 Mbps are mentioned, which is compatible with the figures given in Table IV (27.3% less than 16 Mbps and 47.8% less than 30 Mbps) [1].

TABLE IV. DISTRIBUTION OF DELIVERED BROADBAND CONNECTION SPEEDS

Size	Percentages in Downstream	Percentages in Upstream
Less than 2 Mbps	2.7%	21.6%
Less than 6 Mbps	8.2%	12.2%
Less than 16 Mbps	16.4%	23.0%
Less than 30 Mbps	20.5%	14.9%
Less than 50 Mbps	5.5%	2.7%
Less than 100 Mbps	21.9%	10.8%
100 Mbps an more	24.7%	14.9%

The fact that over 50% (70%) of companies still have download (upload) speeds of less than 50 Mbps is critical. Especially in view of the increasing digitalization of society and business activities, it can be assumed that such bandwidths will not be sufficient in the near future [1].

The problems with broadband coverage are also illustrated by the fact that 58.8% of respondents have not changed their broadband contract in the last four years (see Table V). In this context, it needs to be assessed whether respondents could change their broadband access to improve broadband coverage. In addition to the performance of broadband access in terms of downstream and upstream bandwidth, quality also depends crucially on how often the service is unavailable. 44.3% of companies have stated that they have interruptions in Internet access at least once a month.

Although once a month sounds less dramatic, the duration of the failures could be a critical problem. 54.4% of the failures lasted at least 8 hours, which means that the company was cut off from the commercial world for one working day.

Although 77.6% of the queried enterprises are not satisfied with their broadband access, most of the enterprises are not able to change the current broadband provision, which are shown in Figure 3. Nearly 60% of the queried enterprises face the problem that a better broadband infrastructure is not available. Round about 15.5% of the queried enterprises do not want to change the broadband access in regard the current access satisfies the broadband needs. On the one hand, 22.4% of companies reply that they have no need to use higher bandwidths.

On the other hand, only 15.5% of companies surveyed said they did not want to change their broadband access because it covers their current access. This means that some of the respondents who do not need (directly) higher bandwidths still want to change their current broadband access as a precaution.

In the last step, the questions consider (a) the paid monthly subscription fees and (b) the enterprise perceptions regarding the price-performance ratio, as well as (c) the degree of the satisfaction with the whole broadband access.

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TABLE V. DURATION OF BROADBAND ACCESS CONTRACT

Duration	Percentages in the Survey
Less than 2 years	23.5%
Less than 4 years	17.6%
4 years and longer	58.8%

Considering the monthly subscription fee in Table VI, it can be noted that 58.6% of the enterprises pay a monthly price below 100 Euro. 11.4% of the enterprises spend more than 800 Euro per month. With regard to the price-performance ratio perceived by enterprises, it can be noted that 80.8% of the enterprises are not satisfied with the price-performance ratio of their broadband access (see Table VII).

TABLE VI. DISTRIBUTION OF PAID MONTHLY SUBSCRIPTION FEES (EXCLUDED VAT)

Price Categories	Percentages in the Survey
Less than 25 Euro	2.9%
Less than 50 Euro	38.6%
Less than 100 Euro	17.1%
Less than 200 Euro	17.1%
Less than 400 Euro	7.1%
Less than 600 Euro	4.3%
Less than 800 Euro	1.4%
800 Euro and more	11.4%

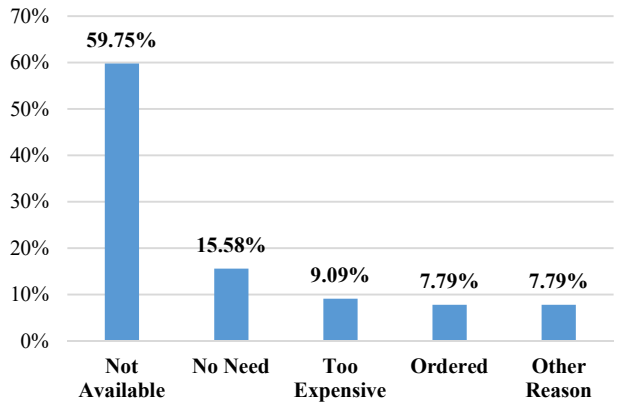

Figure 3. Reasons for the not performed Change of the Broadband Provision

Due to this high level of dissatisfaction, companies are increasingly willing to change the broadband infrastructure and/or the network operators as far as this is technically possible. The dissatisfaction is directly related to the fear of the companies that they may not be able to carry out their business activities in full scope due to the insufficient Internet connections [1]. The shortcomings can lead to e-mails (e.g., with large file attachments) not being processed at all or only very slowly, or video conferences with customers/business partners not being possible, which would have a negative effect on customer relations) [1].

Besides the consideration of the price-performance ratio, the focus of this study targets on the evaluation about the performance of the broadband access. In this regard, only 19.4% of the responding enterprises rates the overall satisfaction with their broadband access as good or very good (see Table VII).

One quarter of the queried enterprises rates the broadband performance on a medium ("neutral") level (see Table VII). In summarizing the whole estimation of the total broadband performance, it needs to be concluded that approx. 55% of the enterprises are not satisfied with their broadband access and rate the broadband performance as weakly or very weakly (see Table VII).

TABLE VII. EVALUATION OF THE PRICE-PERFORMANCE-RATIO AND THE TOTAL PERFORMANCE

Performance Evaluation	Price-Performance-Raito	Total Broadband Performance
Very Weak	16.4%	33.3%
Weak	23.3%	22.2%
Neutral	41.1%	25.0%
Strong	12.3%	12.5%
Very Strong	6.8%	6.9%

In addition, it can be noted that some companies notice large differences between the ordered/paid and the actual connection speeds provided, which further exacerbates their dissatisfaction

C. *Correlation Analysis*

Although a statistical analysis would normally begin with a review of reliability and validity, it exceptionally begins with a correlation analysis to find out which of the variables correlate with broadband access satisfaction. Based on the hypotheses, the authors assume that (a) the currently received connection speeds, (b) the degree of Internet usage in the company, (c) the failure rate, (d) the price-performance ratio, (e) the (monthly) price, (f) the demand for higher bandwidths, and (g) the estimate of whether the connection speeds will cover broadband demand in the future will influence the overall perception of the performance of the current broadband access.

Correlation analysis measures the degree of relationship between two individual variables. Here, it is necessary to distinguish that a correlation analysis would measure the proportionality between two variables instead of a degree of dependency. A correlation coefficient of 1.000 shows a ‘perfect’ relationship. A correlation coefficient higher than 0.500 is classified as a good correlation. Below the mark of 0.300, the correlation coefficients are weak [32][33].

As shown in Table VIII, most variables fulfill the assumption of significant linear proportionality (positive or negative) to the variable evaluation of total broadband performance. However, two variables, (1) the monthly subscription fee, and (2) the level of Internet usage, do not correlate significantly with the evaluation of total broadband performance. For this reason, the presented conceptual model in the second section will be adjusted and the two named variables will be excluded, since on the base of a missing significant correlation, an analysis regarding dependency does not make any sense.

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In a further consideration of Table VIII, it can be seen that most of the other variables present strong correlations with the overall estimated broadband performance. Here, the assessment of the extent to which the connection speeds can cover the future demand shows the clearly highest correlation coefficients (downstream: 0.789; upstream: 0.800). The price-performance ratio (0.648) and the need for higher bandwidth (-0.669) also show high correlation coefficients with respect to the overall rating of broadband performance.

TABLE VIII. RESULTS OF THE CORRELATION ANALYSIS

Variables	Correlation Coefficients with the Evaluation of the Total Broadband Performance
Current Downstream Speed	0.631**
Current Upstream Speed	0.592**
Sufficiency of Downstream Speed	0.789**
Sufficiency of Upstream Speed	0.800**
Actual Monthly Subscription Fee	0.192
Price-Performance Ratio	0.648**
Degree of Internet Usage	-0.025
Need for Higher Bandwidth	-0.669**
Failure Frequency	-0.398**

**. Correlation p=0.01 (2-sided) significant. / *. Correlation p=0.05 (2-sided) significant.

Only for the frequency of failure, there is only a mean correlation with a correlation coefficient of -0.398. Overall, the variables appear to be good predictors for regression analyses with the overall rating of broadband performance. However, the correlation analysis cannot give any information about the degree of dependency or the direction of causality.

D. Explanation fo the Research Concepts

Before the results of the validity and reliability analyses will be introduced, the four research concepts will be explained. In general, all the research concepts include variables, which are used to analyze the stated hypotheses from the second section. The first research concept includes the downstream and upstream connection speed of the current broadband access. The second research concept covers the questions about the sufficiency of the downstream and upstream speeds and the need for higher bandwidths in the future. The following third research concept comprises the questions of the perceived price-performance ratio and the overall broadband performance. The subsequent last concept includes all correlating variables from Table VIII and the dependent variable of the perceived broadband performance. The following reliability and validity analysis will verify the truthfulness of the outcomes.

E. Reliability and Validity Analysis

Table IX and Table X illustrate the outcomes of the reliability and validity analyses to verify if all the concepts, which are used in the research model, stay valid and reliable.

To estimate the validity of the concepts and hypotheses, an exploratory factor analyses will be performed. Here, the factor analysis includes the examination of the Kaiser-Meyer-Olkin value (KMO), the significance test from Bartlett, the consideration of the communalities and the examination of the cumulative variance [34]-[38]. To achieve a good validity, the estimated concepts should reach significant p values below the mark of 5% in the Bartlett-Test and KMO values above 0.7 [34]-[38].

Further the communalities of the variables in the considered concept need to exceed in average the value of 0.6. To verify the validity in a further step, the variables will be split in so-called factors. Here, the validity would be given if the cumulative variance of all factors (with eigenvalue above 1), which show the degree of explained variance in the research concept, of the different possible factors achieve more than 50% [34]-[38].

It should be noted that the concepts are valid as they all meet the Bartlett-Test (see Table IX). With regard to the KMO values, only the concepts of perceived broadband usage and total broadband performance achieve satisfactory values (of at least 0.7). If (as recommended by some references [34]-[38]) less stringent KMO limits are applied and if it is assumed that KMO values from 0.5 are acceptable, the research concepts of speed performance (KMO value 0.677) and perceived broadband performance (KMO value 0.500) can be classified as acceptable.

If one considers the results to date together with the results of the municipalities and the cumulative variance, it can be seen that all research concepts have a cumulative variance above 50%, which indicates that the existing variance can be explained quite well. Regarding the communalities, only the concept with all included variables do not achieve an average of the variable communalities above 0.6. However, the average value of 0.593 is close to the mark 0.6 and therefore the communalities of this concept could be weakly accepted.

Overall, the stated research concepts describe a good validity.

TABLE IX. VALIDITY ANALYSIS

Research Concepts	KMO & Bartlett-Test	Communalities	Cumulative Variance
Speed Performance	0.677 p < 0.000	Ø Com. > 0.6	73.805%
Perceived Broadband Sufficiency	0.705 p < 0.000	Ø Com. > 0.6	81.799%
Perceived Broadband Performance	0.500 p < 0.000	Ø Com. > 0.6	82.385%
Broadband Performance – all Variables	0.860 p < 0.000	Ø Com. < 0.6	59.951%

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TABLE X. RELIABILITY ANALYSIS

Research Concepts	Cronbach's Alpha
Speed Performance	0.864
Perceived Broadband Sufficiency	0.445
Perceived Broadband Performance	0.781
Broadband Performance – all Variables	0.776

Table X shows the results of the reliability analysis. Reliability is evaluated using Cronbach Alpha, whereby the Cronbach Alpha of a research concept for good reliability should be greater than 0.7 [39]-[41].

With the exception of the concept of the perceived broadband supply, for which good reliability could not be proven, all research concepts are to be classified as reliable, since these have Cronbach alpha values of over 0.7.

F. Regression Analysis

The regression analysis is performed on the base of the method of a multiple ordinary least square regression. Here, the regression analysis examines the degree of dependency and linear relationship between the dependent and independent variables For example, it will be examined, in which degree the predictor variables are able to explain the values of the dependent variable [42].

In the taken regression analysis, the following four indicators will be considered in deeply. Firstly, the r-square describes the explanatory power of the whole regression model. Here, the r-square presents the part of the dependent variable, which can be explained by the independent variables. Following Chin [43] and Cohen [44], the r-square should be at least 33%.

Secondly, the Analysis of the Variances (ANOVA) measures the model fit whereby the F-value needs to be higher than 3 and the probability needs to be significant. Thirdly, the regression coefficients of the independent variables need to be significant ($p<0.05$). Lastly, the test of multicollinearities by the Variance Inflation Factor (VIF) needs to be performed to figure out, whether the variables included in the regression analyses have an identical relation. In case of existing multicollinearities, the VIF values would exceed the mark of 10 (or in a stricter definition 3). In this case, it must be assumed that the outcomes of the regression analysis are biased [37][45][46].

Table XI identifies results of regression analysis of the different independent variables and their degree of dependency regarding the enterprise perceptions about the overall performance of their broadband access. The r-square of 78.3% describes a high explanatory rate of the dependent variable. For example, the independent variables are able to explain more than 3/4 of the result of overall perceived broadband performance. The ANOVA analysis shows a significant F-value higher than three, which indicates that a good model fit is given and the assumed model is better than a simple mean model.

The regression outcome shows that, three variables have a significant influence on the evaluation about the overall broadband performance. The price-performance have a positive significant regression coefficient of 0.266, which means if an enterprise perceives a good balance of price and performance, the overall performance of the broadband access will be also well rated.

The sufficiency of the upstream connection speed is also a significantly positive indicator for the estimation of the overall broadband performance. For example, if enterprises perceive that the upstream connection speed would be sufficient, the overall broadband performance would be rated positively.

Finally, it becomes clear that if companies find that they need a higher bandwidth (than they currently have), they will consider the overall performance of the (current) broadband connection to be weak.

TABLE XI. REGRESSION ANALYSIS (ENTER MODE)
BROADBAND PERFORMANCE

Independent variables	Dependent: Estimation of the Overall Broadband Performance	
ANOVA = 29.313	R-Square = 78.3%	
p<0.05	Regression Coefficients with Significance	VIF
Constant	0.681	
Downstream Speed	0.078	3.416
Upstream Speed	0.040	3.154
Sufficiency of Downstream Speed	0.132	4.377
Sufficiency of Upstream Speed	0.253*	4.686
Failure Frequency	-0.108	1.189
Need for Higher Bandwidth	-0.623*	2.052
Price-Performance Ratio	0.266**	1.686

**. Correlation p=0.01 (2-sided) significant. / *. Correlation p=0.05 (2-sided) significant.

In other words, there is a "negative regressive correlation" (due to the binary coding of these variables) between (a) the need for higher bandwidth and (b) satisfaction with the performance of the (current) broadband connection.

However, it should be noted that the speed variable VIF values are above 3, suggesting that multicollinearities could influence the regression results.

In this respect, a stepwise regression analysis is carried out. The stepwise regression analysis implements systematically the significant independent variables in the regression outcome. On the base of this approach, the strength of the single independent variables as predictors for the dependent variable can be identified. In addition, this approach implies the exclusion of the insignificant variables. For the reason of the exclusion of variables, the bias problem of existing multicollinearities can be bypassed.

The results of the stepwise regression analysis in Table XII show a high r-square of 77.0%, indicating a strong model fit. Furthermore, four significant indicators for the explanation of the dependent variable of the overall broadband performance are presented. Since the stepwise regression implements systematically the significant indicators for dependent variables, the strongest predictor for the overall broadband performance would be the sufficiency of the upstream broadband connection.

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Furthermore, the price-performance ratio and the need for higher bandwidth do also significantly explain the overall broadband performance in the same way as in the regression analysis on the base of the enter method displayed in Table XI. Compared to the previous regression analysis, the three indicators mentioned are slightly stronger in their impact on the evaluation of overall broadband performance.

However, in contrast to the previous regression analysis, the current downstream broadband connection speed would be also seen as predictor variable for the perceptions regarding the overall broadband performance. . The regression coefficient of 0.139 shows that companies achieving higher downstream speeds rate overall broadband performance more positively. In the consideration of the VIF values, all the significant parameters indicate VIF values below 3. For this reason, multicollinearities can be excluded.

TABLE XII. REGRESSION ANALYSIS (STEPWISE MODE) BROADBAND PERFORMANCE

Independent variables	Dependent: Estimation of the Overall Broadband Performance	
ANOVA = 50.253 p<0.05	R-Square = 77.0%	
	Regression Coefficients with Significance	VIF
Constant	0.481	
Sufficiency of Upstream Speed	0.343**	2.915
Price-Performance Ratio	0.303**	1.540
Need for Higher Bandwidth	-0.711**	1.949
Downstream Speed	0.139*	1.560

**. Correlation p=0.01 (2-sided) significant. / *. Correlation p=0.05 (2-sided) significant.

Other variables are excluded from the regression on the base of insignificance.

Given that broadband contracts contain fixed conditions for the speed of downstream and upstream connections, it is not surprising that these two speeds depend on each other and present precisely high multicollinearities. To avoid bias in the assumed regression models, the enterprise statements regarding the current downstream and upstream speed will be combined in the term of the access speed. This is done by a simple average of the two variables. The same procedure will be performed for the variables of the sufficiency of downstream and upstream speeds. Here, the resulting variable will be named sufficiency of access speed.

Table XIII presents the regression outcome regarding the estimated overall broadband performance on the base of a further model adjustment by the authors. The r-square with 78.1% presents a high explanatory rate of the dependent variable. The ANOVA analysis identifies a working model fit.

With the exception of default frequency, all the implemented independent variables are significantly. The results shown in Table XIII are quite similar to the results of the first regression analysis (Table XII), especially for the regression coefficients (a) price-performance ratio (0.264) and (b) need for higher bandwidth (-0.637). In this respect, reference can be made here to the explanations given above for Table XII.

Regarding the results of the "new combined" speed variables, it can be seen that both kinds of variables do significant positively influence the evaluation of the overall broadband performance. Here, the sufficiency of the access speed (regression coefficient: 0.385) has a greater impact on the satisfaction with the overall broadband performance than the current access speed of the companies (regression coefficient: 0.114).

From this point of view, it can be concluded that enterprises with a higher current access speed perceive a better broadband performance. Here, it is independently if the broadband connection speed mean the downstream or upstream speed. Since both kinds of speed have normally a (proportional) relation, it can be assumed if an enterprise gets a higher downstream speed, it also gets a higher upstream speed.

TABLE XIII. REGRESSION ANALYSIS (ENTER MODE) BROADBAND PERFORMANCE (COMBINED SPEED PARAMETER)

Independent variables	Dependent: Estimation of the Overall Broadband Performance	
ANOVA = 42.125 p<0.05	R-Square = 78.1%	
	Regression Coefficients with Significance	VIF
Constant	0.727	
Access Speed	0.114*	1.703
Sufficiency of Access Speed	0.385**	3.430
Failure Frequency	-0.110	1.176
Need for Higher Bandwidth	-0.637*	2.028
Price-Performance Ratio	0.264**	1.660

**. Correlation p=0.01 (2-sided) significant. / *. Correlation p=0.05 (2-sided) significant.

Furthermore, if enterprises perceive that the current access speeds would be sufficient to deliver the business services in future, they evaluate also broadband performance better. The same relation of access speeds and sufficiency of access speeds in regard to the evaluation of the broadband performance bases on the positive correlation of these both variables. If enterprises get currently a higher broadband connection speed, they perceive that the current access is sufficient for the provision of the business services in future.

Despite the significant results in Table XIII, it should be noted that the sufficiency of access speeds has a VIF value greater than 3. For example, it could be that the results in Table XIII are distorted by possible existing multicollinearities.

Nevertheless, all four hypotheses (presented in the second section) can be accepted.

V. CONCLUSIONS

The statistical analysis has shown which indicators are responsible for how companies evaluate their broadband access. In general, the satisfaction of enterprises about their broadband access depends in a larger degree on the perception about the sufficiency of the broadband access for the future business life, the price-performance ratio of the

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current broadband access and the need of the enterprise to use higher bandwidths in future. In a lower degree, the current access speeds in downstream and upstream would affect the satisfaction regarding the broadband access. Interestingly, the failure frequency of the broadband Internet access does not sustainably affect the satisfaction regarding the performance of the current broadband access.

Although further research will be necessary to get responses of more enterprises and to rise the quality of the results, it can be concluded that the enterprise satisfaction regarding their broadband access is mostly affected by the sustainability of their broadband access in future. In this respect, it is less important for companies how they currently assess their broadband access. Instead, it is much more important how the current broadband performance can meet future requirements from the companies' point of view. If this is the case, broadband performance will be assessed positively, otherwise it will be assessed negatively.

Network operators and government institutions should therefore primarily pay attention to what broadband services companies will need in the future in order to create the appropriate conditions. Otherwise, companies will be dissatisfied with their location and will think about moving to another location.

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