# USE OF THE BLAND-ALTMAN PLOT FOR GRAPHICAL DEMONSTRATION OF RESULTS IN THE SHARING ECONOMY

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**Abstract:** Today, the sharing economy is a widely discussed topic where people ask themselves what it is, how it works, and what it brings to the society. It occurs in many social spheres; this research paper focuses on the sharing economy in the field of transport. The sharing economy is a phenomenon of the 21st century; the fact that it is a very current topic is also evidenced by the amount of related research published in the databases. This paper aims to apply the Bland-Altman model, commonly used in medicine, to the sharing economy. Its aim is to point out the functionality and possibilities of using non-traditional approaches in various areas of study. The introduction describes the sharing economy and the latest publications dealing with it in the field of transport, with a focus on Uber. The methodology section describes the Bland-Altman model and the authors who discuss it. In the results section, we offer the results of the application of the Bland-Altman model on the data obtained from 110 Uber rides in Prague. In addition to this method, regression analysis was also applied. The discussion and conclusion section summarizes the results and mentions essential publications in the field.

**Keywords:** sharing economy, transport, uber, bland-Altman model

**JEL Classification**: C18, F41

## 1. Introduction

This research paper aims to apply the Bland-Altman model, commonly used in medicine, to the sharing economy. Its aim is to point out the functionality and possibilities of using non-traditional approaches in various areas of study. The concept of the sharing economy was here long before it has taken the form we know today. People borrowed property, rented homes, or offered their knowledge to others before the 21st boom of sharing economy. (Üstündağlı et al., 2020). We perceive the sharing economy today primarily as determined by the technologies that facilitate individual transactions between its users. The internet and smartphones, along with peer-to-peer transactions, have enabled the emergence of online platforms. These

platforms have transformed the way people today can work, consume goods and services, or interact with each other. (Zahoor et al., 2020)

The sharing economy's business models are mediated through digital platforms that allow for a more accurate real-time measurement of spare capacities and can dynamically connect these capacities to those who need them, for example, Airbnb connects the offer of available rooms and apartments with travelers looking for accommodation in a given location (Kwok et al., 2020) and Zipcar links the supply of available cars with the local demand. People have been exchanging goods and services since time immemorial; today, the rise of digital devices makes it easier than ever to connect supply and demand. (MacLaren et al., 2020)

Over the last few years, the term "sharing economy" has become extremely widespread. While many platforms live up to the original promise of the sharing economy—better use of resources, efficiency gains, and social capital building—other platforms appropriate the notion of "sharing" even when they do not represent a sharing economy model (Ritter and Schanz, 2019). This has given rise to the term "sharewashing" which can be understood as false presentation of platforms as instances of the sharing economy, the notable example being Uber. Ironically, the company does not consider itself a part of the sharing economy and has always presented itself as a technology and logistics platform that does not emphasize resource and community building. However, the media and the public do not seem to completely take this into account (Oskam, 2019).

The sharing economy is characterized by transactions that favor access over ownership. We however should not see this model as a panacea; historically, people have kept wealth, such as their homes, in their possession (Akbar and Tracogna, 2018).

Digital platforms enable individuals to offer accommodation more quickly and cheaply in the global marketplace without setting up a website or needing to formalize their business. Before the internet boom, offline peer-to-peer home-sharing and room rentals have existed for centuries. Today, digital platforms offer both market and payment systems to individuals who offer accommodation directly to end consumers without the need to build a website or collect payments directly (Chen et al., 2020).

For many, the Airbnb brand is still unknown, although the platform has now been relevant in the Czech Republic for some time. Many tourists and holidaymakers know that Airbnb is a unique opportunity to find affordable and comfortable accommodation in a holiday destination. Airbnb is the world's most widely used portal providing short-term accommodation, through which you can rent a separate room, apartment, house, or even a large luxury villa practically anywhere. The offer does not involve accommodation complexes—hotels or boarding houses—but rather the owners of individual properties themselves, who offer accommodation in their houses or apartments. This type of rental is used by tourists or people looking for short-term stays (for a maximum of one month) who do not want to stay at hotels or find them too expensive. Such private rentals are preferred by some travelers because they feel "at home" and have access to facilities that are not available in hotels (Volgger et al., 2018).

The sharing economy is characterized by four characteristics. The first is technology. The digital sharing economy assumes the availability of an internet connection and the existence of an electronic infrastructure that supports simultaneous and interactive transactions. This often involves several technologies, such as GPS and social networks (e.g., Facebook). In the eyes of the consumer, the technological element is visible in the form of a website or a smartphone application (Finck and Ranchordás, 2016).

The second feature is the existence of a sociological or cultural element or the so-called "mentality of sharing". The expansion of the sharing economy seems to show that many people possess unused capacities (especially in housing, transport) and many are willing to share them

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with strangers, provided they have access to information on their clients' reputation and receive some sort of financial or non-financial compensation (Ellen, 2015). Sustainability is one of the main incentives of the sharing economy. In addition to those for whom sustainability and co-consumption are important goals, other participants can use the sharing economy for a wider range of products, reputation, economic benefits, and expressions (Hamari et al., 2015; Dao et al., 2019).

The existence of trust is the third essential element of digital sharing. The digital economy means a tripartite relationship of trust and users are required to trust each other as well as the platform that mediates their transactions and payments. This trust is due to the availability of personal photographs of other users, their profiles on social networks, and the ability to provide or receive feedback through review or reputation systems (Ert et al., 2016).

The fourth element concerns the dynamics of the sharing economy. The sharing economy as such is still an urban phenomenon. Sharing occurs where products and services are widely distributed and easily shared. They include high fixed costs but low marginal costs. Sharing is, of course, facilitated by geographical location, population, infrastructure, and economic activity (PWC, 2016).

When assessing the possibility of applying the existing market access conditions, it is necessary to distinguish between professional and non-professional service providers. This is because non-professional service providers are not subject to the same stringent requirements and obligations as professional service providers. The European Union's legislation does not define the criteria for such distinction, it can however be found in the laws of the individual member states, adapted to specific business models. One such difference is based on the objective pursued by the provision of a service, according to which services provided for remuneration are provided by professional service providers, while for non-professionals, the aim is to obtain compensation for the costs incurred by providing the service (e.g., fuel for passenger transport). Another way to differentiate between these entities used in several member states is to set different thresholds, e.g., according to the amount of remuneration acquired or according to the service's regularity. Such criteria can be used, e.g., in the field of accommodation, by establishing a maximum number of days per year. The property may be temporarily rented to ensure a sufficient number of properties available for long-term rental in the market (Krause and Aschwanden, 2020).

Similarly, in a sector, a minimum annual profit threshold may be set before which service providers will not be obliged to meet the specific requirements for authorization for such an activity. The advantage of such limits is the ability to respond to a particular industry's needs and allow non-professional service providers to participate in a collaborative economy (Huckova et al., 2018). In collaborative platforms, the decision on the possible application of relevant market access requirements depends on the nature of the services that the platforms provide. The EU legislation distinguishes between services provided by platforms and information society services, essential services, and ancillary services.

- Information society services are defined as "any service normally provided for remuneration, at a distance, by electronic means and at the individual request of a recipient of services".

The essence of these services is the mediation of interaction between service providers and users. Simultaneously, this activity is exclusively technical, automatic, and passive, which is subsequently a condition for the possibility of applying for exemptions from platform liability (the so-called safe harbor regime). The platform in question provides information society services exclusively. It is not possible to make its activities conditional on the fulfillment of the relevant market access requirements (Huckova, et al., 2018).

- Essential services are services that are the subject of the transaction itself and subject to market access conditions. The EU acknowledges that whether a platform provides essential services needs to be assessed on a platform-by-platform basis, considering specific factual and legal criteria. The purpose of such an assessment is to determine the level of control and influence exercised by the platform over the service provider itself. Examples include assessment criteria such as price (whether the platform determines the final amount paid by the user for the provision of the service), other key contractual terms (whether the platform defines the contractual relationship between the provider and the service user), ownership of the main assets, identification of the cost and risks the provision of a service, the existence of an employment relationship between the platform and the service provider, etc. (Huckova, et al., 2018; Geissinger et al., 2020).
- Additional (ancillary services) follow on from essential services, e.g., mediation of payment, insurance, services provided after the sale (evaluation of the provided service), etc.

## 2. Methodology

The **Bland-Altman plot** was chosen to conduct the analysis. The plot is used to analyze agreement between two different tests. When determining reliability by repeating the test, the test and the re-test coordinate are the data points. Each data point is represented in the graph as two measurements, the test value x and the retest value.

In 1983, Bland and Altman proposed construction of a two-dimensional graph, wherein they plotted on the y-axis the difference of the values of the reference method X and the tested, compared value Y (X - Y). They plotted the average values of the measurements by both methods (X + Y) / 2 on the X-axis. In this way, they obtained a graphic representation, also referred to as a difference graph.

This name describes its main advantage, since, when comparing the two methods, we are interested in the differences between each examined sample. Conversely, we are not interested in the degree of agreement of arithmetic means or medians, which in cases of dependent measurements can be very high, but only indicates the degree of interdependence and not the degree of agreement between the values being compared.

In its basic design, the Bland-Altman plot contains three control lines. The first is the average value of the differences between the two methods. The remaining two lines represent the value of 1.96 times the standard deviation of the two methods' differences (1.96 SD). These are called compliance limits or control intervals. Their construction was derived from the Gaussian distribution (normal distribution, bell curve), where 95% of the whole measured set (=data, assuming a normal distribution of data in the file) is found within the ± 2 SD (exactly 1.96 SD) range of the mean (Gasko, 2017; Sekiguchi et al., 2019)).

The distribution of individual values in the graph allows for assessing the degree of agreement of both tested methods and the presence of systematic error (bias).

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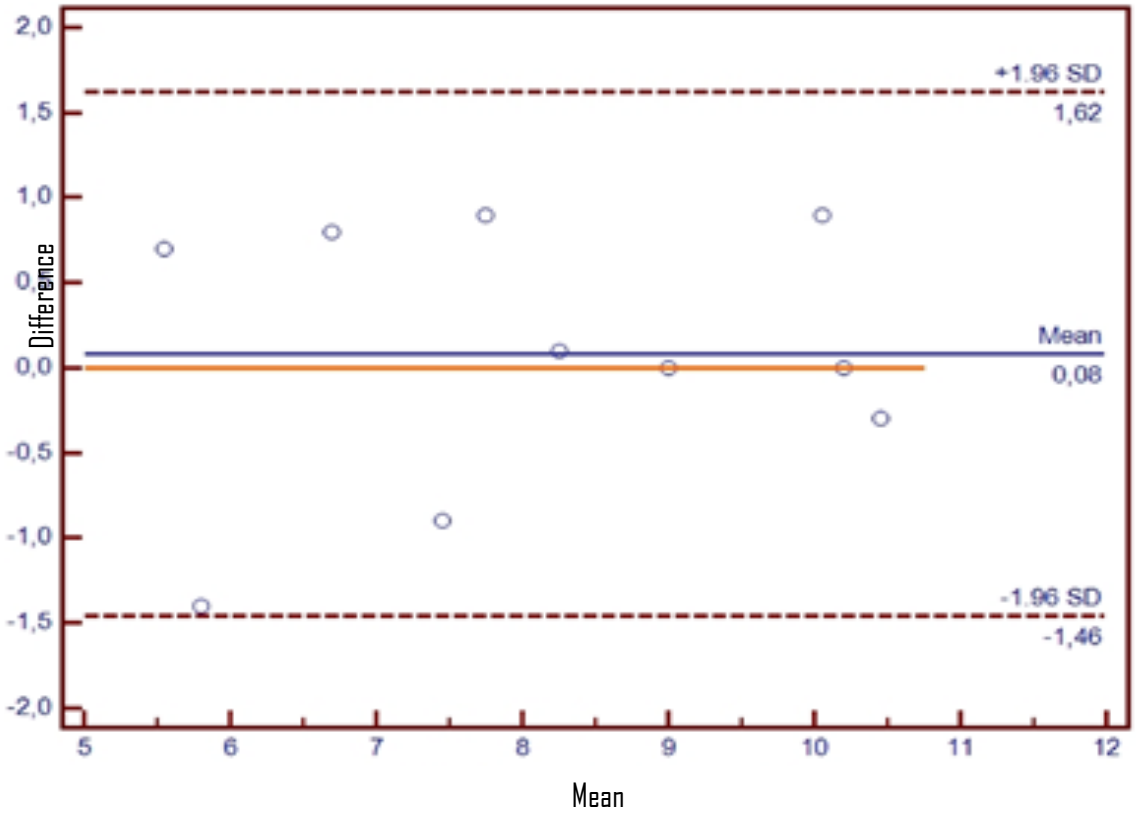
*Figure 1: Bland-Altman difference plot - fundamental scheme (Gasko, 2017)*




There is a wealth of literature on the correct use and interpretation of the Bland-Altman plot. The Bland-Altman (B-A) analysis has replaced the correlation coefficient as the primary tool for assessing the interchangeability of two clinical measurement methods (Preiss and Fisher, 2008). The frequently used statistical methods for comparing two different disease assessment methods are the Pearson correlation coefficient and the usual least squares regression (OLS), these however do have their drawbacks. Bland and Altman proposed an alternative approach to study of agreement between methods using simple plots and basic statistics (Yellareddygari and Gudmestad, 2017). According to Kozak and Wnuk (2014), the Bland-Altman plot is a recognized graphical tool in the study of biometric data. We show that this technique deserves a place in the introductory course in statistics, by encouraging students to think about the type of graph they want to create, rather than simply creating the default graph for the types of variables they have. An important assumption is that differences in paired methods show approximately constant (homogeneous) variance when plotted against paired means. This allows for an estimation of compliance limits that remain valid over the entire range of means. In practice, pairwise differences are often systematically increased with mean, and Bland and Altman used logo-transformed data to achieve approximately homogeneous variance (Sadler, 2019).

The reliability of plot metrics calculated in network analysis is essential for interpreting a complex organization network. These plot metrics are used to derive the characteristics of a small world in networks (Telesford, 2010). The Bland-Altman method was also important in the design of a study by Hermanussen et al. (2009), titled "Statistical agreement and cost-benefit: Comparison of methods for constructing growth reference chart*s"*.

## 3. Results

When processing the results, we worked with data acquired in cooperation with Uber. Specifically, these involved fifty-five repeated rides in different parts of Prague in the Czech Republic. The same distance was covered twice by a car, and the speed was measured. Subsequently, a Bland-Altman difference plot was created. The purpose was to point out the possible benefits of applying this approach outside its standard area of use, as it is usually associated with medicine, biology, and chemistry.

Before creating a mean and difference plot, calculated from the data of an individual ride's first and second timeout, it is necessary to perform the One-Sample t-Test (Table 1). Information about "Mean" and "Standard Deviation" will be needed in the following calculation.

*Table 1: One-Sample t-Test*

**One-Sample Statistics**

| | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| difference | 55 | -,3818 | 3,63364 | ,48996 |

*Source: Own elaboration*

The p-value for the One-Sample Test (Table 2) has a value of 0.439. It is a non-significant result, so it is possible to continue creating the Bland-Altman plot. Otherwise, it would not be possible to develop a plot.

*Table 2: One-Sample Test*

| | **One-Sample Test** | | | | | |
|---|---|---|---|---|---|---|
| | t | df | Sig. (2-tailed) | Test Value = 0 Mean Difference | 95% Confidence Interval of the Difference Lower | Upper |
| difference | -,779 | 54 | ,439 | -,38182 | -1,3641 | ,6005 |

*Source: Own elaboration*

If we look at the Bland-Altman plot (Fig. 2), there is evidence of proportional bias. The value of the difference between the tested devices depends on the size of the determined parameter's numerical value.

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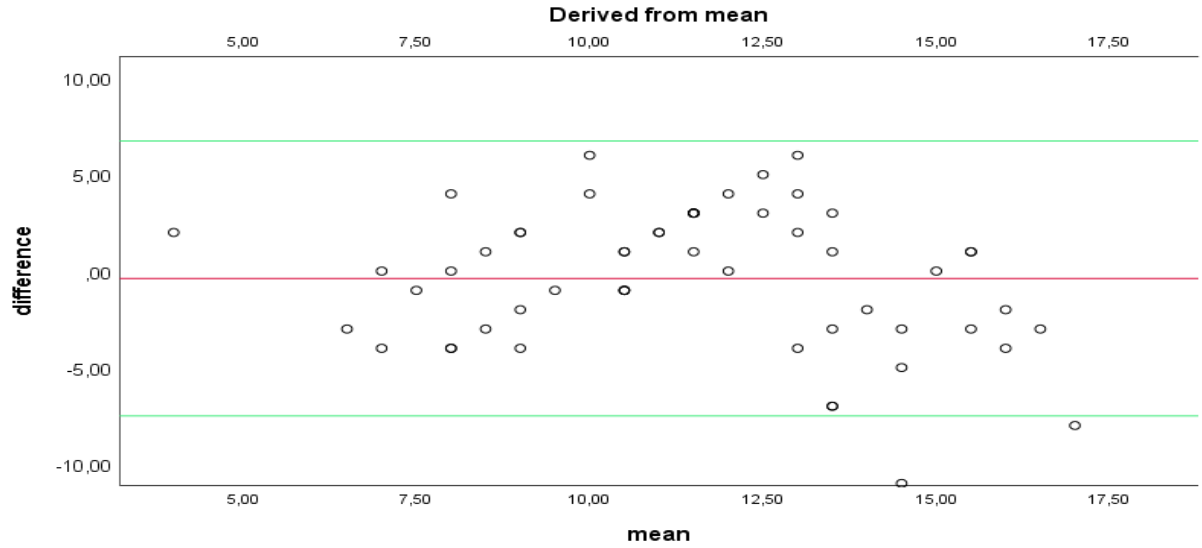
*Figure 2: Bland-Altman difference plot*




*Source: Own elaboration*

Since the mean is high, and the difference is negative, additional information about any potential proportional bias can be obtained from the regression analysis. Results are demonstrated in Tables 3–6.

*Table 3: Variables entered/removed*

**Variables Entered/Removed[a]**

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | mean[b] | . | Enter |

a. Dependent Variable: difference

b. All requested variables entered.

*Source: Own elaboration*

*Table 4: Model summary*

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | ,214[a] | ,046 | ,028 | 3,58247 |

a. Predictors: (Constant), mean

*Source: Own processing*

In this case, the dependent variable is the difference, and the independent variable is the mean. We have established the following hypotheses:

*H0: No or positive association between variables.*

*H1: Negative relationship between variables.*

*Table 5: ANOVA*

| **ANOVA[a]** | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| 1 | Regression | 32,774 | 1 | 32,774 | 2,554 | ,116[b] |
| | Residual | 680,208 | 53 | 12,834 | | |
| | Total | 712,982 | 54 | | | |

a. Dependent Variable: difference

b. Predictors: (Constant), mean
*Source: Own elaboration*

The Beta coefficient is essential, and for the mean, the Beta has a value of -0.266 (the value must be as close as possible to 0). At the same time, we see statistically non-significant results. The relationship is statistically significant when P-value <0.05. Following the 0.05 criteria, we should reject the null hypothesis of no or positive association between the variables. Then, we should conclude that there is a negative relationship.

*Table 6: Coefficients*

| **Coefficients[a]** | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 2,668 | 1,969 | | 1,355 | ,181 |
| | mean | -,266 | ,166 | -,214 | -1,598 | ,116 |

a. Dependent Variable: difference
*Source: Own elaboration*

## 4. Discussion & Conclusion

The sharing economy is a phenomenon of the 21st century, its current prominence evidenced by the amount of related literature published in the databases, e.g., by Geißinger et al. (2020) who see the sharing economy as a discontinuous innovation that creates increased abundance throughout society. According to them, the existing literature on sharing economics has dealt mainly with Uber and Airbnb. (Diamond, 2020) Because little is known about the areas where the sharing economy is growing beyond transport and accommodation, they have focused on identifying the economic sectors in which it is expected to achieve central importance. Similarly, Garud et al. (2020) examined the challenges faced by shared platform businesses in determining the legitimacy of their business models by examining the dynamics that arose when Uber Technologies deployed its carpool business model in the United States. According to the authors, Uber operated between the existing categories and used a series of interrelated market and non-market strategies, which we refer to as marginal movement, to create cognitive and socio-political legitimacy. At the same time, there are problems in this area. The rise of the sharing economy has led to political struggles between users of these platforms, local government officials, city dwellers, and members of the traditional taxi and hotel industry (Connolly, 2020). Political entrepreneurs are finding ways to break the strong relationship between regulators and the industries that control them, Allen (2015) writes, paving the way for a free market. According to Fielbaum and Tirachini (2020), ride-sourcing companies such

as Uber, Lyft, and Didi Chuxing have been disruptive forces in urban mobility environments over the last decade. In their article, they analyze the working conditions, earnings, and job satisfaction of drivers. Nevertheless, empirical evidence shows that becoming a driver for Uber is more a question of tackling unemployment in a more permanent way than looking for temporary and flexible work to supplement income (Valente et al., 2019). A recent survey among consumers in the USA indicated that the sharing economy in the sectors of travel, car sharing, finance, staffing, as well as music and video streaming is supposed to increase its revenues from USD 15 billion today to USD 335 billion within the next years (Bothun et al., 2015; Puschmann and Alt, 2016). Supporters claim that new technologies will bring utopian results - empowerment of ordinary people, efficiency, and even lower carbon footprints. Schor (2016) deals with this issue in his research paper, while also mentioning that critics of these platforms condemn them for their economic self-interest rather than sharing and for being predatory and exploitative. Not surprisingly, the reality is more complex.

Over the last decade, the segment has grown to produce billions of EUR per year. The sharing economy covers a wide range of areas. Since this is a broad topic, we decided to focus on one crucial part: transport. Passenger transport has its traditional form such as taxi services, public transport, and the like. Uber entered the field, providing new opportunities by means of ride sharing. Our goal in creating this research paper was to point out the possibilities of applying the Bland-Altman plot to the sharing economy and demonstrate the results using regression analysis. We chose Uber as the subject and determined the length of journeys at certain distances. The Bland-Altman plot has become a popular method in comparative studies outside of laboratory medicine; "comparison" of methods is understood less precisely in other medical fields. Therefore, the Bland-Altman plot is the statistic method used for comparative studies.

## References

Akbar, Y. H., & Tracogna, A. (2018). The sharing economy and the future of the hotel industry: Transaction cost theory and platform economics. *International Journal of Hospitality Management, 71*, 91-101.

Allen, D. (2015). The sharing economy. *Institute of Public Affairs Review: A Quarterly Review of Politics and Public Affairs, 67*(3), 24.

Bothun, D., Lieberman, M., Egol, M., Clarke, D., Atkinson, J., Blumenthal, J., ... & Shirsekar, S. (2015). *The sharing economy*. PricewaterhouseCoopers, London.

Connolly, J. M. (2020). No Uber, no tourists? Public attitudes toward municipal regulation of the sharing economy. *Local Government Studies*, 1-16.

Dao, M. Ch., Das, M., & Koczan, Z. (2019). Why is labour receiving a smaller share of global income? *Economic Policy, 34*(100), 723-759.

Diamon, W. (2020). Safety transformation and the structure of the financial system. *Journal of Finance, 75*(6), 2973-3012.

Fielbaum, A., & Tirachini, A. (2020). The sharing economy and the job market: The case of ride-hailing drivers in Chile. *Transportation*, 1-27.

Gasko, M. R. (2017). *Porovnávanie metód merania „Method comparison studies*". Príručka správnych štatistických postupov.

Garud, R., Kumaraswamy, A., Roberts, A., & Xu, L. (2020). Liminal movement by digital platform-based sharing economy ventures: The case of Uber Technologies. *Strategic Management Journal*.

Geissinger, A., Laurell, C., & Sandström, C. (2020). Digital disruption beyond Uber and Airbnb-Tracking the long tail of the sharing economy. *Technological Forecasting and Social Change, 155*, 119323.

Hermanussen, M., Assmann, C., & Tutkuviene, J. (2010). Statistical agreement and cost–benefit: Comparison of methods for constructing growth reference charts. *Annals of Human Biology, 37*(1), 57-69.

Huckova, R., Bonk, F., & Rozenfeldova, L. Zdieľané hospodárstvo–otvorené problémy a diskusia (najmä s prihliadnutím na obchodnoprávne a daňovoprávne súvislosti) Collaborative Economy–Open Problems And Discussion (With Regard To Commercial). Studia Iuridica Cassoviensia, *6*(2), 125-140.

Chen, Y., Huang, Y., & Tan, C. H. (2020). Short-term rental and its regulations on the home-sharing platform. *Information & Management*, 103322.

Kozak, M., & Wnuk, A. (2014). Including the Tukey mean-difference (Bland–Altman) plot in a statistics course. *Teaching Statistics*, *36*(3), 83-87.

Krause, A., & Aschwanden, G. (2020). To Airbnb? Factors impacting short-term leasing preference. *Journal of Real Estate Research*, 1-24.

Kwok, L., Tang, Y., & Yu, B. (2020). The 7 Ps marketing mix of home-sharing services: Mining travelers' online reviews on Airbnb. *International Journal of Hospitality Management*, *90*, 102616.

MacLaren, N. G., Yammarino, F. J., Dionne, S. D. et al. (2020). Testing the babble hypothesis: Speaking time predicts leader emergence in small groups. *Leadership Quarterly*, *31*(5), 101409.

Oskam, J. A. (2019). The future of Airbnb and the sharing economy: The collaborative consumption of our cities. *Channel View Publications.*

Preiss, D., & Fisher, J. (2008). A measure of confidence in Bland-Altman analysis for the interchangeability of two methods of measurement. *Journal of Clinical Monitoring and Computing*, *22*(4), 257-259.

Puschmann, T., & Alt, R. (2016). Sharing economy. *Business & Information Systems Engineering*, *58*(1), 93-99.

Ritter, M., & Schanz, H. (2019). The sharing economy: A comprehensive business model framework. *Journal of Cleaner Production*, *213*, 320-331.

Sadler, W. A. (2019). Using the variance function to generalize Bland–Altman analysis. *Annals of Clinical Biochemistry*, *56*(2), 198-203.

Sekiguchi, T., Takeuchi, N., Takeuchi, T., & et al. (2019). How inpatriates internalize corporate values at headquarters: The role of developmental job assignments and psychosocial mentoring. *Management International Review, 59*(5), 825-853.

Schor, J. (2016). Debating the sharing economy. *Journal of Self-Governance and Management Economics*, *4*(3), 7-22.

Telesford, Q. K., Morgan, A. R., Hayasaka, S., Simpson, S. L., Barret, W., Kraft, R. A., ... & Laurienti, P. J. (2010). Reproducibility of graph metrics in fMRI networks. *Frontiers in Neuroinformatics*, *4*, 117.

Üstündağlı, E. E., & Güzeloğlu, E. B. (2020). Transformation of do-it-yourself from altruistic to utilitarian tendency: DIY entrepreneurs and sustainable practices in shared economy market conditions. *Management of Environmental Quality: An International Journal*.

Valente, E., Patrus, R., & Guimarães, R. C. (2019). Sharing economy: Becoming an Uber driver in a developing country. *Revista de Gestão*, *26*(2), 143-160.

Volgger, M., Pforr, C., Stawinoga, A. E., Taplin, R., & Matthews, S. (2018). Who adopts the Airbnb innovation? An analysis of international visitors to Western Australia. *Tourism Recreation Research, 43*(3), 305-320.

Yellareddygari, S. K. R., & Gudmestad, N. C. (2017). Bland-Altman comparison of two methods for assessing severity of Verticillium wilt of potato. *Crop Protection*, *101*, 68-75.

Zahoor, N., Al-Tabbaa, O., Khan, Z., & et al. (2020). Collaboration and internationalization of SMEs: Insights and recommendations from a systematic review. *International Journal of Management Reviews, 22*(4), 427-456.