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STATISTICAL ESTIMATION OF VALUE RANGE
A Methodological Contribution on Uncertainty Measurement in Property Valuation

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ABSTRACT

This paper presents a statistical model of Value Range based on Triangular Distribution which adapts the concept of Control Limits in the Control Chart Theory. It is the purpose/aim of the paper to contribute on the methodological issue of Uncertainty which takes the probabilistic nature of uncertainty into account. Using market comparable data from two cases of commercial land valuation in East Jakarta and Tangerang County, the analytical results of the model suggests that Coefficient of Variation is a key aspect to consider whether the Value Range should be constructed at ± 1*s* or 2*s*. The sensitivity analysis indicates that the model works well with less data and data set with narrower variation is generally more favourable. The practical value of the model is its potential use as a method for valuers to self-examine their valuation output. The model may as well be used as a method to complement fairness analysis, especially when there is a request for external review or even an appeal.

Keywords: control limits, triangular distribution, uncertainty, value range.

1. INTRODUCTION

Although valuation is an art (meaning that two or more valuation opinions will not be exactly the same), very disparate value estimates for the same property in the same time frame would make appraisal profession looks uncoordinated, clumsy, may even be regarded as merely producing guesstimates (Adebayo and Osmond, 2010). Perhaps that is why the notion of uncertainty is reluctantly acknowledged by practitioners (driven by worry and/or fear for being perceived as unprofessional, unreliable, which potentially lead to client's distrust) and hasn't yet attracted scholarly attention as an emerging trend in valuation theory (Kucharska-Stasiak, 2013).

Valuation is the process of estimating price in the market place, in which affected by uncertainties (French and Gabrielli, 2004). Kaluthanthri and Hippola (2023) generically classify variables affecting valuation uncertainty into: market instability, input access, and model technique selection. If market information/data as the input of valuation is uncertain, then it is very likely that there is also uncertainty in the valuation output. Uncertainty is inherent in the valuation process due to the structure of the commercial property market and the techniques and guidelines of the property valuation process (Bowles et al., 2001). In less mature market such as emerging markets, the degree of uncertainty is greater (Kucharska-Stasiak, 2013). Regardless the varying degree of uncertainty in different market conditions, valuers should be able to quantify it (Ibid). According to Thorne (2021), significant differences in the results when using various methods to estimate value is a cause of valuation uncertainty. This means, whichever method selected will carry such uncertainty.

One of the major problems in valuation is that probability is not sufficiently accommodated in the valuation models (French and Gabrielli, 2004) despite the probabilistic nature of uncertainties is well understood. An obvious example regarding this matter in the valuation practice is that the valuation output (opinion) is stated in terms of a single amount, often without any clue how much that amount deviates from the estimated mean. Despite increasing inquiries regarding how to account for uncertainty in the valuation, there haven't been sufficient advices nor consistent approaches of how to do so (French, 2011).

Kucharska-Stasiak (2013) stated that the on-going discussion on the uncertainty of property valuation comprises terminological issue (the definition), methodological issue (the measures) and application issue (interpretation of valuation outcomes and its reliability).

Research publications about valuation uncertainty (e.g., French (2020), Meszek (2013), Zhou et al. (2021)) usually mention and/or discuss value range. French and Gabrielli (2004) distinguishes between the use of probability in looking at the range of possible outcomes of value produced by different valuers and the range of outcomes that would be produced by an individual valuer. If we compare it with Boyd and Irons (2002), the range of possible outcomes produced by different valuers is aligned with valuation variation or variance (difference between value determinations provided by different valuers). Meanwhile, the range of outcomes produced by an individual valuer well reflects the definition of valuation range, i.e. the difference between valuations and specified correct value (either appraisal or transaction based), or the estimation of a probable range of resultant values by a valuer. To sum up, uncertainty of valuation covers both uncertainty concerning a single valuation as well as multiple valuations of the same property if conducted at the same time (Kucharsa-Stasiak, 2013).

The purpose of this paper is to present a statistical model of value range and to contribute on the discussion of methodological issue concerning uncertainty in property valuation. As the terminology suggests, methodological presentation in this paper specifically addresses uncertainty concerning the output of a single/individual valuer. Analytical description using the market comparable data from two cases of commercial land valuation in Tangerang County and East Jakarta demonstrates the applicability of the method. The Sensitivity Analysis conducted provides further insights and guidelines concerning the method's applicability.

2. THEORETICAL BACKGROUND

Control Chart Theory

The underlying model of Valuation Range in this paper is adapted from the concept of control limits in Control Chart, which is originally known as Shewhart's Control Chart (Schoonhoven and Does, 2010), where the limits are *mean* ($\bar{X}$) plus minus *standard deviation* (s) multiplied by k, where k is equal to 3, indicating a 99% confidence level. Hence:

$$Control\ Limits\ (CL) = \bar{X} \pm 3s \quad (1)$$
$$Upper\ CL = \bar{X} + 3s \quad (2)$$
$$Lower\ CL = \bar{X} - 3s \quad (3)$$

Before adopting the control chart theory into valuation, several adjustments need to be made. Firstly, the *mean* and *standard deviation* should be estimated using an underlying distribution other than Normal Distribution. The logic for replacing Normal Distribution is that Normal Distribution has an "infinite" feature (see also Skitmore et al., 2007), meaning that a random number with an "extreme" value may arise although the chance is also very small. This is clearly not well aligned with the fact that fair market price of an asset will likely fall into a "definite" range.

Secondly, the classical $k = 3$ setting of the control limits needs to be revisited (reconsidered). When applied in the Value Range model, this basic premise has a major drawback if the standard deviation is high. Consequently, the range will be wide. Hence, if a price falls very near to the upper or lower limit may be regarded as unreasonable for buyer and seller respectively. Supposed if we push the price approaching the upper limit, a potential buyer might be reluctant to buy the asset. In contrast, if the price being pushed approaching the lower limit, there might be no seller willing to sell. This market mechanism implies that applying the logic of control limits to estimate value range (with an aim to reflect the range of fair price), the k coefficient should not be "locked" at a certain number. Therefore, the k coefficient to set up the limits, must be chosen considerably.

Triangular Distribution

Triangular Distribution seems having characteristics that are compatible with the previously explained market mechanism, in the sense that the a and b parameters may represent the lowest and the highest exchange value (price) for an asset that can be tolerated by both buyers and sellers in the arm length's transactions. Meanwhile, the mode (c) represents the most common price level in which the asset may be exchanged. The following equations describe the mean, median and variance of Triangular Distribution.

$$Mean = \frac{a+b+c}{3} \quad (4)$$

$$Median \begin{cases} a + \sqrt{\frac{(b-a)(c-a)}{2}} & for\ c \geq \frac{a+b}{2} \\ b - \sqrt{\frac{(b-a)(b-c)}{2}} & for\ c \leq \frac{a+b}{2} \end{cases} \quad (5)$$

$$Variance = \frac{a^2+b^2+c^2-ab-ac-bc}{18} \quad (6)$$

3. RESEARCH METHOD

Terminological Explanation

Valuation Range in this paper refers to an interval in which the value opinion (of an asset) produced by an individual valuer, using a set of market comparable data, will likely fall into. The concept of Valuation Range is built upon the assumption that the smallest and the largest market comparable data (which have been selected to determine the value of an object) fairly represent the range where the appropriate and comparable market data are available to choose from in order to determine the value of that specific object. In other words, Value Range assumes that there is no significant gap between the range (distance between minimum and maximum) of sample data and the true spectrum of the price of the asset in the market. No significant gap does not necessarily mean exact precision, because such requirement would be difficult (if not impossible) to fulfill, especially in emerging markets where the market itself is less mature and information about the real (transaction) price is, in most cases, asymmetric. Therefore, such assumption will be reasonable and useful (might be logical as well) when implementation issue is brought to the table. This makes value range *relative* to the set of market comparable data being used and contingent upon the valuer's ability to wisely select such appropriate and comparable data.

Parameters Estimation

Prior to constructing the Valuation Range, it is required to provide an estimation for the three parameters of Triangular Distribution, i.e., a, b and c. Although can be done subjectively based on personal judgement, one can also use quantitative (statistical) estimation, in the sense that the a and b would be set at z times (in which z is an integer) standard deviation [of Normal Distribution] plus minus the data mean (average). The coefficient z should be selected in such a way that a and b would reflect the lowest and the highest price that the market can tolerate. Determining the lowest and the highest points of price tolerance can be tricky. Therefore, for simplicity purpose, the a and b can be subjectively set not too far from the lowest and highest price provided by the chosen market data assuming that price information from the sample is aligned with the market. The a and b parameters should not be set too far away from the smallest and largest market data that the valuer has selected because the data appropriateness and compatibility will easily be questioned. In order to estimate the c, we may select several data around the median and then calculate the weighted average.

Value Range is then the mean of Triangular Distribution plus minus k times the standard deviation. The ± sign indicates that the values are symmetrical about their mean (also stated by e.g. Skitmore et al., 2007).

$$VR = Mean \pm k * s \quad (7)$$

$$s = \sqrt{Variance} \quad (8)$$

Valuation Cases

Before proceeding any further, the following notes need to be brought to the table. The research deliberately and specifically focuses mainly on the market comparable data (of each valuation object in the actual/real valuation cases below), as those are the most relevant when it comes to describing the analytical process of the method presented in this paper. Therefore, aside of confidentiality reason, other valuation-related details are limitedly disclosed.

Since the valuation projects had been conducted long before the development of the method, the appraiser's actual value opinion was not, by any means, influenced by the results presented here. If there are comments made regarding the actual value opinion, those are specifically and restrictedly related to how well the actual value opinion fits in the value range model.

The Triangular Distribution itself requires at least three data as the estimate of its parameters, which is in-line with the fact that Market Comparison Technique in Market Approach also uses three comparable data. However, the more data being used, the more accurate the parameters' estimation will be.

Hence, there is no specific requirement concerning the sample size as long as it fulfils the minimum requirement. The amount of data to be analysed depends on the availability of market comparable data. To conduct a thorough and credible statistical analysis, the more data the better, but the suitability and the quality of data are far more important.

This research demonstrates both conditions, where there are relatively plenty of available data and where the amount of available data fulfils just the minimum requirement.

Case 1

The first case is valuation of the commercial part/area of a special property (a public facility) in Tangerang County in Banten Province, Indonesia, assigned by a government institution for the purpose of determining the equivalent market value (tax base) of the property. The size of the object is ± 200 hectares. It is state-owned land where the local government is given the Right-to-Manage (*Hak Pengelolaan*, *HPL*). The local government has been leasing it to a state-owned enterprise. It should be noted that the term "commercial" as mentioned above covers both: (1) operational area being utilised by the state-owned enterprise to generate income from its operations, and (2) area that the enterprise leases to other parties to engage in traditional buying and selling activities.

The valuation was conducted in December 2021. For the purpose of consistent and coherent comparison with case 2 in the later section of this paper, the coverage of analysis in this research is limited only on the land value.

The valuation object is located very near Jalan Raya Perancis (also in Tangerang County), a main commercial area in the neighborhood. After initial field observation by the valuation team at that time, Jalan Raya Perancis was deemed to have similar/equal characteristics with the valuation object. The valuer then decided to collect and use data from this area as market comparable data. Table 1 presents market comparable data (from internal database) extracted and adjusted from primary data which were previously collected from the market. This research presents the data and opinion of equivalent market value issued by the valuer (and the valuation firm). In case the client (local government) applied various adjustments to convert it into Object's Selling Value (*Nilai Jual Objek Pajak*, *NJOP*), it is beyond the scope of this research.

Table 1. Market data along Jalan Raya Perancis

Market Data	**Land Size (m^2)**	**Legal Certificate**	**Land Unit Price Indication (in Million IDR, rounded)**
Data 1	3,000	Freehold (SHM)	12.80
Data 2	60	Freehold (SHM)	10.77
Data 3	68	Building Right (SHGB)	12.44
Data 4	123	Freehold (SHM)	13.57
Data 5	125	Building Right (SHGB)	13.89

Source: internal database

Case 2

The second case is the valuation of a commercial vacant land on Jalan Otto Iskandardinata in East Jakarta, assigned by a governmental institution for the purpose of land acquisition for a public facility. The land size is ± 1000 sqm equipped with Right of Ownership (*Sertipikat Hak Milik*, *SHM*). The valuation was conducted in September 2021. Table 2 presents five market comparable data (from internal database), which have been collected, analysed and adjusted from the market.

Table 2. Market data along Jalan Otto Iskandardinata

Market Data	**Land Size (m^2)**	**Legal Certificate**	**Land Unit Price Indication (in Million IDR, rounded)**
Data 1	225	Freehold (SHM)	33.1
Data 2	257	Freehold (SHM)	31.0
Data 3	1,518	Freehold (SHM)	28.0
Data 4	4,868	Building Right (SHGB)	29.8
Data 5	400	Building Right (SHGB)	31.3

Source: internal database

4. RESULTS AND ANALYSIS

Analytical Description

Case 1

From the data presented in table 1, we can determine the parameters of Triangular Distribution where *a* = 10 and *b* = 15. Both *a* and *b* are set slightly below and above the data in order to fulfill the basic assumption of the distribution that the frequency of data below *a* and above *b* are practically zero.

Unless we have collected significantly large samples, determining *c* may not be an easy task. Therefore, *c* in this case is calculated as a weighted average of three data around the median, which then gives *c* = 12.9.

Based on the parameters defined above, the mean and standard deviation is 12.63 and 1.03 respectively. If we compare those figures with the mean and standard deviation from Normal Distribution (i.e. 12.69 and 1.22 respectively), the use of Triangular Distribution seems to be advantageous in the sense that the narrower variation may reduce the risk of type 2 error in statistics (i.e. not rejecting data that already exceeds the limits). Thereafter, the upper and lower limits (1*s* and 2*s*) can be calculated and the results are presented in table 3.

It may noticeable from the table that the upper limit of 1*s* and 2*s* deviate 8.11% and 16.23% from the mean or centre line respectively (the lower limits will produce the same figures as they are symmetrical). I then compare these percentages with Coefficient of Variation, defined as the ratio between standard deviation and mean. The deviation of the limit (from the centre line) equals to coefficient of variation multiplied by *k*.

If we look at the minimum and the maximum of the samples (10.77 and 13.89 respectively), they deviate approximately 9% from the centre line. This means that setting the value range at 2*s* might not be effective in detecting whether or not the valuation output has gone too far.

Table 3. Statistical analysis of market data on Jalan Raya Perancis

	(in million IDR)
a	10
b	15
c	12.9
Mean	12.63
Standard Deviation	1.03
Coeff. of Variance	8.11%
Upper Limit (1s)	13.66
Lower Limit (1s)	11.61
Upper Limit (2s)	14.68
Lower Limit (2s)	10.58

Now, let’s revisit the valuer’s actual opinion of value at that time, which was handed in to the client. The valuer reported that the land equivalent market value of the object was IDR 12.37 million per sqm. Since it falls within the range of 1*s*, it can be said that it was a good valuation output.

Case 2

Following the same procedure applied in case 1, table 4 presents the statistical results of data in case 2. Although the coefficient of variation is significantly smaller than in case 1, setting the limits at 2*s* faces similar risk as described in case 1. This is due to the fact that the upper and lower limits of 2*s* deviate around 10% while the minimum and maximum of the sample data deviate approximately 8% from the centre line. This condition may increase the risk of treating a data as “still in the range” while it may be not (type-2 error).

Table 4. Statistical analysis of market data on Jalan Otto Iskandardinata

	(in million IDR)
a	26.5
b	34.5
c	30.8
Mean	30.63
Standard deviation	1.64
Coeff of Variance	5.34%
Upper Limit (1s)	32.26
Lower Limit (1s)	28.99
Upper Limit (2s)	33.9
Lower Limit (2s)	27.36

Looking at the coefficient of variance in both cases and its impact on the setting of upper and lower limits, if the coefficient of variation exceeds 5%, it seems better for a valuer to act conservatively and sets the limit at 1*s*. If the coefficient of variation is below 5%, setting the limits at 2*s* can be considered.

Let’s compare the result presented in table 4 with the valuer’s opinion given to the client. At that time, the valuer stated that the land value of the object was IDR 31.6 million per sqm. The fact that 31.6 is still within the range of 1s (i.e. 30.63 ± 1.64) it can be said that the value opinion is credible.

Sensitivity Analysis

The purpose of sensitivity analysis in this case is to test the applicability of the model if less data is available (due to market conditions and/or the area where the valuation object is located) and to examine how less available data affects the reliability and consistency of the model. Another consideration is to further explore the applicability of the model to analyse comparable data provided by Market Comparison Technique which usually uses only 3 data. Therefore, sensitivity analysis might also be useful to examine the applicability of the suggested value range model in Market Comparison Technique.

Sensitivity analysis is conducted by classifying the data in each valuation case into two categories: *widespread* data set and *narrow-spread* data set. Next, we perform statistical analysis on each data set to extract the mean, standard deviation, and coefficient of variation before calculating the upper and lower limits of the value range.

Case 1

The widespread data set basically has similar characteristics to the original case, except that the *c* is set very close to the median of the original data set. The narrow-spread data set, on the other hand, is obtained by repositioning (shifting) the *a* and *b* to a position where the parameter *a* of the narrow-spread data set is higher than the *a* of the widespread data set. On the contrary, the *b* of narrow-spread data set is smaller than the *b* of widespread data set.

From table 5, we may notice that the variation measures in the narrow-spread data set is reduced by half of the same measures in the widespread data set. As indicated by table 5, the upper and lower limit (2*s*) of the widespread data set exceeds the maximum and minimum data in the original data set. This condition needs to be treated with caution due to the risk of type-2 error (perceiving that data is still in acceptable (in range) while it may not be the case). The same phenomenon does not occur in the narrow-spread data set. Hence, narrow-spread data set seems to be more advantageous, which in turn encourages valuers to be more conservative in their perspective on data-related risk.

Comparing those two sets of data indicates that the coefficient of variation seems to be the key to select whether 1*s* or 2*s* should be used. The sensitivity analysis shows that 5% coefficient of variation becomes the threshold. If the coefficient of variation is higher than 5%, it might be better to tighten the limit to 1*s*. Meanwhile if the coefficient of variation is below 5%, the limits can be relaxed to 2*s*.

Table 5. Sensitivity analysis on case 1

	Widespread data set (in million IDR)	Narrow-spread data set (in million IDR)
a	10	11.5
b	15	14
c	12.7	12.7
Mean	12.57	12.73
Standard Deviation	1.02	0.51
Coeff. of Variance	8.13%	4.01%
Upper Limit (1s)	13.59	13.24
Lower Limit (1s)	11.54	12.22
Upper Limit (2s)	14.61	13.75
Lower Limit (2s)	10.52	11.71

If we once more compare the valuer's actual opinion (12.37) with the upper and lower limits of narrow-spread data set, we may notice that the actual opinion of value falls neatly within even the narrow 1*s* limits (range). Hence, one might notice the meticulousness of the conducted analysis to produce the valuation output.

Case 2

Conducting similar sensitivity analysis on case 2 (see table 6) produces consistent results compared to case 1, in the sense that setting the limits at 2*s* for the widespread data set increase the risk for type-2 error although the coefficient of variance is slightly below 5%. This phenomenon may be affected by the fact that the coefficient of variance of the original data set exceeds 5%. Since the coefficient of variance (of both original data set and widespread data set) is around 5% (just slightly above and below respectively), the risk is partially connected to the upper limit. This is due to the fact that the upper limit's deviation from the centre line is around 9%, higher than the deviation of maximum data (from the centre line) in the widespread data set which is approximately at 8%. Sensitivity analysis on the narrow-spread data set confirms the advantage of selecting data set with lower variation.

Table 6. Sensitivity analysis on case 2

	Widespread data set (in million IDR)	Narrow-spread data set (in million IDR)
a	27	29
b	34	32
c	31	31
Mean	30.67	30.67
Standard Deviation	1.43	0.62
Coeff. of Variance	4.68%	2.03%
Upper Limit (1s)	32.1	31.29
Lower Limit (1s)	29.23	30.04
Upper Limit (2s)	33.53	31.91
Lower Limit (2s)	27.8	29.41

Suppose that we set the value range at ± 2*s* based on narrow-spread data set, then the valuer's actual opinion of 31.6 is still consistently within the range.

5. CONCLUSION

This paper presents a statistical model of Value Range based on Triangular Distribution which adapts the concept of Control Limits in the Control Chart Theory. It is the purpose/aim of the paper to contribute on the methodological issue of Uncertainty which takes the probabilistic nature of uncertainty into account.

Using market comparable data from two cases of commercial land valuation in East Jakarta and Tangerang County, the analytical results of the model suggests that Coefficient of Variation is a key aspect to consider whether the Value Range should be constructed at ± 1*s* or 2*s*. The sensitivity analysis indicates that the model works well with less data (3 data) and data set with narrower variation is generally more favourable.

The model and the research results presented in this paper may become a self-examination tool for valuers to check how much their value opinion deviates from the estimated mean and whether or not such opinion has passed the so-called "fairness" range. Hence, valuers will be able to manage uncertainty-related risks in valuation by having more awareness regarding the "Boundary of Fair Value". The terms "boundary" and "fair" here are conditional, meaning that those terms are data-dependent. Consequently, such terms will be heavily influenced by the data quality.

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