

## Development of user-friendly simple statistical software: Linear regression analysis series

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**Abstract:** Regression analysis is a statistical technique frequently employed across diverse disciplines utilizing SPSS. Users lacking a robust basis in regression and infrequently utilizing SPSS will experience anxiety. Anxiety will be intensified by the interpretation of the analysis results. This work aims to create user-friendly statistical software for regression analysis, requiring little configuration and capable of interpreting analytical results. This study employed the SCLD development model. This paradigm comprises five stages: Planning, Analysis, Design, Implementation, and System. The produced software is titled Simple Statistical Software series Regression Analysis, abbreviated as 3S-AR. The development yielded the 3S-AR program, which possesses functionality for regression analysis. The validation of development results was conducted by comparing the outcomes of 3S-AR analysis with those obtained from SPSS software. 3S-AR provides numerous advantages. Initially, it is user-friendly with minimal configuration required. A single analysis can present the outcomes of the regression analysis alongside all relevant assumptions. Secondly, the capability to offer an interpretation of the analytical findings. Third, if an analysis is incomplete, it can offer recommendations on the user's next steps. Fourth, it is complimentary. The development outcomes can facilitate users in conducting regression analysis with ease. Particularly for individuals lacking a robust statistical background and proficiency in regression analysis tools.

**Keywords:** Linear Regression, Simple Statistical Software, User-Friendly Software

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### INTRODUCTION

Regression Analysis is a statistical analysis method that is widely utilized in a variety of industries. For example, business, economics, psychology, social sciences (Davis & Pecar, 2021), and education (Susanto, 2016). Regression analysis is useful for mathematical modeling and demonstrating causal connection hypotheses with one or more independent variables and one dependent variable (Davis & Pecar, 2021; Nayebi, 2020).

SPSS is a popular software package for conducting regression analyses. SPSS is undeniably useful for regression analysis. However, the author identifies some flaws with SPSS. First and foremost, SPSS is a paid software that is extremely pricey. At the time of writing, SPSS was on its 29th version. Users can use the trial version for free for 30 days, after which the software is no longer usable. Second, there are too many options when performing regression analysis and making assumptions. These settings correspond to the analysis steps (Cunningham & Aldrich, 2016; Nayebi, 2020), which take a significant amount of time to understand. In addition, various assumption tests must be manually calculated and compared to tables. Some of these tests include the Breusch-Pagan and Park tests for heteroscedasticity (Andriani, 2017), as well as the Durbin-Watson test for the autocorrelation assumption (Nihayah, 2019). The third step is to understand the regression analysis results and assumptions. SPSS does not provide a feature that allows users to evaluate analytic findings. This section presents a challenge for users who lack a foundation in data analysis or who work outside of mathematics and statistics (Idris, 2022). Users may have anxiety as a result of the second and third deficiencies, particularly if they do not study mathematics or statistics.

Program R (R Core Team, 2023) is another option for regression analysis. The advantages of this software include a free license and capability comparable to SPSS or other premium applications (Paura and Arhipova, 2012). There are other package alternatives available in R for performing regression analysis, including *lmtest* (Zeileis & Hothorn, 2002) and *car* (Fox & Weisberg, 2019). However, the R application can only be utilized by users who are familiar with data analysis methodologies and the R programming language (Hackenberger, 2020; Paura and Arkhipova, 2012). This significantly raises the chance of new worries appearing, as users must first master the R programming language before performing regression analysis.

One of the R packages with a user interface for regression analysis has already been built. This package is known as SLR App (Simple Linear Regression App) and MLR App (Multiple Linear Regression) (Amir et al., 2022). This package is simple to use because it can be accessible online via the web-based [shinyapp.io](https://shinyapp.io). Some limitations of this application include it cannot use the original names of the analysed variables, it cannot be used for regression analysis with more than two independent variables, there is no feature to save the analysis results, it does not include linearity assumptions, there is no outlier detection, and there is no explanation for how to interpret the analysis results. Furthermore, at the time of writing, the application on [shinyapp.io](https://shinyapp.io) was not functional.

Based on that explanation, it is required to develop user-friendly regression analysis software. To demonstrate the existence of such software, this study seeks to construct simple statistical software with a series of regression analysis characteristics. (1) simple to use, with minimal settings required when performing regression analysis; (2) the results of the regression analysis and its assumptions are displayed concurrently on the same page; (3) can display interpretations of the regression analysis results along with their assumptions; (4) can save all analysis results in files with the *xlsx* extension; (5) can be installed as paid software, whereas (6) can be utilized online without installation.

## **METHODS**

### **Development Model**

The program is built in accordance with the System Development Life Cycle (SDLC) (Dennis et al., 2015; Tilley & Rosenblatt, 2016). The System Development Life Cycle (SDLC) method is highly structured, with each phase's completion being carefully examined before proceeding to the next. This characteristic seeks to reduce errors in application development. Thus, the

SDLC process is ideal for developing statistical applications. The SDLC has five stages: (1) planning, (2) analysis, (3) design, (4) implementation, and (5) system.

### **The Concept of Linear Regression Analysis as a Basis for Development**

Regression Analysis is a mathematical model that can be used for (1) proving causal correlation research hypotheses, and (2) mathematical modeling related to the influence of one or more independent variables on one dependent variable. There are several types of regression analysis, namely linear and nonlinear regression. However, this study only focuses on linear regression.

The quality of regression analysis results must be demonstrated by proving several assumption tests and the regression analysis itself. Some of the assumptions referred to are the linearity assumption, the residual normality assumption, the heteroscedasticity assumption, and the multicollinearity assumption. Next, the main analysis relates to the regression analysis itself. This main analysis consists of model fit analysis and the influence of independent variables on the dependent variable. Additionally, outlier data and data transformation need to be included to address linear regression assumptions if they are not met. All this information is explained in detail as follows.

#### ***Linearity Assumption***

The linearity assumption requires that each independent variable has a linear relationship with its dependent variable (Leech et al., 2013; Nayebi, 2020). The detection of this assumption can be done in several ways, namely through formal tests and visually. Formal testing can be conducted using the Rainbow and Harvey-Collier methods (Niermann, 2007; Zeileis & Hothorn, 2002). In both methods, the presence of a linear relationship is indicated by a p-value  $> 0.05$ . This assumption can be made before the regression analysis is conducted.

The failure to meet this assumption explains that the data is not suitable for analysis with linear regression. If this occurs, it is recommended to use nonlinear regression analysis. However, if you want to maintain regression analysis, you can try data transformation (Hadi et al., 2017).

#### ***Residual Normality Assumption***

This assumption requires that the residuals or errors produced must be normally distributed (Cunningham & Aldrich, 2016; Leech et al., 2013; Nayebi, 2020). The detection of this assumption can be done using formal and visual methods. Several formal methods that can be used for normality testing are Jarque Bera, Anderson Darling, Lilliefors, and Shapiro Wilk (Ogunleye, L et al., 2018). In these four methods, the residuals are said to be normally distributed if the p-value is greater than 0.05. Next, visually, this assumption can be checked by looking at the histogram and Q-Q plot (Nayebi, 2020; Ogunleye, L et al., 2018).

The failure to meet the normality assumption can lead to inaccuracies in estimating the constant and slope of the regression (Davis & Pecar, 2021; Domański & Szczepocki, 2020). If this assumption is not met, it is recommended to remove outlier data or perform data transformation (Hadi et al., 2017; Osborne, 2010).

#### ***Heteroscedasticity Assumption***

This assumption requires that the variance of the residuals is constant at all levels of the independent variable (Davis & Pecar, 2021; Nayebi, 2020). This characteristic is commonly referred to as homoscedasticity (Aljandali, 2017; Davis & Pecar, 2021; Nayebi, 2020). In other words, this assumption requires the absence of heteroscedasticity cases. This assumption can

be detected using formal and visual methods. One of the formal methods that can be used is the Breusch-Pagan method (Andriani, 2017; Maziyya et al., 2015; Zeileis & Hothorn, 2002). It is said that heteroscedasticity does not occur if the p-value from the chi-square is  $> 0.05$ .

The failure to meet this assumption can result in the estimated variance becoming inefficient, due to the tendency of the residual variance to increase (Aljandali, 2017; Maziyya et al., 2015). If this assumption is not met, it is recommended to perform data transformation (Aljandali, 2017; Davis & Pecar, 2021; Hadi et al., 2017; Maziyya et al., 2015; Osborne, 2010).

### ***Multicollinearity Assumption***

This assumption only applies to regression analysis with more than one independent variable. This assumption requires that there is no very strong relationship between the independent variables. This assumption can be detected using variance inflation factors (VIF) (Aljandali, 2017; Fox & Weisberg, 2019; Leech et al., 2013). This assumption is met if the value of VIF  $< 10$  (Aljandali, 2017; Ho, 2013).

The failure to meet this assumption causes a paradox where, although the regression model fits the data well, the independent variables do not have a significant individual impact in predicting the dependent variable. This occurs because highly correlated independent variables practically have the same information (overlapping information) (Aljandali, 2017). The impact can reduce the predictive power of independent variables individually when related to other independent variables, so that none of the predictor variables provide a unique and significant contribution after the others are included (Ho, 2013). This case can be addressed by removing one of the independent variables from the regression model (Aljandali, 2017; Leech et al., 2013).

### ***Autocorrelation Assumption***

This assumption is only used if the data has time series characteristics (Aljandali, 2017). This assumption can be detected using the Durbin-Watson method (Aljandali, 2017; Davis & Pecar, 2021; Zeileis & Hothorn, 2002). In the development of this software, this assumption is not a priority, but it is still displayed in the software.

### ***Model Fit***

A regression model is said to be fit if it has a p-value from the F distribution  $< 0.05$  (the significance level used). The value of the p-value can be seen from the Anova table of the regression analysis results (Ho, 2013; Leech et al., 2013). If the model is detected as not fit, then linear regression analysis indicates no linear influence between the independent variable and the dependent variable. If this occurs, it is recommended to (1) stop the linear regression analysis or no longer conduct assumption tests; (2) try removing outliers and reanalyze with linear regression; and (3) use nonlinear regression analysis.

### ***The influence of the independent variable on the dependent variable.***

The extent of the influence of the independent variable on the dependent variable can be determined by looking at the value of the coefficient of determination in the model summary table (Ho, 2013; Leech et al., 2013). In simple regression, this influence can be seen using the value of  $R^2$ , and for multiple regression, it can be seen with Adjusted- $R^2$  (Leech et al., 2013).

In multiple regression, the value of Adjusted- $R^2$  can only see the simultaneous or collective influence of independent variables on the dependent variable. However, often one or more independent variables individually do not have a significant effect. The significance of the influence of independent variables individually can be seen in the Coefficient table (Ho, 2013;

Leech et al., 2013). Independent variables are said to have a significant influence if the p-value from the t-distribution  $< 0.05$  (the significance level used).

### **Outlier**

This case occurs because there is data with unusual characteristics compared to other data. This case will significantly affect the results of the regression analysis (Nayebi, 2020). In the R program, this case can be easily detected using the MASS package (Venables & Ripley, 2002). To obtain appropriate linear regression analysis results, outlier data must be removed or deleted (Nayebi, 2020).

### **Data transformation**

In some cases, data transformation must be performed to meet the results of linear regression analysis. The transformation method that can be used is the Box-Cox transformation. This method can simplify the data transformation process, as it can guide users to use specific transformation formulas.

In regression analysis, the Box-Cox transformation can be performed under two conditions. First, if the assumption of linearity is not met. Transformation is only performed on the independent variable. Second, if the assumption of residual normality or the occurrence of heteroscedasticity is present, then transformation is only performed on the dependent variable (Cohen, 2013; Lalonde, 2012; Olive, 2010).

All information related to the concept of linear regression analysis above will be the main basis in the development of software for regression analysis.

## **RESULTS AND DISCUSSION**

The material on regression analysis above serves as the basis for the author to develop a simple statistical software series on regression analysis using the SDLC model. The results of the development based on the SDLC model are explained as follows.

### **Planning**

This stage is carried out to determine: (1) the purpose of developing statistical software. The purpose of developing the software is to make it easier for users of regression analysis to prove research hypotheses and perform modeling; (2) The programming language used. R language was chosen for software development. This programming language was chosen because it has an open-source or free license; and (3) the name of the developed software. The name of the developed software is *Software Statistika Sederhana - Series Analisis Regresi*, abbreviated as 3S-AR.

### **Analysis**

This stage aims to conduct a needs analysis required in software development. The needs analysis is conducted to build the user interface and back end of the software. According to the programming language used, the needs analysis involves the packages available in the R program. The packages are listed in Table 1.

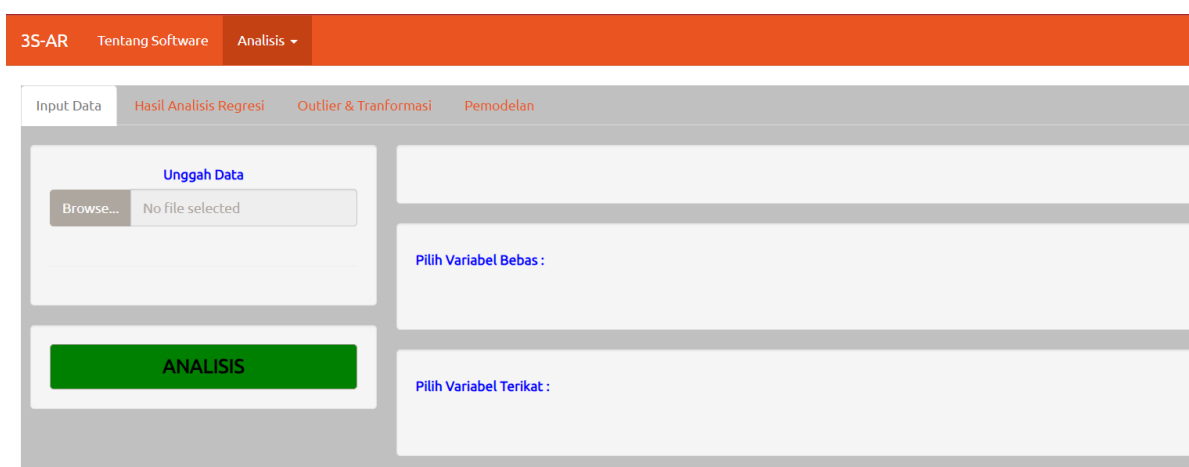
### **Design**

At this stage, the user interface design and functionality of the developed software are carried out. The user interface design in this development is realized with 4 layers or pages. The layers are explained in detail as follows.

The design of the display on layer 1 can be seen in Figure 1. There are several functionalities on this layer (1) uploading the data to be analyzed. The data to be analyzed must be written in a file with the xlsx extension; (2) select independent and dependent variables based on the uploaded data; (3) analysis command. if the analysis button is not pressed, then the functionality on layers 2, 3, and 4 will not work.

**Table 1.** Analysis of package and program requirements

Component	Package name	functionality
Front end or User Interface or display	shiny (Chang et al., 2015)	To build the user interface of <i>software</i> .
	shinytheme (Chang, 2021)	To support the user interface of the <i>software</i> .
	shinyWidgets (Perrier et al., 2023)	To support the appearance of buttons and radio buttons to be more attractive.
Server or back end	readxl (Wickham & Bryan, 2023)	To read files with xlsx extension.
	openxl (Schauberger & Walker, 2023)	To save analysis results with the xlsx extension.
	tseries (Trapletti & Hornik, 2023)	To test normality with the Jarque Bera test.
	nortest (Gross & Ligges, 2015)	To carry out a normality test, use the Lilliefors test.
	lmtest (Zeileis & Hothorn, 2002)	To carry out regression analysis, test linearity with the Rainbow test and Harvest test.
	car (Fox & Weisberg, 2019)	To display visual results of the linear relationship of the independent and dependent variables. Apart from that, a multicollinearity test was also used.
System	olsrr (Hebbali, 2024)	To detect outliers in regression
	MASS (Venables & Ripley, 2002)	Determine the type of data transformation using the box-cox test.
	DesktopDeployR (Lee Pang, 2020)	To make <i>standalone app</i> .
	innosetup	To change the application to exe.
	R Portable	To run R programs portable.
	Shinyapps.io	To run software online.



**Figure 1.** Appearance Design on Layer 1.

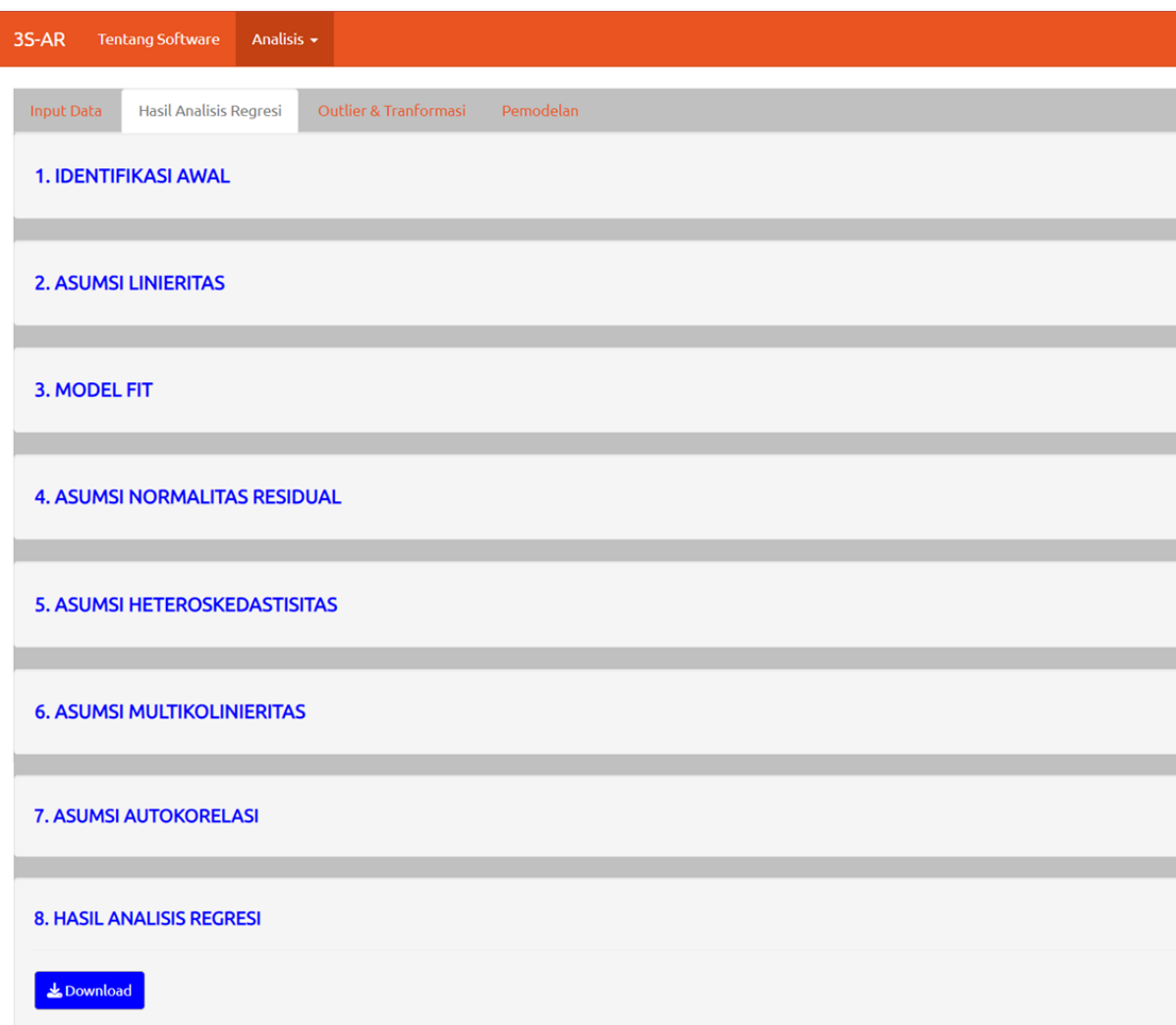


Figure 2. Appearance Design on Layer 2.

The design of the display on layer 2 can be seen in Figure 2. The software functionality on the second screen shows the results of linear regression analysis. These functionalities display: (1) initial identification. This section will provide a general explanation regarding whether the required assumption tests are met or not. If met, each assumption test will be marked with a green label; otherwise, it will be marked with a red label. (2) results of linearity assumption testing; (3) results for determining model fit; (4) results of residual normality assumption testing; (5) results of heteroscedasticity assumption testing; (6) results of multicollinearity assumption. In the multicollinearity assumption, if there is only one independent variable, then this assumption is automatically deactivated by 3S-AR. (7) the result of proving the autocorrelation assumption; (8) The results of the regression analysis in the form of a model summary table and a coefficient table; (9) the results from numbers 2 to 8 can be automatically downloaded in a file with the xlsx extension. All functionalities in Figure 1 are not yet visible because no data has been uploaded for analysis.

As seen in Figure 2. The functionality of the software at layer 2 not only displays results statistically in the form of tables. In the section on the linearity assumption, residual normality assumption, and heteroscedasticity assumption, the results are also displayed visually. In addition, each analysis result for each assumption is accompanied by a direct interpretation that can be seen in the explanation section of each analysis result. Furthermore, if there are any

unmet analysis results, the software will automatically provide suggestions on what the user should do.

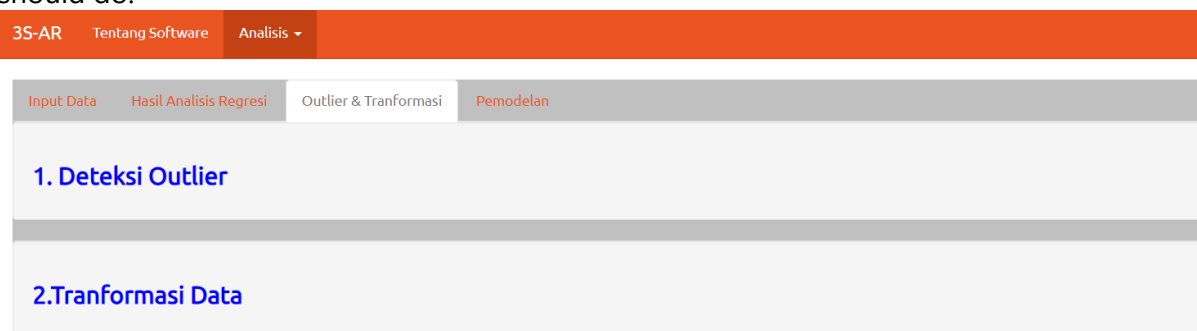


Figure 3. Appearance Design on Layer 3.

The design of the display on layer 3 can be seen in Figure 3. There are two functionalities in this layer, namely detecting outliers based on regression analysis results and data transformation. This layer is a feature of 3S-AR to address situations where the assumptions of linear regression analysis are not met.

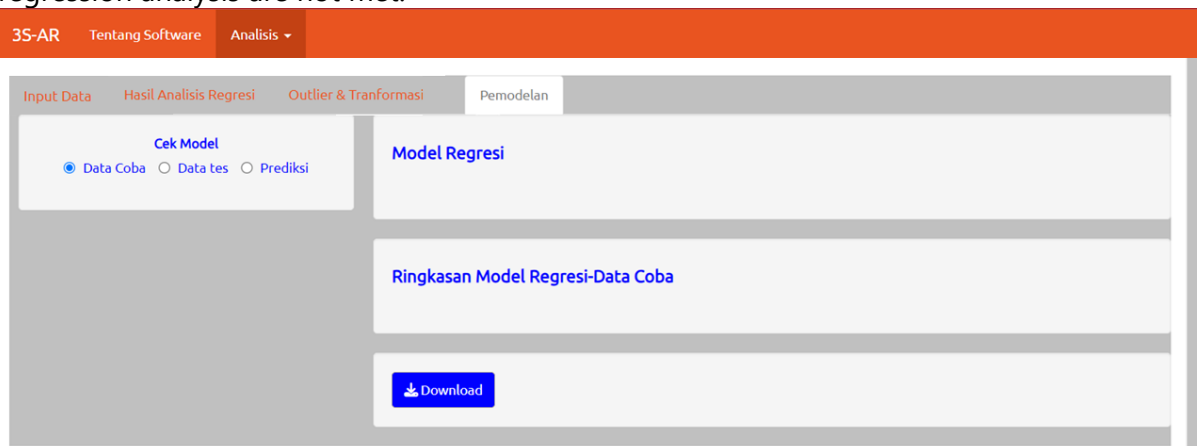


Figure 4. Display Design at Layer 4 for regression model test data.

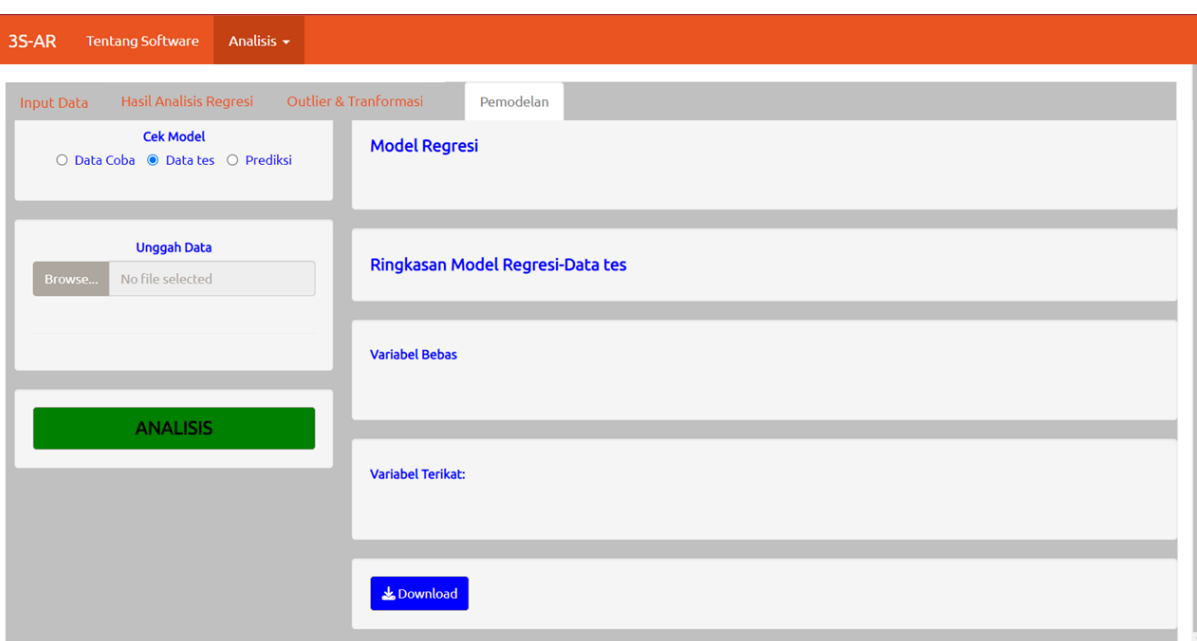


Figure 5. Display Design at Layer 4 for regression model test data.

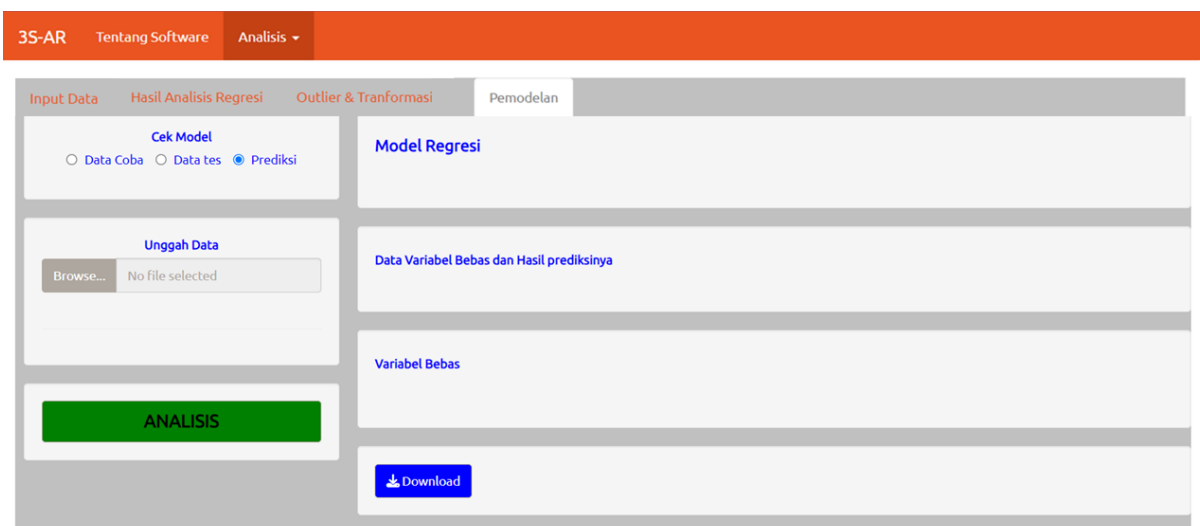


Figure 6. Display Design at Layer 4 to predict the dependent variable

Layer 4 modeling. The main functionality of this layer is to create mathematical modeling using regression analysis. There are three display designs on layer 3. The first design (Figure 4) is used to view the results of regression modeling using trial data. In this section, the regression model and the model analysis table will be displayed. The second design (Figure 5) is used to test the regression model with test data. In this section, users must upload test data with the xlsx extension and specify the independent and dependent variables. The third design (Figure 6) is used for making predictions. In this section, users must upload data in xlsx format that only consists of dependent variables and select the variables.

### Implementation

At this stage, coding is carried out to realize the predetermined design and confirm the results of the regression analysis with the commonly used software. In accordance with the programming language used, the coding is carried out by utilizing the packages listed in Table 1. Next, the confirmation of the linear regression analysis results using SPSS software can be seen in Table 2.

Table 2. Confirm the results of the 3S-AR analysis with SPSS

Comparator	3S-AR	SPSS	information
Linearity Assumption	Harvey-Collier, Rainbow, and visuals	Deviation from linearity, dan visual	Results differ due to different test methods
Model Fit	Anova table	Anova table	Same Results
Residual normality assumption	Lilliefors, Shapiro Wilk, Anderson Darling, Jarque Bera, and visuals	Lilliefors, Shapiro Wilks, Kolmogorov-Smirnov, dan visual	The same two methods in SPSS and 3S-AR produce the same results
Heteroscedasticity Assumption	Breusch-pagan	Breusch-Pagan	Same result
Multicollinearity assumption	VIF	VIF	Same result
Autocorrelation Assum	Durbin Watson	Durbin Watson	Same result
Regression Results	Model summary table Table Coefficient	Model summary table Table Coefficient	Same result

Based on the confirmation of the analysis results in Table 2, it can be a consideration for users who will conduct linear regression analysis. The results of the regression analysis using 3S-AR are the same except for the linearity assumption and two methods for the normality test.

## **System**

This stage is carried out to determine whether the software system can operate on a specific operating system (OS). The developed software is determined to work only on the Windows operating system. The software packaging process is carried out using the DesktopDeployR framework (Lee Pang, 2020) and followed by the innosetap application, resulting in the software having an exe extension. Additionally, to accommodate users who do not use the Windows OS, the team has made 3S-AR accessible online at [https://hpsproject.shinyapps.io/3S\\_AR/](https://hpsproject.shinyapps.io/3S_AR/). The 3S-AR.exe installation file can be installed at the link <https://bit.ly/3W9hY6W>.

The 3S-AR software is designed to be used on the Windows operating system. The process of using this software can be done by (1) double-clicking the 3S-AR icon on the desktop or through the Windows menu on your device. The initial display that appears will contain information about the software's functionality and its development team; (2) Continue by selecting the "Analysis" menu, then choose the "Regression" sub-menu, so that the interface as shown in Figure 5 will be displayed; (3) Upload the data to be analyzed by pressing the "Browse" button in Figure 5; (4) After the data is successfully uploaded, determine the independent and dependent variables that will be used in the analysis; (5) Click the "Analysis" button as shown in Figure 5 to start the regression analysis process; (6) The results of the regression analysis along with their interpretation can be viewed by pressing the "Regression Analysis Results" button. In this section, the software will also provide automatic suggestions on the right side of the screen if the analysis assumptions are met; (7) To check for the presence of outliers or perform data transformations, users can use this feature by pressing the "Outlier and Transformation" button; (8) Finally, if users want to see the regression model, dependent variable estimates, or prediction errors, the feature can be accessed through the "Model" button.

Linear regression analysis with 3S-AR can be done online. The steps to use 3S-AR online can be done by opening the page [https://hpsproject.shinyapps.io/3S\\_AR/](https://hpsproject.shinyapps.io/3S_AR/). Next, for the second step and beyond, it can be done as per the steps for using 3S-AR on Windows devices. For a clearer understanding of using 3S-AR for regression analysis, you can watch the video at the following link: <https://studio.youtube.com/video/OIJrBjZX03k/edit>.

The main functionality of 3S-AR is its ability to perform linear regression analysis easily and practically. This capability is realized with simple commands that do not require much setup like in SPSS (Leech et al., 2013; Nayebi, 2020). With just one press of the Analysis button, all regression analysis results along with their assumptions can be displayed. Next, another convenience provided by 3S-AR is that users can directly view the interpretation of the regression analysis results along with their assumptions, and if any assumptions are not met, the application automatically provides suggestions for the next steps to be taken. Additionally, there are features for outlier detection and data transformation that serve to facilitate the suggestions provided by 3S-AR. The ease of performing regression analysis will reduce user anxiety. Especially users who do not have a statistical background for data analysis (Idris, 2022).

In terms of appearance, 3S-AR has a classic and simple look. This makes it easier for users to remember the steps in performing regression analysis. Unlike SPSS, which has a very nice and modern interface but requires a lot of adjustments to use it. Users who are not accustomed to using SPSS take a long time to remember the steps of regression analysis and its

assumptions, as well as how to interpret the results. However, in terms of core functionality, SPSS remains superior compared to 3S-AR in regression analysis.

3S-AR has several shortcomings. First, the software can only be installed on computers with the Windows operating system. Due to the author's limitations, until now no method or tutorial has been found to install the developed software on operating systems other than Windows. Second, the software can only be installed on computers that already have Windows 8 or higher installed. This weakness is caused by the use of the portable version of R for development. The higher the version of R used, the higher the computer specifications required. Third, the installation of 3S-AR must be done by disabling the built-in Windows antivirus or any additional antivirus installed on the computer. This weakness was found by the author while attempting installation on several computers. Fourth, 3S-AR online on shinyapp.io in free mode is limited to 25 hours of use per month. So if there are already many users in a day and the total time has reached 25 hours, then 3S-AR cannot be used online. You have to wait one month to be able to use it again. Fifth, there is no refresh mode in the 3S-AR OS windows yet. Users must close the application and restart it when performing regression analysis with new data. Sixth, the significance level is only set at 0.05. seventh, the analysis features of 3S-AR are still less complete compared to SPSS or other paid software. The first to fourth weaknesses can actually be addressed by converting the software system to online, so users can access it through an IP Address or a specific domain without installation, like on shinyapps.io. However, the author did not do that, because to make it online and usable indefinitely, renting a Virtual Private Server (VPS) is required, which is expensive.

## CONCLUSION

Based on the development results, a 3S-AR application for linear regression analysis has been obtained with features that make it easier for users. The features include minimal settings required for analysis, explanations related to the interpretation of analysis results, and it is free to use. The contribution of the 3S-AR software development can prevent users from making mistakes in using regression analysis.

In the next development, the author will develop simple statistical software for the series Analysis Of Variance (ANOVA), Analysis Of Covariance (ANCOVA), Multivariate Analysis Of Variance (MANOVA), Multivariate Analysis Of Covariance (MANCOVA), and others. In addition, the development is also focused on addressing the weaknesses of 3S-AR.

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