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Modeling robust regression to factors affecting the exchange rate of Iraqi Dinar

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ABSTRACT

Regression analysis is an important statistical tool iteration used, applied in scientific and practical studies. It is considered the method of least squares most methods of estimating the regression model. However, they are affected when there are outlier values in the data of the research. Hence, it is necessary to find robust methods to estimate the regression model.

In this paper, a robust regression model for the exchange rate was built based on influencing factors of GDP, inflation, exposure index and trade. The robust model was found to be more accurate in the Data Visualization, and the conclusions were consistent with economic theory.

Keywords: M-Estimator, Wight, Exchange rate, Inflation, Gross domestic product, Exposure index, Trade

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1. Introduction

The use of linear models is one of the most used statistical methods in various sciences, because it describes the relationship between the variables in the form of a linear equation. Linear model analysis is used for several purposes including the prediction process. One of the requirements for analyzing phenomena is to determine the appropriate model for the phenomenon. Choosing the appropriate model leads to make the right decision about the problem to be studied and play a special role in statistical analyses. Therefore, appropriate methods should be chosen to estimate its parameters for the purpose of comparison and find the best way to estimate it so that it can be relied upon to reach more accurate results. There is more than one method for estimating features, including traditional methods. However, the estimators of these methods may fail if the data contains outliers. Therefore, the researchers focused on how to deal with data that contains outliers. That process can be done by using robust estimate methods if these estimates are more efficient than the usual methods in the event of outliers [1, 2].

Although the formulas for these estimates differ, but there is the same goal. It is the use of the method of balancing the observations by associating the observations that are believed to be outliers with fewer weights than those that are compared with the rest of the observations to reduce the influence of the outliers, as well as using the method of iterations in the calculation [3].

The use of robust estimation methods is an important means when there are outliers in the data (Outliers) resulting from errors in recording or describing observations, as well as the problem of error distribution and deviation from the normal distribution and other problems. The presence of these problems affects the estimator parameters. Hence, the need to use the robust methods to estimate is characterized by being not very sensitive and affected by the outliers [4].

2. Research objective

In this research, the m-estimator method will be applied in order to build a robust regression model. Here, in this study, we will investigate outliers in the Iraqi dinar exchange rate and the factors affecting it.

3. Theoretical side

3.1. Robust estimators

The robustness word is called on estimators that are not affected or easily sensitive to a violation in one of the hypotheses of multivariate normal distribution or the presence of outliers or contaminated in statistical data. For these reasons, alternative methods of estimation have been found that deal with data in a way that differs from traditional methods. We can consider these alternative estimators as fortified robust estimators [5].

A robust estimator is defined as having the advantage of retaining many desirable properties when violating a hypothesis of multivariate normal distribution or the presence of contaminated outliers in the data [6].

3.2. Outliers observation

There are several definitions of outlier observation including one that defined them as observation (or a subgroup consisting of some observations). They appear to be inconsistent with the rest of the observations of that the main group [2].

In the case of a single variable, the outliers can be observed by arranging the data in an ascending or descending order as they fall into the tail of the arrangement. However, in the case of multiple variables, the process of detecting the outliers becomes difficult in such a way that it is necessary to find a robust mathematical method to detect it necessarily. In this case, we should go beyond visual inspection and personal diagnosis [7].

3.3. The contaminated observation

Let G and F have two distribution functions that belong to two different distribution families (or the same distribution). If a random sample size (n) that includes (n - k) is drawn from observations with an F distribution and (k) from it belongs to the G distribution, then the last observations are called contaminant observation.

3.4. Properties of robust estimators

In order to judgment whether the robust estimator is good or not, some properties must be provided in it, and we can summarize it with the following [5]:

1. Unbiased
2. Consistency
3. Minimum Variance
4. Efficiency
5. Sufficiency

3.5. M estimators method

Andrews in 1974, proposed a general method of highly efficient robust regression instead of $minimize \sum_{i=1}^{n} s^2$. These reweighting based M estimators tries to minimize $(\sum_{i=1}^{n} \rho(s_i))$, where $\rho(s_i)$ is identifiable, positive and symmetric function. We can get the weight function for the standard errors in order to solve the least squares method according to the following equation:

$$W(s) = \begin{cases} 1 & |s| = 0 \\ 0 & |s| > c\pi (c = 1.3390) \\ c\frac{\sin(s/c)}{s/c} & |s| \le c\pi \end{cases}$$

Where c and s in the equation, represent the standard errors of solving the least squares method [8, 9]. The details of procedural steps are:

1. A set of starting values for the regression coefficients is obtained by ordinary least squares (OLS) coefficient estimates.
2. A set of residuals is calculated from step 1 using the regression coefficients.
3. A set of weights are developed, these weights range from zero to one. Observations with large residuals customize small weights.
4. The relationship between the residuals and the weights is determined through the *Andrews function.*
5. The weighted least squares is used to estimate a new set of regression coefficients by using the weights calculated in step 1.
6. By the regression coefficients from step 5, calculate a new set of residuals.
7. Go to step 3 and continue iterating steps 3 to 6 until the convergence occurs.

4. Applied side

4.1. Data description

Data collected from the annual bulletins of the Central Bank of Iraq from 1997 to 2018 to study the relationship between the dependent variable (the exchange rate of the Iraqi dinar against the US dollar), and independent variables such as inflation, GDP, trade exposure, and commercial exchange, and the following is an explanation of the basic concepts of each variable.

4.1.1 The concept of exchange rate (y)

The exchange rate is defined as the price of the currency of a particular country denominated in another country, or the ratio of the exchange between two operations. In other words, it is the number of units of the local currency for obtaining one unit of foreign currency. The exchange rate is an important and essential role in determining the nature of internal and external economic activities. Within the country, the exchange rate can be used as a tool for monetary policy in the country in order to reduce the rate of inflation in a manner consistent with the ultimate objective of monetary policy. As for foreign economic relations, the importance of the exchange rate is determined by the fact that it represents the costs of production and prices, whether at home or abroad, Therefore, it can be used as an indication of a country's competitiveness and, consequently, to the balance of payments. As in the case of an increase in the local currency exchange rate, this indicates an increase in the value of locally produced goods and services, and consequently a negative impact on exports. But, in the case of a decrease in the local currency exchange rate, the situation will be exactly the opposite.

Each country prefers a stable exchange rate to facilitate foreign trade and reduce the degree of risk and uncertainty in the economy. Occasionally, the country may prefer a weaker exchange rate to stimulate aggregate demand and reduce recession or a stronger exchange rate in order to combat inflation. It should be noted that rapid movements from the weak exchange rate to the strong exchange rate may halt export industries. Rapid movements from the strong exchange rate to the weak exchange rate can halt the work of the banking sector. This means that every exchange rate option implies trade-off between possible cases.

4.1.2. The concept of gross domestic product (X1)

The term gross domestic product refers to the value of final goods and services that are produced within the borders of a country during a specific period of time, usually a year. GDP is one of the most important basic indicators used in addition to other indicators in the economy and making international and local comparisons. The growth and development of the gross domestic product as a general trend reflects the economic efficiency and development of the standard of living, and hence the measure of luxury.

4.1.3. The concept of inflation (X2)

Inflation is defined as the general and continuous rise in prices. This rise does not require that it be for all goods and services, as some prices may decrease, except the general trend must be up, and that this rise must be continuous and exclude the temporary rise. The main reason for excluding the temporary rise in prices

from the concept of inflation is related to politics as with inflation taking place. It is necessary to take measures and policies to limit the impact of this phenomenon. If this rise occurs temporarily, the effect of these policies will be negative on economic activity. Therefore, inflation is an economic phenomenon that can contribute to the decline in economic stability and the resulting negative effects on economic activity. As inflation shows the rise in the general level of prices, this rise must have negative internal and external economic impacts, especially when it is not expected.

4.1.4. The concept of exposure index (X3)

The commercial exposure index is an indication of the extent to which foreign trade contributes to the formation of gross domestic product. It shows the extent of the economic activity of any country on the conditions prevailing in the export and import markets of this country. We can get acquainted with the measurement of the sensitivity of the national economy to external influences and is calculated according to the following equation:

$$\text{Exposure index} = \frac{Export + imports}{GDP} * 100$$

As the ratio of exports and imports to GDP is higher, the economy will be more affected and exposed to changes in foreign trade between the countries of the world.

Measuring foreign trade to GDP is an important indicator that shows the degree of any economy's relationship with the economies of the outside world.

4.1.5. The concept of trade (X4)

It means the exchange of goods and services, or one of them between two parties (bilateral trade) or between more than two parties (multi-faceted trade). The increase in the volume of trade exchanges relates to the volume of public spending, where we note that it greatly affects the national economy.

4.2. Analysis and interpretation of results

Weights were extracted for the original data to be applied with the least squares method in order to obtain the initial values in the iterations. We can describe the statistical summary for each variable according to the following table:

Table 1. Descriptive statistics

Variable	Count	Mean	Standard Deviation
X1	20	84975.2	58866.99
X2	20	12.78609	15.23564
X3	20	0.8501076	0.2686151
X4	20	1.082535E+07	4.135733E+07
Y	20	1345.792	183.9573

Table 2 explains the results of the multiple regression analysis, and Table 3 explains the variance analysis for the relationship between the exchange rate of the dinar and the independent variable. Therefore, the linear regression equation for this model can be represented by the following formula:

Y=672.493+ 7.582039E-04*X1+ 3.318974*X2+ 655.0809*X3+ 8.816278E-07*X4

This model indicates that the dinar exchange rate increases with increasing of the gross domestic product, inflation, trade exposure and trade. To see if it is possible to simplify the model, we note that the P Value for the two variables (X1, X4) is (1) which is greater than (0.10). Namely, these two variables have a not significant effect on the exchange rate of the Iraqi dinar. Therefore, it is preferable to exclude them from the model, and this result is considered acceptable in the presence of some outliers in the data. But, for the importance of their effect on the exchange rate, we cannot remove them from the model as shown in Figures1-5.

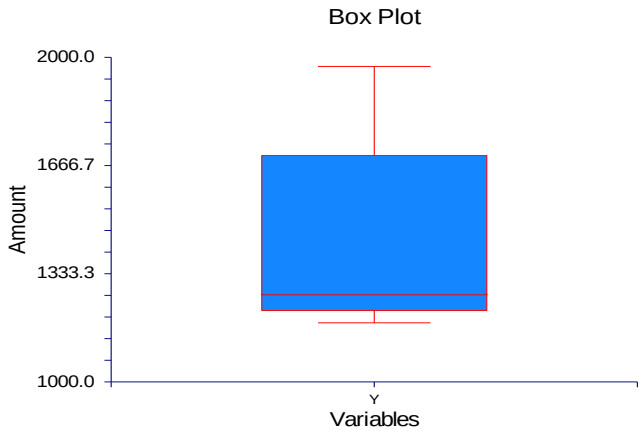

Figure 1. Box plot of exchange rate (y)

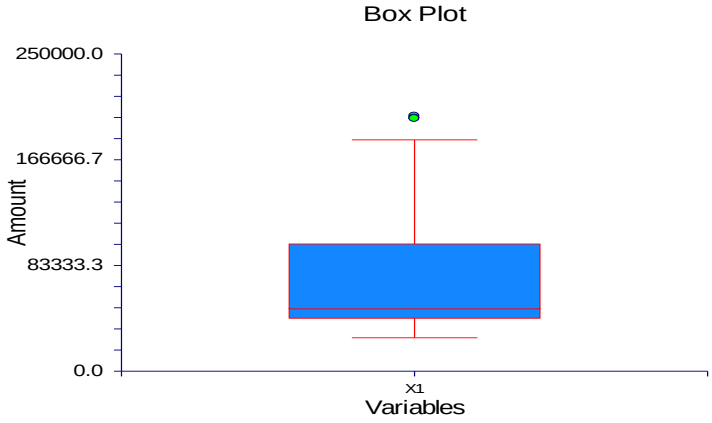

Figure 2. Box plot of gross domestic product (X1)

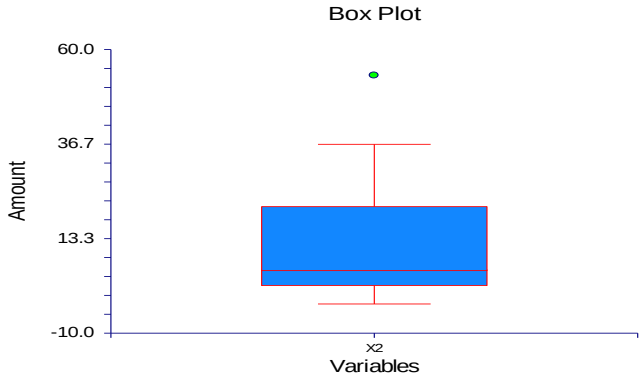

Figure 3. Box plot of inflation (X2)

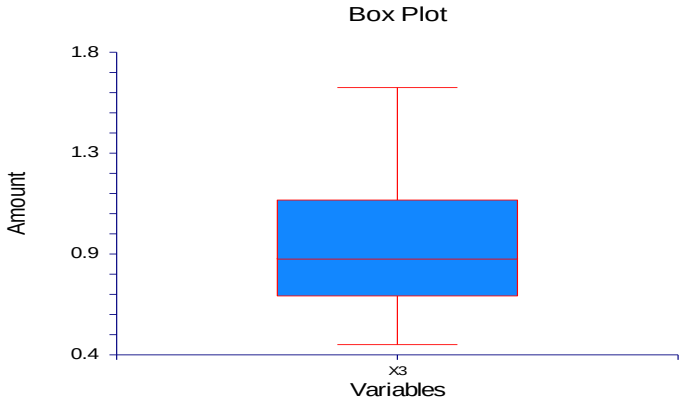

Figure 4. Box plot of exposure index (X3)

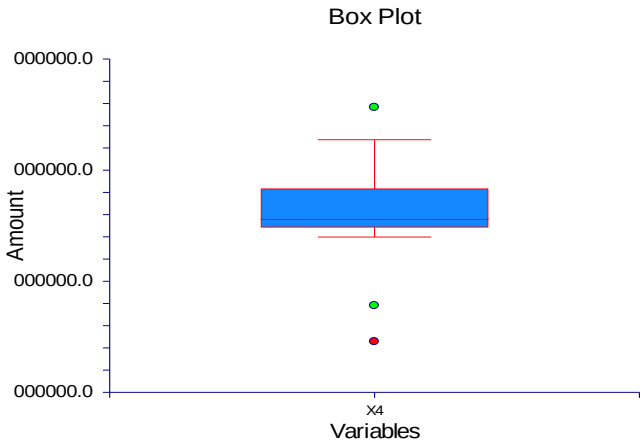

Figure 5. Box plot of trade (X4)

Table 2. Regression coefficient

Independent Variable	Regression Coefficient	Standard Error	T-Value (H0: B=0)	Prob Level	Decision (5%)	Power (5%)
Intercept	672.493	92.10463	7.3014	0.000003	Reject H0	0.999999
X1	7.582039E-04	0	0.0000	1.000000	Accept H0	0.050000
X2	3.318974	1.29242	2.5680	0.021418	Reject H0	0.670528
X3	655.0809	83.90536	7.8074	0.000001	Reject H0	1.000000
X4	8.816278E-07	0	0.0000	1.000000	Accept H0	0.050000

Table 3. Analysis of variance section

Source	DF	Sum of Squares	Mean Square	F-Ratio	Prob Level	Power (5%)
Intercept	1	3.031957E+07	3.031957E+07			
Model	4	567653.4	141913.4	28.2650	0.000001	1.000000
Error	15	75312.26	5020.817			
Total(Adjusted)	19	642965.8	33840.3			

Root Mean Square Error	70.85773	R-Squared	0.882867
Mean of Dependent Variable	1345.792	Adj R-Squared	0.851632
Coefficient of Variation	5.265134E-02		

We note that the adjusted R-Squared value of the equation was equal to the effect of the independent variables on the Iraqi dinar exchange rate.

After extracting the regression coefficients using the least squares method, a set of successive iterations was made until to reach beta value less than 0.05, where these percentages were used in calculating robust estimates for the standard deviation, $\hat{\sigma} = 1.5\ median|e_i|$ as in the Table 4.

Table 4. Residual percentile

Iter. No.	Max % Change in any Beta	---------- Percentiles of Absolute Residuals ---------- 25th	50th	75th	100th
1	0.0000	91.14764	115.0294	154.3618	394.5317
2	232.1577	74.89172	101.2439	150.4381	426.7945
3	32.6778	65.10226	96.54179	139.7368	444.1981
4	12.5310	57.74823	91.25543	136.8725	453.7986

Iter.	Max % Change	---------- Percentiles of Absolute Residuals ----------			
No.	in any Beta	25th	50th	75th	100th
5	10.1246	52.77922	84.35903	135.2259	462.5134
6	11.5261	46.701	76.44971	133.1455	473.6211
7	12.1178	40.1193	72.97031	129.818	487.4923
8	6.7912	36.95459	68.35529	126.2798	496.9185
9	6.6499	34.23846	63.98907	122.3654	506.2784
10	7.0600	31.83921	63.50605	118.1364	515.5301
11	3.6384	32.85674	64.07464	115.3706	520.3461
12	1.1588	35.22992	63.31502	114.2336	521.938
13	1.1699	35.46287	62.52536	113.8995	523.5632
14	1.1578	37.47886	61.73116	113.3915	525.1921
15	1.1286	40.92683	60.94595	112.8195	526.8
16	1.0772	41.45882	60.1855	112.232	528.3544
17	0.9997	40.4697	59.46909	111.6567	529.816
18	0.8954	39.58038	58.81762	111.1145	531.1418
19	0.7688	38.81565	58.24987	110.6233	532.2941
20	0.6298	38.19024	57.77818	110.1967	533.2485
21	0.4916	37.70468	57.64328	109.8419	534.0006
22	0.2386	37.44946	57.9635	109.6844	534.377
23	0.1222	37.49216	57.8908	109.8196	534.2523
24	0.0182	37.47607	57.90924	109.8293	534.2745
25	0.0131	37.47728	57.9058	109.8445	534.2669

Table 5 shows the regression coefficients estimates for all iterations, where the first iteration stands for the least squares estimates. So, we can see the changes that occur during the iteration process until the last iteration is reached.

Table 5. Robust regression coefficient

Iter.	Intercept	X1	X2	X3	X4
1	599.2742	3.01492E-04	0.3494444	895.5178	1.159749E-06
2	576.4576	5.134867E-04	1.160707	873.7043	1.130133E-06
3	572.9044	6.052324E-04	1.54	854.6408	1.10501E-06
4	574.7435	6.45287E-04	1.732977	840.9424	1.087394E-06
5	576.9398	6.80299E-04	1.908435	828.0449	1.071251E-06
6	580.8773	7.226088E-04	2.128403	810.603	1.050324E-06
7	590.5264	7.638742E-04	2.386319	784.758	1.021076E-06
8	603.6126	7.73284E-04	2.548378	761.6614	9.959115E-07
9	618.7058	7.77389E-04	2.717843	736.8481	9.69769E-07
10	635.1552	7.774536E-04	2.909723	710.8691	9.431062E-07
11	645.0914	7.704526E-04	3.01559	696.2831	9.268347E-07
12	649.1042	7.637055E-04	3.050533	690.9528	9.193227E-07
13	652.4472	7.611569E-04	3.086222	686.0562	9.131335E-07
14	655.5984	7.599789E-04	3.121956	681.2792	9.076762E-07
15	658.633	7.593393E-04	3.15719	676.6132	9.026703E-07
16	661.5298	7.589694E-04	3.1912	672.126	8.980422E-07
17	664.2283	7.587867E-04	3.223104	667.9236	8.938382E-07
18	666.6536	7.587676E-04	3.251964	664.1266	8.901551E-07

Iter.	Intercept	X1	X2	X3	X4
19	668.738	7.58898E-04	3.276964	660.8425	8.870854E-07
20	670.4409	7.59153E-04	3.297602	658.1384	8.846759E-07
21	671.7602	7.594922E-04	3.313812	656.0228	8.829048E-07
22	672.4824	7.593744E-04	3.321721	654.9168	8.819538E-07
23	672.4373	7.584468E-04	3.31864	655.1386	8.819037E-07
24	672.4821	7.583559E-04	3.319173	655.0754	8.817429E-07
25	672.4855	7.582563E-04	3.318984	655.0853	8.816878E-07

After completing the last iteration, the robust weights are obtained to be used in the weighted regression analysis. They are used as a filter to delete the observations of the lowest weight as in Table 6.

Table 6. Robust residuals and weights

Row	Actual Y	Predicted Value	Residual	Robust Weight
1	1471	1390.35	80.65009	0.894107
2	1620	1567.127	52.8731	0.953583
3*	1972	1637.748	334.2516	0.038106
4*	1930	1395.733	534.2667	0.000000
5*	1929	1577.772	351.2281	0.015958
6*	1957	1500.945	456.0549	0.000000
7	1936	1879.047	56.95344	0.946262
8	1453	1523.762	-70.76157	0.917812
9	1472	1530.86	-58.86042	0.942667
10	1475	1472.445	2.555351	1.000000
11	1267	1229.524	37.47562	0.976552
12	1223	1278.681	-55.68124	0.948599
13	1182	1186.288	-4.28761	0.999800
14	1186	1213.537	-27.53747	0.987344
15	1212	1245.209	-33.20941	0.981579
16	1222	1263.686	-41.68581	0.971016
17	1232	1206.988	25.01163	0.989570
18	1214	1322.132	-108.1317	0.815104
19	1247	1173.818	73.18153	0.912260
20	1275	1165.148	109.8525	0.809577
21	1258	1204.716	53.28374	0.952870
22	1209	1353.24	-144.2397	0.687697

3. Conclusions and Recommendations

1. Although the probabilistic value extracted by the least squares method for the variables of the GDP and trade exchange is not significant, but we did not exclude them from the model due to their importance in the Iraqi dinar exchange rate.
2. The robust regression model reduces the effect of outliers on the regression coefficients estimates by performing an iterative system of equations.
3. When extracting robust weights, their values range between zero and one, where we notice that when the weight approaches zero, observations are deleted from the analysis, and that these weights will be used in the weighted least squares method in order to assess the statistical significance of variables in the model.

4. We recommend to taking other factors as independent variables to know their effect on the Iraqi dinar exchange rate, and therefore their impact on the Iraqi economy.
5. Using other robust methods to detect and treat outliers.
6. Using robust methods to building economic models.

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