

# Asymptotic Least Squares Estimation of Tobit Regression Model. An Application in Remittances of Iraqi Immigrants in Romania

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**Abstract** This paper proposes an alternative to maximum likelihood estimation of the Tobit regression model based on the method of moments which is suitable for repeated observers at first moments equal to zero as well as for cases containing censored observers at threshold point. This approach, called asymptotic least-squares (ALS) delivers strongly consistent and asymptotically normal estimates. It is shown that ALS can be used to obtain asymptotically efficient estimates for a large range of econometric problems. ALS is applied to the amount remitted by Iraqi immigrants in Romania to their home country demonstrating the potential of the method in the estimation of censored regression models. The study applies the Tobit regression model in order to reveal the most important factors affecting remittances sent and the best method to estimate data.

**Keywords** Tobit regression, Asymptotic Least Squares, Remittances, International migration

## 1. Introduction

According to James Tobin's research, the domestic income and spendings are in a statistical relationship. This relationship is particular, and it generally follows a linear model but at a certain value, data clustering occurs [21]. This value is the limiting value for the expenditures, which represent the dependent variable. The limiting value is censoring limit on the data where it clusters. This clustered data depicts the dependent variable information in a region, and it does not produce a linear operation with a representation of a unique independent variable. As shown in the work of Wang [22], the application of the Tobit regression model is mostly suitable in dose-response analysis with censored and continuous result variable [4]. A biased model is produced in case of overlooking the censored data or in case the data is forced into a linear model.

The use [19] Tobit regression model in the field of financial analysis (Iraqi Banks Loans), by providing empirical evidence about factors affecting in Iraqi Bank Loans, Formal studies have been scarce and mostly confined to OLS analysis, in spite of censored data with limited dependent variable at zero, shows that the bias can result when estimating bank loans using OLS if bank loans

are censored. The Tobit model is the most suitable statistical model to solve the case in which a dependent variable is limited.

International migration has become a widespread phenomenon and associated with this phenomenon are the financial practices of the migrants, which have impacted both the country of origin as well as the receiving country. The receiving countries are mainly concerned with the immigrants' integration (social and economic), debated by economists and politicians. On the other hand, the countries of origin are also impacted by the financial behaviour of the migrants, as the remittances sent by the immigrants have become a source of external income for many of these countries. The impact of these funds can be estimated at country, regional or even household level by the amount of the international remittances, which have become constant financing sources for the families and friends of the immigrant workers.

The first solid theoretical basis for explaining determinants of remittances was developed by [17]. They define two broad motives: altruism and self-interest. Pure altruism and pure self-interest are inadequate to explain variation in remittances, as often the migrant and the family left behind both benefit from migration through implicit contractual arrangements.

The development literature has largely focused on the size and potential impact of migrants' remittances [1, 10]. In addition, a sizeable theoretical and empirical literature has revealed that a variety of motives may induce migrants to send remittances to their countries of origin [5-8, 15, 2].

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The study of Hagen-Zanker and Siegel [13] analysed the duration of the residence of migrants and how they affect the remittances to their country of origin and the relationship between migration and remittances because of their significant impact in the economies of countries that have a large proportion of migrants sending money to their original country.

According to the World Bank [23], remittances in 2005 have exceeded US\$ 233 billion worldwide. In comparison with \$229 billion in 2002 and more than double the level recorded in 2001. Moreover, recorded remittances to developing countries have doubled between 2000 and 2005, indicating a substantial increase in payments of migrants to their families abroad. In 2007, remittances recorded by migrants from developing countries totalled \$265 billion. During 2007, the top three recipients of remittances were India, China and Mexico, accounting for a total of more than US\$77 billion in migrant transfers (worth almost a third of the remittances received by developing countries as a whole) [24]. In 2013, recorded remittance flows across international borders into developing economies exceeded US \$410 Billion [25].

The paper contributes to the existing literature in several respects. Firstly, empirical evidence on the determinants of Iraqi migrants' remittances is generated by examining data using Asymptotic Least Squares estimation of Tobit regression model alternative to maximum likelihood estimation of the Tobit regression model. While the major part of the existing literature on remittances mainly concentrates on migrants' transfers to developing countries, the analysis focuses on remittances of Iraqi migrants' in Romania to home country. Secondly, in addition to migrants' payments to family members in their countries of origin which are typically addressed by the literature on remittances, existing studies have often adopted more restrictive models for censored dependent variables to assess the determinants of Iraqi migrants' remittances.

The paper is structured as follows: Section 2 Asymptotic Least Squares estimation of Tobit regression model; Section 3 The studied sample and data analysis; Section 4 Results and comments; Section 5 Conclusions.

## 2. Asymptotic Least Squares Estimation of Tobit Regression Model

Since the use of econometric models with truncated or censored response variables has started to increase, it is important that the information they provide is fully and correctly used [14]. One of these models that has an increasing use is the Tobit regression analysis, a model devised by Tobin, in which it is assumed that the dependent variable has a number of its values clustered at a limited value, usually zero.

Determine the threshold point for the social phenomenon of divorce, through a two-stage estimation model (Heckman) with Tobit regression, In order to obtain consistent estimates;

the censoring threshold in divorce is zero. The difficulty is the determination of the threshold point in economic and social research and other phenomena where the limited dependent variable [18].

In other words, the Tobit regression models are censored regression models where the threshold point that is considered is equal to zero. The Tobit technique uses all the observations, both those at the threshold and those above it, to estimate a regression line, and it is to be preferred, in general, over alternative techniques that estimate a line only with the observations above the threshold.

Following the main methodological trends in recent literature, our empirical analysis Tobit regression model was applied in order to reveal the most important factors affecting remittances sent by Iraqi immigrants in Romania to their home country.

In this model, the limited dependent variable because a Iraqi migrant sends money to the home country, the dependent variable is considered as quantity, if the immigrant does not send money, the dependent variable takes the value "zero". The amount sent differs from one individual to another.

The present work builds on a survey of 153 Iraqi immigrants in Romanian, resulting from our questionnaire survey conducted during June 22nd and October 3th 2017. In what follows, we understand the Tobit regression model the censored regression model through the functions of the model under the normality assumption. R Software also provides pseudo R squared based as in this paper when applying the Tobit model estimation.

The Tobit regression model takes the following form:

$$y_i = \max(y_i^t, 0) \quad (1)$$

$$y_i^t = \beta^t x_i + e_i \quad e_i \sim N(0, \sigma^2) \quad (2)$$

$$y_i = \begin{cases} \beta_i^t x_i + e_i, & \text{if } \beta^t x_i + e_i > \varepsilon \\ 0 & \text{if } \beta^t x_i + e_i \leq \varepsilon \end{cases} \quad (3)$$

Where:

$y_i^t$ : Represents the latent variable and it is generated through traditional linear regression model according to the formula ( $I_i = \beta^t x_i$ ); it is non-observer when  $y_i^t < 0$ . It is sum of cash remittances sent by Iraqi immigrants in Romania, measured in USD.

$e_i$ : Is the random error; the set represents all the variables and is non-observed influencing in the dependent variable  $y^t$  distributed  $y^t \sim N(0, \sigma^2)$  which i.i.d.

$y_i, x_i$ : Are the independent variable and the dependent variable each known;  $i = 1, 2, \dots, n$ .

$\varepsilon$ : Represents the threshold point, the Tobit regression is performed on  $y_i^t$ , by  $\varepsilon$  to inference the estimate. In our search the threshold point is equal to zero and represents immigrants who do not send money.

To apply the Asymptotic Least Squares estimation of Tobit regression model, the following equation is used we use the method of moments that provides a useful approach in the case of censored observations [12]. The "zero" and first order moments of  $y_i$  are:

$$\Pr(y_i > 0) = \Phi(x_i\beta/\sigma) = \Phi(x_i\tau) \quad (4)$$

$$\begin{aligned} E(y_i) &= x_i\beta\Phi(x_i\beta/\sigma) + \sigma\phi(x_i\beta/\sigma) \\ &= \frac{x_i\beta/\sigma}{\sigma} \Phi(x_i\beta/\sigma) + \frac{1}{\sigma} \phi(x_i\beta/\sigma) \end{aligned} \quad (5)$$

These moments can be asymptotic by the appropriate applied iterations by the following equations:

$$\alpha_i = \frac{1}{n_i} \sum_{i=1}^{n_i} y_i$$

$$\bar{y}_i = \frac{1}{n_i} \sum_{i=1}^{n_i} \bar{y}_i$$

$$\tau = \beta/\sigma$$

Thus, when  $n$  is sufficiently large, we have:

$$\begin{aligned} \alpha_i &= \Phi(x_i\tau) \\ \bar{y}_i &= x_i \frac{\tau}{k} \Phi(x_i\tau) + \frac{1}{h} \phi(x_i\tau) \end{aligned} \quad (6)$$

Finally, we obtain a model which is linear through the following equations, assuming that

$$\begin{aligned} h &= \frac{1}{\sigma} \\ \Phi^{-1}(\alpha_i) &= x_i\tau + v_i^1 \\ \phi[\Phi^{-1}(t_i)] &= -\alpha_i x_i\tau + h\bar{y}_i + v_i^2 \end{aligned} \quad (7)$$

The covariance asymptotic matrix is obtained by  $(v_i^1, v_i^2)$ ,  $i = 1, 2, 3, \dots, I$ , through derivation in the matrix matching an easy-derivative  $(\alpha_i, \bar{y})$  that can be applied in the equation (7). Weighted least squares are used to obtain consistent estimates of the model [16]. The weighted least squares method is widely used in parameter estimates for consistent estimates, as well as for model estimations.

The asymptotic covariance matrix of the error term is expressed by the asymptotic covariance matrix that contains the disturbance terms  $(v_i^1, v_i^2)$ , where  $i = 1, 2, 3, \dots, I$ . The asymptotic correlation obtained is:

$$\text{var}_{\text{asy}} \left[ \sqrt{n} \begin{pmatrix} v_i^1 \\ v_i^2 \end{pmatrix} \right] = \frac{1}{\vartheta_i} \begin{pmatrix} \frac{\Phi_i(1-\Phi_i)}{\Phi_i^2} & -\frac{(1-\Phi_i)\omega_i}{\Phi_i} \\ -\frac{(1-\Phi_i)\omega_i}{\Phi_i} & \Phi_i + x_i\tau\omega_i - \omega_i^2 \end{pmatrix} \quad (8)$$

Where  $\vartheta_i = \frac{n_i}{n}$ ,  $i = 1, 2, 3, \dots, n$ , represent the proportion of independent experiments conducted under environmental conditions  $x_i$ . The observations on the endogenous variables are:

$$\omega_i = x_i\beta\Phi(x_i\beta) + \phi(x_i\beta) \quad (9)$$

We will express the right side of the equation (8) by the symbol (A) in order to appreciate the parameters of the model and to obtain consistent estimate as close as possible to zero in the metric of a given weighting matrix. This approach, called asymptotic least squares (ALS) delivers strongly consistent and asymptotically normal estimates [9]. Since the results after compensation is a matrix, the asymptotic least squares estimators of parameters  $(\beta, \sigma)$  are given by:

$$\begin{pmatrix} \beta \\ \sigma \end{pmatrix} = \left( \sum_{i=1}^I D_i^t \hat{A}_i^{-1} D_i \right)^{-1} \sum_{i=1}^I D_i^t \hat{A}_i^{-1} P_i \quad (10)$$

As:

$$D_i = \begin{pmatrix} X_i & 0 \\ -\alpha_i X_i & \bar{y} \end{pmatrix} \quad \& \quad P_i = \begin{pmatrix} \Phi^{-1}(\alpha_i) \\ \phi[\Phi^{-1}(\alpha_i)] \end{pmatrix}$$

Where  $D$  is a column vector with elements  $\frac{\phi(X_i\beta)}{\Phi(X_i\beta)}$ .

### 3. The Studied Sample and Data Analysis

Gathering accurate data on remittances is a difficult task both at the micro and macro level, as Iraqi official statistics supply not enough data is available. In order to obtain the necessary data on Iraqi immigrants in Romania. We conducted our survey through applying a questionnaire on 153 individuals, Iraqi immigrants in Romania, 61.4% of surveyed individuals being males and 38.6% females. The data were collected during the period from: between June 22nd and October 3th 2017. This questionnaire contains a set of questions. The survey was conducted on Iraqi immigrants in Romania based on 16 questions split into 3 sections. The questionnaire covered information about the migrants and their households, such as individual characteristics, degree of migrants' integration in Romania, and links with the home country. In this way, the selection of the variables was inspired by the existing literature [20, 3]. We consider a similar distinction between the factors that describe the individual motivation to remit and therefore the variables taken into account were structured into the next three categories:

(I) Individual factors: income, age, education, gender and tax payer;

(II) Factors that evaluate the degree of migrants' integration in Romania: the length of stay in Romania, owning a business or having investments in Romania;

(III) Factors that evaluate the presence and intensity of the migrants' links with the home country: number of visits, future plans with respect to remaining in Romania or not, parents, spouse and number of children living in the country of origin and owning a house in the country of birth. The explanatory variables (Table 1) representing potential factors that influence the remittance.

To capture the influence of migrants' income, we employ the net monthly income as natural logarithms. The age of the remitter plays an important role in remitting and in the sample, age ranges between 19 and 67, with an average age of about 42. We expect that as age is increasing, the remittances will decrease, since the connections with the home country become more diluted over time. Considering gender, we use the dummy variable Gender, coded 1 if male and 0 if female. There is an almost distribution between men and women in the respondent sample, her men being slightly more numerous than women.

**Table 1.** Description of the variable

Category	Variable definitions	Symbol
Individual characteristics	Age of the migrant (years)	AGE
	Gender of the migrant: 1 - Male 0 - Female	GEN
	Education – the highest level of education completed: 1-Less than Tertiary education 0-Tertiary education	EDU
	Net monthly income (USD)	INC
	Tax payer	TAXES
Degree of migrants' integration in Romania	Time spent in Romania (years)	TIME
	Business investments in Romania: 1 - Migrant owns a business or investments 0 - Otherwise	AFA
	Occupational status: 1-The immigrant has a job 0- Other	OCC
Links with the home country	Owner of the house: 1-Migrant owns a house in country of origin 0-otherwise	HOUSE
	Number of children living in the country of origin	CHILD
	Spouse in the home country: 1 - Wife / husband is living in the country of origin 0 - Otherwise	SPOUSE
	Parents in the country of origin: 1 - At least one parent is living in the country of origin 0 - Otherwise	PAR
	Remittance recipient: 1- Wife / husband, children and parents 0- Otherwise	SEND
	The aim of sending money: 1-To meet the essential needs of the family 0-Others	AIM
	Future plans: 1 - Migrant plans to return to the country of origin in the next 5 years 0 - Otherwise	PLANS
	Number of visits to the home country	VISIT

Countries need to attract the higher educated migrants in order to increase the innovative capacity and competitiveness. In our approach, the value of the human capital of the migrant is reflected by the last level of education completed, for importance of diaspora as academic and intellectual communities living abroad is addressed. There is a dynamic debate in recent literature concerning the role of education in the remitting process. We do not expect a strong influence of education on remittances, since labour migrants from the observed countries are employed mostly in low-skilled jobs. We expect that the tax payment will have an impact on the migrants remit, tax rates vary from one country to another where they are paid by the migrant.

The length of stay in Romania is expressed in years, which is computed based on the year in which the migrant arrived in Romania. In our sample the average length of stay in Romania was about 12 years. We hypothesize that the more time a person spends in the host country, the lower the probability of remitting. At the same time, owning a business in Romania is an expression of the economic migrants' interests in Romania. It is less likely for migrants to remit if they have an investment in Romania, but we assume that the amount remitted could be positively affected by a migrant's higher income due to his / her business or investments.

Home links are stronger if individuals own real estate assets (land or houses) in the countries of origin. Considering that a dummy equals 1 if the migrant owns a house in their

country of birth and 0 otherwise, we expect a positive influence of this variable on the amount of remittance. With respect to the links with the home country, it is important to notice that 57 % of the migrants in the sample own a house in their country of birth. We also control for the future plans of the migrants, using a dummy for the decision of moving back to the home country in the next 5 years. We assume that a person who intends to move back will have a higher probability to remit compared to a person who is willing to remain in Romania.

A strong argument for remitting is the size of the family left in the country of origin. We expect an increase in the propensity to remit with the number of children living at home and if the wife / husband is there. We also consider the presence of parents in the home country, counted by a dummy with 1 if the individual has at least one parent at home.

One important basis for remittances is personal contact with the home country and the number of visits to the country of origin is considered to be an important indicator for such personal links. The impact of this factor on the volume of remittances and on the decision to remit is expected to be positive. More than that, an increase in the number of visits might contribute to a decrease in the transfer costs of the money.

The Table 2 below shows the statistical description for the dependent variable and independent variables while the following is an analytical presentation of these measures mean with the standard deviation for each variable of the model variables.

**Table 2.** Descriptive statistics

Variable	Observations	Mean	Std.dev.
AGE	153	42.2353	11.31183
GEN	153	0.5621	0.49776
EDU	153	0.4837	0.50137
INC	153	612.1699	743.95169
TAXES	153	0.7255	0.44773
TIME	153	12.8693	6.88887
AFA	153	0.6928	0.46284
OCC	153	0.6471	0.47945
HOUSE	153	0.5752	0.49594
CHILD	153	0.5033	0.93277
SPOUSE	153	0.1111	0.31530
PAR	153	0.8170	0.38794
SEND	153	0.5425	0.49983
AIM	153	0.5817	0.49490
PLANS	153	0.6536	0.47739
VISIT	153	4.0980	3.12621
Remit	153	178.6209	142.12393

The analysis table of variance below shows that the model applied in estimating the variables of the phenomenon under study has the value of the Fisher statistic  $F=86.3$  which confirms that the model overall is statistically significant.

**Table 3.** Analysis of variance in the Tobit regression model

	Source df	S.S	M.S	F	Sig.
Regression	18	781.360	43.409	86.3	.000
Residual	134	67.402	0.503		
Total	152	848.762	43.912	86.3	

In table (3) we find the value ( $F_c$ ) greater than ( $F_T$ ) at confidence level (0.01, 0.05).

## 4. Results and Comments

In this section, we present the results of running the regression model specified in the equation (10) using the questionnaire data on Iraqi emigrants in Romania. This method allows for the estimation of model Asymptotic Least Squares estimation coefficient of Tobit regression model. Using R package, the objective of our study is to determine the variables influencing remittances and to diagnose the factors clearly contributing to the increase of remit, through three categories of factors described above affect the propensity to remit. When analyzing the probability to remit, the results of the Tobit regression model are presented in Table (4).

**Table 4.** Asymptotic Least Squares estimation for the coefficients of Tobit regression model

Variables	Coefficient	Std. Error	t-value	p-value
AGE	1.7653	0.3884	4.5451	0.0002
GEN	1.2068	0.4333	2.7851	0.0312
EDU	31.9759	51.4721	0.6212	0.8617
INC	5.261	1.302	4.0407	0.0054
TAXES	16.6712	3.3047	5.0447	0.0000
TIME	-0.9662	0.2662	-3.6296	0.0042
AFA	16.2327	30.7264	0.5283	0.4057
OCC	12.7816	9.3357	1.3691	0.2206
HOUSE	11.5432	2.7851	4.1446	0.0391
CHILD	10.7514	3.0922	3.4769	0.0412
SPOUSE	5.3672	14.6013	0.3676	0.7877
PAR	0.5471	0.3324	1.6574	0.3905
SEND	6.6193	10.9756	0.6031	0.8236
AIM	9.5347	5.1863	1.8384	0.4791
PLANS	7.2143	2.0583	3.5050	0.0079
VISIT	22.2306	58.2716	0.3815	0.4079
Constant	121.724			
Pseudo R <sup>2</sup>	0.863			
N	153			

The main focus of the analysis is to explain the relationship between the sum of cash remittances sent by Iraqi immigrants in Romania, and a set of independent variables, in order to identify the main individual and family characteristics of the migrant that affect the remittances, including selecting of important independent variables that

affect the sum of sent remittances. Illustrated through the value of the pseudo-R squared (0.863), the best method to estimate the model is ALS Tobit. The analysis also showed that there is a statistically significant relationship between the dependent variable and the independent variables. The results of the analysis presented in table below show that there are eight statistically significant factors in the model.

As it was expected, the main factors that directly affect the remittance are the income and the intention to return to homeland (future plans considering returning home). The income of the emigrants is very important in explaining the size of remittances. This confirms what both basic theories on remittances (altruism and exchange) predict: the more the emigrants earn, the higher the amount of money that they send back home. At the same time, demographic factors (age and gender) significantly affect the remittance. Additionally, a very strong positive factor is the pay taxes in the immigration country, if the immigrant is not taxed, which probably allow for more remit.

Time spent in Romania is a significant factor that determines, in a negative way, the propensity to remit. In time, as the period spent by emigrants in Romania increases, the probability to remit slightly decreases. One explanation might be that the degree of integration in the society of the host country, this is in line with other studies that prove that inclination to send remittances may decline with integration in the receiving country.

Having investments in Romania does not significantly affect the remit, but its influence is positive, which is against our expectations.

Family connections with the home country are the most influential factors that increase the remittance propensity. Having children in the country of origin is the factor with the greatest impact on remitting, while the effect of the presence of parents or spouse in the home country is not statistically significant. Therefore, the Iraqi migrants in Romania are more prone to remit if they have to support their children left in the country of origin, ensuring their daily living, increasing their quality of life and providing better access to education. Owning a house in the home country also significantly increases the probability to remit, since many migrants are house owners and they aim to improve the living conditions for the families left at home. These results are in line with other findings that explain the determinants of remittances in the developing receiving countries [11].

Against our expectations, the other variables describing the connections with the country of origin, respectively the number of personal visits to the home country had no significant impact on the probability to remittances.

## 5. Conclusions

In this paper, remittances by Iraqi immigrants in Romania were estimated to their country of origin. The Tobit regression model was used with ALS method ALS to estimate the variables of the studied phenomenon because

the dependent variable data is censored. The Tobit regression model has been applied instead of OLS so that we do not produce biased estimate were zero has been determined as a threshold point for the dependent variable and the censored point is the boundary of the data. It has been identified censored threshold point as zero: is if the immigrant does not send money, the dependent variable takes the value "zero". Through the results of the analysis we were able to determine the most important variables affecting the migrant remittances. The results of the analysis show a high pseudo-R squared value of the interpretation and analysis of the results of the data that affect the identification of the most important variables in remittances. This means the Tobit model is an appropriate model to be applied on the phenomenon of remittances because not all migrants send money to their home country. In addition to table 3, we find that the value of the Fisher statistic is  $F=86.3$  which also reinforces the fact that the analysis model is the best model in the analysis of remittances.

The present research helps to recognize that migration and remittances play an important role in developing countries, helping to reduce poverty in some families as well as in the local economy. Considering that Iraq is a developing country, with a large share of the population affected by severe poverty in a was context, remittances are an important source for poverty alleviation and for providing the necessary resources for satisfying the basic needs.

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