CHAPTER - IV

METHODOLOGY

4.1. INTRODUCTION

Classical gravity models generally are used cross-section data to estimate trade effects and trade relationships for a particular time period, for example on year. In reality show ever, cross-section observed over several time periods (panel data methodology) result in more useful information than cross-section data alone. The advantages of this method are first, panels can capture the relevant relationships among variables over time; second, panels can monitor unobservable trading-partner-pairs individual effects if individual effects are correlated with the repressors. OLS estimates omitting individual effects will be biased therefore; we have used panel data methodology for our empirical gravity model of trade. The generalized gravity model of trade states that the volume of trade/export/imports between pairs of countries, \( x_{ij} \) is a function of their incomes (GNPs or GDPs), their populations, their distance (Proxy of transportation costs) and a set of dummy variable either facilitating or restricting trade between pairs of countries that is

\[
x_{ij} = \beta_1 y_i \beta_2 y_j \beta_3 P_{ci} \beta_4 P_{cj} \beta_5 D_{ij} \beta_6 A_{ij} \beta_6 U_{ij} \quad (4.1)
\]

Where \( Y_i (Y_j) \) indicates the GDP or GNP of the country \( i(j) \), \( P_{ci} (P_{cj}) \) are per-capita the country \( i(j) \), \( D_{ij} \) measures the distance between the two countries’ capital (or economic centre). \( A_{ij} \) represents dummy variables, \( U_{ij} \) is the error term and \( \beta_s \) are parameters of the model. Using per capita income instead of population, an alternative formulation or equation (1) can be written as

\[
x_{ij} = B_0 Y_i B_1 Y_j B_2 P_{ci} B_3 P_{cj} B_4 D_{ij} B_5 A_{ij} B_6 U_{ij} \quad (4.2)
\]

Where \( Y_i (Y_j) \) are per capita income of country \( i(j) \), As the gravity model is originally formulated in multiplicative form, we can laniaries the
model by taking the natural logarithm of all variables. So for estimation purpose, model (4.2) in log-linear form in year is expressed as where L denoted variables in natural logs. Aij is a sum of preferential trade dummy variables. Dummy variables takes the value on when a certain condition is satisfied, zero otherwise

4.1.1. Basic Gravity model

In this section, the gravity model in its most basic form explains bilateral trade \((T_{ij})\) as being proportional to the product of \(GDP_i\) and \(GDP_j\) and inversely related to the distance between them.

\[
\log(T_{ij}) = \beta_0 + \beta_1 Y_{it} + \beta_2 Y_{jt} + \beta_3 P_{cit} + \beta_4 P_{cjt} + \beta_5 D_{ijt} + U_{ijt} \tag{4.3}
\]

Where \(T_{ij}\) is the value of total of trade

- \(Y_i\) and \(Y_j\) are value of incomes for countries i and j
- \(P_{cit}\) and \(P_{cjt}\) are per-capita incomes for countries i and j
- \(D_{ij}\) is the distance between countries i and j

To account for other factors that may influence trade levels, variables have been added to the basic model. The augmented gravity equation is thus expressed as follows:

4.1.2. Augmented Gravity Model:

\[
\log(T_{ij}) = \beta_0 + \beta_1 Y_{it} + \beta_2 Y_{jt} + \beta_3 P_{cit} + \beta_4 P_{cjt} + \beta_5 D_{ijt} + \beta_6 (TR/Y)_{it} + \beta_6 (TR/Y)_{jt} + \beta_6 RC_{ijt} + \beta_7 TCA_{ijt} + U_{ijt} \tag{4.4}
\]

Here: \(TR/Y = \) Trade-GDP ratio \(RC = \) Race Common (dummy variable)

Total exports contribute a portion of \(Y_{ij}\) if not exports are negative, under the very rate situation where the country has a balanced trade (a very special case of zero not export), the \(Y_{ij}\) is independent form the net exports. Wherever not exports are not zero, the dependent variable of total exports in
the gravity model is not independent from the explanatory variable of total exports in the gravity model is not independent from the explanatory variable of Y. As a result the Y variable is contemporaneously correlated with the error term in the regression through the dependent variable, thus the ordinary least squares (OLS) estimators are inconsistent and hence the estimates are biased. For the same reasoning, foreign country’s Y is also correlated with home country’s total exporters as they constitute a proportion of the foreign country’s total imports, but the endogenously is to a lesser extent.

A number of studies acknowledged that the dependent variable in the gravity model has endogenous problem with the GDP variable and attempted to replace the GDP variables by instrument variables. For example, Wei (1996) used a quadratic function of population as an instrument for GDP.

However, the impact of the endogenous problem on the OLS estimates might be less significant when the gravity model is applied on commodity specific trade rather than total trade and if the commodity in study does not make up a significant share of the country’s total trade

4.1.3. The Application of the Gravity Model in International Trade Flow Analysis

The application of the gravity model in international trade was pioneered independently by the Dutch economist Tinbergen (1962) and Finnish economists Pulliainen (1963) and Poyhonen (1963). Their studies were presented as preliminary results to be tested further in future studies. The simplest form of the gravity trade model was used by Tinbergen (1962) as:

\[ E_{ij} = \alpha_0 Y_i^{\alpha_0} Y_j^{\alpha_1} D_{ij}^{\alpha_1} \]  

(4.5)

Where: $E_{ij}$ = Exports from country i to country j  
$Y_i$ = GNP of country i  
$Y_j$ = GNP of country j
\[ D_{ij} = \text{Distance between country } i \text{ and country } j \]
\[ \alpha = \text{Scaling factors} \]

Tinbergen made an analogy of a country’s exports \( E_{ij} \) with Newtonian’s Universal Gravitation force \( F \) in equation 4.5 the masses of \( M_1 \) and \( M_2 \) were replaced by \( Y_j \) and \( Y_j \), which are the income levels or the sizes of economies of the trading partner countries. Tinbergen believed that the size of exporting country’s economy positively influences its ability to supply to the world market; and the importer’s income level is positively related to the market size for imported goods. He reasoned that transportation costs and other natural trade impediments create a price wedge between the exporting country and the importing country. This price wedge raised the relative price of traded goods to non-traded goods, and hence inversely (negatively) affected the volume of trade. Due to the complexity of those natural trade impediments, it is difficult to quantify those individually. Tinbergen used the proxy of distance variable \( D_{ij} \) to capture the essence of those natural trade impediments.

To capture the artificial trade enhancing and trade discrimination effects, Tinbergen (1962) modified the basic gravity model by introducing three dummy variables: the common border affect dummy, the Commonwealth preferential dummy and the Benelux preferential dummy. The gravity model in Equation (4.6) was then expanded as:

\[ E_{ij} = \alpha_0 Y_i^{\alpha_1} Y_j^{\alpha_2} D_{ij}^{\alpha_3} N^{\alpha_4} P_c^{\alpha_5} P_b^{\alpha_6} \]  

(4.6)

Where \( N \) is common border dummy variable, \( P_c \) is Commonwealth preference dummy variable and \( P_b \) is Benelux preference dummy variable. The dummy variables were assigned positive values if the arguments of the dummies are satisfied and zero otherwise. Equation 4.7 was then estimated in the double log form of:

\[ \log E_{ij} = \alpha_1 \log Y_i + \alpha_2 \log Y_j + \alpha_3 \log D_{ij} + \alpha_4 \log N \]
\[ + \alpha_5 \log P_c + \alpha_6 \log P_b + \alpha_0 \]  

(4.7)
Where $\alpha'o = \log \alpha o$. However, the logarithm of dummy variables, which consist of zeros and ones, would result in the regression being inoperative. Linnermann (1966) rectified this problem by using the values of ones and twos for the dummy variables.

The model with trading countries’ income variables and the distance variable is viewed as the basic gravity model in the analysis of international trade flows. Any trade obeying this rule is regarded as the expected trade or as the standard trade level. The purpose of Tinbergen (1962) was to develop a model to determine the standard pattern of international trade in the absence of discriminatory trade impediments. An expected or standard-trade between countries can be revealed by the “average” trade estimated from the model, and the trade impediments are of a stochastic nature. By comparing the actual exports with the expected exports, a positive deviation between them means that actual export are greater than the expected exports. Any countries whose actual exports are greater than their expected exports are receiving preferential treatment by the importing countries. In contrast, a negative deviation shows that actual exports are less than the expected exports. Any negative deviations indicate that exports of the given countries are discriminated against by the importing countries. For policy makers who are looking at trade expansion the negative deviations are of greater interest as they indicate the existence of untapped trade potential in the importing countries, and attention could be focused on any existing trade barriers or resistances to trade, for trade negotiation purposes.

4.2. Specification of Gravity Equation for the Study

Using our data set, study estimate three models of Iran trade: a) the gravity model of exports by panel data, b) the imports demand model by panel data method, c) export model by time series data Analysis
Study have followed Frankel (1993), Sharma and Chua (2000) and Hassan (2001, 2002). Since the dependent variable in the gravity model is bilateral trade (Some of exports and imports) between the pairs of countries, the product of GNP/GDP and the product of per capita GNP/GDP have been used as independent variables. The study added some additional independent variable to-the model. Thus the gravity model of trade in this study is:

4.2.1. Export Model

\[ L_{xjt} = \beta_0 + \beta_1 L_{Y_{it}} + \beta_2 L_{Y_{jt}} + \beta_3 P_{jt} + \beta_4 (TR/Y)_{jt} + \beta_5 D_{ijt} + \beta_6 EXR_{ijt} + \beta_7 IN_{jt} + \beta_8 RC_{ijt} + \beta_9 TCA_{ijt} + U_{ijt} \]  

(4.8)

Where:

- \( X_{it} = \) export
- \( Y_{it} = \) GDP
- \( P_{jt} = \) population of partner country
- \( D_{ij} = \) Distance,
- \( EXR_{ij} = \) exchange rate
- \( IN_i = \) Inflation of Iran
- \( (TR/Y)_{jt} = \) Trade-GDP ratio of partner country
- \( RC = \) Common Race (dummy variable)
- \( TCA = \) Trade and Co-operation Agreement

4.2.2. The explanatory variables in the gravity made

The GDP Variables

The empirical relationship between GDP variable and the total exports is not clear. Most studies found that the GDP variables are positive and significant. These studies include Tinbergen (1962), Byhoner (1963), Linnemann (1966), Aitken (1973), Aitken and Obuteleuliz (1976), Gerari and Prewo (1977; 1982), Frankel and Wei (1993), Frankel et al (1995), Bergstrand (1985; 1989, 1990). However, Glosser (1968, cited inagulated and Machphee, 1994) found that exporters GDP has a negative and significant impact on total trade.
While home country’s GDP partially determines total exports that export also contribute a portion of home country’s GDP. GDP is measured as the sum of aggregate consumption (c), aggregate investment (I), Government expenditure (a) and net exports (Nx), which are total exports (x) minus total imports (Im).

Population:

The impact of the population variable is not clear. Linnomann (1966), Aitken (1976), Blomgrist (1994), Aqueledo and Macphee (1994), Christin 1996) and Matgas et al (1997) found the populations of the trading countries have a negative and statistically significant impact on the trade flows. However Brada and Mendez (1983) found population size to have a positive and significant impact on trade flows in the study of Asian countries. Frankel, Romer and Cyrus (1996) found that the population of exporting countries has negative and significant impact on trade flows, while the populations of importing countries have positive and significant impact.

Distance

It is the distance between country I and j measured “as the crow flies” technically called the great-circle distance measured between the two latitude – longitude combinations. A major proportion of trade today goes by air (and not by sea or land) and therefore the air routes provide the most convenient justification is of course given by the fact that this measure seems to be a reasonable measure of averaging across different modes of transportation and works well in practice.

Race language: is equal to one when two countries share a common race; otherwise it is zero. Common race is expected to increase bilateral trade when have countries common cultural.
**Race language:** is equal to one when two countries share a common currency; otherwise it is zero. Common currency is expected to increase bilateral trade between countries.

**Trade Agreement and co-operation (TCA).** Is equal to one when two countries share a common TCA; otherwise it is zero. Trade and co-operation Agreement is expected to increase bilateral trade between countries.

### 4.3. Methods to Estimate Panel Data.

#### 4.3.1. Pooled Ordinary Least Squares (POLS)

The class of models that can be estimated using a pooled ordinary least square estimator can be written as follows:

\[
Y_{ij} = x_{it} \beta + z_i \alpha + e_{it} \quad i=1, 2, \ldots, N, \quad t=1, 2, \ldots, T \tag{4.10}
\]

Where \(Y_{it}\) is the dependent variable, \(X_{it}\) are \(k\) regressors not including a constant term. The heterogeneity or individual effect is \(Z_{it}\) where \(Z_i\) contains a constant term and a set of individual or group specific variables, which may be observed or unobserved, all of which are taken to be constant over time \(t\).

Ordinary Least Squares (OLS) is often used to estimate the gravity model but does not permit to control the individual heterogeneity and hence may yield biased results due to a correlation between some explanatory variables and some unobservable characteristics. If the Breusch-Pagan test rejects the null hypothesis in favor of random effects, the OLS method is not adequate.

#### 4.3.2. within Estimator and Random Estimator (FEM and REM)

The fixed effect model can be written as:

\[
y_{ij} = \sum_{k=1}^{K} \beta_k x_{ik} + \alpha_i + u_{its}, \quad t=1, 2, \ldots, T, \quad k=1, 2, K \text{ regresses, } i=1, 2, n \tag{4.11}
\]
Individuals (2), where \( \alpha_i \) denotes individual effects fixed over time and \( u_{it} \) is the disturbance terms. If we subtract from (2) average of this equation over time for each \( t \), we obtain
\[
y_{it} - \bar{y}_i = \sum_{k=1}^{k} \beta_k (x_{itk} - \bar{x}_{it}) + (u_{it} - \bar{u}_i) \tag{4.12}
\]
Where \( \bar{y} = T^{-1} \sum_{t=1}^{T} y_{it}, \bar{x}_i = T^{-1} \sum_{t=1}^{T} x_{it} \) and \( \bar{u}_i = T^{-1} \sum_{t=1}^{T} u_{it} \) \tag{4.13}

\( y_{it} - \bar{y}_{it}, x_{it} - \bar{x}_{it} \) and \( u_{it} - \bar{u}_i \) are the time-demeaned data on \( y, x \) and \( u \).

In the fixed effect transformation, it can remark the disappearance of unobserved effect \( \alpha_i \), which yields unbiased and consistent results. This pooled OLS estimator that is based on the time-demeaned variables is called the fixed effects estimator or the within estimator. The random model has the same form.
\[
y_{it} = \beta_0 + \beta_1 x_{it1} + \beta_2 x_{it2} + \cdots + \beta_k x_{itk} + \alpha_i + u_{it} \tag{4.14}
\]
Where an intercept \( \beta_0 \) is included, Equation (4.12) can become a random effect model in assumption that the unobserved effect \( \alpha_i \) are uncorrelated with each explanatory variable:
\[
\text{Cov}(x_{itk}, \alpha_i) = 0, \text{ for } t = 1, 2, \ldots, T; \text{ for } j = 1, 2, \ldots, k \tag{4.15}
\]

In the presence of correlation of the unobserved characteristics with some of the explanatory variables the random effect estimator leads to biased and inconsistent estimates of the parameters. In this case, even if there is correlation between unobserved characteristics and some explanatory variables, the within estimator provides unbiased and consistent results.

The Hausman (\( \chi^2 \)) test consists in testing the null hypothesis of no correlation between unobserved characteristics and some explanatory variables and allows us to make a choice between random estimator and within estimator. The within estimator has however, two important limits:
- It may not estimate the time invariant variables that are eliminated by data transformation;
- The fixed effect estimator ignores variations across individuals. The individual’s specificities can be correlated or not with the explanatory variable. In traditional methods, these correlated variables are replaced with instrumental variables uncorrelated to unobservable characteristics.

4.3.3. Demand Function for Import

To estimate the coefficient of import demands of five members of European Union by Panel data method

\[ D_{xit} = \alpha_0 + \alpha_1 GDP_{it} + \alpha_2 EXR_{it} + \alpha_3 (PM/PD)_{it} + \alpha_4 TR/GDP + \varepsilon_{it} \]  

(4.16)

Hereby,

DXit: Demand imports of Iran from countries of the Europe Unions  
(Iranian imports from European Union members)

EXR: Real exchange rates between Iran and European Union members

PM/PD: The ratio of import price to domestic price

D: Dummy variable (This variable indicates the degree of openness economy of importers)

Eit: Error Term

According to the empirical evidence it is we expect that \( \alpha_1, \alpha_2 \) and \( \alpha_4 \) are positive, and \( \alpha_3 \) is negative

In this chapter first researcher has attempted to study foundation gravity models and has than explained the application of this model in Trade. Further, specified model to Exports and it has also dealt with methods to estimate the models.