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**Generalized Method of Moments' Characteristics and its Application on Panel Data.pdf**

## AUTHOR

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## WORD COUNT

**2949 Words**

## CHARACTER COUNT

**14265 Characters**

## PAGE COUNT

**6 Pages**

## FILE SIZE

**571.8KB**

## SUBMISSION DATE

**Oct 17, 2022 8:59 PM GMT+7**

## REPORT DATE

**Oct 17, 2022 9:00 PM GMT+7**

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# GENERALIZED METHOD OF MOMENTS' CHARACTERISTICS AND ITS APPLICATION ON PANEL DATA

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**ABSTRACT:** Generalized Method of Moments (GMM) is an estimation procedure that allows econometric models especially in panel data to be specified while avoiding often unwanted or unnecessary assumptions, such as specifying a particular distribution for the errors. Panel data is combination of time series and cross section data that contain observations on thousands of individuals or families, each observed at several points in time. Furthermore, the Generalized Method of Moments estimator is obtained by minimizing the criterion function by making sample moment match the population moment. The point of this research is to analyze characteristics GMM estimator on panel data fixed effect models especially unbiasedness, variance minimum, consistency, and normal asymptotic distributed estimator properties. This paper also provide the application of GMM estimation on the area of "Cost for United States Airlines on Six Firms from 1970-1984".

**Keywords:** Panel Data; Generalized Method of Moments; Unbiasedness; Variance Minimum; Consistency; Normal Asymptotic Distributed.

## 1. INTRODUCTION

Econometrics is the field of economics that concerns itself with the application of mathematical statistics and the tools of statistical inference to the empirical measurement of relationships postulated by economic theory [1]. The methodologies that combine mathematical statistics and economics theory produce an econometrics model. Many recent studies in econometrics model have analyzed panel or longitudinal data sets that combine time series and cross section data sets [2].

Panel data sets analyzed time series data on sets of firms, states, countries, or industries simultaneously so its model linear may be written as follows:

$$y_{it} = x'_{it} \beta + z'_i \alpha + \varepsilon_{it} \quad (1)$$

there are  $K$  parameter slope in  $x'_{it}$ , with  $t = 1, 2, \dots, N$  show analysis in cross section and  $t = 1, 2, \dots, T$  show analysis in time series. The vector  $z'_i \alpha$  is called individual effect with  $z'_i$  contains a constant term and a set of individual or group specific variables [1]. The various cases of individual effect on panel data are pooled regression, fixed effect, and random effect.

Gujarati [3] wrote that using panel data giving more data and information so increasing degree of freedom, anticipating heteroscedasticity problem and provide better estimation econometrics. On panel data analysis, often produces over determined systems where there are more moment equations than number of parameters. Hansen introduced the estimation method to solve this case is Generalized Method of Moments (GMM) by minimizing criterion weighted function [4]. Generalized Method of Moments is convenient for estimating interesting extensions of the basic unobserved effect model [5].

The purpose of this paper is to prove characteristics of GMM estimator on panel data especially unbiasedness, variance minimum, consistency, and normal asymptotic distributed properties. To show all of the properties, Section 2 will presents parameter estimation on panel data fixed effect model linear using GMM. Furthermore, Section 3 will show unbiasedness estimator property, Section 4 will show variance minimum property, consistency property will be shown in Section 5 and Section 6 will discuss asymptotic normal distributed.

Finally, Section 7 will present estimation of GMM estimator to estimate linear model panel data sets "Cost for United States Airlines on 6 Firms from 1970-1984".

## 2. PARAMETER LINEAR MODEL PANEL DATA ESTIMATION USING GMM

In exactly identified cases, where number of equation moments equals to number of parameters there will be a single solution by Method of Moments. But, when the number of moment conditions exceeds the number of parameters, we cannot hope to obtain an estimator by setting the empirical equivalent  $\bar{g}(\theta)$  of our moment condition equal to zero [6]. In other word, over determined system there is no unique solution so it will be necessary to minimize criterion function as the criterion a weighted sum of squares

$$q = \bar{m}(\beta)' W \bar{m}(\beta),$$

this estimation method is called Generalized Method of Moment (GMM).

The linear model panel data fixed effect is written as:

$$y_{it} = x'_{it} \beta + \alpha_i + \varepsilon_{it}$$

where  $\beta$  is  $K \times 1$  parameter vector and  $\alpha_i = z'_i \alpha$ , embodies all the observable effects and specifies an estimable conditional mean. This fixed effects approach takes  $\alpha_i$  to be a group-specific constant term in the regression model [1].

The preceding linear model in Section 1 help us to make sample moments equation as below:

$$\left[ \frac{1}{n} \sum_{i=1}^n z_i (y_i - x_i \beta) \right] = \left[ \frac{1}{n} \sum_{i=1}^n m_i(\beta) \right] = \bar{m}(\beta) = 0$$

Using GMM, the criterion a weighted sum of squares is defined as

$$\text{Min}_\beta q = \bar{m}(\beta)' W \bar{m}(\beta)$$

then minimizing  $q$  as follows:

$$\frac{\partial q}{\partial \beta} = 0$$

$$\frac{\partial \bar{m}(\hat{\beta})' W \bar{m}(\hat{\beta})}{\partial \beta} = 0$$

$$2 \frac{\partial \bar{m}(\hat{\beta})'}{\partial \beta} W \bar{m}(\hat{\beta}) = 0. \tag{2}$$

From exactly identified, we get the solution of

easily as:

$$\bar{m}(\hat{\beta}) = \left( \frac{1}{n} Z'y \right) - \left( \frac{1}{n} Z'X \right) \hat{\beta} \tag{3}$$

Then substitute (2) to (3) we will get:

$$2 \left( \frac{\partial}{\partial \beta} \left[ \left( \frac{1}{n} Z'y \right) - \left( \frac{1}{n} Z'X \right) \hat{\beta} \right] \right)' W \left[ \left( \frac{1}{n} Z'y \right) - \left( \frac{1}{n} Z'X \right) \hat{\beta} \right] = 0$$

$$2 \left( -\frac{1}{n} Z'X \right)' W \left[ \left( \frac{1}{n} Z'y - \frac{1}{n} Z'X \hat{\beta} \right) \right] = 0$$

$$-\frac{2}{n^2} [(X'Z)W(Z'y - Z'X\hat{\beta})] = 0$$

$$[(X'Z)W(Z'y - Z'X\hat{\beta})] = 0$$

Associative property on matrix algebra allows that:

$$(X'Z)W(Z'y) - (X'Z)W(Z'X\hat{\beta}) = 0$$

So we get

$$\hat{\beta} = [(X'Z)W(Z'X)]^{-1} (X'Z)W(Z'y).$$

In over identified case ( $L > K$ ), the weighted matrix  $W$  can be identity  $I$  or inverse of covariance matrix  $V^{-1}$ . Furthermore analysis show that efficient and consistent estimator is obtained by using inverse of asymptotic covariance  $V^{-1}$ , with

$$V_{GMM} = \frac{1}{n} [G' \Phi^{-1} G]^{-1}$$

where

$$\Phi = Var[\sqrt{n}(\bar{m} - \beta)]$$

and

$$G = \frac{\partial \bar{m}_1(\hat{\beta})'}{\partial \beta'}$$

So, the GMM estimator on panel data fixed effect model can be written as

$$\hat{\beta} = [(X'Z)\hat{V}^{-1}(Z'X)]^{-1} (X'Z)\hat{V}$$

### 3. UNBIASEDNESS PROPERTY OF GMM ESTIMATOR

From the result of parameter estimation using GMM in Section 2, then the estimator  $\hat{\beta}_{GMM}$  can be rewritten as

$$\hat{\beta}_{GMM} = My$$

where

$$M = [(X'Z)\hat{V}^{-1}(Z'X)]^{-1} (X'Z)\hat{V}^{-1}Z'$$

Thus

$$E(\hat{\beta}_{GMM}) = E(My)$$

$$= ME(y)$$

$$= \{[(X'Z)\hat{V}^{-1}(Z'X)]^{-1} (X'Z)\hat{V}^{-1}Z'\} \cdot E(y)$$

$$= \{[(X'Z)\hat{V}^{-1}(Z'X)]^{-1} (X'Z)\hat{V}^{-1}Z'\} \cdot E(X\beta + \varepsilon)$$

Since  $X\beta$  is not random variable and  $E(\varepsilon) = 0$ , we get

$$= \{[(X'Z)\hat{V}^{-1}(Z'X)]^{-1} (X'Z)\hat{V}^{-1}Z'\} \cdot X\beta$$

$$= (Z'X)^{-1} \hat{V} [(X'Z)^{-1} (X'Z)] \hat{V}^{-1} Z' X \beta$$

$$= (Z'X)^{-1} [\hat{V} \hat{V}^{-1}] Z' X \beta$$

$$= X^{-1} [(Z')^{-1} Z'] X \beta$$

$$= [X^{-1} X] \beta$$

$$= \beta$$

So, it is proven that  $\hat{\beta}_{GMM}$  is unbiased estimator of  $\beta$ .

### 4. VARIANCE MINIMUM PROPERTY OF GMM ESTIMATOR

Econometrics model estimations using GMM is one of semiparametric estimation types that move away from parametric assumptions, such as specifying a particular distribution for the errors. Sometimes it makes some difficultness to analyze characteristic of an estimator. But, the semiparametric efficiency bound is associated with the minimum variance that plays the role of the Fisher Information bound in a semiparametric setting as mentioned by Nekipelov [7]. Since GMM estimator has normal asymptotic normal distributed property where its probability density function is form of exponential family. Hogg and Craig [8] defined that exponential class one parameter has probability density function of the continuous type as follows:

$$f(x; \theta) = \begin{cases} \exp\{p(\theta)K(x) + S(x) + q(\theta)\}, & a < x < b \\ 0, & \text{otherwise} \end{cases}$$

where:

- Neither  $a$  nor  $b$  depends upon  $\theta, \gamma < \theta < \delta$ ,
- $p(\theta)$  is a nontrivial continuous function of  $\theta, \gamma < \theta < \delta$ ,
- Each of  $K'(x) \neq 0$  and  $S(x)$  is a continuous function of  $x, a < x < b$

Since asymptotic property, it can be assumed that disturbances have normal multivariate distribution with mean  $\theta$  and matrix covariance  $V$ ,  $\varepsilon \sim N(\theta, V)$  as

$$f(X; \theta) = \frac{1}{\sqrt{2\pi|V|}} \exp \left[ \frac{-(X - \theta)' V^{-1} (X - \theta)}{2} \right]$$

Thus

$$\ln f(X; \theta) = \ln \left\{ \frac{1}{\sqrt{2\pi|V|}} \exp \left[ -\frac{(X - \theta)' V^{-1} (X - \theta)}{2} \right] \right\} \cong \frac{J'J}{n \cdot V^{-1}}$$

$$= -\frac{1}{2} \ln(2\pi|V|) - \frac{(X - \theta)' V^{-1} (X - \theta)}{2} \cong \frac{1}{n} [J'VJ]$$

The derivative of  $\ln f(X; \theta)$  with respect to  $\theta$  as follows:

$$\frac{\partial \ln f(X; \theta)}{\partial \theta} = \frac{\partial}{\partial \theta} \left[ -\frac{1}{2} \ln(2\pi|V|) - \frac{(X - \theta)' V^{-1} (X - \theta)}{2} \right]$$

$$= \frac{\partial}{\partial \theta} \left[ -\frac{(X - \theta)' V^{-1} (X - \theta)}{2} \right]$$

$$= -\frac{1}{2} \left\{ \frac{\partial}{\partial \theta} [(X' V^{-1} - \theta' V^{-1})(X - \theta)] \right\}$$

$$= -\frac{1}{2} \left\{ \frac{\partial}{\partial \theta} [X' V^{-1} X - X' V^{-1} \theta - \theta' V^{-1} X + \theta' V^{-1} \theta] \right\}$$

$$= -\frac{1}{2} [0 - X' V^{-1} - V^{-1} X + 2V^{-1} \theta]$$

$$= -\frac{1}{2} [-2V^{-1} X + 2V^{-1} \theta]$$

$$= V^{-1} (X - \theta)$$

And the second derivative  $\ln f(X; \theta)$  with respect to  $\theta$  is:

$$\frac{\partial^2 \ln f(X; \theta)}{\partial \theta^2} = \frac{\partial}{\partial \theta} [V^{-1} (X - \theta)] = V^{-1}$$

We get Fisher Information as:

$$I(\theta) = \left( E \left[ \frac{\partial \ln f(X; \theta)}{\partial \theta} \right] \right)^2 = -E \left[ \frac{\partial^2 \ln f(X; \theta)}{\partial \theta^2} \right] = -E[-V^{-1}] = V^{-1}$$

So the Rao-Cramer lower bound is:

$$Var(T) \geq \frac{\left[ \frac{\partial}{\partial \theta} g(\theta) \right]^2}{n \cdot I(\theta)}$$

$$Var(T) \geq \frac{\begin{pmatrix} \frac{\partial x_{1i}}{\partial \theta_1} & \frac{\partial x_{1i}}{\partial \theta_2} & \dots & \frac{\partial x_{1i}}{\partial \theta_n} \\ \frac{\partial x_{2i}}{\partial \theta_1} & \frac{\partial x_{2i}}{\partial \theta_2} & \dots & \frac{\partial x_{2i}}{\partial \theta_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial x_{ni}}{\partial \theta_1} & \frac{\partial x_{ni}}{\partial \theta_2} & \dots & \frac{\partial x_{ni}}{\partial \theta_n} \end{pmatrix} \begin{pmatrix} \frac{\partial x_{1i}}{\partial \theta_1} & \frac{\partial x_{1i}}{\partial \theta_2} & \dots & \frac{\partial x_{1i}}{\partial \theta_n} \\ \frac{\partial x_{2i}}{\partial \theta_1} & \frac{\partial x_{2i}}{\partial \theta_2} & \dots & \frac{\partial x_{2i}}{\partial \theta_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial x_{ni}}{\partial \theta_1} & \frac{\partial x_{ni}}{\partial \theta_2} & \dots & \frac{\partial x_{ni}}{\partial \theta_n} \end{pmatrix}}{n \cdot V^{-1}}$$

As we have defined earlier in section 2, that

$$V_{GMM} = \frac{1}{n} [G' \Phi^{-1} G]^{-1}$$

where

$$\Phi = Var[\sqrt{n}(\bar{m} - \beta)]$$

and

$$G = \frac{\partial \bar{m}_i(\beta)'}{\partial \beta'}$$

So we can write variance of Rao-Cramer and variance of GMM estimator as relationship as follows:

$$\frac{1}{n} [J'VJ] > \frac{1}{n} [G' \Phi^{-1} G]^{-1}$$

$$[J'VJ] > [G' \Phi^{-1} G]^{-1}$$

Since variance of GMM estimator less than Rao-Cramer lower bound then it is proven that variance of GMM estimator has variance minimum.

### 5. CONSISTENCY PROPERTY OF GMM ESTIMATOR

We have discussed that GMM estimator is obtained by minimizing criterion function

$$q_n(\beta) = \bar{m}_n(\beta)' W_n \bar{m}_n(\beta)$$

where

$$\bar{m}_n(\beta) = \frac{1}{n} \sum_{i=1}^n z_i (y_i - x_i' \beta)$$

And  $W_n$  is positive definite matrix as discussed in [9].

it must first be established that  $q_n(\beta)$  converges to a value  $q_0(\beta)$ , where

$$\lim_{n \rightarrow \infty} q_0(\beta) = \lim_{n \rightarrow \infty} \bar{m}_n(\beta)' W_n \bar{m}_n(\beta)$$

$$= \lim_{n \rightarrow \infty} \left\{ \left[ \frac{1}{n} \sum_{i=1}^n z_i (y_i - x_i' \beta) \right] W_n \left[ \frac{1}{n} \sum_{i=1}^n z_i (y_i - x_i' \beta) \right] \right\}$$

$$= \lim_{n \rightarrow \infty} \left\{ \frac{1}{n^2} \left( \sum_{i=1}^n z_i (y_i - x_i' \beta) \right)^2 W_n \right\} = 0$$

So,  $q_n(\beta)$  converges to 0.

For the proof of  $p \lim \hat{\beta}_{GMM} = \beta$  reader see Greene[1].

So, GMM estimator is consistent estimator.

### 6. NORMAL ASYMPTOTICALLY DISTRIBUTED PROPERTY OF GMM ESTIMATOR

Asymptotic normality of GMM estimators follows from taking a mean value expansion of the moment conditions

around the true parameter, see [10]. To show normal asymptotic distributed property, the first order condition for the GMM estimator are:

$$\frac{\partial q_n(\hat{\beta}_{GMM})}{\partial \hat{\beta}_{GMM}} = 0$$

$$\frac{\partial}{\partial \hat{\beta}_{GMM}} (\bar{m}_n(\hat{\beta}_{GMM})' W_n \bar{m}_n(\hat{\beta}_{GMM})) = 0$$

$$2 \frac{\partial \bar{m}_n(\hat{\beta}_{GMM})'}{\partial \hat{\beta}_{GMM}} W_n \bar{m}_n(\hat{\beta}_{GMM}) = 0$$

Let  $\bar{G}_n(\hat{\beta}_{GMM}) = \frac{\partial}{\partial \hat{\beta}_{GMM}} \bar{m}_n(\hat{\beta}_{GMM})$ .

Then

$$2 \bar{G}_n(\hat{\beta}_{GMM})' W_n \bar{m}_n(\hat{\beta}_{GMM}) = 0$$

$$\bar{G}_n(\hat{\beta}_{GMM})' W_n \bar{m}_n(\hat{\beta}_{GMM}) = 0 \quad (4)$$

The orthogonality equations (4) are assumed that vector  $\bar{m}_n$  to be continuous at closure interval  $[\beta_0, \hat{\beta}_{GMM}]$  and continuously differentiable at  $(\beta_0, \hat{\beta}_{GMM})$  so there are  $\bar{\beta} \in (\beta_0, \hat{\beta}_{GMM})$ , and this allows us to employ the Mean Value Theorem

$$\frac{\partial \bar{m}_n(\bar{\beta})}{\partial \hat{\beta}_{GMM}} = \frac{\bar{m}_n(\hat{\beta}_{GMM}) - \bar{m}_n(\beta_0)}{\hat{\beta}_{GMM} - \beta_0}$$

or it can be written as

$$\bar{m}_n(\hat{\beta}_{GMM}) = \bar{m}_n(\beta_0) + \frac{\partial \bar{m}_n(\bar{\beta})}{\partial \hat{\beta}_{GMM}} (\hat{\beta}_{GMM} - \beta_0)$$

$$\bar{m}_n(\hat{\beta}_{GMM}) = \bar{m}_n(\beta_0) + \bar{G}_n(\bar{\beta})(\hat{\beta}_{GMM} - \beta_0) \quad (5)$$

where  $\bar{\beta}$  is a point between  $\hat{\beta}_{GMM}$  and the true parameter  $\beta_0$ .

Substitute (4) to the (5) and we get

$$\bar{G}_n(\hat{\beta}_{GMM})' W_n [\bar{m}_n(\beta_0) + \bar{G}_n(\bar{\beta})(\hat{\beta}_{GMM} - \beta_0)] = 0$$

$$\bar{G}_n(\hat{\beta}_{GMM})' W_n \bar{m}_n(\beta_0) + \bar{G}_n(\hat{\beta}_{GMM})' W_n \bar{G}_n(\bar{\beta})(\hat{\beta}_{GMM} - \beta_0) = 0$$

$$\bar{G}_n(\hat{\beta}_{GMM})' W_n \bar{G}_n(\bar{\beta})(\hat{\beta}_{GMM} - \beta_0) = -\bar{G}_n(\hat{\beta}_{GMM})' W_n \bar{m}_n(\beta_0)$$

Using left cancellation law by

$$[\bar{G}_n(\hat{\beta}_{GMM})' W_n \bar{G}_n(\bar{\beta})]^{-1}, \text{ obtained } (\hat{\beta}_{GMM} - \beta_0) =$$

$$-[\bar{G}_n(\hat{\beta}_{GMM})' W_n \bar{G}_n(\bar{\beta})]^{-1} \bar{G}_n(\hat{\beta}_{GMM})' W_n \bar{m}_n(\beta_0)$$

And multiply by  $\sqrt{n}$ , produces

$$\sqrt{n}(\hat{\beta}_{GMM} - \beta_0) =$$

$$-[\bar{G}_n(\hat{\beta}_{GMM})' W_n \bar{G}_n(\bar{\beta})]^{-1} \bar{G}_n(\hat{\beta}_{GMM})' W_n \sqrt{n} \bar{m}_n(\beta_0)$$

now the quantities on the left- and right-hand sides have the same limiting distribution that is  $N(\beta, V_{GMM})$ .

Furthermore see [1], and we have asymptotic normal distribution with mean  $\beta$  and variance  $V_{GMM}$ ,

$$\hat{\beta}_{GMM} \sim N[\beta, V_{GMM}]$$

### 7. APPLICATION OF GMM ESTIMATION ON PANEL DATA SETS

In this section, we will presents numeric analysis on panel data sets of “Cost for United States Airlines on Six Firms from 1970-1984 (15 years)” by

<http://www.indiana.edu/~statmath/stat/all/panel/airline.dta>

has been accessed on 20<sup>th</sup> December 2013. Using program R3.0.1, we get the panel data linear model about cost for United States airlines on six firms from 1970-1984 with GMM is

$$\hat{Y} = 0.7708 * X_1 + 1.0743 * X_2 + 0.9654 * X_3 \quad \text{and}$$

shown in the table as follows:

**Table1:** Parameter Estimation Using GMM

| Method | Estimator       | Estimation | Standard Error Mean |
|--------|-----------------|------------|---------------------|
| GMM    | $\hat{\beta}_1$ | 0.7708356  | 0.0934              |
|        | $\hat{\beta}_2$ | 1.0743491  | 0.0919              |
|        | $\hat{\beta}_3$ | 0.9653712  | 0.0053              |

From the table, the estimations of the distribution variance of sample mean are 0.0934, 0.0919 and 0.0053. The measure of standard error is influenced by standard deviation of population and number of sample. Actually we should have expected the GMM estimator to improve the standard errors. As a comparison, will be presents parameter estimation using Feasible Generalized Least Square (FGLS) method is presented as below:

**Table2:** Parameter Estimation Using FGLS

| Method | Estimator       | Estimation | Standard Error Mean |
|--------|-----------------|------------|---------------------|
| FGLS   | $\hat{\beta}_1$ | 0.89784    | 0.01459             |
|        | $\hat{\beta}_2$ | 1.19594    | 0.04607             |
|        | $\hat{\beta}_3$ | -2.03970   | 0.46191             |

So, we have panel data linear model about cost for United States airlines on six firms from 1970-1984 using FGLS

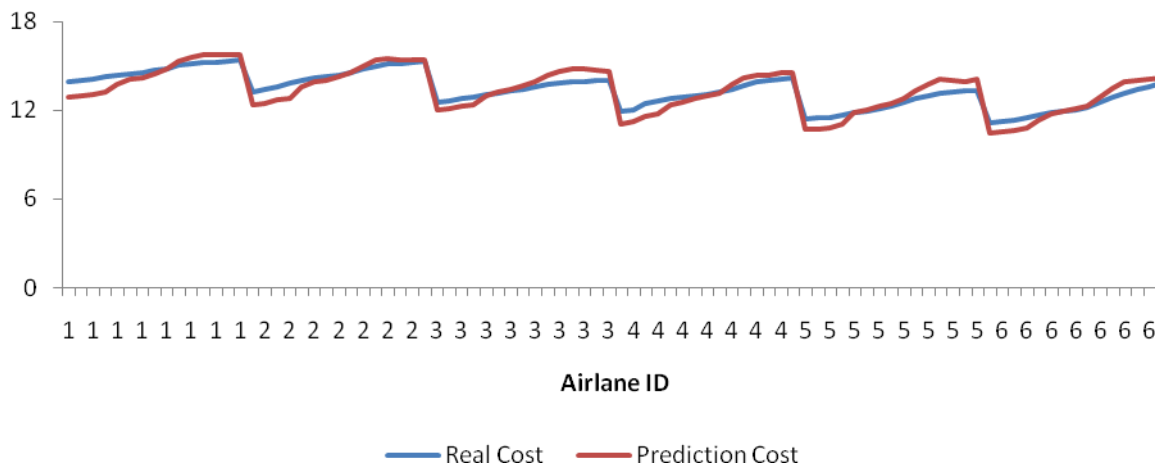
$$\hat{Y} = 0.8978 * X_1 + 1.1959 * X_2 - 2.03970 * X_3.$$

From the table we can say that estimation for  $\beta_1$  is 0.89784 with standard error mean 0.01459. While the estimation for  $\beta_2$  is 1.19594 with standard error mean 0.04607 and for  $\beta_3$  is -2.03970 with standard error mean 0.46191. In fact, the standard error of mean of and by using GMM is bigger than using FGLS but

standard error of mean of

by using GMM is smaller than using FGLS. And the

graph of  $Y$  and using GMM is shown as follows:



**Figure 1:** Plot  $Y$  and Cost of Six Airlines Using GMM

The figure represent total cost of six airlines for fifteen years so that we have 90 (ninety) number of cases. Blue line shows the real value of total costs on six firms airlines from 1970-1984 and red line states the estimation of total costs on six firms airlines from 1970-1984. For example, the first airline in 1970, we have total cost of 13.94710 but using the estimation GMM we have 12.91675. From the figure we can state that estimation of total cost has closed value to real total cost. In the center of every hills, the estimation is similar with real value.

**8. CONCLUSION**

For the general case of the instrumental variable estimator, there are exactly as many moment equations as there are parameters to be estimated. Thus, each of these are exactly identified cases. There will be a single solution to the moment equations, this is called Method of Moment Estimation. But there are cases in which there are more moment equations than parameters, so the system is over determined. The Generalized Method of Moments technique is an extension of the Method of Moments by minimizing criterion function as the criterion a weighted sum of squares. In fact, a large proportion of the recent empirical work in econometrics, particularly in macroeconomics and finance, has employed GMM estimators. Based on the explanation in the previous chapters, we have that Generalized Method of Moments estimator on panel data linear model has characteristics as unbiasedness, variance minimum, consistency and normally asymptotic distributed property. From numeric analysis on panel data sets of “Cost for United States Airlines on Six Firms from 1970-1984 (15 years)” using GMM we have model linear as  $\hat{Y} = 0.7708 * X_1 + 1.0743 * X_2 + 0.9654 * X_3$ . The measure of standard error is influenced by standard deviation of population and number of sample. Actually

we should have expected the GMM estimator to improve the standard errors. From the figure plot  $Y$  and , we can

state that estimation using GMM of total cost has closed value to real total cost, Although, we realize that estimation using GMM on real panel data sometimes will be biased.

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**Appendix 1. Y Value and The Estimation Using GMM**

| Airlines | Year |          |          | Airlines | Year |          |          |
|----------|------|----------|----------|----------|------|----------|----------|
| 1        | 1970 | 13.94710 | 12.91675 | 4        | 1970 | 11.88564 | 11.04837 |
| 1        | 1971 | 14.01082 | 12.97791 | 4        | 1971 | 12.04468 | 11.19323 |
| 1        | 1972 | 14.08521 | 13.07349 | 4        | 1972 | 12.41919 | 11.54639 |
| 1        | 1973 | 14.22863 | 13.22924 | 4        | 1973 | 12.64236 | 11.72778 |
| 1        | 1974 | 14.33236 | 13.78041 | 4        | 1974 | 12.77801 | 12.32571 |
| 1        | 1975 | 14.41640 | 14.09737 | 4        | 1975 | 12.83185 | 12.53035 |
| 1        | 1976 | 14.52004 | 14.18012 | 4        | 1976 | 12.95019 | 12.77574 |
| 1        | 1977 | 14.65482 | 14.43735 | 4        | 1977 | 13.06900 | 12.96246 |
| 1        | 1978 | 14.78597 | 14.79953 | 4        | 1978 | 13.18551 | 13.14863 |
| 1        | 1979 | 14.99343 | 15.35413 | 4        | 1979 | 13.42509 | 13.72605 |
| 1        | 1980 | 15.14728 | 15.61570 | 4        | 1980 | 13.68818 | 14.21035 |
| 1        | 1981 | 15.16818 | 15.75955 | 4        | 1981 | 13.86622 | 14.34572 |
| 1        | 1982 | 15.20081 | 15.77612 | 4        | 1982 | 13.99255 | 14.34383 |
| 1        | 1983 | 15.27014 | 15.77030 | 4        | 1983 | 14.08048 | 14.51689 |
| 1        | 1984 | 15.37330 | 15.74729 | 4        | 1984 | 14.17805 | 14.54340 |
| 2        | 1970 | 13.25215 | 12.37964 | 5        | 1970 | 11.42257 | 10.68275 |
| 2        | 1971 | 13.37018 | 12.45999 | 5        | 1971 | 11.46613 | 10.70741 |
| 2        | 1972 | 13.56404 | 12.71241 | 5        | 1972 | 11.49463 | 10.81105 |
| 2        | 1973 | 13.81480 | 12.83174 | 5        | 1973 | 11.66106 | 11.07242 |
| 2        | 1974 | 14.00113 | 13.60834 | 5        | 1974 | 11.83777 | 11.81599 |
| 2        | 1975 | 14.12160 | 13.89774 | 5        | 1975 | 11.95907 | 11.99659 |
| 2        | 1976 | 14.22188 | 14.04386 | 5        | 1976 | 12.11816 | 12.25827 |
| 2        | 1977 | 14.35158 | 14.26279 | 5        | 1977 | 12.25587 | 12.49411 |
| 2        | 1978 | 14.52128 | 14.53040 | 5        | 1978 | 12.52097 | 12.82635 |
| 2        | 1979 | 14.75096 | 15.02174 | 5        | 1979 | 12.78525 | 13.35413 |
| 2        | 1980 | 14.95901 | 15.45870 | 5        | 1980 | 12.97698 | 13.73985 |
| 2        | 1981 | 15.08463 | 15.53138 | 5        | 1981 | 13.16981 | 14.07458 |
| 2        | 1982 | 15.12863 | 15.46155 | 5        | 1982 | 13.18237 | 14.02826 |
| 2        | 1983 | 15.19235 | 15.44143 | 5        | 1983 | 13.27328 | 13.97698 |
| 2        | 1984 | 15.25283 | 15.39542 | 5        | 1984 | 13.32164 | 14.08373 |
| 3        | 1970 | 12.56479 | 12.02883 | 6        | 1970 | 11.14154 | 10.44438 |
| 3        | 1971 | 12.64203 | 12.09713 | 6        | 1971 | 11.22396 | 10.53358 |
| 3        | 1972 | 12.74273 | 12.23954 | 6        | 1972 | 11.33653 | 10.61042 |
| 3        | 1973 | 12.83360 | 12.35569 | 6        | 1973 | 11.49423 | 10.76885 |
| 3        | 1974 | 13.01709 | 12.99271 | 6        | 1974 | 11.68224 | 11.35805 |
| 3        | 1975 | 13.14297 | 13.28480 | 6        | 1975 | 11.79931 | 11.78324 |
| 3        | 1976 | 13.26273 | 13.44731 | 6        | 1976 | 11.88492 | 11.91468 |
| 3        | 1977 | 13.41403 | 13.66847 | 6        | 1977 | 12.04773 | 12.10480 |
| 3        | 1978 | 13.57191 | 13.95441 | 6        | 1978 | 12.20495 | 12.28832 |
| 3        | 1979 | 13.72546 | 14.34397 | 6        | 1979 | 12.53104 | 12.93120 |
| 3        | 1980 | 13.85619 | 14.63267 | 6        | 1980 | 12.85181 | 13.51567 |
| 3        | 1981 | 13.93400 | 14.81400 | 6        | 1981 | 13.13620 | 13.97539 |
| 3        | 1982 | 13.90724 | 14.77627 | 6        | 1982 | 13.35884 | 14.00739 |
| 3        | 1983 | 13.99694 | 14.71668 | 6        | 1983 | 13.59784 | 14.11097 |
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