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FORECASTING: A DILEMMA OF MODULES (A Comparison of Theory Based and Theory Free Approaches)

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Abstract. Forecasting is an important aid in effective and efficient planning. It is used as an input in the planning process. Thus it is the key to every decision making process. Generally it is concerned with the process used to predict the unknown future. Typically it is used to make predictions about people, firms or other objects. In this study, comparisons of regression models and time series (ARIMA) models have been made. The primary objective is to determine which of the models, *i.e.* theory based approach (regression model) or theory free approach (univariate non-seasonal ARIMA model) is more relevant for forecasting purposes in the real world situation.

It has been found that the estimates obtained by using ARIMA model are closer to the actual values of the variables of that period than the forecast estimates obtained by using regression model.

Measures of forecasting power also indicate that forecasts obtained by regression models are inferior to those obtained by ARIMA model. Thus the performance of ARIMA model was better than the regression model for future decision-making.

I. INTRODUCTION

Forecasting is concerned with the process used to predict the unknown. Typically, it is used to predict the unknown future (time series forecasting), but sometimes we make predictions about people, firms, or other objects (cross-section forecasting). The field includes the study and application of judgment as well as quantitative I (statistical) methods. Research on forecasting has produced many changes in recommended practice since 1960. During the decade of the 1960s and in the early 1970s, regression

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method of forecasting became very popular. Many of these methods used multi-variable and multi-equation regression models (Naylor *et al.*, 1972). However, much of the advice given about the best way to produce forecasts had proved to be incorrect. For example, the advice to develop regression models based upon their fit to historical data has had a detrimental effect upon forecast accuracy.

As far organization of the paper is concerned, Section II presents the review of previous studies. In section III, objectives of the study, sources and nature of data are described and methodology is given in section IV. Section V presents the empirical results and their analysis whereas section VI, the final section, presents conclusion.

II. REVIEW OF PREVIOUS STUDIES

According to Christ (1951), econometric models are not superior to time series approaches and are not successful in improving accuracy in forecasting during structural changing phase in the economy. Steckler (1968), Cooper (1972) and Naylor *et al.* (1972) made a more extensive and detailed comparison of alternative methods and examined the Box-Jenkins approach in contrast to the Wharton econometric model for the years 1963 through 1967. They concluded that the accuracy of ARIMA models of the Box-Jenkins methodology was considerably better than the accuracy of the Wharton econometric model. Another study by Nelson (1972) compared econometric (regression) and time-series (ARIMA) models for an even longer time horizon. This comparison was made using the FRB-MIT-PENN econometric model. The study focused on the one-quarter ahead predictions of 14 endogenous macro economic variables of the US economy. According to the study results, ARIMA got seven points, the composite got five points and econometric model (FMP) earned only two points. Nelson concluded that "the simple ARIMA Model was relatively more robust with respect to post sample predictions than the complex FRB-MIT-PENN models. Thus if the mean squared error were an appropriate measure of loss, an unweighted assessment clearly indicates that a decision maker would have been best off relying simply on ARIMA predictions in the post sample periods" (that is, in the forecasting phase).

Within the sets of time-series approaches and regression approaches, studies have also been performed to compare the relative accuracy of individual techniques. In case of regression and econometric models, both Cooper (1972) and Fromm and Klein (1973) concluded that no single econometric model was overwhelmingly superior to all others. These

researchers recognize that differences may exist in the forecasting performance for single items or over a limited time horizon, but on the average, these differences in accuracy do not consistently favour one model over another.

McNees (1982) considered three claims made against econometric models for which he found no strong support from empirical evidence. These claims were:

- Forecasts from econometric models were generally poor and specifically inferior to judgmental forecasts;
- Econometrically generated forecasts were inferior to those from time-series models; and
- Existing econometric models were worthless for policy analysis.

At the same time, McNees (1982) stated that none of the major forecasters dominated the others for all or even most variables and forecast horizons. Even for a specific variable and horizon, the difference in accuracy among the major forecasters was typically (though not invariably) rather small. In addition, he was not aware of any test to determine whether the differences were significant in a statistical sense.

Armstrong (1985) and Fildes (1985) have compared the forecasting performance of econometric and extrapolative models. Armstrong concluded that extrapolative methods were more accurate than causal methods under short to medium term forecast horizons. In contrast Fildes reported that forecasts from causal methods were more accurate than extrapolative forecasts, regardless of the forecast horizon, discussing forecasting in terms of ex-ante and ex-post forecasts, he stated the ex-post forecasts are expected to do better in comparative studies than ex-ante forecasts, because they use more information. Overall econometric forecasts were more accurate than extrapolative though the difference was not significant because some of the extrapolative forecasts were naive, *i.e.* no change forecasts (Allen, 1994; Fildes, 1985 and Witt, 1985). There is also some evidence that at longer horizons the relative performance of econometric methods improves.

In a study reported by Kirby (1966), three different time-series methods, *i.e.* moving averages, exponential smoothing, and regression were compared. Kirby found that in terms of month-to-month forecasting accuracy, the exponential smoothing methods did best; both moving averages and exponential smoothing gave similar results when the forecasting horizon was

increased to six months. The regression model included in that study was the best method for longer-term forecasts of one year or more.

The same three forecasting methods examined by Kirby were compared by Levine (1967) and concluded that there was an advantage of simplicity with the moving average method, but exponential smoothing offered the best potential accuracy for short-term forecasting. Other study reported by Gross and Ray (1965) had arrived at conclusion similar to those of Levine and Kirby. Unfortunately, comparisons among alternative decomposition methods and other techniques of forecasting have not been reported in the literature. However, there had been studies which compared exponential smoothing with Box-Jenkins models. Reid (1971) and Newbold and Granger (1974) concluded that the Box-Jenkins approach of ARIMA models gave more accurate results than exponential smoothing or step-wise regression methods. When the comparison was made for a single period time horizon, the Box-Jenkins results were found to be the most accurate of the three in 73 percent of the cases. When the lead time for the forecast was increased to six periods, Box-Jenkins models still gave the best results of the three, but accuracy decreased to 57 percent. The conclusion that exponential smoothing gave results as accurate as autoregressive models and sometimes could compete with ARIMA methods in terms of accuracy was surprising to many forecasters. However, this conclusion was also reached by Geurts and Ibrahim (1975). This later study was somewhat limited because it was related to only a single time-series application.

In the late 1970s some additional studies dealt with comparisons of forecasting accuracy among time-series methods. Makridakis and Hibon (1979) found, for instance, that exponential smoothing methods performed quite well in comparison with ARIMA models. They used 111 series (of actual data) in this comparison.

In a more recent study, Makridakis *et al.* (1982) compared the forecasting accuracy of up to 1001 series (of actual data) using recognized experts to model and forecast each type of forecasting method. They concluded that simple exponential smoothing methods did relatively better when compared with the more advanced statistically based time series forecasting techniques. However, in his later study exponential smoothing methods did not perform the best, although they usually did better than fixed parameter ARIMA (Box-Jenkins) models.

The differences in the conclusions reached by researchers examining various time-series methods of forecasting deserve some further consideration. That is particularly true when one recognizes that exponential

smoothing models are simply a special case of the general ARIMA methods. The best explanation can be found in recognizing that the accuracy of a forecasting method depends upon several factors and that those factors cannot be completely summarized in a single measure of accuracy. Reid (1971) discussed several of these factors including the number of observations in the series, seasonality of the data, the number of periods in the time horizon to be forecast, the extent of randomness in the series, and others. As reported by Adam (1973), these factors had a substantial impact on the accuracy and performance of individual forecasting models.

A logical explanation for the differences in the results reported in some of these studies was simply that different factors played different roles in the specific situations examined and thus biased the results in terms of accuracy in different ways. The later research had investigated ways to express the accuracy of a forecasting method as a function of the various factors that affect accuracy (Makridakis and Hibon, 1979; Makridakis *et al.*, 1982). This approach is the relevant one for forecasters, since differences do exist among methods which make them more or less desirable for specific forecasting situations.

Eventually, additional research will need to be done on the determinants of accuracy and on developing procedures that can be used by the forecasters in estimating the relative accuracy of different methods. That information can then be used to apply the criterion of accuracy more effectively in comparing and selecting a forecasting method.

III. OBJECTIVE OF THE STUDY

The primary objective of this empirical work is to determine which of the models, *i.e.* regression model (theory based model) or univariate non-seasonal ARIMA model (theory free model), is more relevant for forecasting purposes in the real world situation. The specific objectives are as under:

- Obtaining of ex-post forecast after empirically estimating the two types of models.
- Comparison of forecasting performance of both types of models by using certain statistical measures as proposed in the methodology.

DATA SOURCES

The ensuing study comprises of a comparison of forecasting performance of regression and univariate non-seasonal ARIMA time series models based on data on Pakistan exports and their determinants. In this study the annual data

for the period 1959-60 to 1995-96 are used and the main sources of data are Pakistan Economic Survey, Pakistan Statistical Yearbook, 50 Years of Pakistan in Statistics, State Bank of Pakistan Annual Reports, Agricultural Statistics of Pakistan, National Accounts of Pakistan and International Financial Statistics.

IV. METHODOLOGY

To estimate the regression model (theory based model) and univariate non-seasonal ARIMA models (theory free model) following three endogenous variables are considered:

1. Exports of primary goods (X_p)
2. Exports of manufactured goods (X_m)
3. Exports of services (X_s)

The specification of the regression model for the variable, exports of primary goods (X_p), is given below:

$$X_p = f(Y_A, P_{xp}/P_{gn}, RER) \quad (1)$$

The specification of the regression model for the variable, exports of manufactured goods (X_m), is given as:

$$X_m = f(Y_m, P_{xm}/P_{gn}, RER) \quad (2)$$

The specification of the regression model for the variable, exports of services (X_s), is given as:

$$X_s = f(Y, t, RER) \quad (3)$$

Whereas

X_s = Exports of services

X_p = Exports of primary goods

X_m = Exports of manufactured goods

Y_A = Value added in agriculture sector

Y_m = Value added in manufactured sector

P_{xp}/P_{gn} = Relative price of primary goods exports to GDP deflator.

P_{mp}/P_{gn} = Relative price of manufactured goods exports to GDP deflator.

Y = Gross national product at factor cost

t = Time trend

RER = Real Exchange Rate

For the time series analysis a univariate non-seasonal ARIMA time series models have been developed after applying various diagnostic tests based on autocorrelation and partial autocorrelation functions. The methods of estimation for ARIMA model for the same three endogenous variables have been used as proposed by Box-Jenkins (1976).

The previous studies such as PIDE (1983, 1986) have included similar variables as determinants of exports of primary goods as included in equation (1) of the study. However, because of the change in the composition of exports of primary goods, there is a rationale for including Y_A (value added in agriculture sector instead of the value added in agriculture (crop) sector used by PIDE (1983, 1986). This study uses P_{xp}/P_{gn} (Relative price of primary goods exports to GDP deflator) as another determinant like one by PIDE (1983, 1986). The last variable, *i.e.* RER (Real Exchanging Rate) is included in the study to determine the impact of nominal exchange rate, the effective value of financial incentives, and domestic as well as world prices on Pakistan's exports of primary goods as used in the studies by Ahmed (2000) and Oskooee (2001). It is expected that the coefficient of Y_A and P_{xp}/P_{gn} are positive while the expected coefficient of RER is negative.

In equation (2) the variables included were similar to the variables used in previous studies conducted by PIDE (1983, 1986) as determinants of exports of manufactured goods. However, because of change of composition of exports of manufactured goods, there is a rationale for including Y_m (value added in manufacturing sector instead of value added in large scale manufacturing sector used by PIDE. The present study includes P_{xm}/P_{gn} (relative price of manufactured goods exports to GDP deflator) as another determinant of exports of manufactured goods as used by PIDE. The variable RER is taken as an exogenous variable as included in the studies by Ahmed (2000) and Oskooee (2001) to determine the impact of nominal exchanges rate, tariffs, trade subsidies, and domestic as well as world prices. The variable RER reflects the change in the competitive position of a country relative to its trading partners. The signs of coefficients of Y_m and P_{xm}/P_{gn} are expected to be positive while sign of coefficient of RER is expected to be negative.

Similarly in equation (3) the variables used were already considered for such type of studies such as PIDE (1983,1986) as determinants of exports of

services. This empirical work includes Gross National Product (GNP) at factor cost and *t* (Time Trend) as determinants of exports of services as used by PIDE. The study includes RER as used by Ahmed (2000) for investigating the response of aggregate merchandise exports of Bangladesh to a real exchange rate-based on their trade liberalization programme during the period 1974-95 and by Oskooee (2001). The expected relationship between X_s and Y, and X_s and RER is positive while the sign of the coefficient of t (time trend) is expected to be negative.

V. RESULTS OF THE STUDY

REGRESSION ANALYSIS (THEORY BASED ANALYSIS)

Various functional forms of the model were estimated. However, only the best possible forms are presented in this study. The regression models have been estimated by using ordinary least squares (OLS).

The empirical results derived from the regression based model for each of the dependent variables are given in Table 1.

TABLE 1

Estimated Results for Regression Analysis

Exports of Primary Product (X_p) Equation I		Exports of Manufactured Goods (X_m) Equation II		Export of Service (X_s) Equation III	
Items	Coefficient	Items	Coefficient	Items	Coefficient
Constant	26.455 (0.986)	Constant	–40.635 (–0.891)	Constant	–35.709 (–7.866)
Y_A	.000842 (2.620)*	Y_m	0.004501 (7.484)*	Y	0.0006718 (12.145)*
P_{xp}/P_{gn}	0.00807 (0.044)	P_{xm}/P_{gm}	0.436 (0.622)	t	–4.110 (–4.781)
RER	–0.05176 (–1.92)	RER	–0.525 (–0.538)	RER	0.209 (2.189)*
R^2	0.505	R^2	0.760	R^2	0.981
F	10.868	F	33.714	F	538.641

Note: Figures in parenthesis indicate t value of the respective coefficient.

*Significant at 95 percent precision level.

The data presented in Table 1 for equation 1 shows that the coefficient of Y_A is significant at 95 percent confidence level. This indicates that value added in agriculture Y_A was positively contributing in exports of primary product (X_p), whereas relative price of primary goods exports to GDP deflator contributed in positive but insignificant. However, real exchange rate registered negative change in export of primary product as per expectation.

As far as the estimates regarding exports of manufactured goods are concerned, the relationship between X_m and Y_A as well as P_{xn}/P_{gn} are positive as expected, while a negative contribution of RER was observed in this context.

In case of exports of services, the time trend contributed negatively, whereas Gross National Product and RER contributed positively as well as significantly.

TIME SERIES ANALYSIS (THEORY FREE ANALYSIS)

Univariate Non-Seasonal ARIMA (p, d, q) Time Series Model

In this section Box-Jenkins's methodology has been applied and the best model for forecast has been selected with the help of major tools used in the identification phase, *i.e.* plots of the series, correlograms of autocorrelation function (ACF) and partial autocorrelation function (PACF).

The condition for ARIMA model to be applied is that the time series is stationary, *i.e.* it has constant mean, variance and autocorrelation. So one has to check the condition of stationarity before fitting the ARIMA model.

To check the stationarity of the time series, the actual values were plotted and it was found that the series was not stationary. To make it stationary, its first difference was taken. Autocorrelation function and partial autocorrelation function were estimated with and without differencing. This suggested that the appropriate model for X_p was ARIMA (1, 1, 1). The appropriate models for X_m and X_s were ARIMA (0, 2, 1) and ARIMA (1, 0, 0) respectively.

The empirical results based on ARIMA model for each of the dependent variables have been presented in Table 2.

TABLE 2

Estimated Results for Time Series Analysis

Exports of Primary Goods (X_{Pt})		Exports of Manufactured Goods (X_{mt})		Export of Service (X_{st})	
Items	Coefficient	Items	Coefficient	Items	Coefficient
Constant	1.8567 (2.4300)	Constant	1.2993 (0.6939)	Constant	108.5911 (1.2339)
X_{Pt-1}	0.6353 (2.8232)				
e_{t-1}	0.9961 (0.4345)	e_{t-1}	0.9998 (0.0187)	X_{st-1}	0.9914 (61.8313)

Note: Figures in parentheses indicate t value of respective coefficient.

COMPARISON OF EX-POST FORECASTING PERFORMANCE

Ex-post forecast for the period from 1995-96 to 1999-2000 for the three endogenous variables X_p, X_m and X_s are obtained and a comparison of actual data and ex-post forecasts obtained from each of the models is made which is then analyzed by using accuracy measures like TIC, RMSPE, MAE, MPE and MAPE for regression and time series approaches.

It has also been observed that the plots of predicted values obtained by ARIMA are closer to the plots of actual values of the variables than the plots of the predicted values obtained by Regression model as shown in Figures 1 to 4.

Furthermore, to evaluate the estimates derived by using the two forecasting techniques, measures of forecasting power (accuracy measures) such as: Mean Absolute Error (MAE), Root Mean Square Error (RMSE), Mean Percent Error (MPE), Mean Absolute Percent Error (MAPE) and Theil Inequality Coefficients have been applied (*see* Butt, 1999). The results presented in Table 4 reflect that all of these accuracy measures consistently show that the percentage of error is relatively higher in case of forecasts obtained by regression models than those obtained by ARIMA model in case of all the measured equations. Thus, the forecasting estimates on the basis of ARIMA model were closer to the actual (Table 3). Furthermore, similarity was observed through accuracy measures. It can be concluded from the above findings that ARIMA model's performance was better than that of regression model.

TABLE 3

Comparison of Actual and Forecast Values Based on Regression and Univariate Non-Seasonal ARIMA Models (1995-96 to 1999-2000)

(Million Rupees)

Year	Value of primary goods exports at constant prices of 1980-81 (X_p)			Value of manufactured goods exports at constant prices of 1980-81 (X_m)			Value of Exports of services at constant prices of 1980-81 (X_s)		
	Actual	Regression Forecasts	ARIMA (1, 1, 1) Forecasts	Actual	Regression Forecasts	ARIMA (0, 2, 1) Forecasts	Actual	Regression Forecasts	ARIMA (1, 0, 0) Forecasts
1995-96	141.37	147.64	101.68	540.90	430.56	550.65	208.33	217.82	211.29
1996-97	94.93	147.91	109.82	578.08	440.49	589.37	186.84	218.79	210.40
1997-98	114.56	153.39	115.67	646.14	433.72	629.38	178.49	222.49	209.53
1998-99	103.16	156.32	120.06	628.24	453.17	670.70	150.66	233.92	208.66
1999-00	118.46	164.25	123.53	707.74	454.98	713.31	170.76	245.41	207.80

FIGURE 1

Comparison of Actual and Predicted Values of Exports of Primary Goods Based on ARIMA and Regression Models

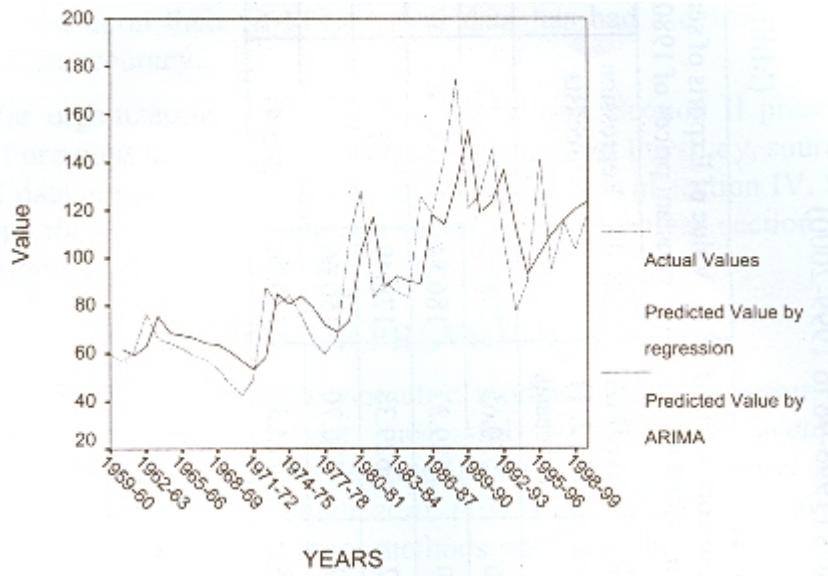

FIGURE 2

Comparison of Actual and Predicted Values of Exports of Manufactured Goods Based on ARIMA and Regression Models

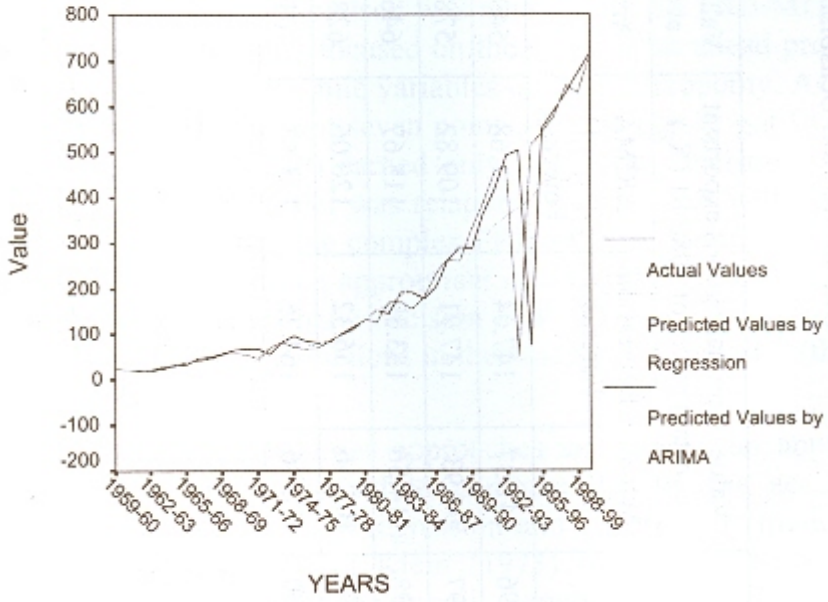

FIGURE 3

Comparison of Actual and Predicted Values of Exports of Services Based on ARIMA and Regression Models

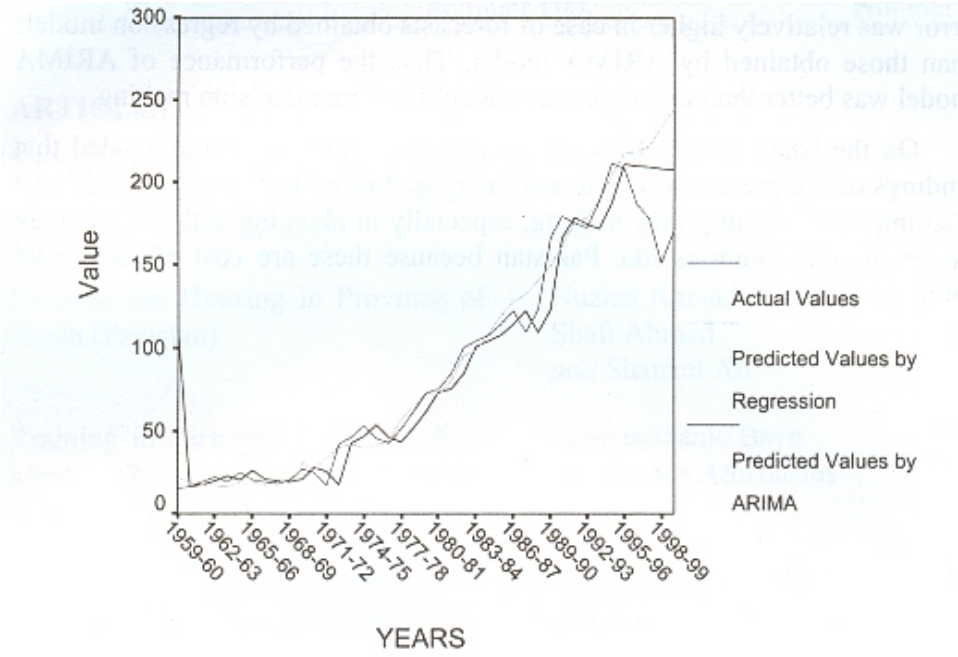

TABLE 4

Evaluation of Forecasting Techniques by Using Accuracy Measures

Items	Forecasting Technique	Accuracy Measures				
		MAE	RMSE	MPE	MAPE	TIC
Exports of Primary Goods	Regression	39.41	43.07	0.37	0.37	0.16
	ARIMA	15.57	20.54	0.02	0.13	0.09
Exports of Manufactured Goods	Regression	177.64	184.81	0.28	0.28	0.17
	ARIMA	17.06	21.61	0.02	0.03	0.02
Exports of Services	Regression	48.67	55.77	0.29	0.29	0.41
	ARIMA	30.52	35.39	0.18	0.18	0.09

VI. CONCLUSION

The estimates obtained by using ARIMA model are closer to the actual values of the variables of that period than the forecast estimates obtained by using regression model. Accuracy measures showed consistently that the error was relatively higher in case of forecasts obtained by regression models than those obtained by ARIMA model. Thus the performance of ARIMA model was better than the regression model for future decision making.

On the basis of the above discussion, it is strongly recommended that findings of the present research work may be further tested, generalized and also implemented in policy making, especially in planning and development in developing countries like Pakistan because these are cost effective and more accurate.

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