A Dynamic Macroeconometric Model of Pakistan's Economy

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ABSTRACT

In this study, an attempt has been made of develop a dynamic macroeconometric model of Pakistan's economy to examine the behaviour of major macroeconomic variables such as output, consumption, investment, government expenditure, money, interest rates, prices, exports, and imports. The model consists of 21 equations, of which 13 are behavioural and the rest are identities. The Engle-Granger two-step cointegration procedure is used to derive the long-run and short-run elasticities for the period 1972-2009. The test of significance of each estimated equation seems to validate the model. The estimated long-run parameters are used to perform simulation experiments to determine the model's ability to track historical data and to assess the behaviour of the key macroeconomic variables in response to the changes in selected exogenous variables. The results indicate that the majority of macroeconomic variables follow an increasing trend over the period of simulation, 2009-2013.

1. INTRODUCTION

Over the past three decades, macroeconometric models have served as important tools of analysis for macroeconomic forecasting and policy assessment [Herve, *et al*. (2010)]. Macroeconometric models provide a useful understanding of structural relationship among different key macroeconomic variables. It also provides cause and effect relationship between policy and target variables and helps in generating forecasts which are important for policy formulation [Bhanumurthy and Kumawat (2009)]. Among the different models, macroeconometric models are useful because they depict the structure as well as temporal behaviour of the macroeconomy. Macroeconometric models also provide a useful means of tracking the implications of a variety of shocks, both exogenous and policy driven within and between economies and regions [Herve, *et al*. (2010)].

The concept of macroeconometric modeling can be traced back to the work of Jan Tinbergen in the 1930s. Since then a number of policymaking institutions and academic researchers have developed macroeconometric models to shed light on the domestic output growth and inflation trends, reaction of monetary and fiscal policies in the face of unexpected shocks and the prospects of macroeconomic stability.[1] These models provide frameworks to account for many aspects of macroeconomic behaviour simultaneously and allowing the model builders to explore the implications of the economic theories by imposing macroeconomic consistency on the analysis [Laxton, *et al*. (1998)].

Attempts to construct macroeconometric model of Pakistan's economy have been limited and policy evaluation with the help of macroeconometric models are rarely undertaken. At present two macroeconometric models are available that attempt to model Pakistan's economy. These include PIDE macro econometric model developed by Naqvi, *et al*. (1983) and Social Policy and Development Centre (SPDC) macroeconometric model developed by Pasha, *et al*. (1995).[2] However, these

[1]A number of researchers have developed macroeconometric models focusing on single country, *inter alia* by Klein and Goldberger (1955), Klein, *et al*. (1961) and Duesenberry, *et al*. (1965). Bryant, Hooper, and Mann (1993) provide references to a number of the multi-country macroeconometric models that are currently in use [see for example, Edison, Marquez, and Tryon (1987); Gagnon (1991); Helliwell, *et al*. (1990); McKibbin and Sachs (1991) and Meredith (1989)].

[2]PIDE macro econometric model consists of 97 equations of which 45 are behavioural and 52 are definitional. The SPDC model consists of 321 equations of which 159 are behavioural.

models are respectively based on the data up to 1988 and 1993 and thus fail to fully portray the present structure of the economy. Besides, the SPDC's model is centered around social sector development with heavily reliance on public finance. Two other macroeconometric models developed by Chishti, *et al.* (1989) and Haque, *et al.* (1990) but these cover only some sub-sectors of the economy.[3] Therefore, analytical exercises with regard to the effectiveness of different alternative options have not contributed much to the macroeconomic policy discourse of the country.[4]

Given the global macroeconomic environment, Pakistan has been following liberalization policies since early eighties. These policies include liberalisation of trade and payments system, shift to the managed float exchange rate regime in 1982 and then to the free float in 2000, more autonomy to the State Bank of Pakistan, greater role of the market forces in the determination of interest rate, permission to the residents to hold bank deposits in foreign currency and host of other reforms in the financial sector. An introduction of General Sales Tax (GST) in the nineties and host of other reforms in the area of public finance meant to contain the fiscal deficit. Most of these reforms were put into practice after the development of macroeconometric models referred above while the full thrust of others had not been felt then. International developments, following 9/11 terrorists attack in 2001 had also influenced domestic economic environment. For example, remittances through banking channels from Overseas Pakistanis registered a dramatic upsurge following global concern about money laundering. The foregoing developments had, without doubt, caused structural changes in the economy. One consequence of these developments and other exogenous changes was to change the sectoral composition of the GDP, with significant increase in contribution of the services sector and corresponding reduction in the share of industry and agriculture.

It is only logical to suspect that the policy changes as well as the global environment referred have changed the structural relationship between various economic variables. Moreover, Pakistan being a small open economy is now more vulnerable to external shocks in the face of more liberalised environment. Lastly, foreign aid, which Pakistan has been accessing ever since, has now more conditions attached to it then in the past.

Change in structural relationship amongst economic variables, greater openness of the economy and the conditionalties attached to aid, all call for the development of a new macroeconometric model that takes into account the

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[3] Khan (1996) also formulated a macroeconometric model, but it mainly concentrated on the monetary side of the economy.

[4] State Bank of Pakistan and Planning Commission of Pakistan is still uses naïve approaches to forecast economic trends in Pakistan.

developments referred above. It is in this context the present study develops a parsimonious medium-size dynamic macroeconometric model of Pakistan's economy to accounts for a number of important macro linkages in the economy and seeks to provide an operational framework that can be used for policy analysis and for tracking out the impacts of various exogenous changes in the economy over the past three decades.

The model developed in the study is based on the small open economy framework and attempts to take into account the unique features of the Pakistan's economy. The model consists of 24 equations of which 13 are behavioural and rest is identities. For example, the model can be shown to 5 blocks, viz. (i) production, (ii) aggregate demand and expenditures, (iii) fiscal block, (iv) foreign trade block, and (v) monetary and price. It captures the nexus between output, aggregate demand, government expenditures and revenues, foreign trade and money and prices, and can be used to examine the effects of domestic and external shocks to the economy. The model is also suitable for examining the impacts of monetary, fiscal and exchange rate policies on the overall economy.

1.1. Main Features of the Model

The present model has several distinguishing features that lead to important contributions to the applied macroeconometric literature on Pakistan. *First*, most macroeconometric models tend to rely on Keynesian framework emphasising only on the demand side of the economy. However, like many developing countries including Pakistan, supply side constraint is the major problem. Mallick (1999) argued that in a supply constraint economy increase in government expenditures to stimulate effective demand results inflation rather than increase in employment and output. As a result, the present macroeconometric model has attempted to incorporate the supply side of the economy by specifying an aggregate production function [e.g. Musila (2002)]. To gain deep insights into the supply side we specify the production function for agriculture, manufacturing and services sectors separately. The production dynamics in these sectors are quite different and hence the use of different specifications may be considered more appropriate. Therefore, along with the demand side of the economy the present model also takes disaggregated production function into consideration.

Second, to overcome the shortcomings of the traditional econometric methodology, the present model utilises single-equation approach for each sector/sub-sector. Due to this the danger of specification mining is eliminated. Furthermore, plausible signs on the parameters and their statistical significance in the estimated equations seem to suggest the appropriateness of our specification.

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Third, another distinguishing feature of the present model has been the consideration of the time series properties of the data and use of appropriate technique for dealing the non-stationary data. Previous studies on Pakistan failed to consider the time series properties of the data. Since almost all the variables appear to be non-stationary on their level and stationary at their first difference. Therefore, cointegration technique has been employed for empirical estimation and short-run dynamic equations are estimated following error-correction modeling technique. For majority of the equations valid long-run relationships are obtained. It should be worth mentioning here that unlike previous studies, serious attention has been focused to various diagnostic tests concerning the estimated equations.

Finally, the sector specific equations are chosen by running several regressions and then selecting the best one on the basis of goodness of fit and signs and significance of the parameters. This method is no longer considered as a good practice in modern econometrics [Charemza and Deadman (1994)]. In addition, we have also used PcGets approaches for model selection.[5]

The rest of the study is organised as follows: Section 2 describes the specification of the structural model. Data sources and econometric methodology is explained in Section 3. Section 4 reports the empirical results. The performance of the model is evaluated in Section 5. This section also carries out simulation experiments, while concluding remarks are given in the final section.

2. SPECIFICATIONS OF THE STRUCTURAL MODEL

In this section, we outline theoretical specification of the macroeconometric model. The current model included both supply side as well as the demand side of the economy. On the supply side production functions for agriculture sector, manufacturing sector and services sector has been considered. On the demand side, the model largely focuses on the behaviour of consumption, investment and foreign trade of goods and services respectively. The model covers five key blocks of the economy viz. the production block, aggregate demand block, fiscal block, foreign trade block and monetary block. This section presents the structural specification of each block.

2.1. Production Block

To model the production activities, we have disaggregated the production into three major sub-sectors: (1) agriculture, (2) manufacturing, and (3) services. The selection of the sectors is primarily based on the structure of the economy. However, data availability constraints have also played a role in the selection of sectors for disaggregating of production.

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[5]For detailed description of PcGets, please see Campos, *et al*. (2003) and Hendry and Krolzig (2004). The model selection procedures were used only as first step to guide our choices of included variables.

2.1.1. *Production Function for Agriculture Sector*

Following Zerfu (2002), Iqbal, *et al*. (2003) and Naqvi, *et al*. (1983) agriculture sector production is assumed to be a function of labour force engaged in agriculture (L_t^a), disbursement of credit to agriculture sector (CD_t^a) and availability of water (W_t). The functional form is given by:

$$Y_t^a = f(L_t^a, CD_t^a, W_t) \qquad \dots \qquad \dots \qquad \dots \qquad \dots \qquad \dots \qquad (1)$$

Where Y_t^a = Agriculture value added

        L_t^a = Labour engaged in agriculture

     CD_t^a = Credit disbursed to agriculture

        W_t = Water availability.

Factors other than the ones included in Equation (1) that may influence agricultural output include land; fertiliser, pesticides, tractors and biological inputs like seeds of high yield variety. These, excluding land, are typically purchased using credit. This is especially true for biological inputs [Iqbal, *et al*. (2003), and Dhanasekaran (1999)]. Thus the inclusion of agricultural credit disbursed in Equation (1) accounts for the influence of these factors. We have abstracted from the use of the variable 'land' or 'cropped area' in the production function because all other inputs like labour, credit, water, etc. are applied to the cropped area and therefore this variable is already subsumed in other inputs included in the functional form described by Equation (1).

The influence of infrastructure like farm to market roads and electricity on agricultural output needs no emphasis. Parikh (1983) assumes that infrastructure and water availability influences agricultural output significantly.[6] To capture the effect of infrastructure Equation (1) incorporates road length as proxy for infrastructure ($IFRS_t$). Now Equation (1) takes the following form:

$$Y_t^a = f(L_t^a, CD_t^a, W_t, IFRS_t) \qquad \dots \qquad \dots \qquad \dots \qquad \dots \qquad (2)$$

We hypothesised that all the right-hand side variables exerts positive impact on agriculture sector value added.

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[6]Pakistan has undertaken a variety of reforms since 1990 under the nomenclature of liberalisation. Some of these reforms directly influenced the agricultural output, for example, cut in subsidies, restricting the purchase of inputs other than wheat by the government, emergence of seed marketing companies in the private sector. While others like reforms in the financial sector are supposed to have influence agricultural output indirectly. In empirical section we also introduces dummy variable to capture the impacts of reforms.

2.1.2. *Production Function for Manufacturing Sector*

The manufacturing sector includes small-scale and large-scale industries, construction, electricity and gas sub-sectors. Furthermore, export-processing industries are also included in this sector. In the manufacturing sector, capital stock and labour force are important factor of production and hence it is included in the manufacturing production function. The production function for manufacturing sector is specified as:

$$Y_t^m = f(K_t^m, L_t^m) \quad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (3)$$

Where Y_t^m = Manufacturing value added.

K_t^m = Capital stock employed in manufacturing

L_t^m = Labor employed in manufacturing

Besides capital stock and labour that have been included in the production function for the manufacturing sector, other factors such as credit disbursed to manufacturing sector, availability of infrastructure, import of machinery and equipments and use of raw material are likely to influence the volume of production in manufacturing sector [Zerfu (2002)]. Therefore, we extend Equation (3) by incorporating credit disbursed to manufacturing sector (DC_t^m), infrastructure ($IFRS_t$), import of machinery and equipments (IMM_t) and use of domestic raw material (DRM_t). The rationale for this proxy is that a significant part of manufacturing output is agro-based, for example textile industry and sugar industry uses the output of the agriculture sector as raw material. Now the production function for manufacturing sector takes the following form:

$$Y_t^m = f(K_t^m, L_t^m, DC_t^m, IFRS_t, IMM_t, DRM_t) \qquad \ldots \qquad \ldots \qquad (4)$$

All the right-hand side variables are expected to influence manufacturing sector value added positively.

2.1.3. *Production Function for Services Sector*

The services sector value added is taken as function of aggregate demand in real term (domestic absorption). Real aggregate demand is defined as the sum of private consumption, government consumption and investment divided by consumer price index. The equation for services sector can be specified as:

$$Y_t^s = f(RAD_t) \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (5)$$

Where Y_t^s = Services sector value added.

RAD_t = Real aggregate demand.

The aggregate output (*GDP*) is defined as the sum of the value added of agriculture, manufacturing and services sectors, i.e.

$$GDP_t = Y_t^a + Y_t^m + Y_t^s \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (6)$$

2.2. Aggregate Demand Block

The aggregate demand for goods and services is the sum of domestic absorption and the trade balance [Zerfu (2002) and Basdevant and Kaasik (2003)]:

$$Y_t = A_t + (X_t - M_t) \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (7)$$

Where *A* is domestic absorption refers to consumption (*C*), investment (*I*) and government expenditures (*G*) respectively. Whereas, *X* and *M* denotes exports and imports of goods and services respectively. The national income now is defined as:

$$Y_t = C_t + I_t + G_t + (X_t - M_t) \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (8)$$

This relationship always holds as an identity

The aggregate demand can be decomposed into consumption and investment sub-sectors. The consumption sub-sector is disaggregated into private consumption and government consumption.

2.2.1. Consumption Sub-block

2.2.1.1. Private Consumption

The specification of real private consumption function is based on an optimising model of life-cycle behaviour. The main variables explaining the real private consumption are the real disposable income and real interest rate [Tjipe, *et al.* (2004)]. To capture the wealth effect, real money balances is included in the real private consumption function (Elliott *et al.*, 1986, Rashid, 1981 and Rankaduwa, *et al.* (1995)].

$$P_t^c = f(Y_t^d, r_t^d, RM_t) \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (9)$$

Where P^c is real private consumption, Y^d is real disposable income, r^d is real interest rate and *RM* is the real money balances (M_2 definition). Following Haque, *et al.* (1990) we define real disposable income (Y^d) as:

$$Y_t^d = (GDP_t - DTXR_t - INDTXR_t + WREM_t + CRP_t) / CPI_t \qquad \ldots \qquad (10)$$

Where *DTXR* denote direct tax revenues and *INDTXR* is indirect tax revenues. *WREM*, *CRP* and *CPI* are worker's remittances, credit to private sector and consumer price index respectively. Worker's remittances are included to capture the effect of remittance on private consumption.

According to the absolute income hypothesis the real disposable income exerts positive effect on real private consumption [Odada, *et al*. (2000)]. The life-cycle and the permanent income hypothesis introduced real interest rate (or inflation rate) as an explanatory variable, whose impact is not clear *a priori*.

2.2.1.2. Government Consumption

The real government consumption depends on the development expenditure relative to GDP, government revenues and inflation.[7]

$$C_t^g = f\left(EXDEVY_t, R_t^g, \pi_t\right) \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (11)$$

Where C_t^g = Government Consumption

$EXDEVY$ = Ratio of Development Expenditure to GDP

R^g = Government Revenues

π = Inflation Rate

It is assumed that ratio of development expenditures to GDP, government revenues and inflation rate are positively related to real government consumption.

2.2.2. *Investment Sub-block*

Aggregate investment is disaggregated into private investment (I_t^p), government investment (I_t^g) and increase in stocks ($\Delta stocks$). Increases in stocks may be an important component of business cycle. It can be thought that increase in stocks may be heavily dependent on the fluctuations in agricultural production, which in turn affected by exogenous factors such as climate. Hence, increase in stocks is assumed to be exogenous [Ra and Rhee (2005)].

2.2.2.1. Private Investment

Private investment continuously plays a key role in sustaining the development process by promoting economic growth. Private investment decisions depend on the investment in long-lived capital assets and expectations about the future [Guru-Gharsns (2000)]. In this study we included real income, real interest rate, ratio of private sector credit to GDP and government investment as explanatory variables.

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[7]Current government expenditures consists of gneral public service, defense affairs and services, public order and safety affairs, economic affairs, environment protection, housing and community amenities, health services, recreation, culture and religion, education affairs and services and social protection [for further detail, see State Bank of Pakistan's Annual Report FY09, p. 27]

$$I_t^p = f(Y_t, r_t^l, CRPY_t, I_t^g) \quad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (12)$$

Where $\quad I_t^p \; = \;$ Private Investment

$\qquad\qquad Y_t \; = \;$ Real Income

$\qquad\qquad r_t^l \; = \;$ Real Interest Rate.

$\qquad CRPY_t \; = \;$ Ratio of private sector credit to GDP.

$\qquad\qquad I_t^g \; = \;$ Government Investment.

The accelerator theory suggests that as income increases, investment is also increases. Therefore, real income is included to capture the effect of accelerator principle. The real interest rate is another important variable determining the level of private investment. The neoclassical theory predicts negative relationship between interest rate and investment. However, McKinnon (1973) and Shaw (1973) argued that interest rate could exert positive impact on the level of investment because real interest rate could increase savings, which led to increase investment [Khan and Khan (2007)]. Furthermore, interest rate can also be used as a measure of cost of borrowings that may affect the cost of capital and debt-equity ratio [Guru-Gharsns (2000)]. Availability of credit to private sector is another important determinant of private investment and influences the investment behaviour positively [Jongwanich and Kohpaiboon (2008)]. It also provides a link between real and monetary sectors [Guru-Gharsns (2000)]. Furthermore, government investment, which concentrates mostly on infrastructure, exerts an important influence on private investment. It is often suggested that government investment complements private investment instead of crowding-out in developing countries [Hossain and Razzaque (2003)]. Therefore, government investment is included in the specification to capture the 'crowding-out' or 'crowding-in' effects [Jongwanich and Kohpaiboon (2008)].

2.2.2.2. Government Investment

Government investment is measured by the expenditures on capital construction such as infrastructure and innovations. Government investment serves as fiscal policy instruments and is assumed to be exogenously determined.

$$I_t^g \; = \; \bar{I}_t^g \qquad\qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (13)$$

$$G_t = C_t^g + I_t^g \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (14)$$

2.3. Fiscal Block

The fiscal sector constitutes government revenue and government expenditures. In this sector the budget deficit is resulted when government spending exceeds government revenues. Like many other countries, in Pakistan

domestic and external resources are used to finance budget deficit. The budget deficit is defined as:

$$BD_t = (EX_t^g - R_t^g) \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (15)$$

Where BD_t = Budget Deficit

EX_t^g = Government expenditures

R_t^g = Government revenue

The government revenues (R_t^g) originates from direct tax revenues ($DTXR_t$), indirect tax revenues ($INDTXR_t$) and non-tax government revenues ($NTXR_t$) sources, i.e.

$$R_t^g = DTXR_t + INDTXR_t + NTXR_t \quad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (16)$$

Non-tax revenues are usually fees and other similar kind of charges, which are proportional to aggregate economic activities (i.e. NY). The direct and indirect tax revenues are modeled as endogenous variable whereas, non-tax revenues of the government is taken as exogenous variable [Tjipe, *et al*. (2004); Guru-Gharsns (2000)]. Two different revenues functions are modeled as they are of different in nature and having different degrees of response to changes in income.

2.3.1. *Direct Tax Revenues*

Direct tax revenues may be influenced by activity level of the economy (i.e. NY), average direct tax rate ($ADTXR$), which is defined as the ratio of direct taxes to nominal output (NY) and inflation rate. Therefore:

$$DTXR_t = f(NY_t, ADTXR_t, \pi_t) \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (17)$$

An increase in the NY (tax base) is expected to raise revenues from direct taxes. Direct tax revenues will go up as average tax rate rises [Tjipe, *et al*. (2004)]. It is also assumed that there is positive relationship between direct taxes and inflation rate because in each year public and private employees compensations are adjusted for cost of living and those additional compensations are taxed.

2.3.2. *Total Indirect Tax Revenues*

The indirect tax revenues can also be influenced by nominal income (NY), the average indirect tax rate ($AINDTXR$) and inflation rate (π), i.e.

$$INDTXR_t = f(NY_t, AINDTXR_t, \pi_t) \quad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (18)$$

The large proportion of indirect taxes is raised in the form of sales tax, custom duties, etc.; therefore a higher price level would contribute to higher indirect tax revenues. A higher output level led to increase revenues from indirect taxes due to higher spending. Similarly, positive relationship between indirect taxes, average tax rate and inflation is predicted.

The elasticity of taxes with respect to income is assumed to be about unity [Elliott, *et al*. (1986)]. Such as response implies that the tax system, on average, is neither progressive nor regressive.

2.3.3. *Government Expenditure*

Government expenditures (EX^g) consists of current expenditures ($EXCUR$), development expenditures ($EXDEV$) and expenditures on capital disbursement ($EXCD$). The total government expenditure is therefore given by:

$$EX_t^g = EXCUR_t + EXDEV_t + EXCD_t \qquad \ldots \qquad \ldots \qquad \ldots \quad (19)$$

This model treats development expenditure and expenditures on capital disbursement as exogenous variables, while current expenditures on goods and services are taken as endogenous variables.

$$EXDEV_t = \overline{EXDEV}_t \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (20)$$

$$EXCD_t = \overline{EXCD}_t \quad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (21)$$

The government current expenditures are assumed to be influences by nominal income and inflation rate. As nominal income increases, the expenditure on development projects is also expected to increase. Similarly, a rise in inflation rate is also expected to increase government's development expenditures. Therefore, we specify the following function for government expenditures.

$$EXCUR_t = f(NY_t, \pi_t) \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (22)$$

2.4. Foreign Trade Block

The trade block consists of two equations explaining the determination of volume of exports of goods and services and volume of imports of goods and services.

2.4.1. *Exports Function*

It is assumed that Pakistan is a small open economy and is price taker in the world markets. Accordingly, changes in the world prices affect the domestic production level, which in turn, affects export levels. The quantity of real exports of goods and services (X_t) depends positively on the real effective exchange rate as well as world income [Tjipe, *et al*. (2004)]. However, the more

fundamental determinants in the exports equation may be the real effective exchange rate (*REER*), domestic real income (*Y*), foreign real income (Y^f) and the price of exports relative to domestic price (RP^x) level. Thus, following Khan (1996), Zerfu (2002) and Murty and Soumya (2007) the aggregate export function can be specified as:

$$X_t = f(Y_t, REER_t, Y_t^f, RP_t^x) \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (23)$$

The domestic real income, foreign income and relative of exports is expected to influence real export demand positively, while real effective exchange rate exerts negative impact on exports because an increase in the real effective exchange rate (i.e. real deprecation) affects exports demand negatively.

2.4.2. *Imports Function*

The demand for real imports (IM_t) is assumed to be determined by domestic demand for imports (i.e. real income), real effective exchange rate, foreign capital (K_t^f) and relative price of imports (RP^{im}), which is given by the ratio of imports price index (P^{im}) to domestic price level (P). Thus, we can specify the real imports equation as:

$$IM_t = f(REER_t, Y_t, K_t^f, RP_t^{im}) \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (24)$$

Depreciation in real effective exchange rate or an increase in the price of imports relative to domestic price level leads to a contraction in imports demand. While an increase in the domestic real income and foreign direct investment results in an increase in imports.

Finally, the trade balance (*TB*) is defined as:

$$TB_t = (X_t - IM_t) \quad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (25)$$

2.5. **Monetary and Price Block**

The monetary block of the present macro-econometric model explains the behavior of money demand, short-term interest rate and the domestic price level.

2.5.1. *Money Demand Function*

The main objective of the monetary policy is to provide adequate liquidity for economic growth while maintaining price stability. The effectiveness of monetary policy depends on the stability of money demand function. The standard literature suggests that the demand for real money balances (M_2) is positively related to the level of real income. If the level of real income increases, there is an opportunity for the agents to hold more money. The literature also suggests that demand for real money balances is negatively

related to the opportunity cost of holding money (i.e. short-term interest rate). The functional form of real money balances can be expressed as:

$$\left(\frac{M_t^d}{P_t}\right) = f(Y_t, i_t) \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (26)$$

Where M^d/P = Demand for real money balances

i_t = Short-term nominal interest rate.

2.5.2. *Interest Rate*

This model treats short-term interest rate as monetary policy instrument. The short-term interest rate can be modelled as a function of money supply (M^S), domestic price level (P) and policy discount rate (dr). Therefore, the monetary policy reaction function can be expressed as:

$$i_t = f(M_t^s, P_t, dr_t) \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (27)$$

Policy discount rate (dr) is included to capture the pass-through effect of monetary policy changes on the market rate of interest.

2.5.3. *Price Equation*

Taking the lead from Moser (1995) the general price level can be expressed as a weighted average of the tradable goods price (P_t^T) and non-tradable goods price (P_t^N). The log-linear form can be expressed as:

$$LnP_t = \theta LnP_t^T + (1-\theta)LnP_t^N \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (28)$$

Where θ represent the share of tradable goods in the total expenditures. It is assumed that the price of tradable goods (P_t^T) is determined exogenously in the world market. In domestic currency term, it can be represented by foreign price (P_t^f) adjusted for nominal exchange rate (E_t) and can be written as:

$$LnP_t^T = LnP_t^f + LnE_t \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (29)$$

Increase in the foreign prices adjusted for exchange rate will lead to increase in the overall price level.

The price of non-tradable goods (P_t^N) is assumed to be determined in the domestic money market. The demand for tradable goods is assumed to move in the line with demand in the economy. Consequently, the price of non-tradable

goods is determined by the money market equilibrium condition, where money supply (M^s) equals real money demand (M^d/P). The disequilibrium in the money market affects non-tradable goods prices, which can be written as:

$$LnP_t^N = \phi[LnM_t^s - Lnm_t^d] \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (30)$$

Where m^d is the demand for real money balances. The ϕ is a scale variable representing the relationship between economy -wide demand and demand for non-tradable goods. By replacing the real money demand function into the Equation (26) leads to the following price equation for non-tradable goods:

$$LnP_t^N = \phi[LnM_t^s - (LnY_t, i_t)] \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (31)$$

By substituting the value of LnP^T and LnP^N into Equation (27) we can reach the final form of general price equation:

$$P_t = f(M_t^s, Y_t, i_t, P_t^f, E_t) \quad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (32)$$

Equation (32) is in line with the monetarist and structuralist theories of inflation.

2.6. Working of the Model

The model consists of 24 equations of which 13 are behavioural equations and 8 are identities and linking equations. The model works in the following ways:

(i)   Production affects consumption, exports, imports, government revenues, government expenditures, which in turn affects the domestic price level.

(ii)   Credit to private sector affects private investment which influences output level through the channel of capital stock.

(iii)   Public investment influences private investment, which in turn affects output level.

(iv)   Foreign price affect domestic price level, which in turn affect the prices of raw material.

(v)   Domestic price level is also affected by real and monetary variables.

(vi)   Real effective exchange rate determines the volume of imports, which in turn, affect private investment.

(vii)   Private investment affect real output, which effect government revenues and expenditures and hence budget deficits.

(viii)   Disequilibrium between aggregate demand and aggregate supply also affects the domestic price level.

Therefore, market clearing may be achieved through monetary and fiscal policies adjustment.

3. DATA AND ESTIMATION STRATEGY

3.1. The Data

Annual data for the period 1972-2009 is used for estimation. The details of variables construction can be seen in Table 4 (Appendix). All variables except interest rate are in logarithms which are indicated by small letters instead of capital letters in Section 4.[8] The data has been taken from different sources; mainly form the *Handbook of Pakistan's Economy* 2005, *Bulletin of the State Bank of Pakistan* (Various Issues), *Pakistan Economic Survey* (various issues), *Federal Bureau of Statistics* and the *International Financial Statistics (IFS)* of the International Monetary Fund.

3.2. Estimation Methodology

The applicability of the estimation methodology has often seen in the light of data availability. Due to the short time span, the number of feasible estimation methods is limited. Therefore, we have used single-equation based cointegration approach (Engle-Granger two-step procedure) to estimate the model. The performance of all estimated equations will then be evaluated using mean absolute percentage error (*MAPE*) and Theil's inequality coefficient (*U*) and slight misspecification will be tolerated if the forecasting ability of the equations is good.

It is well documented in the recent literature that most of the macroeconomic time series displays a non-stationary behaviour. If two series have unit root processes then ordinary least squares (*OLS*) method gives spurious results even though the estimated coefficients are highly significant [Granger and Newbold (1974) and Phillips (1986)]. Engle and Granger (1987) suggest the estimation of cointegration relationship in the first step with static *OLS* method. The resulting residuals are then tested for stationarity. If they are found to be stationary then in the second step one can estimate error-correction model as long-run equilibrium relationship.

According to the Granger (1986) representation theorem, the existence of linear cointegration relationship can be represented as an error correction model (*ECM*). The advantage of *ECM* is that the long-run and short-run properties can be estimated jointly and it makes possible to examine the direction of long-run and short-run causality. Therefore, we use *ECM* to represent the dynamic behaviour of the variables under consideration in the following way:

$$\Delta y_t = \gamma + \rho\, u_{t-1} + \sum_{i=1}^{k1} \alpha_i \Delta y_{t-i} + \sum_{i=1}^{k2} \beta_i \Delta x_{t-i} + v_t \qquad \ldots \qquad \ldots \quad (33)$$

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[8]A complete list of all the endogenous and exogenous variables is given in Table 5 (Appendix).

Where y_t is dependent variable and x_t is a set of explanatory variables. The lag lengths k_1 and k_2 are chosen to make error term v_t white noise. If the error-correction mechanism is working then the parameter ρ should be negative and statistical significant, otherwise the deviations from the equilibrium path will not be corrected [Tjipe, *et al*. (2004)].

Although, multivariate cointegration method advanced by Johansen (1991) is superior to that of Engle-Granger method. However, multivariate cointegration technique requires high frequency data, but we are dealing with a limited number of observations (38 observations), which makes possible to apply Engle-Granger cointegration method.

The applicability of estimation technique has always been seen in the light of data availability. Due to short data span, structural break and data with low frequency, the available methods of estimation is limited. Therefore, we have employed a single-equation method and all the estimated single-equations have been seen in the light of the objectives of building a model for Pakistan's economy.

4. ESTIMATION RESULTS OF THE STRUCTURAL MODEL

The behavioural equations in the model have been estimated using error-correction model, which accounts for the long-run behaviour of the variables included in theoretical specifications. We have undertaken the general-to-specific procedure to obtain more parsimonious results because we have a small sample at hand with annual frequency data of 38 years. This constrains us to report only parsimonious equations.[9]

We started with the Augmented Dickey-Fuller (*ADF*) unit root test to examine the time series properties of the data and the results are reported in Table 5 (Appendix). The results show that only government investment follows I (0) process, while the remaining series under consideration following I (1) processes. However, Harris (1995) points out that the most important problem faced when applying unit root test is their poor size and power properties. This is often reflected in the tendency to over-reject the null hypothesis when it is true and under-reject the null hypothesis when it is false. In case of small sample the problem is likely to be worse [Hossain and Razzaque (2003)]. Thus in this case inspection of autocorrelation function and correlogram are important tools in determining whether the variables are stationary or not [Hall (1986)]. Therefore, we have considered *ADF* test as well as autocorrelation function and correlograms to determine the integration properties of the variables.

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[9]We use PcGets approach to select an appropriate model. [For further details of PcGets modeling approach, see Hendry and Krolzig (2004)].

Several dummy variables are also introduced in different equation to capture structural break that might have resulted from the financial sector reforms of 1990s, liberalisation of trade and payments system, after effects of nuclear tests, after effects of 9/11 events, etc. For the long-run and short-run equations the *t*-values of the estimated coefficients are given in parentheses. Residual sum of squares (*RSS*), standard deviation of dependent variables (σ) and the adjusted coefficient of multiple determination ($\overline{R}^2$) are listed below each equation. The *ADF*-conitegration test performed on the residuals obtained from the long-run equations is reported below each long-run equation.

In addition, to assess the appropriateness of the estimated equations, we have employ a battery of diagnostic tests such as; Jarque-Bera (*JB*) for normality of residuals, Lagrange Multiplier (*LM*) for series correlation, autoregressive conditional heteroscedasticity (*ARCH*) for heteroscedasticity, Remsay's *RESET* for functional specification and *CUSUM* and *CUSUMSQ* for the structural stability of each equation. However, slight misspecification of the single equation will be tolerated.

4.1. Production Block

4.1.1. *Agriculture Sector*

The more parsimonious long-run and short-run results of the production function for agriculture sector are reported by Equations (34) and (35).

Long-run Estimates

$$y_t^a = 3.41 + 0.62l_t^a + 0.33ifrs_t + 0.31w_t - 0.05dc_t^a$$
$$\quad (6.63)(4.76) \quad (5.63) \quad (5.76) \quad (-2.52)$$

$$RSS = 0.05 \qquad \sigma = 0.04 \qquad \overline{R}^2 = 0.99 \qquad ADF = -4.97^*$$
$$Normality\ test\ = 1.55[0.461] \qquad\quad LM-test \quad = 0.01[0.913]$$
$$ARCH\ test \quad = 0.37[0.542] \qquad\quad Heterotest \quad = 8.70[0.368]$$
$$RESET \qquad\quad = 15.11[0.000]$$

(34)

Short-run Estimates

$$\Delta y_t^a = 0.26\Delta l_{t-1}^a + 0.04\Delta dc_{t-1}^a + 0.51\Delta ifrs_t - 0.73\varepsilon_{t-1}^a$$
$$\qquad (1.93) \qquad (1.74) \qquad (3.79) \qquad (-4.20)$$

$$RSS = 0.03 \qquad \sigma = 0.04 \qquad \overline{R}^2 = 0.19$$
$$Normality test \quad = 3.58[0.167] \qquad LM-test \quad = 0.00[1.000]$$
$$ARCH\ test \qquad = 0.15[0.697] \qquad Heterotest \quad = 7.91[0.442]$$
$$RESET \qquad\qquad = 2.28[0.131]$$

(35)

The results reported by Equation (34) suggest that labour force engaged in the agriculture sector, infrastructure and water availability play a major role in the long- run productivity of the agriculture sector, with the impact of labour force and infrastructure being greater relative to water availability. Moreover, in the long-run credit disbursed to agriculture sector exerts negative and significant impact on the productivity of agriculture sector. This could be due to the misallocation and misuses of the agriculture credit. The long-run impact of labour on agricultural output is positive and significant. The marginal product of labour in the agriculture sector is 0.62 in the long-run. The impact of this variable is relatively large as compared to infrastructure and the availability of water. The estimated equation fits the data well as indicated by the diagnostic statistics. Furthermore, the *ADF* statistic used to test the stationarity of the residuals is equal to -4.97, which is higher than the critical values, confirming the long-run relationship between the variables included in Equation (2).

The short-run estimates of agriculture value added are reported in Equation (35). It can be observed that in the short-run labour force associated to agriculture sector lagged by one year, credit disbursed to agriculture sector lagged by one year and infrastructure influences agriculture value added positively. However, the relative impact of infrastructure is dominated as compared to other factors in the short-run. The error-correction term (e_{t-1}^{a}), is correctly signed and significant at the one percent level of significance confirming the existence of long-run relationship. The coefficient of error correction term is -0.73, which suggests that it takes one and a half year to correct all the deviations to achieve the long-run equilibrium path. Finally the estimated short-run model fit very well as indicated by the diagnostic statistics.

4.1.2. *Manufacturing Sector*

The value added in manufacturing sector is significantly explained by the labour, infrastructure, import of machinery, credit disbursed to manufacturing sector and raw material provided by agriculture sector to industries in the long-run. However, credit disbursed to manufacturing sector influences manufacturing output negatively. This could be due to the misallocation of credit in the industrial sector. The fact that non-performing loans of the manufacturing sector in 1990s have caused some of the banks to fail and forced the government to inject equity in some others to save these from apparent bankruptcy, lends credence to the suspicion of misallocation. Capital stock plays no significant role in the determination of output of the manufacturing sector.

Long-run Results

$$y_t^m = 0.39l_t^m + 0.60ifrs_t + 0.18imm_t - 0.14dc_t^m + 0.25drm_t$$
$$\quad (2.09) \quad (3.97) \quad (4.35) \quad (-3.39) \quad (1.85)$$

$RSS = 0.13 \qquad \sigma = 0.06 \qquad \overline{R}^2 = 0.99 \qquad ADF = -3.72^{**}$ (36)

$Normality test = 2.29[0.318] \qquad LM - test = 10.84[0.001]$

$ARCH\ test = 1.37[0.242] \qquad Hetero test = 16.90[0.077]$

$RESET = 0.28[0.598]$

Short-run Dynamics

$$\Delta y_t^m = 0.66\Delta y_{t-1}^m + 0.74\Delta ifrs_t - 0.14\Delta dc_t^m - 0.40\varepsilon_{t-1}^m + 0.02D_{97}$$
$$\quad (6.08) \quad (4.44) \quad (-2.09) \quad (-3.79) \quad (2.05)$$

$RSS = 0.02 \qquad \sigma = 0.03 \qquad \overline{R}^2 = 0.49$ (37)

$Normality test = 0.15[0.928] \qquad LM - test = 0.21[0.645]$

$ARCH\ test = 0.60[0.437] \qquad Hetero test = 9.35[0.406]$

$RESET = 0.29[0.588]$

The long-run elasticities of labour force, infrastructure, import of machinery, credit disbursed to manufacturing sector and raw material is respectively 0.39, 0.60, 0.18, −0.14 and 0.25. The *ADF* statistic is -3.10 which is significant at the 5 percent level of significance, confirms a valid long-run relationship between manufacturing value added and its determinants.[10]

The short-run error-correction model corresponding to the long-run manufacturing value added relationship is given by Equation (37). In the short-run the infrastructure and the manufacturing value added lagged by one year are found to be influencing the manufacturing value added positively and significantly. Credit disbursed, like its long run impact, influences manufacturing value added negatively in the short run as well. Hence, the infrastructure and the manufacturing value added lagged by one year play a dominant role in determining the manufacturing output in the short-run. The coefficient on the error-correction term (ε_{t-1}^m) is correctly signed and significant. The magnitude of the error-correction term is −0.40 suggesting that it takes more than 2 years to correct all the deviations to achieve long-run equilibrium. The short-run model explains 49 percent variations in the growth of manufacturing value added and the diagnostic tests do not indicate any misspecification problem. In overall, the result of the manufacturing sector is quite satisfactory.

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[10]*ADF* performed on the residuals obtained from the long-run Equation (36).

4.1.3. *Services Sector*

The estimation of the services sector value added suggests that services contribution to the total production is significantly determined by real aggregate demand in the long-run. The contribution of real aggregate demand in the services value added is 0.96 in the long-run. To correct the outlier in the data that might be due to the economic reforms of 1990, we introduced a dummy variable (D_{90}), taking value 1 from 1990-2009 and zero other wise, is also significant in the long-run with the coefficient equal to 0.14. The *ADF* statistic is –2.64, which is insignificant indicating no long-run relationship between services value added and real aggregated demand. Therefore, we estimate a simple vector-autoregressive (VAR) model to examine the short-run impact of the real aggregate demand on the services value added. The results reported by Equation (39) suggest that services value added lagged by one year and real aggregate demand exerts positive and significant impact on services sector contribution in the short-run. Despite a low value of $\overline{R}^2$, the short-run model does not have any problem of serial correlation, functional form, non-normality of residuals and heteroscedasticity.

Long-run Estimates

$$y_t^s = 4.28 + 0.96 rad_t + 0.14 D_{90}$$
$$\quad (27.76)(61.96) \quad (6.38)$$

$$
\begin{aligned}
&RSS = 0.12 && \sigma = 0.06 && \overline{R}^2 = 0.99 && ADF = -2.00 \\
&Normality test = 1.28[0.529] && && LM - test = `18.78[0.000] \\
&ARCH\ test = 11.60[0.001] && && Hetero test = 6.85[0.077] \\
&RESET = 51.96[0.000] &&
\end{aligned}
\tag{38}
$$

Short-run Estimates

$$\Delta y_t^s = 0.03 + 0.31 \Delta y_{t-1}^s + 0.20 \Delta rad_t - 0.01 D_{96}$$
$$\quad (3.61)(1.96) \quad (2.09) \quad (-1.37)$$

$$
\begin{aligned}
&RSS = 0.01 && \sigma = 0.02 && \overline{R}^2 = 0.15 \\
&Normality test = 1.02[0.601] && LM - test = 0.005[0.942] \\
&ARCH\ test = 0.71[0.400] && Hetero test = 5.20[0.393] \\
&RESET = 0.001[0.977]
\end{aligned}
\tag{39}
$$

4.2. Aggregate Demand Block

4.2.1. *Private Consumption*

Equation (40) reports the long-run estimates of real private consumption. It can be seen from the results that in the long-run real disposable income exert

positive and significant impact on real private consumption.[11] The marginal propensity to consume (*mpc*) is equal to 0.94, which implies that individuals spend 94 percent of their income on consumption.[12] This means that marginal propensity to save out of real disposable income is very small (1-0.94=0.06). The autonomous consumption is 5.22, which is much higher than that of induce consumption in the long-run. This result is consistent with the earlier findings of Guru-Gharana (2000) and Ra and Rhee (2005). The interaction term of real interest rate adjusted for dummy variable (D_{00}) exerts negative impact on private consumption. However, the magnitude of this variable is very small.

Long-run Estimates

$$c_t^p = 5.22 + 0.94\,y_t^d - 0.006 r_t^d.D_{00}$$
$$(23.67)(42.08)(-2.42)$$

$$RSS = 0.05 \qquad \sigma = 0.04 \qquad \overline{R}^2 = 0.99 \qquad ADF = -3.23^{***} \quad (40)$$
$$Normality\,test = 0.36[0.836] \qquad\qquad LM-test = 6.18[0.013]$$
$$ARCH\ test = 0.06[0.809] \qquad\qquad Hetero\,test = 4.83[0.306]$$
$$RESET = 0.43[0.514]$$

Short-run Estimates

$$\Delta c_t^p = 0.05 - 0.51\Delta\varepsilon_{t-1}^p$$
$$(7.05)(-3.09)$$

$$RSS = 0.04 \qquad \sigma = 0.04 \qquad \overline{R}^2 = 0.23 \qquad\qquad (41)$$
$$Normality\,test = 2.21[0.332] \qquad LM-test = 0.02[0.895]$$
$$ARCH\ test = 0.77[0.381] \qquad Hetero\,test = 3.88[0.144]$$
$$RESET = 0.10[0.758]$$

The *ADF* statistic for testing the non-stationarity of the residuals is –3.31, higher than that of critical value at the 10 percent level of significance which supports the existence of long-run relationship between real private consumption, real disposable income and real interest rate. Therefore, we estimate short-run dynamics in the form of error-correction model.

Equation (41) presents the results of the short-run error-correction model. In the short-run error-correction model only intercept term and lagged error-correction term is statistically significant. This imp lies that in the short-run real

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[11] Real money balances appears to be insignificant, therefore, we left out these variable from the analysis.

[12] This result further implies that a 10 percent rise in disposable income will results in a direct increase in real private consumption by 9.4 percent in the long-run.

private consumption is determined by some unusual movements in the residuals. This result is in line with the Hall's (1978) predictions that consumption responds unobservable changes in the short-run. The real interest rate also disappeared from the short-run dynamics due to its insignificance. This may reflect the fact that interest rates were not set at market rates in the short-run. The error-correction term is negative and significant, confirms that the error-correction mechanism working correctly and the deviations are corrected at the rate of 51 percent per year to achieve the long-run equilibrium path. The diagnostic tests indicate no misspecification of the estimated model, despite low $\overline{R}^2$.

4.2.2. *Government Consumption*

In Pakistan government consumption heavily depends on the total government revenues and development expenditures relative to GDP. The results reported in Equation (42) suggest that in the long-run development expenditures and government revenues exerts positive influence on government consumption. The elasticities of government consumption with respect to development expenditures and government revenues are 0.19 and 0.32 respectively. The *ADF* statistic for testing the non-stationarity of the residuals is equal to –2.09, which is lower than that of critical value even at the 10 percent level of significance, indicating no long-run relationship between the government consumption, ratio of development expenditures to GDP and government revenues during the period under consideration. Hence, we estimate simple vector autoregressive (VAR) model to examine the short-run dynamics.

Long-run Estimates

$$c_t^g = 9.62 + 0.19 exdevy_t + 0.32\, r_t^g - 0.21 D_{00}$$
$$\quad (16.87)(3.73) \qquad (9.43) \quad (-2.46)$$

$$RSS = 0.44 \qquad \sigma = 0.13 \qquad \overline{R}^2 = 0.91 \qquad ADF = -2.09 \tag{42}$$
$$Normality test = 0.67[0.714] \qquad LM-test = 3.17[0.075]$$
$$ARCH\ test = 1.85[0.173] \qquad Hetero test = 8.43[0.134]$$
$$RESET = 5.91[0.015] \qquad T = 1979 - 2008$$

Short-run Estimates

$$\Delta c_t^g = -0.60 \Delta c_{t-1}^g + 0.10 \Delta exdevy_t + 0.45 \Delta r_{t-1}^g + 0.29 D_{06}$$
$$\quad (-3.81) \qquad (1.60) \qquad (2.98) \qquad (2.56)$$

$$RSS = 0.27 \qquad \sigma = 0.10 \qquad \overline{R}^2 = 0.47 \tag{43}$$
$$Normality test = 0.03[0.985] \qquad LM-test = 0.61[0.434]$$
$$ARCH\ test = 0.01[0.315] \qquad Hetero test = 5.67[0.579]$$
$$RESET = 1.31[0.252]$$

Due to the non-existence of cointegration between government consumption, ratio of development expenditures to GDP and government revenues we have estimated simple VAR model to examine the short-run dynamics. The results reported by Equation (43) reveal that government consumption lagged by one year and government revenues lagged by one year are the significant determinants of government consumption in the short-run. However, the ratio of development expenditures to GDP is significant only at the 15 percent level of significant. The model passes all the diagnostic statistics both in the long-as well as in the short-run.

4.2.3. *Private Investment*

The long-run estimates of the real private investment are given by Equation (44). It is evident from the results that real private investment is significantly determined by real income, ratio of private sector credit to GDP, real interest rate and government investment (I^g). The real income, ratio of private sector credit to GDP and government investment is highly significant with positive impact on real private investment. These results confirm the earlier findings by [Guru-Gharana (2000)] in the case of Pakistan. The positive and significant coefficient of real income verifies the famous accelerator principle. The most striking finding is that government investment has crowding-in effect on real private investment. The findings of crowding-in effect from government investment is inline with a majority of the empirical studies, *inter alia*, Sakr (1993), Looney (1997), Looney and Frederiken (1997), Hyder (2001), Naqvi (2002), Atukeren (2004) and Rashid (2005) in the case of Pakistan. The crowding-in effect of government investment on real private investment implies that despite privatisation efforts, in Pakistan government still play a leading role in influencing private sector activities. The coefficient of private sector credit to GDP is positive and significant which supports the view the supply of funds is an important factor in investment decisions. Furthermore, it also implies that well developed financial markets are essential to mobilise funds for investment purpose. This result confirms the finance-led investment hypothesis in the case of Pakistan. The real interest rate represents the cost of capital, which constraints private investment. The coefficient of real interest rate is negative and significant which supports the view that cost of capital is an important factor in investment decisions.[13] However, the impact of real interest rate is very small (i.e. 0.007), suggesting that a higher real interest rate exerts very weak effect on private investment in the long-run. The presence of interest rate in the investment function also represents a channel through which monetary policy shocks are transmitted to the real sector [Ra and Rhee (2005)].

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[13]Weighted average lending rate is used to calculate real interest rate.

Long-run Estimates

$$i_t^p = 0.70y_t - 0.007r_t^l + 0.11crpy_t + 0.21i_t^g$$
$$\quad (11.48) \quad (-2.28) \quad (515) \quad\quad (2.64)$$

$$RSS = 0.24 \qquad \sigma = 0.09 \qquad \bar{R}^2 = 0.98 \qquad ADF = -3.95^{**}$$
$$Normality\,test = 0.49[0.782] \qquad\qquad LM - test \quad = 2.51[0.113]$$
$$ARCH\ test \quad = 0.02[0.882] \qquad\qquad Heterotest \quad = 20.89[0.007]$$
$$RESET \qquad = 0.26[0.608]$$

(44)

Short-run Estimates

$$\Delta i_t^p = 0.70\Delta y_{t-2} + 0.09\Delta crpy_t + 0.31\Delta i_{t-1}^g - 0.58\varepsilon_{t-1}^i + 0.16D_{02}$$
$$\quad (1.90) \qquad (0.50) \qquad (2.68) \qquad (-3.90) \quad (2.19)$$

$$RSS = 0.09 \qquad \sigma = 0.06 \qquad \bar{R}^2 = 0.49$$
$$Normality\,test = 0.25[0.880] \qquad\qquad LM - test \quad = 4.92[0.027]$$
$$ARCH\ test \quad = 0.83[0.362] \qquad\qquad Heterotest \quad = 14.31[0.112]$$
$$RESET \qquad = 0.18[0.675]$$

(45)

The corresponding value of the *ADF* statistic for the residuals stationarity is 3.95, which yield significance at the 5 percent level of significance, indicating the presence of cointegration among the real private investment and its determinants. Based on the long-run estimates we have estimated short-run error-correction model and Equation (45) reports the results. The short-run estimates suggest that real income lagged by two years and public investment lagged by one year is the important determinant of private investment with positive and significant coefficients. The private sector credit remains insignificant in the short-run. The dummy variable (D_{02}) used to capture the after effects of first generation financial reforms had positive and significant effects on real private investment in the short-run. The lagged error-correction term is significant with theoretical expected sign. Diagnostic tests associated with the short-run error-correction model do not detect any specification problem.

4.3. Fiscal Block

4.3.1. *Direct Tax Revenue*

Equation (46) reports the long-run estimates for direct tax revenues (*dtxr*). The result reveals that nominal income (*ny*) contributes positively to the collection of direct tax revenues. This result supports the theoretical views that direct taxes are positively correlated with nominal income. The variable average tax rate remains insignificant, therefore, we left out this

variable form the analysis. The estimated long-run elasticity of direct taxes with respect to nominal income is 1.22 representing a one percent increase in nominal income translates more then unity increase in direct taxes. This result is inline with previous findings of Mukarram (2001) and Chaudhary and Hamid (2001). The *ADF* test performed on the residuals generated by Equation (47) is equal to -1.84 which is insignificant, indicating no long-run relationship between direct tax revenues and nominal income. The nonstationarity of the residuals forces us to estimate simple VAR model and Equation (47) reports the results. The results show that in the short-run changes in direct tax revenues lagged by one year and growth of nominal income (*ny*) exerts positive impact on the direct tax revenues. The long-run direct tax elasticity with respect to nominal income (*ny*) is 1.22, whereas the short-run direct tax elasticity is 0.75. These results have very important implications in the context of Pakistan.

Long-run Estimates

$$dtxr_t = -7.01 + 1.22ny_t + 0.16D_{98}$$
$$\quad\;\; (-17.94)\;\; (45.03)\;\; (1.52)$$

$RSS = 0.80$	$\sigma = 0.17$	$\bar{R}^2 = 0.99$	$ADF = -1.84$	(46)
$Normality\,test = 0.42[0.811]$		$LM - test = 19.80[0.000]$		
$ARCH\ test = 14.10[0.000]$		$Hetero\,test = 8.92[0.030]$		
$RESET = 5.80[0.016]$		$T = 1979 - 2008$		

Short-run Estimates

$$\Delta dtxr_t = 0.36\Delta dtxr_{t-1} + 0.75\Delta ny_t$$
$$\quad\;\; (2.57)\qquad\quad (3.67)$$

$RSS = 0.19$	$\sigma = 0.08$	$\bar{R}^2 = 0.37$	(47)
$Normality\,test = 2.18[0.335]$		$LM - test = 0.41[0.522]$	
$ARCH\ test = 0.27[0.602]$		$Hetero\,test = 5.33[0.255]$	
$RESET = 0.59[0.444]$	$T = 1981 - 2008$		

4.3.2. Indirect Tax Revenues

Similar to the direct tax revenue, the indirect tax revenues is assumed to depend on the nominal income.[14] The long-run results are reported by Equation (48).

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[14]Because of the insignificance of the average tax rate and inflation rate we left out these variables.

Long-run Estimates

$$indtxr_t = -1.38 + 0.91ny_t - 0.02D_{96}$$
$$\qquad\quad (-2.92)\ \ (26.56)\ \ (0.29)$$

$RSS = 0.51 \qquad \sigma = 0.14 \qquad \overline{R}^2 = 0.98 \qquad ADF = -4.95^*$

$Normalitytest\ = 319.80[0.000] \qquad LM-test\ \quad = 0.23[0.629]$

$ARCH\ test\ \qquad = 0.06[0.804] \qquad Heterotest\ \quad = 1.32[0.725]$

$RESET\ \qquad\qquad = 0.07[0.793] \qquad T = 1979 - 2008$

(48)

Short-run Estimates

$$\Delta indtxr_t = 0.91\,\Delta ny_{t-1} - 0.91\,\varepsilon_{t-1}^{indtxr} + 0.02D_{0406}$$
$$\qquad\qquad (4.71)\qquad\ (-4.42)\qquad\ (0.21)$$

$RSS = 0.51 \qquad \sigma = 0.14 \qquad \overline{R}^2 = 0.41$

$Normalitytest\ \quad = 311.10[0.000] \qquad LM-test\ \qquad = 0.00[1.000]$

$ARCH\ test\ \qquad = 0.05[0.816 \qquad Heterotest\ \quad = 1.34[0.931]$

$RESET\ \qquad\qquad = 0.46[0.497] \qquad T = 1981 - 2008$

(49)

It is found that nominal income (ny) exerts positive impact on the indirect tax revenues in the long-run. The long-run elasticity of indirect tax revenue with respect to nominal income is 0.91, which implies that indirect tax system is neither regressive nor progressive. The *ADF* statistic is -4.95 imply the cointegration among the variables included in Equation (49). In the short-run nominal income lagged by one year (ny_{t-1}) exerts positive impact on indirect tax revenues. The error-correction term is negative and significant implies the existence of cointegration among the variables. The diagnostic tests suggest that except normality, no further problem in the estimated model. Together with the direct tax revenues and indirect tax revenues, government consumption expenditures are determined by government revenues, which, in turn, affect the monetary base [Musila (2002)].

4.4. Foreign Trade Block

4.4.1. *Export Function*

Theoretically exports of goods and services are determined by world income, the real effective exchange rate and relative price of exports. Based on the functional form specified in Equation (23) we have estimated the following long-run equation for exports.

Long-run Estimates

$$x_t = 7.46 + 1.21 y_t^f - 1.13 reer_t - 0.77 rp_t^x$$
$$\qquad (2.21) \ (5.10) \ (-4.02) \quad (-2.77)$$

$RSS = 0.84 \qquad \sigma = 0.16 \qquad \overline{R}^2 = 0.95 \qquad ADF = -5.66^*$ (50)

$Normality test = 3.09[0.213] \qquad LM-test = 16.22[0.000]$

$ARCH \ test = 9.72[0.002] \qquad Heterotest = 7.08[0.313]$

$RESET = 0.33[0.567]$

Short-run Estimates

$$\Delta x_t = 0.10 - 1.72 \Delta y_t^f - 0.67 \Delta reer_{t-1} - 0.35 \Delta rp_{t-1}^x - 0.23 \varepsilon_{t-1}^x$$
$$\qquad (3.38)(-2.14) \quad (-2.46) \qquad (-2.02) \qquad (-2.08)$$

$RSS = 0.29 \qquad \sigma = 0.10 \qquad \overline{R}^2 = 0.30$ (51)

$Normality test = 0.50[0.780] \qquad LM-test = 2.08[0.149]$

$ARCH \ test = 1.68[0.195] \qquad Heterotest = 6.35[0.609]$

$RESET = 1.46[0.226]$

It is evident from the results reported in Equation (50) that all the variables possesses expected sign and are statistically significant at the one percent level of significance in the long-run. The coefficient of world income possesses theoretical expected positive sign, while the real effective exchange rate influences exports negatively. The positive coefficient on foreign income suggests that increase in foreign economic activity would boost the real demand for exports. The negative coefficient of real effective exchange rate implies that increase in competitiveness in the world market would decrease Pakistan's exports in the long-run. Similarly, relative price of exports also influences real exports negatively. The estimated relationship between real exports of goods and services, world income, real effective exchange rate and relative price of export is found to be cointegrating as the *ADF* statistic for residuals stationarity is equal to –5.66, which is significant at the one percent level of significant. Because of the existence of long-run relationship, we have estimated the error-correction model and Equation (51) reports the results.

In the short-run world real income and real effective exchange rate depreciation lagged by one year and relative price of exports lagged by one year exerts significant impact on the real exports. However, surprisingly the coefficient of world real income influences real exports negatively in the short-run. The negative effect of world income on exports implies that some of Pakistan's exported goods are inferior so that as income of foreigners increases they consume fewer of these goods and services in the short-run. The coefficient

on the error-correction term possesses expected negative sign and is statistically significant, which implies that the deviations from the equilibrium path are corrected in the following period. In overall term, the diagnostic statistics indicate that the model is well specified.

4.4.2. *Import Function*

The import of goods and services is estimated as function of real domestic income, real effective exchange rate, relative price of imports and foreign capital inflows. The long-run and short-run estimates are reported in Equation(s) (52) and (53) respectively.

Long-run Estimates

$$im_t = -9.29 + 1.34\,y_t + 0.60\,reer_t - 0.30\,rp^{im} + 0.07\,k_t^f$$
$$\quad\quad (-9.68)\ (14.57)\ (4.48)\ (-3.00)\quad (4.19)$$

$$
\begin{aligned}
RSS &= 0.19 & \sigma &= 0.08 & \overline{R}^2 &= 0.96 & ADF &= -5.66^* \\
Normality\,test &= 0.02[0.990] & & & LM-test &= 0.10[0.748] \\
ARCH\,test &= 0.49[0.484] & & & Hetero\,test &= 8.98[0.344] \\
RESET &= 0.31[0.578]
\end{aligned}
$$

$$(52)$$

Short-run Dynamics

$$\Delta im_t = 0.23\Delta im_{t-1} + 1.42\Delta y_t + 0.47\Delta reer_t + 0.06\Delta k_t^f - 1.15\varepsilon_{t-1}^{im}$$
$$\quad\quad (1.92)\quad\quad (7.54)\quad (2.10)\quad\quad (2.17)\quad\quad (-5.57)$$

$$
\begin{aligned}
RSS &= 0.16 & \sigma &= 0.07 & \overline{R}^2 &= 0.74 \\
Normality\,test &= 1.23[0.539] & & & LM-test &= 1.18[0.277] \\
ARCH\ test &= 0.68[0.410] & & & Hetero\,test &= 6.62[0.915] \\
RESET &= 0.22[0.637]
\end{aligned}
$$

$$(53)$$

It can be seen from the results presented in Equation (53) that domestic real income, real effective exchange rate and foreign capital exerts positive impact on real imports of goods and services in the long-run, whereas relative price of imports produces negative influence on imports. The *ADF* statistic for the residuals stationarity yields the statistic equal to –5.66, which is significant at the one percent level, confirming the long-run relationship among the variables.

The results of short-run model for import of goods and services are given in Equation (53). The results suggest that real imports lagged by one year, real domestic income, real effective exchange rate and foreign capital inflows (k_t^f) produces positive and significant impact on real imports in the short-run. The

error-correction term is negative and significant confirming the existence of cointegration among the variables entered in Equation (53). The overall fit of the model is good as indicated by the diagnostic statistics.

4.5. Monetary and Price Block

4.5.1. *Money Demand Function*

The demand for broad money M_2 is supposed to be influenced by real income (Y) as scale variable and the nominal interest rate (i). Equation (54) reports the estimated long-run results:

Long-run Estimates

$$(m-p)_t = -9.59 + 1.27 y_t - 0.02 i_t + 0.11 D_{05}$$
$$(-25.83)(51.43)\ (-3.19)(2.82)$$

$$RSS = 0.14 \quad \sigma = 0.07 \quad \overline{R}^2 = 0.99 \quad ADF = -3.73^{**} \quad (54)$$
$$Normality test\ = 1.37[0.505] \quad\quad LM-test\ = 10.23[0.001]$$
$$ARCH\ test\ = 1.50[0.220] \quad\quad Hetero test\ = 5.32[0.378]$$
$$RESET\ = 1.46[0.228]$$

Short-run Estimates

$$\Delta(m-p)_t = 0.34\Delta(m-p)_{t-1} + 0.80\Delta y_t - 0.01\Delta i_t - 0.43\varepsilon^m_{t-1}$$
$$(1.96)\quad\quad (3.12)\quad (-2.39)\quad (-2.77)$$

$$RSS = 0.04 \quad \sigma = 0.04 \quad \overline{R}^2 = 0.34 \quad\quad (55)$$
$$Normality test\ = 0.87[0.647] \quad\quad LM-test\ = 1.85[0.173]$$
$$ARCH\ test\ = 0.18[0.668] \quad\quad Hetero test\ = 5.38[0.716]$$
$$RESET\ = 0.79[0.374]$$

It is evident from the estimates presented in Equation (54) that real income (y) and nominal interest rate (i) possesses expected signs and statistically significant in the long-run. The income elasticity of money demand is 1.27. This result is inline with earlier findings of Qayyum (2005) and Khan and Sajjid (2005) among others. The semi-interest elasticity of money demand is equal to –0.02 which is quite low. This implies that domestic financial market is not yet well developed and the interest rates were not set at market rates before 1991. The *ADF* test for the non-stationarity of the residuals is –3.73, which is significant at the 5 percent level of significance, indicating significant long-run co-movements among the variables.

The results of the error-correction model presented in Equation (55) suggest that real money balances lagged by one year, growth of real income lagged by one year and changes in short-term interest rate exerts significant

effects on the real money balances in the short-run. The error-correction term is correctly signed and statistically significant shows that it takes more than 2 years for short-run deviations to converge to the long-run steady-state path. The correct sign and the significance of the error-correction term is an indication of the existence of a valid long-run relationship. The overall fit of the model is good as indicated by the various diagnostic checks.

4.5.2. *Interest rate Function*

The results reported in Equation (56) suggest that nominal money balances, price level and policy discount rate determine the short-term nominal interest rate. The nominal money balances exerts negative impact, while price level exerts positive impact on the short-term nominal interest rate in the long-run. The policy discount rate influences short-term nominal interest rate positively in the long-run. The pass-through effect of discount rate is substantial (i.e. 0.43 percent) on short-term nominal interest rate in the long-run. The *ADF* test performed on the residuals generated by Equation (56) is equal to –3.06, which is insignificant, implying no cointegration between the interest rate, money balances, price level and policy discount rate. The co-movement among the interest rates is very important for the successful conduct of the monetary policy through the changes in policy discount rate. Hence, we have estimated a sample VAR model in difference form to examine the impact of policy discount rate on short-term market interest rate and Equation (57) reports the result.

Long-run Estimates

$$i_t = -12.27m_t + 18.15p_t + 6.28y_t + 0.43dr_t - 1.35D_{9104}$$

$$(-4.75) \quad (4.52) \quad (5.03) \quad (4.26) \quad (-2.14)$$

$RSS = 67.97 \qquad \sigma = 1.46 \qquad \overline{R}^2 = 0.59 \qquad ADF = -3.06$ (56)

$Normality test \quad = 0.51[0.775] \qquad LM-test \quad = 4.31[0.038]$

$ARCH \ test \quad = 0.62[0.430] \qquad Hetero test \quad = 8.43[0.230]$

$RESET \quad = 12.17[0.204]$

Short-run Estimates

$$\Delta i_t = 0.49\Delta dr_{t-1}$$

$$(3.87)$$

$RSS = 54.53 \qquad \sigma = 1.37 \qquad \overline{R}^2 = 0.34$ (57)

$Normality test \quad = 6.48[0.039] \qquad LM-test \quad = 0.30[0.582]$

$ARCH \ test \quad = 0.11[0.735] \qquad Hetero test \quad = 0.12[0.941]$

$RESET \quad = 2.33[0.127]$

It is clear from the results reported in Equation (57) that unlike the long-run, in the short-run only changes in discount rate lagged by one year exerts positive and significant impact on nominal short-term interest rate. The short-run pass-through effect of policy rate on current nominal market interest rate is completed after one year. The overall fit of the equation is very good as indicated by the diagnostic statistics apart from normality test.

4.5.3. *Price Equation*

The domestic price level proxied by consumer price index (CPI) is significantly determined by real income, nominal money balances, interest rate, import price index and dummy variable D_{03} used to capture the effect of after 9/11 event. Equations (58) and (59) report the long-run and short-run estimates respectively:

Long-run Estimates

$$p_t = 3.61 + 0.51m_{2t} - 0.53y_t + 0.007i_t + 0.28\,p_t^f - 0.13\,D_{03}$$
$$\quad (2.40)(10.09) \quad (-3.75) \quad (2.25) \quad (6.83) \quad (-5.09)$$

$$RSS = 0.03 \qquad \sigma = 0.03 \qquad \bar{R}^2 = 0.99 \qquad ADF = -4.22^*$$
$$Normality\,test = 0.46[0.795] \qquad LM-test \quad = 7.11[0.008]$$
$$ARCH\ test \quad = 11.31[0.001] \qquad Hetero\,test \quad = 26.39[0.002]$$
$$RESET \qquad = 6.63[0.010]$$

(58)

Short-run Estimates

$$\Delta p_t = 0.30\Delta p_{t-2} - 0.18\Delta y_{t-1} + 0.24\Delta m_{2\,t-1} + 0.004\Delta i_t + 0.16\Delta p_t^f + 0.12\Delta p_{t-1}^f$$
$$\quad (3.87) \qquad (-1.08) \qquad (3.45) \qquad (1.88) \qquad (4.25) \qquad (3.21)$$

$$-0.29\varepsilon_{t-1}^p$$
$$(-2.21)$$

(59)

$$RSS = 0.009 \qquad \sigma = 0.02 \qquad \bar{R}^2 = 0.79$$
$$Normality\,test \quad = 0.43[0.808] \qquad LM-test \quad = 0.04[0.842]$$
$$ARCH\,test \quad = 0.11[0.741] \qquad Hetero\,test \quad = 14.93[0.383]$$
$$RESET \quad = 0.39[0.531]$$

The results reported in Equation (58) suggest that foreign price level, money supply and interest rate are the main factors accelerating inflationary pressure in Pakistan in the long-run. The impact of money supply is 0.51 percent on domestic price level, followed by import prices (0.28 percent) and interest rate (0.004 percent). On the other hand, the coefficient of real output is

–0.53 implies that an increase in real GDP would significantly depresses the inflationary pressure by 0.53 percent in the long-run. In overall term, the result supports the view that monetarist and structuralist factor are responsible in accelerating inflationary pressure in Pakistan in the long-run. To examine the cointegration among the variables we employ *ADF* test on the residuals obtained from Equation (58). The *ADF* statistic is equal to –4.22, which is significant, indicating the existence of cointegration among the variables. Therefore, we estimate the error-correction model to examine the short-run dynamics.

The results of the error-correction model are reported in Equation (59) suggest that expected inflation (i.e. Δp_{t-2}), monetary growth and growth in imports prices are significantly accelerating inflation in Pakistan in the short-run. These findings are consistent with earlier findings of Khan and Qasim (1996). The error-correction term is negative and significant, indicating that the past period's deviations are corrected in the current period at the rate of 29 percent per year. However, this speed of convergence is very low. On the whole, the model fit well as indicated by the battery of diagnostic tests.

5. MODEL EVALUATION AND FORECASTING

In this section the results of two set of simulation experiments are reported following Musila (2002). The first set of experiment evaluating the predictive accuracy of the model. In this regards, the experiment requires that the structural model be solved simultaneously for the current values of endogenous variables conditional on the given values of exogenous and pre-determined variables. The second set of experiment is conducted by taking judgmental values of some selected exogenous variables to determine the responses of the endogenous variables. Both set of experiments were conducted using long-run elasticities.[15]

5.1. Forecast Evaluation

It can be argued that well-specified individual equations are pre-requisite for a good macroeconometric model. From the statistical prospective individual equations should exhibit high $\overline{R}^2$ with significant coefficients of the variables. However, the statistical accuracy does not necessarily imply a good performance of the model as whole [Ra and Rhee (2005)]. The criterion used to evaluate the performance of the model over the entire sample period is that how the estimated equations are linked to each other with plausible coefficients of the variables and how closely each endogenous variable tracks its corresponding historical data series [Rashid (1981); Ra and Rhee (2005) and Rankaduwa, *et al*. (1995)].

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[15]The advantage of using long-run elasticities is that it excludes much of the dynamics and provides useful framework in identifying key linkages in the model (Musila, 2002). We are still working on the 'Dynamic Macroeconometric Model of Pakistan's Economy' and will considering the simulation experiments with short-run elasticities in sometime future studies.

The validity of the present model is checked via the mean absolute percentage errors (*MAPE*) and the Theil's inequality coefficient (*U*). The two measures are scaled invariant and can be used to assess the forecasting performance of a model directly. Theil's inequality coefficient compares the forecast with the random walk and always lies between zero (i.e. zero indicate perfect fit) and one (i.e. forecast is not better than that of the random walk). The *MAPE* is not normalised but it should be as smaller as possible. If *MAPE* is equal to zero, there has no error while forecasting [Green (2003) and Tjipe, *et al.* (2004)]. Table 1 summarises the forecast evaluation for key endogenous variables.

Table 1

Model Validation Statistics

Variable	MAPE	Theil's Inequality (*U*)
Agriculture Sector Value Added	2.99	0.02
Manufacturing Sector Value Added	4.01	0.02
Services Sector Value Added	4.00	0.03
Real Private Consumption	3.09	0.02
Real Government Consumption	10.17	0.07
Real Private Investment	6.57	0.04
Demand for Real Money Balances	4.16	0.03
Short-term Nominal Interest Rate	18.66	0.08
Consumer Price Index	2.03	0.03
Direct Tax Revenues	13.04	0.04
Indirect Tax Revenues	0.02	0.006
Export Demand	10.17	0.05
Import Demand	5.53	0.03

The mean absolute percentage errors (*MAPE*) and the Theil's inequality coefficient (*U*), for key macroeconomic variables are reported in Table 1, which indicate that the model is able to track the historical developments of the Pakistan's economy reasonably well. The *MAPE* is reasonable and lies within the range of 0.02 to 10 percent except for short-term nominal interest rate and direct tax revenues. One reason for unsatisfactory forecast of the interest rate could be the structural and institutional factors that have influences interest rate since 1990. Since taxes are related to nominal GDP, unsatisfactory forecast of the interest rate has also affected the forecast of the direct tax revenues. The Theil's inequality coefficient (*U*) is less than unity and close to zero for all the endogenous variables. The overall forecast ability of the estimated equations is satisfactory and the model has good forecasting ability as indicated by *MAPE* and *U* statistics.

5.2. Model Building

After obtaining the satisfactory forecast performance of each equation (in level form), now we built the model based on estimated behavioural equations to assess the in-sample performance of the model before the policy simulation. We then compare the actual data with in-sample simulation to evaluate the accuracy of the model. The summary of the stochastic equations and identities in a functional form are reported in Table 2.

Table 2

List of Equations Included in the Model

Production Block

Stochastic Equations
$$Y_t^a = f(L_t^a, CD_t^a, W_t, IFRS_t)$$

$$Y_t^m = f(L_t^m, DC_t^m, IFRS_t, IMM_t, DRM_t)$$

Identity
$$Y_t^s = f(RAD_t)$$

$$GDP_t = Y_t^a + Y_t^m + Y_t^s$$

Aggregate Demand Block

Stochastic Equations
$$P_t^c = f(Y_t^d, r_t^d, D_{00})$$

$$C_t^g = f\left(EXDEVY_t, R_t^g\right)$$

$$I_t^p = f(Y_t, i_t^l, CRPY_t, I_t^g)$$

Identity
$$Y_t = A_t + (X_t - M_t)$$

$$A_t = C_t + I_t + G_t$$

$$C_t = C_t^p + C_t^g$$

$$C_t^g = EXDEV_t + EXCD_t$$

$$I_t = I_t^p + I_t^g$$

$$Y_t = C_t + I_t + G_t + (X_t - M_t) + \Delta stocks$$

$$Y_t^d = (GDP_t - DTXR_t - INDTXR_t + WREM_t + CRP_t) / CPI_t$$

Fiscal Block

Stochastic Equations
$$DTXR_t = f(NY_t, D_{04})$$

$$INDTXR_t = f(NY_t, D_{05})$$

Identity
$$BD_t = (EX_t^g - R_t^g)$$

$$R_t^g = DTXR_t + INDTXR_t + NTXR_t$$

$$EX_t^g = EXCUR_t + EXDEV_t + EXCD_t$$

Foreign Trade Block

Stochastic Equations
$$X_t = f(REER_t, Y_t^f, RP_t^x)$$

Identity
$$IM_t = f(REER_t, Y_t, RP_t^{im}, K_t^f)$$

$$TB_t = (X_t - IM_t)$$

Monetary and Price Block

Stochastic Equations
$$\left(\frac{M_t^d}{P_t}\right) = f(Y_t, i_t, D_{05})$$

$$i_t = f(M_t^s, P_t, dr_t, D_{03})$$

$$P_t = f(M_t^s, Y_t, i_t, P_t^f, D_{03})$$

Note: In the empirical section we have used lower case letters which represents the logarithms of all the variables except for interest rates

We solve the model for the period 1980-2009 to assess the in-sample forecasting ability of the model and compare the actual valu es for all the endogenous variables with the in-sample simulated values. The solution paths for the endogenous variables are depicted in Figure 1.

Figure 1 depicts the trajectories of the *ex post* simulation along with the actual values of the endogenous variables over the period 1980-2009. It is clear from the Figure 1 that the simulation tracks the actual time paths for all the endogenous variables very well. The responses of each endogenous variable to the simulation are inline with the expected signs and the coefficients and the assumed interrelationships between the series.

Fig. 1.   In-sample Forecast of the Model, 1980-2009
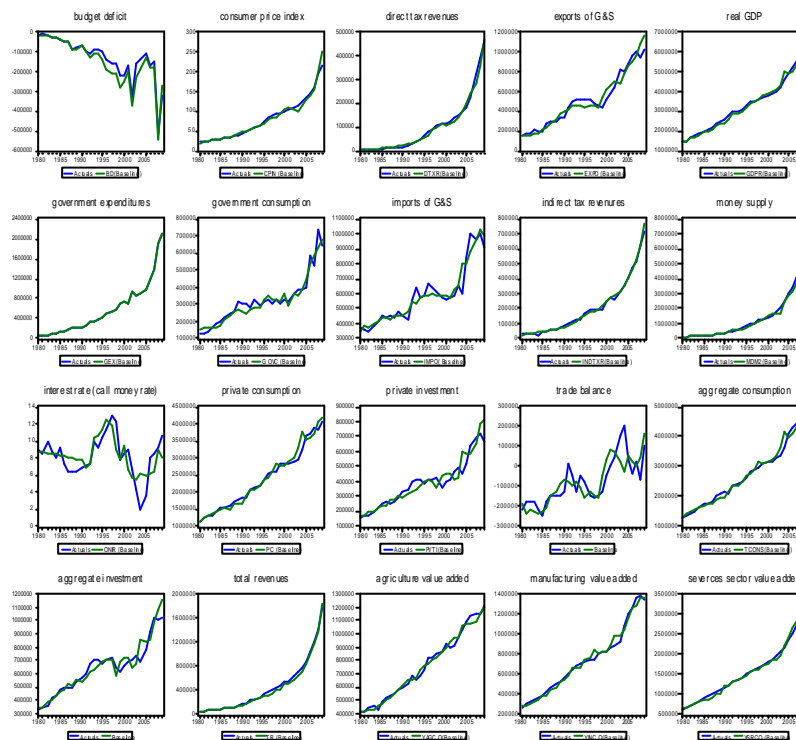
5.3. Out-of-Sample Forecast

One of the objectives of the present modeling exercise is to examine the impact of changes in exogenous variables on the current values on endogenous variables. To achieve this objective we have solve the estimated model to obtain

the future path of the endogenous variables by considering judgmental (projected) values of some selected exogenous variables.[16] The projection of private sector credit, government investment, policy discount rate and world output are taken from the various sources (e.g. Ministry of Finance Government of Pakistan and Report of the Panel of Economists of Planning Commission Government of Pakistan) and World Economic Outlook of International Monetary Fund and OECD Economic Outlook. We assume constant growth for the remaining exogenous variables. Based on these information we have solved the model from 1980-2013. Table 3 reports the projected values of some selected macroeconomic variables.

Table 3

Out-of-Sample Forecast Results (in % Changes)

|	2009	2010	2011	2012	2013	Average
Real GDP	3.71	1.82	2.60	5.36	6.89	4.08
Inflation	14.42	13.75	13.96	14.95	15.46	14.51
Private Consumption	4.36	−2.44	−1.11	2.49	4.57	1.57
Government Consumption	7.43	17.81	12.32	12.41	12.71	12.54
Private Investment	−12.30	0.97	0.98	5.18	6.71	0.31
Money Supply (M2)	20.29	16.03	16.09	23.09	26.17	20.34
Exports of Goods and Services	6.50	7.28	9.23	9.88	10.21	8.82
Import of Goods and Services	−6.02	−1.30	0.03	3.99	6.19	0.57
Direct Tax Revenues	30.62	12.38	14.90	18.67	22.47	19.81
Indirect Tax Revenues	22.0	9.08	10.88	13.59	16.28	14.37

Note: Negative (–) values indicate decrease and positive values indicate increase. Average is taken from 2010-2013.

The growth rate of GDP is projected to 1.82 percent for the year 2010. This could be due to external shocks attributed by energy shortage, after effects of the hikes of global food and oil prices, depreciation of Pak-rupee, global financial crisis and deterioration of security and law and order situation in Pakistan. However, the sign of recovery is expected from 2011 and real GDP growth rate approaches to 6.9 percent by the year 2013. The average growth rate is expected for the period 2009-2013 is 4.08 percent. The projected trends of GDP growth rate is depicted in Figure 2.

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[16]We have considered the values for policy discount rate as: for the year 2010=12.5 percent, for 2011=13.0 percent, for 2012=12.0 percent and for 2013=11 percent.

Private sector credit growth assumed for the year 2010=5.06 percent, for 2011=8.00 percent, for 2012=10 percent and for 2013=13 percent.

Government investment growth for 2010=5.66 percent, for 2011=5.66 percent, for 2012=−1.96 percent and for 2013=1 percent (note: negative values indicate decrease in the growth rate). While, assuming the remaining exogenous variables follow the growth rate of the year 2009 for the entire period of 2010-2013.

**Fig. 2. Projected Trends of GDP Growth Rate (2009-2013)**
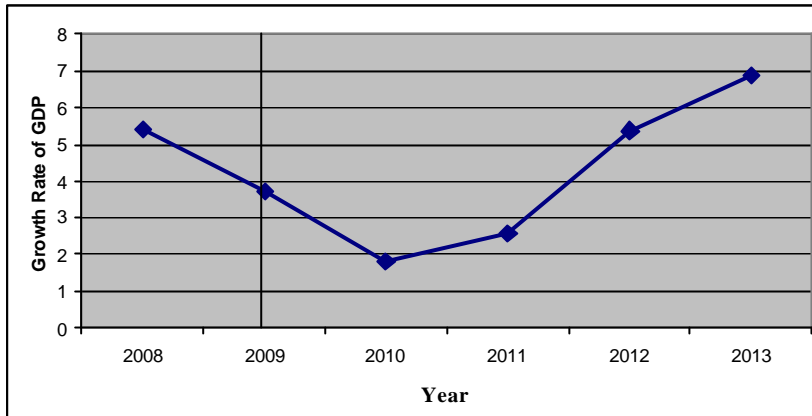
The model predicts that inflation rate will remains in double digit over the period 2010-2013. The average inflation rate for 2010-2013 will be 14.5 percent. Therefore, tight monetary policy stance does not have any impact on the inflation in future. The inflationary trends can be examined in Figure 3.

Fig. 3. Projected Trends of Inflation
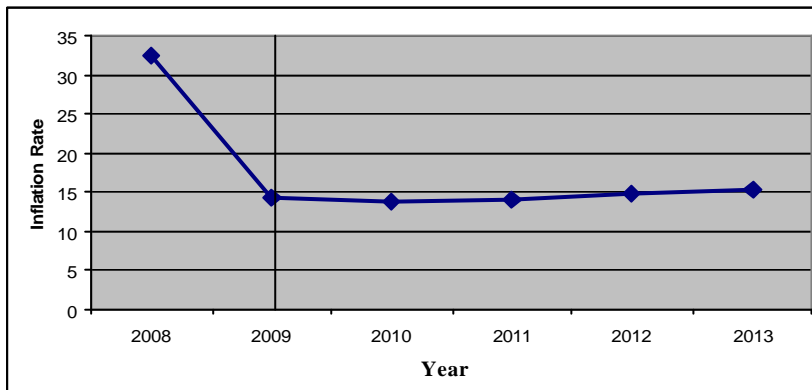
The projection of private investment suggests that real private investment takes positive growth since 2010. However, the signs of recovery have been seen since 2009. The positive and sustainable growth in real private investment is expected for the period 2010-2013 subject to the improvements in the business conditions and law and order situation in the country. The increasing growth in private investment stimulates growth rate of GDP as depicted in Figure 1. The projected behaviour of real private investment over the period 2009-2013 can be seen in Figure 4.

Fig. 4. Projection of Private Investment (%)
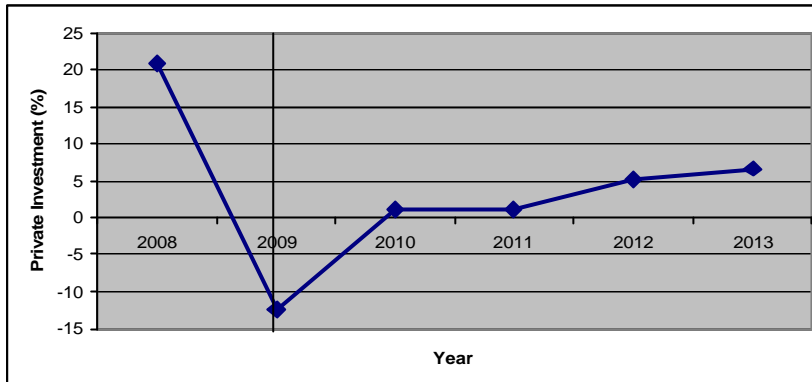
The projection of real private consumption (*PC*) and real government consumption (*GC*) shows that real private consumption decreases successively for the year 2010 and 2011. After 2011 it starts increasing gradually and reached to 4.6 percent by the year 2013. Whereas, the government consumption is expected to decrease from 17.8 percent in 2010 to 12.3 percent in 2011, for the coming years it almost remains constant at the 12.5 percent. Figure 5 give a clear picture of real private and government consumption.

Fig. 5. Projection of Private and Government Consumption (%)
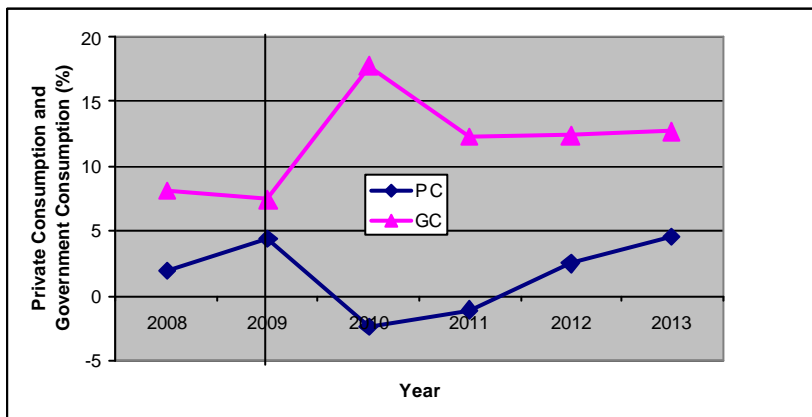
Export of goods and services and import of goods and services showing rising trends over the period 2009-2013. However, exports are expected to increase faster than that of imports of goods and services. The expected average growth rate of exports and imports is 8.8 and 0.57 percent during the period 2009-2013. Figure 6 depicts the projected trends of exports and imports.

Fig.6. Projected Trends of Export and Import of Goods and Services (%)
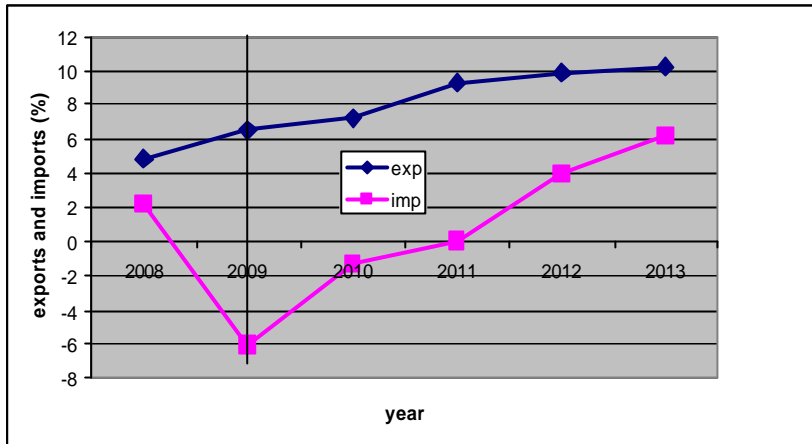
The projection of direct tax revenues (DTXR) and indirect tax revenues (INDTR) reveals decreasing trends for the year 2009-2010. After 2010 growth in both sources revenue is expected to pick up and reached to 22.5 and 16.3 percent respectively by the year 2013. Figure 7 depicts the projection of direct tax revenues and indirect tax revenues.

Fig. 7. Projection of Direct and Indirect Tax Revenues (2008-2013)
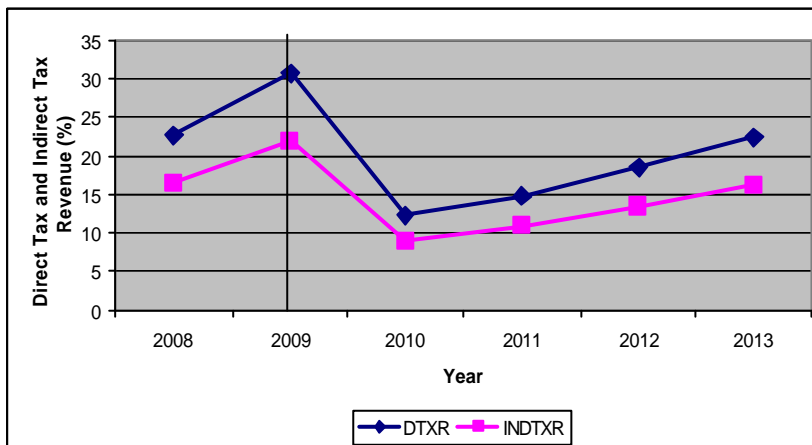
On the whole, forecasts of key macroeconomic variables showing optimistic future outlook of Pakistan's economy. However, these forecasts depend on the exogenous assumptions that we have made and future developments of the Pakistan's economy.

6. CONCLUDING REMARKS

This study has described the structure of a small-scale dynamic macroeconometric model of the Pakistan's economy. The primary objectives of this study are: first, to construct a medium-scale dynamic macroeconometric model for Pakistan that capture the nexus between output, aggregate demand, fiscal, monetary and external sectors of the economy. Second, use the estimated elasticities of the model to perform simulation experiments and assess the effects of changes in exogenous variables on the key macroeconomic variables.

Since macroeconometric modelling is a very complex exercise because the working of present day economy is very complicated; therefore we hardly claim that our model gives detailed picture of the Pakistan's economy. However, the present model does focus attention to study the behaviour of some key macroeconomic variables and provides some useful findings for the policymakers. The model is estimated using time series data for the period 1972-2009 and the estimated parameter are used to determine the effects of changes in some selected exogenous variables on the key macroeconomic variables. The main findings are summarises below:

1 Infrastructure, water and labour force play a significant role in the agriculture sector in the long-run. In the short-run, infrastructure and credit disbursed to agriculture sector significantly affect the agricultural productivity. In the manufacturing sector labour force, infrastructure, import of industrial machinery and raw material exerts positive and significant impact on the manufacturing sector in the long-run. However, in the short-run infrastructure and lagged manufacturing value added plays a dominant role in enhancing the productivity of manufacturing sector. The effect of credit disbursed to manufacturing sector exerts negative impact in the long-as well as in short-run. The contribution of services sector is significantly determined by the real aggregate absorption in the long-run as well as in the short-run.

2. Real private consumption is significant determined by the real disposable income and real interest rate in the long-run. However, in the short-run, real disposable income and real interest rate plays no role in the determination of real private consumption and short-run consumption is affected by some unobservable fluctuations in residuals . In case of government consumption, development expenditures relative to GDP and government revenues are the major determinants in the long-run. The impact of government revenues is larger than that of development expenditures relative to GDP in the long-run. In the short-run development expenditure and government revenues lagged by one year is positively and significantly influences the government consumption. Private investment is determined by real

income, real interest rate, government investment and ratio of private sector credit to GDP in the long-run. However, among all real income plays a dominant role in the determination of private investment in the long-run as well as in the short-run. Government investment is positive and significant influences private investment implies that government investment exerts crowding-in effect on private investment in long-as well as in short-run. Furthermore, the positive coefficient of private sector credit provides an indication for the effectiveness of credit channel of the monetary policy both long-as well as in short-run. The small coefficient of the real interest rate implies that interest rate channel of the monetary policy is weak and is not much effective in Pakistan.

3. In the fiscal sector, nominal income is the main determinant of direct tax and indirect tax revenues in the long-run and in the short-run. A one-to-one correspondence between direct tax revenues and nominal income is found in the long-run. Revenues from indirect taxes are also highly responsive to the nominal income and the income elasticity is close to unity.

4. In external sector, foreign income, real effective exchange rate and relative price of exports are the most important determinants of exports in the long-run and in the short-run. Similarly, domestic real income, real effective exchange rate, relative price of imports and capital inflows are the main factors influencing the demand for imports in the long-run. In the short-run, real income, real effective exchange rate and capital inflows affects the demand for imports significantly.

5. In monetary sector, the main determinants of money demand include real income and short-term nominal interest rate in the long-run as well as in the short-run. The short-term nominal interest rate is significantly determined by nominal money balances, domestic price level and policy discount rate in the long-as-well as in the short-run. Furthermore, money supply, real GDP, interest rate and foreign prices are the major determinants of general price level in the long-run. Among these factors, the impact of money supply is much larger (i.e. 0.51) than that of foreign price level (0.28) and interest rate (0.007) in the long-run. Similarly, the overall impact of foreign price level (i.e. 0.28) on general price level is larger than that of money supply (i.e. 0.24) and interest rate (0.004) in the short-run. Furthermore, the impact of expected inflation (i.e. general price level lagged by two years) is another major factor influences general price level in the short-run. Real income exerts negative and significant influence on domestic price level in the long-run and in the short-run.

6. The performance of the model is evaluated using mean absolute percentage error and Theil's inequality forecasting criterion. The results of both statistics suggest that the model is able to track the historical values of all the endogenous variables.

7. The long-run elasticities of the model are used to carry out-of-sample forecasts for the period 2009-2013. The projection of major macroeconomic indicators reveals positive trends for the forecast period. Particularly, real GDP, private investment, revenues and exports growth expected to remains positive. Similarly, average CPI-inflation rate is expected to remain at 14.5 percent for the period 2011 to 2013. The model-based simulation results give an indication of optimistic future outlook for the Pakistan's economy.

One the whole, the estimated model generally yields plausible results. Our sole objective is to build a medium-size dynamic macroeconometric model of Pakistan's economy, so it is very hard to carry out in depth analysis of any particular sector or direction. However, the present model has explored a number of important macroeconomic dynamics and these results are theoretically consistent and plausible in the context of Pakistan. Although, the present model describes the behaviour of demand side and supply side of the Pakistan's economy with in the dynamic framework. However, there are still several limitations. Lack of accurate and reliable data is always a big issue for any quantative study, for this reason the specification of the present model is very simple one. Besides this, out-of-sample forecast is based on certain judgmental assumptions on the future development of the exogenous variables; hence there is a need to consider different possible scenarios instead of one point forecast. In addition, there is also need to carry out simulations based on short-run elasticities. We are still working on the model simulation experiments to evaluate the impact of changes in exogenous variables on endogenous variables with different scenarios and short-run parameters.

However, the present modeling exercise unearthed a number of important dynamics in the context of Pakistan's economy and provide an important platform and scope for in-depth research in future.

Appendices

Table 4

Definition and Construction of Variables

S. No.	Variable	Definition
1	BD_t	Budget deficit calculated as the difference between government total expenditures and government total revenues
2	$CONS_t$	Aggregate consumption calculated as the sum of private consumption (C_t^p) and government consumption (C_t^g).
3	CPI_t	Consumer price index (2000=100)
4	$DTXR_t$	Direct tax revenue
5	X_t	Exports of goods and services at constant prices
6	Y_t	Real Gross Domestic Product at constant prices
7	C_t^g	Government consumption at constant prices
8	IM_t	Imports and goods and services at constant prices
9	$INDTXR_t$	Indirect tax revenue
10	M_{2t}	Money Supply (M2 definition)
11	i_t	Interest rate (overnight call money rate)
12	C_t^p	Private consumption at constant prices
13	I_t^p	Private Investment (i.e. gross fixed capital formation at constant prices).
14	TB_t	Trade balance define as the difference between exports of goods and services (X_t) and imports of goods and services (IM_t).
15	R_t^g	Government total Revenues calculated as sum of direct tax revenues ($DTXR_t$), indirect tax revenues ($INDTXR_t$) and non-tax revenues ($NTXR_t$).
16	Y_t^a	Agriculture sector value added
17	Y_t^m	Manufacturing Sector value added
18	Y_t^s	Services sector value added
19	CD_t^a	Credit Disbursement to Agriculture Sector
20	$\Delta stocks$	Change in Stocks
21	CRP_t	Credit to Private Sector
22	$CRPY_t$	Ratio of private sector credit to GDP calculated as private sector credit divided of GDP.
23	CD_t^m	Credit Disbursement to Manufacturing Sector
24	DR_t	Discount Rate
25	$EXDEV_t$	Development Expenditures

Table 4—(*Continued*)

26	$EXDEVY_t$	Ratio of development expenditures to GDP calculated as development expenditures divided by GDP
27	NY_t	Nominal GDP
28	EX_t^g	Total Government expenditures
29	I_t^g	Government Investment (i.e. public sector gross fixed capital formation at constant prices)
30	IMM_t	Import of Machinery
31	W_t^a	Water availability proxied by number of Tube Wells
32	L_t^a	Labour force engaged in agriculture sector
33	L_t^m	Labour force engaged in manufacturing sector
34	DR_t	Nominal exchange rate
35	$NTXR_t$	Non-tax government revenue
36	P_t^x	Price of exports proxied by unit value of exports (2000=100)
37	P_t^m	Price imports proxied by unit value of imports (2000=100)
38	RAD_t	Real aggregate demand (absorption) calculated as sum of aggregate consumption, investment and government expenditures at constant prices
39	$IFRS_t$	Infrastructure proxied by Total Road Length (in 000 kilometers)
40	r_t^d	Real interest rate calculated as Weighted Average Deposit Rate minus inflation rate.
41	r_t^l	Real interest rate calculated as Weighted Average Lending Rate minus inflation rate.
42	$REER_t$	Real Effective Exchange Rate
43	Y_t^d	Real Disposable Income calculated as (nominal GDP-total taxes+worker's remittances+private sector credit) divided by CPI
44	Y_t^f	Foreign Real Income (i.e. US income) calculated as UN income multiplied by nominal exchange rate.
45	K_t^f	Foreign Capital inflo ws proxied by foreign Direct Investment (FDI)
46	P_t^f	Foreign price proxied by the unit value of imports (2000=100)
47	RP_t^x	Relative price exports calculated as price of exports divided by CPI
48	RP_t^{im}	Relative price imports calculated as price of imports divided by CPI
49	DRM_t	Domestic raw material proxied by the agriculture value added

Table 5

List of Variables Included in the Model

S. No.	Variable	Unit	Definition
		Endogenous	
1	BD_t	Million Rs	Budget deficit
2	$CONS_t$	Million Rs	Aggregate consumption
3	CPI_t	Index 2000=100	Consumer price index
4	$DTXR_t$	Million of Rs	Direct tax revenue
5	X_t	Million of Rs	Exports of goods and services at constant prices
6	Y_t	Million of Rs	Real Gross Domestic Product at constant prices
7	C_t^g	Million of Rs	Government consumption at constant prices
8	IM_t	Millions of Rs	Imports and goods and services at constant prices
9	$INDTXR_t$	Millions of Rs	Indirect tax revenue
10	M_{2t}	Millions of Rs	Money Supply (M2 definition)
11	i_t	Percent	Interest rate (overnight call money rate)
12	C_t^p	Millions of Rs	Private consumption at constant prices
13	I_t^p	Millions of Rs	Private Investment (i.e. gross fixed capital formation)
14	TB_t	Millions of Rs	Trade balance
15	R_t^g	Millions of Rs	Government total Revenues
16	Y_t^a	Millions of Rs	Agriculture sector value added
17	Y_t^m	Millions of Rs	Manufacturing sector value added
18	Y_t^s	Millions of Rs	Services sector value added
		Exogenous	
1	CD_t^a	Millions of Rs	Credit Disbursement to Agriculture Sector
2	$\Delta stocks$	Millions of Rs	Change in Stocks
3	CRP_t	Millions of Rs	Credit to Private Sector
4	CD_t^m	Millions of Rs	Credit Disbursement to Manufacturing Sector
5	D_{00}	–	Dummy Variable for 2001-2007 = 1, 0 otherwise

Continued—

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Table 5—(*Continued*)

6	D_{03}	–	Dummy variable for 2003-2008=1, 0 otherwise
7	D_{04}	–	Dummy variable for 2004-2005=1, 0 otherwise
8	D_{05}	–	Dummy Variable for 2005-2008=1, 0, otherwise
9	D_{0508}	–	Dummy variable for 2005-08=1, 0 otherwise
10	D_{90}	–	Dummy Variable for 1991-1992=1, 0 otherwise
11	D_{9099}	–	Dummy variable for 1990-99 =1, 0 otherwise
12	DR_t	%	Policy Discount Rate
13	$EXDEV$	Millions of Rs	Development Expenditures
14	NY_t	Millions of Rs	Nominal GDP
15	EX_t^g	Millions of Rs	Government expenditures
16	I_t^g	Millions of Rs	Government Investment
17	IMM_t	Millions of Rs	Import of Machinery
18	W_t	Nos.	Water Availability
19	L_t^a	000 persons	Labour force engaged in agriculture sector
20	L_t^m	000 persons	Labour force engaged in manufacturing sector
21	E_t	Rupee/US Dollar	Nominal exchange rate
22	$NTXR_t$	Millions of Rs	Non-tax government revenue
23	P_t^x	Index	Exports price index (2000=100)
24	P_t^{im}	Index	Import price index (2000=100)
25	RAD_t	Millions of Rs	Real aggregate demand (absorption)
26	$IFRS_t$	000 kilometer	Infrastructure
27	r_t^d	%	Real interest Rate (deposits)
28	r_t^l	%	Real Interest Rate (lendings)
29	$REER_t$	Index	Real Effective Exchange Rate
30	Y_t^d	Millions of Rs	Real Disposable Income
31	Y_t^f	Millions of Rs	Foreign Real Income
32	K_t^f	Millions of Rs	Foreign Capital inflows
33	DRM_t	Millions of Rs	Domestic raw material

Table 6

Unit Root Test Results

Series	None/Constant/Trend	ADF-Level	ADF-First Difference
p_t	C and T	–2.443 (1)	–3.539 (0)*
p_t^f	C and T	–2.343 (1)	–4.983 (1)*
$dtxr_t$	C	–2.108 (2)	–3.433 (1)*
$Indtxr_t$	C	–2.408 (1)	–6.592 (1)*
x_t	C	–0.883 (2)	–6.191 (0)*
im_t	C	–1.929 (0)	–5.281 (0)*
y_t	C	–1.932 (2)	–3.844 (0)*
ny_t	C	–1.280 (0)	–3.902 (0)*
y_t^d	C	–0.647 (0)	–5.688 (0)*
m_{2t}^d	C	–1.948 (2)	–3.521 (1)*
i_t	C	–2.137 (0)	–5.098 (0)*
r_t^d	C	–2.274 (2)	–4.771 (0)*
r_t^l	C	–1.823 (0)	–3.986 (2)*
dr_t	C	–1.942 (0)	–5.512 (0)*
c_t^p	C	–1.219 (2)	–6.430 (0)*
c_t^g	C	–1.828 (0)	–8.724 (0)*
i_t^p	C	–0.909 (0)	–5.264 (1)*
i_t^g	C	–3.615 (0)*	–4.951 (2)*
y_t^a	C	–0.500 (0)	–5.836 (0)*
y_t^m	C	–1.372 (1)	–3.916 (2)*
y_t^s	C	–1.377 (2)	–4.092 (2)*
dc_t^a	C	–0.397 (2)	–3.353 (2)*
dc_t^m	C	–0.504 (2)	–3.211 (1)*
$cpry_t$	C	–0.735 (2)	–3.203 (2)*
dr_t	C	–1.942 (0)	–5.512 (0)*
$exdevy_t$	C	–2.507 (1)	–3.619 (2)*
imm_t	C	–1.401 (0)	–6.489 (0)*
w_t	C	–0.900 (1)	–4.773 (0)*
$ifrs_t$	C	–1.851 (1)	–3.955 (0)*
l_t^a	C and T	–1.939 (0)	–6.239 (0)*

Continued—

Table 6—(*Continued*)

l_t^m	C	–0.243 (0)	–7.324 (0)*
rad_t	C and T	–0.055 (2)	–5.207 (1)*
$reer_t$	C	–1.072 (1)	–4.576 (0)*
rp_t^x	C	–1.618 (2)	–7.614 (0)*
rp_t^{im}	C and T	–2.048 (0)	–5.214 (0)*
y_t^f	C	–1.051 (2)	–3.999 (2)*
r_t^g	C	–2.442 (0)	–5.573 (1)*
k_t^f	C	–0.822 (1)	–4.405 (0)*
Critical Values	Level of Significance	Constant	Constant and Trend
	1%	–3.63	–4.24
	5%	–2.95	–3.54

Note: Number of lags is selected on the basis of AIC. Figures in parentheses indicate number of lags. * indicate significant at the 1 percent level of significance. For first difference ADF test only constant is included. Lower case letters represents the logarithmic values except interest rates. C stands for constant and T for trend.

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