STRUCTURAL CHANGES AND ECONOMIC GROWTH IN PAKISTAN

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Abstract

Over the time period, the structure of the economy does not remain same. This study examines the interaction between economic growth and its determinants for Pakistan. Since fixed parameter approaches do not take into account effect of structural changes on parameter constancy, the study employs Kalman Filter based time-varying parameter approach for the empirical analysis. Result shows significant effect of inflation, gross fixed capital formation, gross national expenditures and remittances received on economic growth of the country. However, the effect of significant macroeconomic determinants on growth process of the country is not constant but time-varying.

Keywords: Kalman Filter, Rolling Regression, Inflation, Economic Growth.
JEL Classification: E31, E51, F24, F41.

I. Introduction

Economic growth has remained the focus of researchers and policy makers around the world for a long time. It is considered the most important indicator of country's economic health and refers to the annual percentage change in national income of the country. Sustainable long run economic growth has been considered the most important factor behind higher living standards in rich countries.

Economic growth has both opportunities and obstacles for the country. Increase in economic activity creates employment opportunities, which in turn leads to reduction in unemployment in the economy through Okun's Law [Higgins (2011)]. Government tax collection also expands with the increase in the size of the economy. As a result, government spending on social indicators such as provision of better education [Asteriou and Agiomirgianakis (2001)], improved living standard and reduction in poverty [Dollar, et al. (2016)], better infrastructure [Canning and Pedroni (2004)] and provision

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of improved health facilities [Rivera and Currais (2010)], also expand. Increased economic growth also results in growth in exports of the country and thus enables the country to address its balance of payment problem. Inflation is controlled through increase in output produced and stable exchange rate. The increase in country's foreign exchange reserves either through increase in exports or reduction in imports or both are benefits to increased in economic growth. Negative effects of economic growth includes; creative destruction defined as the replacement of old infrastructure with new ones [Schumpeter (1942)], rise in new complex health issues such as ageing population, spread of chronic diseases and rise in population growth due to better health facilities and better nutrition [Frenk (2004) and Bloom and Canning (2008)]. Increase in unequal distribution of wealth [Acemoglu (2009)] and environmental degradation due to increased emission of carbon dioxide per capita are also some of the disadvantages of the economic growth [Asafu-Adjyae (2000)].

Due to its importance, a number of growth models have been developed to study growth process, determinants of economic growth and reasons for differential growth in developing and developed countries. However, empirical literatures focusing on relevant determinants of growth for different countries have mostly used fixed parameter approaches.

Fixed parameter approaches assume parameter constancy which is hard to justify when the structure of the economy changes over time. In such a situation estimated parameters obtained from fixed parameter approaches will not be reliable. This is because fixed parameter methods do not consider the effects of structural shifts on parameter constancy and results based on such estimation procedures could be misleading and biased if parameters estimated are in fact time-varying [Terasvirta and Anderson, (1992), McCulloch and Tsay, (1994), Terasvirta, (1994); Stock and Watson; (1996) and Phillips (2001)].[1] Non-linear approach overcomes constancy assumption of fixed parameter approaches and integrates efficaciously structural changes in estimation process [Kim, et al. (2010)]. It is preferred to conventional methods because: (a) it considers the effect of structural changes on parameter constancy [Slade (1989)], (b) is considered better to fixed parameter approaches when parameters estimated are actually time-varying [Morisson and Pike (1977)]; and (c) it is applicable to non-stationary data. Furthermore, unlike F-statistic or dummy variable approach, state-space based time-varying parameter model captures change in propagation mechanism optimally and enables dating of change in dynamic relationship [Arslanturk, et al. (2011)].[2]

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[1] See Priestley (1980 and 1988) for state-dependent methods of estimation and Lundbergh et al. (2003) for time-varying smooth changeover autoregressive methods.

[2] A large number of studies have focused determinants of economic growth in Pakistan. All of them assume parameter constancy and use autoregressive distributed lag model [Ahmad and Wajid, (2013) and Tahir, et al. (2015)], autoregressive distributed lag model and error correction model [Shahbaz, et al. (2008), Rahman and Salahuddin (2010), Sami Ullah, et al. (2014) and Ali and Hafiz ur Rahman (2015)], ordinary least square [Iqbal and Zahid (1998); Khan (2005); Azam and Khattak (2009) and Saqib, et al. (2015)], OLS and Johansen (1988) cointegration approach [Atique and Malik (2012)], vector error correction model [Khan and Chapra (2016)], cointegration and vector error correction model [Sajid and Sarfraz (2008)] and ARDL and Granger causality [Shaheen, et al. (2011)] for finding out factors affecting economic growth of the country.

Pakistan economy has also seen a large number of structural changes and policy shifts during the sample period and it is probable that these changes might have caused parameter instability. This makes it necessary to use non-linear approach for finding out macroeconomic variables having a significant effect on economic growth of the country. The basic objective of this study is to overcome weaknesses of fixed parameter approaches and find out macroeconomic variables having significant effect on the growth process of the country using non-linear approach. It also aims at finding out whether the effect of significant macroeconomic variables on economic growth of the country is fixed or it is time-varying.

This study makes two contributions to empirical economic growth literature in Pakistan. First, macroeconomic variables determining economic growth around the world are identified from earlier empirical growth literature. Second, a non-linear method with general to specific approach is employed for finding out which of these macroeconomic variables are significant determinants of economic growth in the country. According to this approach, growth equation includes all macroeconomic determinants identified from empirical growth literature around the world as its covariates are estimated. Macroeconomic variables that appeared insignificant at first step are dropped and the growth equation is re-estimated. This process is continued till the parsimonious model with all estimated parameters significant is achieved. Contrary to fixed parameter approaches a non-linear approach (time-varying parameter) considers structural shifts in an economy and results in stable and reliable estimates. Furthermore, data determines number and timing of changes in slope parameters that are independent of each other and it is possible to detect evolution of each slope parameter in the model [Arisoy and Ozturk (2014)].

The remaining paper proceeds as, Section II focuses on structural changes that have taken place in the country during the sample period, followed by literature review in Section III. Data discussion is given in Section IV and details about methodology are provided in Section V. Results are discussed in Section VI and Section VII concludes the study.

II. Structural Changes in Pakistan

The decade of 1970s focused on nationalization of state owned enterprises. However, during the decade of 1980s, attention was given to denationalization and reduction in role of public sector enterprises in the economy. In this regard, Pakistan signed two agreements: (a) Extended Fund Facility (EFF) with International Monetary Fund in 1988 [Nasir, (2012)] and (b) Structural Adjustment Loan (SAL) with World Bank in 1986. In return, Pakistan agreed to stabilizing and bringing structural changes in the economy. All these steps intended to control inflation, bring budget deficit by eliminating subsidies, improve balance of payment by increasing exports and reducing imports, reducing debt to GDP ratio, elimination of supply of domestic

credit for budgetary support, liberalizing external trade, increasing foreign exchange reserves, devaluation of domestic currency against the US dollar and reforming financial sector of the country. The Objective of all these reforms was to augmented economic growth and to reduce inflation in the country.

Government started a major reform programme by implementing Economic Reform Order in 1991. It included liberalizing of foreign exchange regime, lifting of controls on investment, privatization of public sector enterprises and provision of incentives to domestic and foreign investors [Hussain (2012)]. Agricultural sector reform targeted four areas: (a) provision of water and its efficient use, (b) increasing role of market forces in determining input and output prices, (c) extension of physical infrastructure and provision of funds for research and innovation and (d) access good land for cultivation. Overall these reforms affected agricultural sector output growth positively [Hussain (2012)].

Financial sector reforms were also undertaken during the decade of 1990s with a view to enhance its efficiency and create a competitive environment by liberalizing interest rate and credit ceiling. Amendment of Banks (Nationalization) Act 1947 in 1997 enhanced the Central Bank authority to supervise and effectively regulate the financial sector of the country [Akram (2011)]. Public sector banks were denationalized and new banks were permitted to start their business in the country. Prior to financial sector reforms, State Bank has used direct instruments such as government set interest rate, credit ceilings and subsidized credit for conducting monetary policy. Finance Ministry was also actively involved in formulating and implementing monetary policy. This situation was dealt with the introduction of financial sector reforms in the country. As a result, the Central Bank authority to conduct market base monetary policy using open market operation was enhanced. Prior to financial sector reforms, Islamic Banking System was introduced in the country with a view to provide people with profit and loss sharing facility. Furthermore, a shift in the exchange rate regime occurred when Pakistan quit fixed exchange rate and adopted managed float on 8th January, 1982 [Akram and Ahmad (2013)].

Pakistan becomes nuclear power on 28th May, 1998, in the aftermath, capital movement was restricted foreign currency accounts were frozen and multiple exchange rate was introduced in the country. Basic objective of all these measures was to mitigate investors' uncertainty about the country's ability to meet its external obligations [Akram (2011)].

The terrorist attack on US on September 11, 2001 substantially contributed the advancement of macroeconomic indicators of the country. Sanctions imposed on the country in wake of its nuclear explosions were lifted. The country was given liberal financial assistance due to its alignment with Western countries in their war against terrorism. As a result, Pakistan foreign exchange reserve increased substantially. The decade of 2000, also featured the continuation of more liberal outward oriented economic policies aimed at strengthening and integrating of the country

with the rest of the world. Unpopular decisions like, imposition of sales tax, raising oil prices and withdrawing of subsidies were undertaken with a view to control the rising budget deficit. Due to structural policy reforms coupled with better governance, Pakistan witnessed accelerated growth from 2002 to 2007.

Domestic factors accompanied with recessionary conditions particularly in Western countries due to global financial crisis severely affected the process of growth in the country. Deterioration of economic conditions was so severe that it impacted country's ability to meet its external obligation and forced it to approach International Monetary Fund for averting default on its external obligations [Gilal, et al. (2017)]. Economic conditions further deteriorated due to floods and security issues in the subsequent years.

The study discussed structural changes that have taken place during the sample period might have affected stability of macroeconomic determinants of growth in the country. This makes it necessary to take into account time-varying nature of estimated slope parameters while estimating growth equation.

III. Literature Review

Sustainable economic growth is a pre-requisite for countries economic development. Due to its enormous importance, sustainable economic growth is given top priority by relevant policy makers in each country. Arslanturk, et al. (2011) focused time-varying linkage between tourism receipts and economic growth for Turkey for the period 1963 to 2006. Granger causality results based on VECM for entire sample do not show any bidirectional relationship between tourism receipts and economic growth. Rolling regression estimates on the other hand reveals the significant positive predictive effect of tourism receipts on GDP after 1979. Non-linear VECM estimates that overcome disadvantages of full sample and rolling regression VECM Granger causality results shows significant effect of tourism receipts on economic growth after 1989. GDP effect on tourism receipts however, appears insignificant. Ak, et al. (2016) examined stability of the causal relationship between financial development and economic growth for Turkey for the period 1960 to 2013. Granger causality and Toda Yamamoto causality results show unidirectional causality that headed from financial sector development to economic growth. However, null hypothesis of no causality from growth to financial development could not be rejected. Time-varying Granger causality that addresses effects of regime shift and structural changes on parameter constancy show absence of significant positive effect of tourism receipts on economic growth for the entire period except for three short periods which are 1979-1980, 1990-1993 and 1997-2010. Balcilar, et al. (2014) evaluated causal link between real tourism receipts and real economic growth for South Africa from 1960 to 2011. Full sample vector error correction model results reject null of no causality between both series. However, rolling window and state space

TABLE 1

Summary of Selected Studies on Determinants of Economic Growth*

Study	Period	Country	Methodology	Variables
Ahmad and Wajid (2013)	1979 – 2009	Pakistan	ARDL	Productive expenditures, Non productive expenditures, Distortionary taxes and non-distortionary taxes.
Ali and Hafeez ur Rehman (2015)	1980 – 2012	Pakistan	ARDL and Granger Casualty test	Secondary School Enrolment, Financial Development, Total Labor Force, Macro-economic Instability and Foreign Direct Investment.
Alodadi and Benhin (2015)	1970 – 2011	Saudi Arabia	Johansen Cointegration and ECM	Exports, Government Spending, Private and Public Investment, Religious Tourism, Labor and Capital.
Atique and Malik (2012)	1980 – 2010	Pakistan	OLS	Domestic and External Debt, Labor Force, Corruption and Investment.
Azam and Khattak (2009)	1971 – 2005	Pakistan	OLS	Domestic Investment, Foreign Direct Investment, Human Capital and Trade Openness.
Iqbal and Zahid (1998)	1959 – 1960 to 1996 – 1997	Pakistan	OLS	Primary Scholl enrolment to total employed labor force, Middle School Enrolment to Total Employed Labor Force, High School Enrolment to Total Employed Labor Force, Enrolment in Other Educational Institutions to Total Employed Labor Force, Physical Capital to GDP Ratio, Budget Deficit to GDP Ratio, Exports to GDP Ratio, Imports to GDP Ratio, External Debt to GDP Ratio, Per Capita Income and Per Capita Income Square.
Khan (2005)	1980 – 2002	72 Developing Countries	OLS	Investment, Initial Income, Macroeconomic Policy, Institutional Quality and Labor Quality.
Khan and Chhapra (2016)	1983 – 2012	Pakistan	Cointegration and ECM	Inflation, Unemployment, Foreign Direct Investment and Import Prices of goods and Services.
Meyer and Shera (2017)	1999 – 2013	Albania, Bulgaria, Macedonia, Moldova, Romania and Bosnia Herzegovina	Quasi Fixed Panel Effect, OLS and Random Effect	Workers' remittances received to GDP, Gross Fixed Capital Formation, Household Final Consumption Expenditures, Ratio of School Enrolment per cent to GDP, Current Account Balance as per cent of GDP, Real Exchange Rate and Government Debt as per cent of GDP.

Continue .....

TABLE 1 *(Continued)*

Summary of Selected Studies on Determinants of Economic Growth*

Study	Period	Country	Methodology	Variables
Musayev (2015)	1970 – 2010	Panel of 89 Countries	System GMM	Initial GDP per Capita, Military Expenditures as per cent of GDP, Natural Resources, Corruption, Threat, Population Growth, Life Expectancy, Investment to GDP Ratio, Openness and Schooling.
Ncanywa and Makhenyane (2016)	1960 – 2014	South Africa	Johansen Cointegration and VECM	Gross Fixed Capital Formation, Government Expenditures, Consumption Expenditures, Net Exports and Consumer Price Index.
Radu (2015)	1990 – 2010	CEE Countries	Multivariate Regression	Primary School Enrolment, Share of Investment in GDP, Inflation, Birth Rate, Economic Freedom, Political Freedom, Political Stability and Political Certainty.
Rahman and Salahuddin (2010)	1971 – 2006	Pakistan	FMOL, ARDL and ECM	Market Capitalization, Financial Development, Financial Instability, Inflation Rate, FDI, Literacy Rate and Stock Market Liquidity.
Ramanayake and Lee (2015)	1995 – 2009	Developing Countries	Cross Section Effect, Fixed Effect and GMM	Initial GDP per Capita, Population Growth, Human Capital, Gross Capital Formation, Export Growth Rate, Trade Openness, Trade Diversification, FDI, Democracy and Life Expectancy.
Sajid and Sarfraz (2008)	1973Q1 to 2003Q4	Pakistan	Johansen Cointegration and ECM	Gross Domestic Product, Gross National Product and National Savings.
SamiUllah, et al. (2014)	1980 – 2009	Pakistan	ARDL and ECM	Real Gross Fixed Capital Formation, Literacy Rate, Real FDI and Real Exports.
Saqib, et al. (2013)	1981 – 2010	Pakistan	OLS	FDI, Debt, Trade, Inflation and Domestic Investment.
Shahbaz, et al. (2008)	1980Q1 to 2007Q4	Pakistan	ARDL and ECM	Credit to Private Sector, FDI, Trade Openness and Annual Inflation.
Tahir, et al. (2015)	1977 – 2013	Pakistan	ARDL	Remittances, FDI and Imports.
Upreti (2015)	2010, 2005, 2000, 1995	76 Developing Countries	OLS	Initial GDP per Capita, Exports, Govt Debt, Net Foreign Aid Received, Life Expectancy, Investment Rate, FDI Inflows.

*Table 1 shows factors determining economic growth across different countries using fixed parameter methods.

time-varying hypothesis coefficient based VECM results show bidirectional causal link between real GDP and real tourism receipts. It appears from the results that tourism receipts have significant positive predictive power on GDP for entire sample period except the period between 1985 and 1990 when this link was broken. Criminal acts are also negatively associated with the growth of the country. Detotto and Otranto (2010) employed state space time-varying parameter approach for evaluating effect of criminality on growth in Italy from 1979 to 2002. Crimes committed in the country were represented with intentional homicide. Results reveal the negative asymmetric effect of criminal activity on growth process of the country. Effect of crime on GDP was five per cent more during recession than during booming period. Sirikanchanarak, et al. (2016) applied quarterly data from 1994 to 2014 for evaluating the effects of bank credit on economic growth and inflation in Thailand. For analysis Kalman Filter based time-varying approach was employed as in threshold model with two regimes it allows regression coefficients to vary over time. Strong sign of non-linearity in relevant data and global economic conditions determined choice of the estimation method. Time-varying posterior mean based on normal flat distribution show significant negative effect of bank credit on inflation and economic growth of the country during the sample period. Time-varying estimated coefficient however, shows asymmetric effect. Prior to the 1997-1998 economic crisis period, increase in domestic credit resulted in economic growth by increasing aggregate demand in the economy. Post crisis period results however, indicate smooth behavior of estimated credit coefficient for the entire period except for 2009-10, when this link was broken due to the global financial crisis and domestic political instability. Similarly, the effect of domestic credit on inflation prior to inflation targeting monetary policy implemented in 2000 is time-varying. Post inflation targeting monetary policy period does not reveal large fluctuations hence, the effect of domestic credit on inflation seems quite low.

IV. Data

Annual data taken from World Bank World Development Indicators for the period 1976 to 2014 is used in the analysis. Two factors determined the choice of sample period: (a) disintegration of the country in December, 1971 and, (b) non-availability of data on most of the variables before 1975. External debt is used as a percentage of gross national income. Net foreign direct investment, gross fixed capital formation, gross national expenditures, remittances, credit to private sector, exports of goods and services and broad money are scaled by GDP to avoid multi-collinearity. Real exchange rate data is obtained by adjusting foreign to domestic price ratio with the nominal exchange rate. Data is used in log form which enables us to interpret estimated parameters in terms of elasticities. Table 2 shows World Bank World Development Indicators definition of variables used in this study.

TABLE 2

Variables Description and Sources

Variables	Code	Definition
Real GDP Growth	NY.GDP.MKTP.KD.ZG	It refers to nominal GDP adjusted with inflation rate. Nominal GDP is sum of gross value added by all resident producers in the economy plus taxes less subsidies.
External Debt Stock	DT.DOD.DECT.GN.ZS	Total external debt stocks scaled by gross national income. Total external debt is the sum of public, publicly guaranteed, and private non-guaranteed long-term debt, use of IMF credit, and short-term debt.
Inflation	FP.CPI.TOTL.ZG	Consumer price index is used for measuring inflation rate in the economy. It refers to annual percentage change in price of a fixed basket of goods and services to consumer.
Net Foreign Direct Investment	BX.KLT.DINV.WD.GD.ZS	New investment inflows less disinvestment in the recipient country scaled by GDP are called Net Foreign Direct Investment.
Gross Fixed Capital Formation	NE.GDI.FTOT.ZS	It includes betterment of land, physical capital, infrastructure development and capital formation in the country.
Gross National Expenditure	NE.DAB.TOTL.ZS	Household and government consumption expenditures plus expenditures incurred on gross fixed capital formation constitute, Gross Fixed Capital Formation.
Personal Remittances, received	BX.TRF.PWKR.DT.GD.ZS	Personal remittances consist of personal transfers and employees compensation.
Domestic Credit to Private Sector	FD.AST.PRVT.GD.ZS	It refers to financial resources provided to private sector by banks and other financial institutions.
Broad Money (m_{2t})	FM.LBL.MQMY.GD.ZS	Sum of money and quasi money as share of GDP.
Real Exchange Rate		Nominal exchange rate adjusted with foreign to domestic price ratio.
Trade Openness	NE.TRD.GNFS.ZS	Sum of exports and imports of goods and services as per cent of GDP.

Source: World Bank World Development Indicators.

V. Methodology

There is a substantial empirical economic literature that has examined determinants of economic growth for different countries, for different sample periods using different econometric techniques. The most often used econometric methods on both time series and panel data are; auto regressive distributed lag model, ordinary least square, cointegration and error correction method and impulse response

function. These approaches assume parameter constancy and equally weight all the observations [Arisoy and Ozturk (2014)]. Hence estimates of growth equation derived from such estimation procedures are constant elasticities. However, there is no prior reason to assume parameter constancy and employ fixed parameter approaches for evaluating the interaction between economic growth and its macroeconomic determinants. This is because parameter constancy and stable relationship between economic growth and its determinants may change with the change in structure of the economy. In such a situation, estimates of growth determinants obtained from fixed parameter approaches will not be stable and reliable.

This study addresses such methodological issues and uses Kalman Filter based time-varying parameter approach for estimating growth equation for Pakistan. The growth Equation in general form is given as:

$$y_t = \alpha_0 + \alpha_{1t}\,cpi_t + \alpha_{2t}\,ed_t + \alpha_{3t}\,fdi_t + \alpha_{4t}\,k_t + \alpha_{5t}\,gne_t + \alpha_{6t}\,rem_t + \\ \alpha_{7t}\,fd_t + \alpha_{8t}\,to_t + \alpha_{9t}\,m_{2t} + \alpha_{10t}\,q_t + \mu_t \qquad (1)$$

where, y_t shows real GDP growth. Other variables included in the Equation are as inflation (cpi_t), external debt (ed_t), foreign direct investment (fdi_t), gross fixed capital formation (k_t), gross national expenditures (gne_t), remittances (rem_t), domestic credit to private sector (fd_t), trade openness (to_t), financial deepening (m_{2t}) and real exchange rate (q_t). The slope parameters are t subscripted showing that they are not fixed but time-varying.

Equation (1) in state space form can be written as:

$$y_t = \alpha_t x_t + v_t \qquad (2)$$

where, y_t represents real GDP growth and x_t is a vector of independent variables. α_t refers to vector of time-varying coefficients [in our case constant and slope parameters]. v_t is a stochastic disturbance term with zero mean and variance [var(v_t) = $\sigma^2_{R,T}$]. Equation (2) is called observation or measurement equation [Akram and Ahmad (2013) and, Arisoy and Ozturk (2014)].

Slope parameters are assumed to follow random walk:

$$\alpha_t = \alpha_{t-1} + \mu_t \qquad (3)$$

Equation (3) is called transition equation. Contrary to fixed parameter approaches that assume parameter constancy, random walk assumption allows frequent changes in all parameters. Stochastic disturbance term in Equation (3) is distributed normally with zero mean $E(u_t) = 0$ and variance [var(u_t) = $\sigma^2_{Q,T}$]. Furthermore, v_t and u_t are assumed independent of each other that is $E(u_t v_t) = 0$. Moreover, it is assumed that error terms in measurement Equation (2) and transition Equation (3) and slope parameters are in-

dependent of each other. Together Equation (2) and (3) constitute space state system which is estimated using the Kalman Filtering algorithm.

In matrix form, state space Equations can be written as:

$$
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
\alpha_{0t} \\ \alpha_{1t} \\ \alpha_{2t} \\ \alpha_{3t} \\ \alpha_{4t} \\ \alpha_{5t} \\ \alpha_{6t} \\ \alpha_{7t} \\ \alpha_{8t} \\ \alpha_{9t} \\ \alpha_{10t}
\end{bmatrix}
= X
\begin{bmatrix}
\alpha_{0t-1} \\ \alpha_{1t-1} \\ \alpha_{2t-1} \\ \alpha_{3t-1} \\ \alpha_{4t-1} \\ \alpha_{5t-1} \\ \alpha_{6t-1} \\ \alpha_{7t-1} \\ \alpha_{8t-1} \\ \alpha_{9t-1} \\ \alpha_{10t-1}
\end{bmatrix}
+
\begin{bmatrix}
u_t \\ u_{t1} \\ u_{t2} \\ u_{t3} \\ u_{t4} \\ u_{t5} \\ u_{t6} \\ u_{t7} \\ u_{t8} \\ u_{t9} \\ u_{t10}
\end{bmatrix}
\tag{4}
$$

Kalman Filter updates the system with the availability of new information. If a_t and P_t are optimal estimate of state vector α_t and its covariance and estimation begins in period t, then optimal state vector and covariance in period $t+1$ can be given as:

$$a_{t+1/t} = a_t \tag{5}$$

$$P_{t+1/t} = P_{t/t} + Q \tag{6}$$

Equation (5) and (6) are one step ahead from state vector and its covariance. Current period information determines the economic growth of the country in the next period ($\hat{y}_{t+1/t}$) and is given as:

$$\hat{y}_{t+1/t} = x_{t+1}\, a_{t+1/t} \tag{7}$$

and prediction error is given as:

$$\vartheta_t = y_{t+1/t} - \hat{y}_{t+1t} = k_{t+1}\,(y_{t+1t} - x_{t+1}\, a_{t+1/t}) \tag{8}$$

While optimal state vector and its covariance once new observation becomes available can be estimated as:

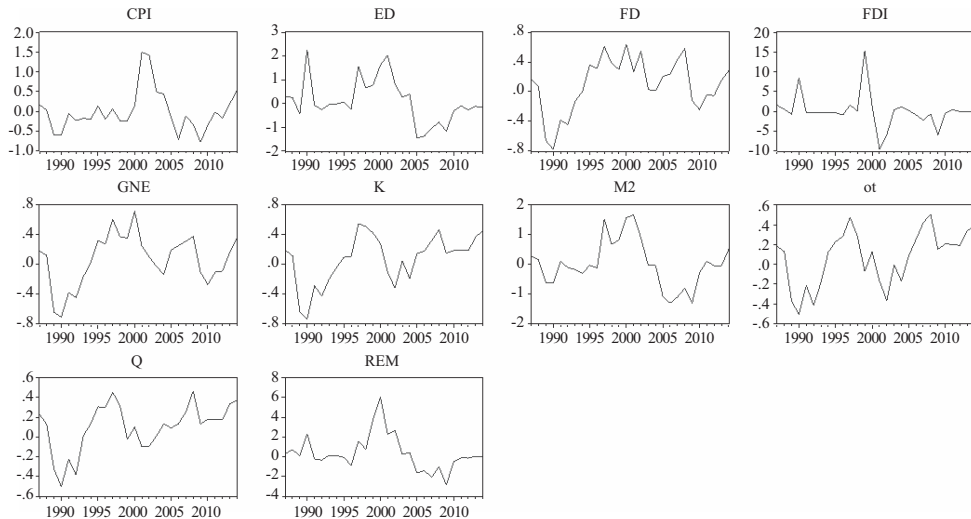$$a_{t+1/t} = a_{t+1/t} + k_t\,(y_t - x_{t+1}\, a_{t+1/t}) \tag{9}$$

and

$$P_{t+1/t} = a_{t+1/t} + k_{t+1} \, x_t \, P_{t+1/t} \tag{10}$$

where $k_{t+1} = \mathrm{P}_{t+1t} x'_{t+1} [x_{t+1} \, P_{t+1/t} \, x'_{t+1} + R]^{-1}$

State vectors mean in Equation (9) and covariance in Equation (10) is updated once new information becomes available. Equation (2 to 11) constitutes the Kalman Filter algorithm. Given initial state vector a_t and its covariance P_t, Kalman Filter updates the system once new information becomes available and estimates state vectors optimally.

VI. Results

Prior to employing Kalman Filter based time-varying approach, growth equation is estimated using rolling regression also called fixed window estimator. It moves sequentially and alters fixed length benchmark sample by adding one observation from forward direction and dropping one from the end [Balcilar, et al. (2014)]. In this study, 12 observation window is used for estimating rolling regression coefficients which is

Source: Rolling regression estimates of the variables are generated by the authors.
Note: Sample period is from 1975 to 2014. Twelve observations are used as rolling regression window. These graphs represent time-varying estimates in Equation (1) for foreign direct investment (fdi_t), remittances (rem_t), external debt (ed_t), broad money (m_{2t}), inflation (CPi_t), domestic credit to private sector (fd_t), gross national expenditures (gne_t), gross fixed capital formation (k_t), trade openness (to_t) and real exchange rate (q_t).

FIGURE 1

Rolling Regression Estimates

in line with the duration of almost one business cycle.[3] Figure 1 shows that rolling regression estimates of all included macroeconomic indicators are not fixed but time-varying hence, validates estimating growth in Equation (1) using non-linear approach.

There are inherent weaknesses in rolling regression such as: (a) sub-sample information is used in estimating them, hence, information based on the entire sample is lost, (b) window size determines results and (c) rolling regression estimates, cannot be true estimate of time-varying parameters in the presence of unstable relationship among the variables [Arslanturk, et al. (2011)].

Kalman Filter based time-varying parameter approach overcomes rolling regression weaknesses and is used for estimating the growth in Equation (1). It does not require testing non-stationary of time series data before model estimation because time-varying parameter estimates are based on their past realization and hence are well fitted to deal with non-stationary data [Stracca (2003)].

General to specific approach is used for estimating growth equation. According to this approach growth equation is first estimated in general form and then insignificant estimates are dropped and the equation is re-estimated. This process continues till the parsimonious model with all estimated parameters significant is obtained.

Table 3 shows all estimated parameters are insignificant when growth equation is estimated in general form (Model 1). Dropping of trade openness, broad money and

TABLE 3

Determinants of Overall Economic Growth

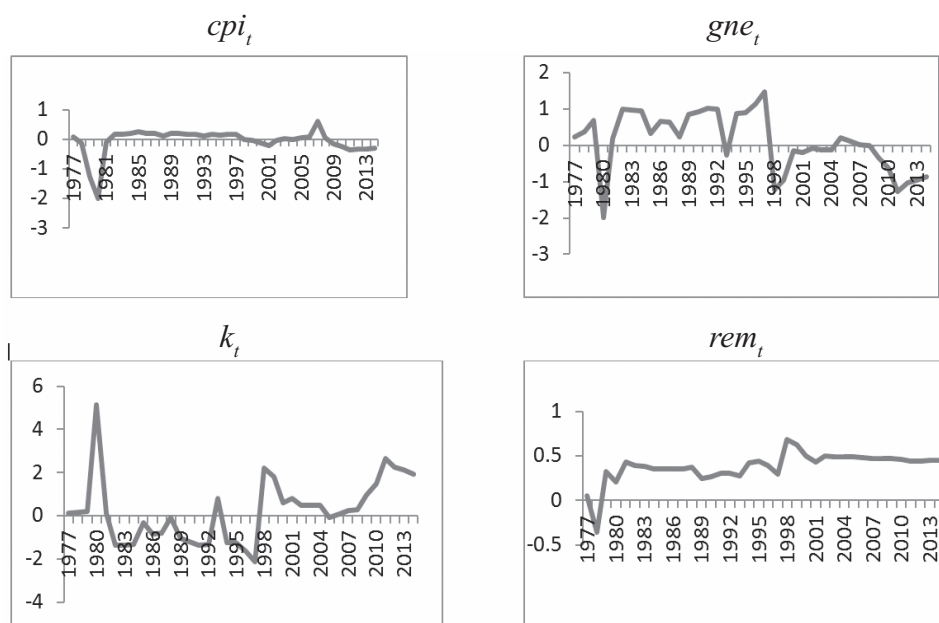| Variables	Model 1	Model 2	Model 3
C	-3.153(-15.301)[a]	-3.232(-17.126)[a]	-3.275(-17.079)[a]
cpi_t	-0.220(-0.716)	-0.291(-1.480)	-0.311(-1.910)[b]
ed_t	-0.573(-0.982)	-0.550(-1.148)	
fdi_t	-0.183(-1.079)	-0.122(-0.987)	
k_t	1.808(1.429)	1.821(1.586)	1.809(2.328)[a]
gne_t	-1.259(-0.939)	-0.608(-1.192)	-0.778(-1.657)[b]
rem_t	0.285(1.102)	0.262(1.170)	0.460(3.094)[a]
fd_t	0.536(0.621)	0.438(0.562)	
to_t	0.658(0.544)		
m_{2t}	0.010(-0.007)		
q_t	0.109(0.514)		

Source: Authors' Estimation.
Note: *a* and *b* shows significance of the estimated parameters at 5% and 10% significance level. Calculated z-values are given in parentheses.

[3] There are four types of cycles: (a) Kitchen inventory cycle with a duration of 3 to 5 years, (b) Juglar fixed investment cycle of 7 to 11 years' duration, (c) Kuznets infrastructural investment cycle having a duration of 5 to 25 years and (d) Kondratieff wave or long technological cycle with duration of 45 to 60 years [Isaiah et al., (2015)].

real exchange rate, however; improves the significance of rest of the variables (Model 2). It is apparent from Model 3 that dropping of external debt, foreign direct investment and domestic credit to private sector results in significant estimates of the consumer price index, gross fixed capital formation, gross national expenditures and received remittances. Model 3 is called a specific model because all estimated parameters in this model are significant.

Inflation retards growth through three channels: (a) it results in uncertainty about the future profitability of investment projects and hence lowers investment and economic growth of the country, (b) an increase in prices reduce competitiveness of domestic products in international market, reduce exports and thus affect growth of the country negatively and (c) rise in prices reduce real purchasing power of money and thus reduce economic growth. Positive effect of gross fixed capital formation on economic growth results in because: (a) directly building up of physical capital enhances growth of the country (b) indirectly promoting technology and hence affects economic growth positively [Levine and Renelt (1992)]. Gross national expenditures could have a positive and negative effect on the economic growth of the country. Directly, increases in gross national expenditure augments over all aggregate demand and thus cause economic growth of the country. Indirectly, a rise in gross national expenditures leaves little to save and invest which retards growth of capital in the country. This has a negative effect on the growth process of the country which seems more plausible in our case. An increase in remittances increases household consumption and saving by increasing their income which in turn positively affect growth process of the country through multiplier effect [Meyer and Shera (2017)]. Hence in our case, inflation, gross fixed capital formation and remittances received significantly affect economic growth of the country within Kalman Filter based time-varying parameter approach.

Figure 2 shows estimates of inflation (consumer price index), gross fixed capital formation, gross national expenditures and remittances with GDP growth (y_t) as time-varying dependent variables. It represents the evolution of macroeconomic variables that have significant effect on growth process of the country in Kalman Filter based time-varying parameter framework. It is apparent from the figure that inflation affected growth negatively during the initial period of 1977 to 1981. Thereafter, it appears to be insignificant determinant of economic growth till 2006. Between 2007 and 2009 inflation effect on growth appears to be positive and negative. Estimate of gross national expenditure estimate shows large fluctuations over the entire sample period. From 1977 to 1979 gross national expenditures effect on growth is positive. Between 1980 and 1981, it affected economic growth negatively. From 1982 to 1998, gross national expenditure estimate appears to be positively signed except in 1985 when it appears not to be significantly different from zero. From 1998 and onwards, gross national expenditure is negatively signed except from 2005 to 2008 when it is not significantly different from zero. Gross fixed capital formation appears to be insignificant determinant of economic growth for the initial three years. From 1979 to 1981 its estimate is positive and quite large followed by negative estimate from 1982 to

Source: Authors' estimates of state vectors.
Note: cpi_t, gne_t, k_t and rem_t refers to consumer price index, gross national expenditures, gross fixed capital formation and remittances received.

FIGURE 2

Estimates of Significant State Vectors

1992. During 1992-1993, gross fixed capital formation affected growth positively followed by negative effect from 1994 to 1997. From 1998 onwards, gross fixed capital formation estimate is positive except during 2005-2006, when it appears almost equal to zero.

Remittances effect on growth is positive for entire period, except from 1977 to 1978 when it appears downward sloped; however, magnitude of positive effect of remittances on growth is not the same.

VII.   Conclusion

In this study, we examined the determinants of economic growth using Kalman Filter based time-varying parameter approach. This approach was adopted because fixed parameter approaches assume parameter constancy and hence do not take into account the effect of structural changes on parameter constancy. Prior to estimating growth equation using time-varying parameter approach, a rolling regression estimates were obtained using 12 observations window. Rolling regression results indicated that the estimated parameters are not fixed but time-varying, hence, provided justification for evaluating determinants of economic growth for Pakistan within Kalman Filtering

based time-varying parameter approach framework. Time-varying parameter estimates show that inflation, gross fixed capital formation and remittances received significantly affected the economic growth of the country. The growth process of the country is negatively associated with inflation and gross national expenditures and positively affected by the rise in remittances received and gross fixed capital formation. Recursive estimate of significant macroeconomic variables except inflation shows large fluctuations implying that the effect of significant macroeconomic variables on economic growth of the country is not fixed but time-varying. Based on empirical evidence, it is recommended that relevant authorities should augment macroeconomic variables that cause economic growth and control those macroeconomic indicators that retard growth process of the country. This will help the relevant authorities to overcome poor economic issues of the country and will eradicate the need to knock doors of international financial institutions for bailout packages after every political cycle.

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