

**Determinants of Sectoral Growth in Pakistan: A Kalman
Filter Based Time Varying Parametric Approach**

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Structure of the economy changes over a time. Fixed parameter approaches do not consider impact of structural changes on constancy of estimated parameters. The study addresses the weaknesses of non-varying parametric techniques and uses non fixed parametric technique to examine association between sectoral growth and their determining factors. The findings reveal that capital formation, foreign remittances, and permanent crop land reduce agricultural sector growth while gross national expenditures results in growth of the sector. The significant factors that affect industrial growth are external debt, foreign direct investment and gross national expenditures. Above mentioned determinants are positively associated with the industrial sector growth in Pakistan. Services sector growth is determined by consumer price index, gross national expenditures and foreign direct investment. The foreign direct investment and gross national expenditures cause services sector growth while consumer price index retard it. While considering findings, the concerned authorities should control growth retarding factors and augment the factors that increase sectoral growth of the country.

Keywords: economic growth, Services, Industry, Agriculture

JEL Classification: C82, F24, F43, O11, O41, O5

Economic growth is one of the most important political and economic national objectives as it is highly significant factor for everlasting economic success of a country (Samuelson & Nordhaus 2001). Despite almost all countries having this common goal, there are wide disparities in standards of living across them. So, a natural question arises what determines economic growth? and how a country can ensure the development of the factor so to have its economy growing in long run. Said issue has been discussed in vast empirical and theoretical literature.

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Contribution of Authors: Muhammad Ajmair has done preliminary research work, acquisition of data, statistical measurements, econometric estimations and preparation of the first draft. Dr. Khadim Hussain has contributed through developing the conceptual framework, designing of model, providing analytical discussion of empirical results and refining the draft. Whereas, Dr. Zahra Masood Bhutta has contributed in preparing the initial draft, improvement of literature and proofreading the manuscript.

The origin of modern growth theoretical literature can be approached back to inspiring work by Schumpeter (1934). This theory introduced the idea of creative destruction. According to which, economic growth is primarily determined by innovations. This Schumpeter theory later became the starting point of many of the new growth theories to come. After Schumpeter (1934), the contribution of John Maynard Keynes has changed the course of entire macroeconomic thinking. Although, Keynes (1936) theory aggregate economic activity is principally determined by aggregate demand that is determined by investment spending.

In post-Keynesian period two models developed by (Harrod, 1939; Domer, 1946) are worth mentioning. These models tried to integrate Keynesian beliefs and economic growth. In these models: Harrod (1939) gave the concept of “warranted growth rate”. The ratio of saving rate to investment coefficient gives us the “warranted growth rate”. So, to have a greater “warranted growth rate” we need to have higher saving rate or/and low investment coefficient. According to Domer (1946), equilibrium would only be achieved if capacity created by investment is equal to the demand created by the investment.

And then a very important and one of the most famous contributions was made by Solow and Swan known as Solow (1956) and Swan (1956) model. A daring prediction of Solow-Swan model is; in absence of technological growth economy would reach in a situation where capital, output consumption per capita would be constant. Solow-Swan model has another very important prediction of conditional convergence. It means that countries which are more distant from their steady state will have greater accumulation rate of capital than the countries which are nearer to their respective steady states.

The biggest problem with Solow model is its only determinant of long run growth, technological progress, is exogenous. This is clearly very unsatisfactory. To endogenize the economic growth determinant Cass (1965) and Koopmans (1965) utilized Ramsey (1928) consumer’s optimization analysis to determine optimal level of saving. Diamond (1965) extended the idea of Cass and Koopman model and developed overlapping generation model. This has been done by introducing finite time horizon of individuals into analysis. For this purpose, he utilized the Samuelson’s life cycle hypothesis.

With this neo-classical growth model got completed. From early 1970 to mid-1980s there was no substantial input in area of growth theory and lot of the efforts were dedicated to the incorporation of rational expectations into the models of business cycle. This was done to explain the short-term fluctuations in aggregate output. And then with Lucas (1988) and Romer (1986) theories once again got attention. They tried to remove the biggest dissatisfaction that the major determinant of economic growth in long run, technological progress, is exogenous. These models tried to treat technological progress as endogenous. It is because of this; these new models of economic growth were named as “Endogenous Growth Models”.

According to Romer (1986) technological progress is determined by firms’ decision to invest in knowledge. A firm can invest in physical capital or in research. A unit investment into research increases knowledge by more than a unit which increases human capital. Another quite similar contribution is the early work of Arrow (1962) which was adopted by Romer (1986). He asserted that technological progress occurs because of firms’ decision of investment in capital in each period and experience gained by using that equipment (learning by doing). So, according to him, endogenization of technological progress is the byproduct of physical capital and it is not the result of individual decision.

Like Romer (1986), another model was proposed by Lucas (1988) based on Uzawa (1965) model of human capital. He distinguished between human capital and physical capital. Both are different individual decisions to be taken. Human capital enters in the model as a distinct production factor and technology is also affected by it. And it is human capital not physical capital which has spillover effect.

Then there comes second generation of endogenous growth models. Starting with Romer (1990). According to these theories, modernization is root cause of economic growth. These models explicitly followed research and development (R&D) investment and technological innovations. These models dropped the neo-classical tradition of assuming perfect competition. Instead of innovation in inputs, Grossman and Helpman (1991a, b) given the idea of invention of new goods and it is supposed that people like the diversity of commodities, so their income increase with invention of new goods. One way in which innovation occurs at faster rate is the international trade. It is because when economies will get engaged in international trade, they would have greater competition and greater incentive to innovate.

Young (1991) model also predicts the fruits of international trade for developing countries. According to this model trade between under developed and developed countries will augment the learning by doing opportunities for developing countries although they carry risk for developing countries that they may get engaged in production of the goods from which learning opportunity has already ceased to exist. Then the vertical innovation (quality improvement) concept was given by Aghion and Howitt (1992). This vertical innovation stems from research. This model is also known as to be Schumpeterian as it is based on the concept of creative destruction. Where new and innovative products make old products obsolete. According to Lucas (1993) although learning by doing also have diminishing returns but the experience of east Asian economies tells us exhaustion of learning by doing can be avoided by engaging in international trade. These countries liberalized international trade and the import of high-quality product from developed countries helped workers of these countries to continue learning by doing by getting shifted to new production activities.

Based on these economic growth theories, a large number of research papers were written to evaluate the determining factors of economic growth. As with growth theories these different studies utilized different factors as determinants of economic growth. For example, studies based on classical growth model has studied role of capital formation on economic growth. Among many others these studies include; Abou-Ali & Kheir-El-Din, (2009), Bal, et al., (2016) Silaghi and Medeşfălean (2014). There are many empirical studies based on endogenous growth models that has focused human capital as determinant of economic growth. These studies include: De la Fuente & Doménech (2000), Bundell, et al., (1999), Mankiw, Romer and Weil (1992) Fayissa and Nsiah (2010).

Then there are empirical investigations which have explored the relationship between economic growth and foreign remittance. These studies include; Jongwanich (2007) Gupta, et al., (2009). Studies have also treated public debt as determinant of economic growth. Such studies include; Pattillo, Poirson, and Ricci (2011) Cordella, Ricci and Ruiz-Arranz (2010). Then inflation has also been included as a determinant in many empirical studies. For example; Anyanwu (2104), Awan (2010). There are many such empirical studies which are focusing determinants of economic growth for the Pakistan economy (Azam & Khattak, 2009; Shaheen et al., 2011; Ahmed & Wajid, 2013).

In the beginning, share of services and industrial sector was smaller than agricultural sector growth in Pakistan. Gradually this share of agricultural sector growth started to decrease and share of industrial and services sector started to increase. This shows that structure of economy has been

reshaped based on sectoral inputs in overall economic growth. Till 1980, agricultural sector was dominant over other two sectors as a larger part of growth was received by agricultural sector. The situation has totally changed now. Contribution made by agriculture sector, industrial and services sector growth is 20.90, 20.30 and 58.8 percent respectively (Economic Survey of Pakistan, 2014-15). The services and industrial sectors contribute about eighty percent in gross domestic product (GDP) of the country. This changing structure of the nation income demands for identifying the sectoral based more deep determinants of output growth.

Earlier empirical literature has used non-varying techniques for finding out overall economic growth and sector wise growth in the country. Fixed parameter approaches assume parameter constancy which may not be true when structural changes take place in the economy. In such circumstances, it is better to use time varying parameter approach for finding out relevant determinants of sectoral growth. A strand of existing empirical literature found to make use such approaches (Priestley, 1980 & 1988) for state-dependent approaches of estimation, Lundbergh, Terasvirta and VanDijk (2003) for non-fixed autoregressive approaches. Another strand of literature emphasizes the significance of structural changes in construction of economic models (Cooley & Prescott, 1976; Teräsvirta & Anderson, 1992; Teräsvirta, 1994; McCulloch & Tsay, 1994; Stock & Watson, 1996; Phillips, 2001; & Kim et al., 2010).

The study makes twofold contribution to the existing empirical growth literature. Firstly, contrary to fixed parameter approaches, it employs time varying parameter approach for finding out sector specific growth determinants. Secondly, sectoral based growth determinants are initially recognized from the existing empirical literature and then adopt the general to specific approach for examining which one of them has significant effect on relevant sector in Kalman filter framework.

Method

Annual time series data for the period 1976-2014 is used for the study. The data of selected variable are taken from the World Development Indicators (WDI), World Bank. We used two factors for determining the choice of time period of sample (a) the country broken into two separate parts in 1971 and (b) There was unavailability of data of some selected variables in data source before 1976. Most of explanatory variables are standardized by gross domestic product (GDP) to avoid multicollinearity that is the common issue in time series data. The data variables are transformed into logarithmic form because a log transformed time series data permits to recognize the estimation of parameters in terms of elasticities as well. The data converted in log form makes linear the exponential functions (Asteriou & Hall, 2007).

The Kalman filter estimation approach has certain advantages over other econometric estimation techniques. Firstly, Kalman filter is a perfect estimation technique which give estimates of variables whose effect is time varying (Slade, 1989). Second, if instability exists in parameters' estimation, Kalman filter technique is easy to use than any other technique (Pike & Morisson, 1977). Thirdly, no confirmed evidence about integration order checking for Kalman filter estimation (Inglesi, 2011).

Following equations were estimated for finding out relevant significant determinants of sectoral growth¹:

¹The basic derivations of the Kalman filter referred to the paper published earlier (see Gilal, Ajmair and Farooq: 2019).

$$y_t^a = \eta_0 + \eta_{1t} fdi_t + \eta_{2t} cpi_t + \eta_{3t} gne_t + \eta_{4t} gdp_t + \eta_{5t} pcl_t + \eta_{6t} k_t + \eta_{7t} rem_t + \eta_{8t} pop_t + \eta_{9t} to_t + v_t \quad (1)$$

$$y_t^i = \theta_0 + \theta_{1t} fdi_t + \theta_{2t} fd_t + \theta_{3t} ed_t + \theta_{4t} cpi_t + \theta_{5t} to_t + \theta_{6t} rem_t + \theta_{7t} k_t + \theta_{8t} gne_t + u_t \quad (2)$$

$$y_t^s = \psi_0 + \psi_{1t} fdi_t + \psi_{2t} gne_t + \psi_{3t} cpi_t + \psi_{4t} fd_t + \psi_{5t} to_t + \psi_{6t} k_t + \psi_{7t} rem_t + v_t \quad (3)$$

y_t^a , y_t^i and y_t^s refer to agriculture, industrial and services sector growth respectively. Other variables included in equation 1 to 3 are consumer price index representing inflation rate of the country (cpi_t), external debt (ed_t), domestic credit (fd_t), foreign direct investment (fdi_t), gross domestic product (gdp_t), gross national expenditures (gne_t), gross fixed capital formation (k_t), permanent crop land (pcl_t), population (pop_t), remittances received (rem_t), and trade openness (to_t). t subscripted slope parameters imply that they are not fixed but time varying. GDP and agriculture sector growth are positively associated because increase income results in increase demand for agricultural products which may augment growth in latter. Similarly, gross national expenditures, gross fixed capital formation, remittances, trade openness, external debt and domestic credit are expected to increase sectoral growth. Permanent crop land and population growth are determinants of agriculture sector only. A rise in crop land may increase agriculture sector growth while population growth effect on agriculture sector growth is unclear a priori. An increase in population will lead to agriculture sector growth if the sector is faced with shortage of skilled people. If there is abundance of labor in such case increase in population will retard growth. All the variables are taken as real terms.

Results and Discussion

Before using Kalman filter a non-fixed parametric approach, the rolling regression estimates of sectoral growth equation are obtained using twelve observation windows. The objective is to justify the use of Kalman filter approach for estimation of sectoral growth equations. Initially to estimate rolling regression, first twelve observations are used. Another observation is added after dropping the first observation and till the observation at the end, this process is continued in the analysis² that is well related to the duration of single business cycle³. It is apparent from Figure 1(a) to Figure 1(c) that all the estimated parameters explain variation over the sample period hence justifying estimating sectoral growth equations using the Kalman a non-fixed parametric technique for finding out variables having significant effect.

² Moosa (1997), and Gilal & Chandio (2013) used 14 and 9 observation windows for rolling regression estimates respectively.

³ We can see four types of cycles (a) Kondratieff wave or long technological cycle that has 45 to 60 years' duration. (b) Kuznets cycle that has 5 to 25 years' duration. (c) Juglar fixed investment cycle of 7 to 11 years' duration and (d) Kitchen inventory cycle with duration of 3 to 5 years (Thamae et al., 2015).

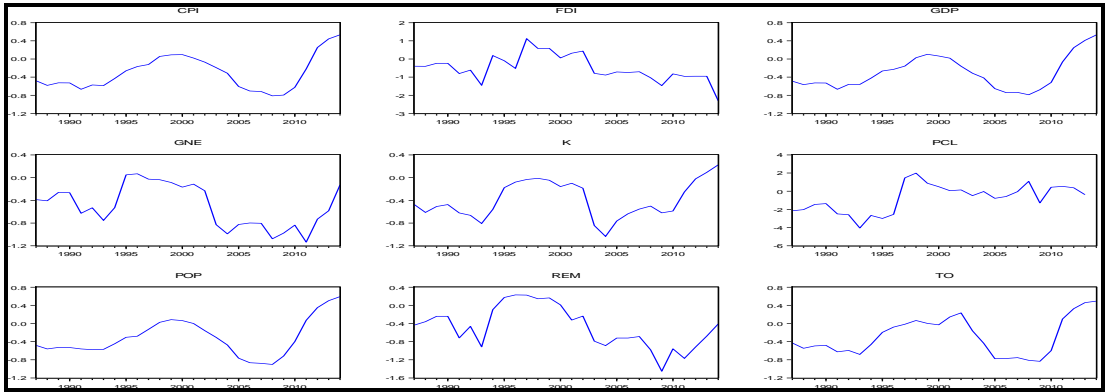


Figure 1(a): Agricultural sector's estimates of rolling regression

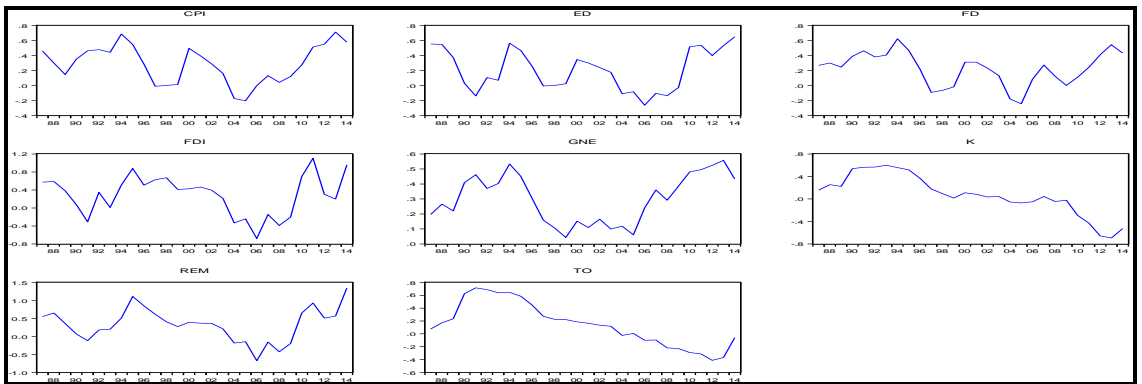


Figure 1(b): Industrial sector's estimates of rolling regression

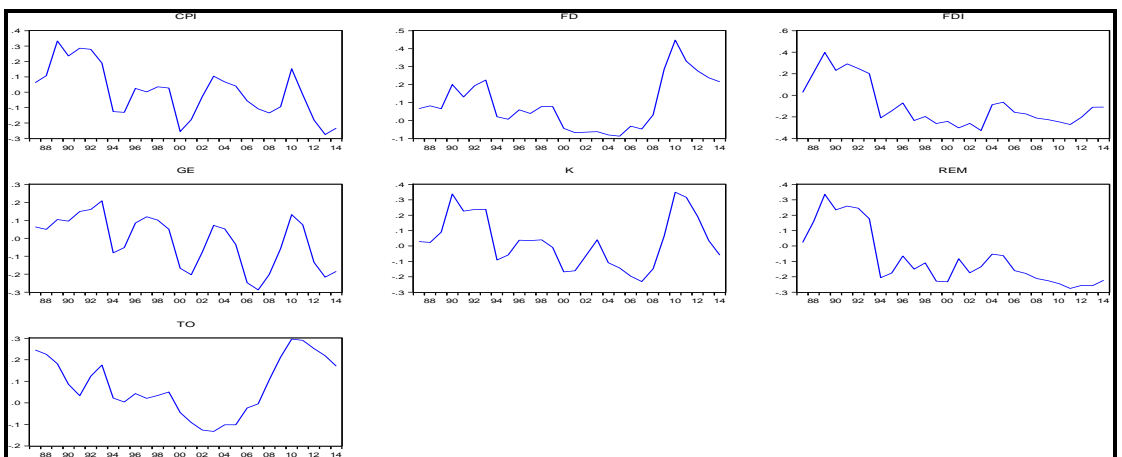


Figure 1(c): Services sector's estimates of rolling regression

Estimates of agriculture sector growth are given in Table 1. The specific model (Model 2) estimates indicate gross fixed capital formation (k_t), gross national expenditures (gne_t),

remittances received (rem_t) and permanent crop land (pcl_t) are the relevant significant determinants of agriculture sector output growth. The negative estimate of gross fixed capital formation (k_t) refutes with existing empirical literature that advocates positive inference between agricultural sector growth and gross fixed capital formation.

Table 1
Factors affecting the agricultural sector

Variable	Estimation 1	Estimation 2
c	-8.25 ^a (-28.14)	-8.23 ^a (-26.89)
cpi_t	0.02 (1.60)	
fdi_t	-0.00 (-0.40)	
k_t	-0.37 ^a (-3.56)	-0.40 ^a (-5.15)
gne_t	0.99 ^a (4.05)	0.93 ^a (19.45)
rem_t	-0.04 ^a (-2.40)	-0.05 ^a (-3.93)
to_t	-0.00 (-0.06)	
gdp_t	-0.02 (-1.13)	
pcl_t	-0.26 ^a (-3.68)	-0.29 ^a (-13.56)
pop_t	-0.03 (-0.34)	

Note: a and b shows at 5% and 10% level of significance respectively. z statistics are in parentheses

Positive estimate of gross national expenditures implies that a rise in gross national expenditures raises the employment level, profit rate and investment while affecting aggregate demand that results in further agricultural sector growth. Here gross national expenditures represent the gross national investment particularly. Percentage annual growth rate of GDP was included in estimated equation to assess its impact on agricultural sector growth only that is insignificant. The estimate of remittances received is like the findings of Castelhana et al., (2016), who said that remittances prevented the investment in agriculture sector and hence negative association was found between agricultural sector growth and remittances. The negative association between permanent crop land and agricultural sector growth may be due to nonexistence of trend in permanent crops cultivation in country. It is to be worth noted that on permanent cropland, such crops are cultivated that remains for longer time period and no need to replant such crops after harvesting, such as coffee, cocoa and rubber.⁴ A controversial association was found between economic growth and population growth (Wesley & Peterson, 2017). Social and economic issues are

⁴ This category excludes land under trees grown for wood or timber but includes land under flowering shrubs, fruit trees and nut trees. Though these crops are not relevant to Pakistan’s agriculture, yet they occupy land for longer period hence rise in their cultivation may have negative effect on the country agriculture sector growth.

created by low population in high-income countries while rising level of population is curse in low-income countries.

The rationalization of one-step ahead could be that both initialization approaches diverge in the amount of information used from the estimation sample. The one-step ahead uses information up to the commencement of the forecast period, whereas smoothed uses information from the entire estimation period. Figure 2 represents one step ahead estimate of state vectors of gross fixed capital formation, gross national expenditures, permanent cropland and foreign remittances after recursive estimation with agricultural sector output growth as dependent variable. It indicates that all the state vectors except remittances received are more volatile in the start and get stabilize afterwards.

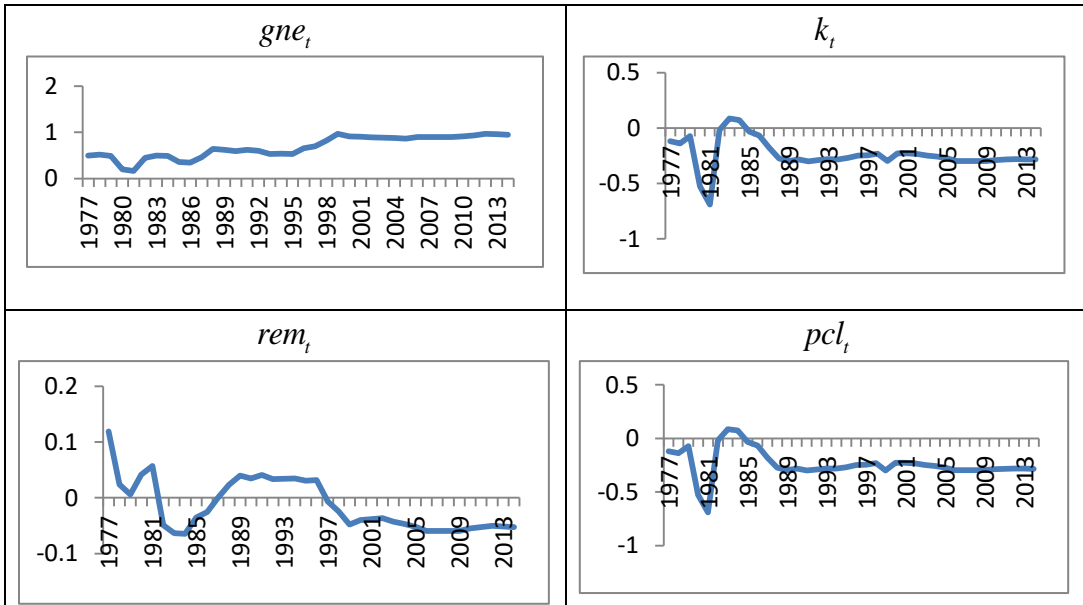


Figure 2: One step ahead state vectors of agriculture sector growth

Initial instability could be due to small numbers of observations used to forecast one step ahead state vector in state vectors of determinants. As it is evident that once the number of observations to forecast one step state vector of variable increases, the state vector gets stabilizing. Remittances received are beyond policy control and are determined by prevailing economic condition in rest of the world may explain their fluctuation for large part of the sample period.

The estimates of industrial sector growth are given in table 2. The specific model (Model 2) estimates show that external debt, gross national expenditures and FDI are the most relevant determinants having significant positive effect on industrial sector productivity growth. Positive estimate of external debt identifies its importance as driver of economic growth if used wisely.

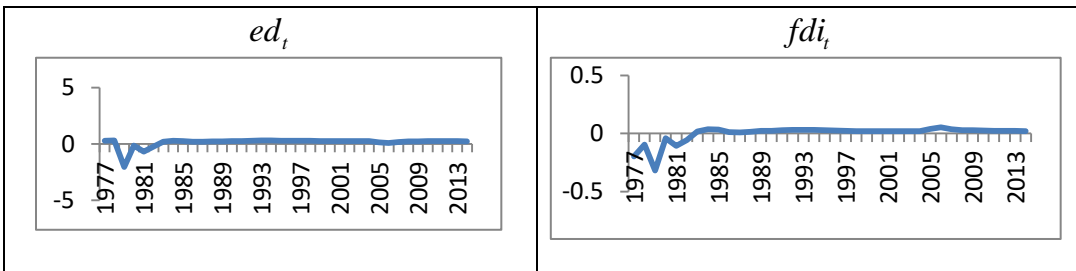
Table 2
Factors affecting the industrial sector

Variables	Estimation 1	Estimation 2
c	-7.21 ^a (-46.05)	-7.24 ^a (-40.36)
cpi_t	-0.02 (-0.78)	
ed_t	0.13 ^b (1.79)	0.23 ^a (5.68)
fd_t	0.06 (-0.66)	
fdi_t	-0.00 (-0.16)	0.02 ^b (1.92)
k_t	0.03 (0.23)	
gne_t	0.35 ^a (3.18)	0.49 ^a (15.24)
rem_t	-0.03 (-1.05)	
to_t	0.23 (1.41)	

Note: *a* and *b* show at 5% and 10% level of significance respectively. *z* statistics are in parentheses

The positive estimate in our case reveals that the marginal benefit of each borrowed unit is greater than principal amount plus interest rate paid that results in positive effect of external debt on industrial sector output growth of economy. Managerial skills, long-term capital with new technologies and marketing proficiencies are supplied by foreign direct investment which creates employment, increase managerial skills further, diffuse technologies and foster modernizations to boost up industrial sector growth. All these dynamics are due to FDI contribute positively to the industrial sector output growth of the economy. Positive estimate of gross national expenditures implies that government expenditures rise rate of employment, profit level and investment by increasing aggregate demand to boost up the industrial sector growth increases.

Figure 3 shows that recursive estimates of state vectors of determinants having significant effect on industrial sector growth. Large fluctuations are evident in the beginning and stabilize subsequently. Small number of observations used for prediction are responsible for initial instability. The state vectors stabilize as the number of observations used in their prediction increases.



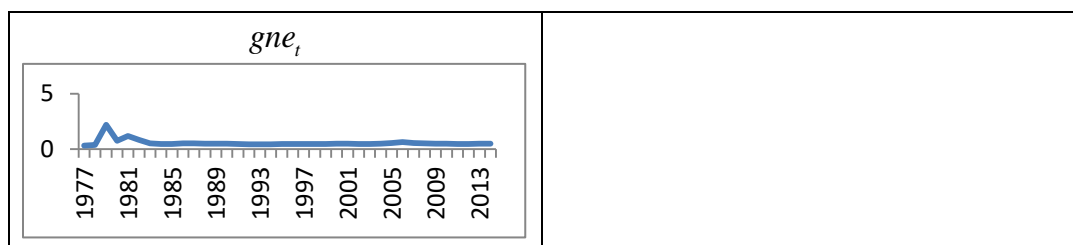


Figure 3: One step ahead state vectors of industrial sector growth

Table 3 shows the estimates of the services sector growth. The estimates reveal that inflation, FDI and gross national expenditures significantly affect services sector growth in Kalman filtering based time varying parameter approach. Negative estimate of inflation infers that an increasing price is not favorable for services sector. Inflation results lower steady level of services sector productivity growth and hence demand for domestic credit in the economy. As a rise in general price level also lessens real purchasing power of money which affects services sector growth adversely. The findings are consistent with Boyd et al., (2001) that establish negative marginal effect of inflation on financial institution lending and hence decline in the development of financial sector. Through physical investment, economic growth is promoted by foreign direct investment (Barro & Sala-i-Martin, 1995; Grossman & Helpman, 1991; Lucas 1988; Romer 1986). Due to capital formation, growth of labor force and total factor productivity, gross national expenditures affect services sector and overall economic growth positively. The gross national expenditures affect services sector positively through capital formation, growth of labor force and total factor productivity growth.

Table 3

Factors affecting the services sector

Variable	Estimation 1	Estimation 2
c	-8.40 ^a (29.79)	-7.78 ^a (-28.53)
cpi_t	-0.04 ^a (-3.05)	-0.04 ^a (-2.49)
fd_t	-0.14 ^a (-2.61)	
fdi_t	0.07 ^a (9.06)	0.07 ^a (8.55)
gne_t	1.05 ^a (17.56)	0.86 ^a (105.00)
k_t	-0.12 (-1.46)	
rem_t	-0.02 ^b (-1.71)	
to_t	-0.01 (-0.14)	

Note: a and b shows at 5% and 10% level of significance respectively. z statistics are in parentheses

cpi_t

fdi_t

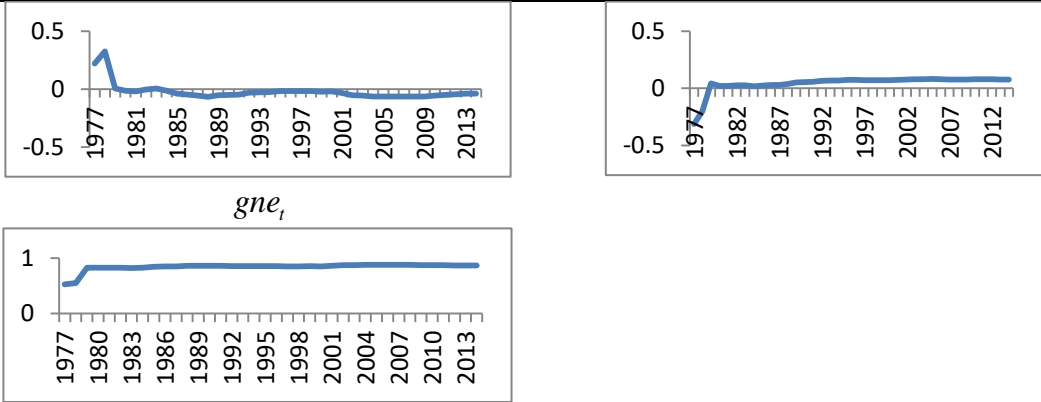


Figure 4: One step ahead state vectors of services sector growth

The small number of observations to estimate an additional parameter of interest are responsible for initial instability in state vectors that is clear from figure 4. The parameters appear stabilize and their corresponding root mean square errors are reduced, as soon as information used for predicting $t+1$ observation increases.

Conclusion

We have performed dynamic analysis for the economy of Pakistan to examine the determinants of sectoral growth. The dynamic behavior of the variables is analyzed by using Kalman filtering based time varying parameter approach using annual data for the period 1976-2014. Rolling regression estimates show that sectoral growth determinants are time varying that justify estimating sectoral growth equations while using Kalman filter a non-fixed parametric approach.

We conclude that in case of Pakistan economy, Inflation, Gross Fixed Capital Formation, Remittances and Permanent Crop Land hamper growth process. On the other hand, External Debt, FDI and Gross National Expenditures are supporting factors for economic growth in Pakistan. One step ahead state vector analysis shows more instability in the initial period of analysis, but State vectors stabilize as the number of observations used to predict them increases. This indicates the dynamic behavior of the variables that is affected by the length of time span. In the short period of time. Behavior of variables is more volatile but as time period increases the behavior smoothed out.

The government should frame policies that enhance economic growth creating aspects and control the variables that retard growth process of the country while considering empirical findings.

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