PDR

# The PAKISTAN DEVELOPMENT REVIEW

## ARTICLES



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## BOOK REVIEW



**Volume 56** **Autumn 2017** **Number 3**

www.pide.org.pk

**PDR** **The PAKISTAN DEVELOPMENT REVIEW**

Volume 56 Number 3
Autumn 2017

**C O N T E N T S**

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56:3 (Autumn 2017) pp. 193–219

# The Unreliability of Output-Gap Estimates in Real Time

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Most research on monetary policy assumes availability of information regarding the current state of economy, at the time of the policy decision. A key challenge for policy-makers is to find indicators that give a clear and precise signal of the state of the economy in real time—that is, when policy decisions are actually taken. One of the indicators used to asses the economic condition is the output gap; and the estimates of output gap from real time data misrepresents the true state of economy. So the policy decisions taken on the basis of real time noisy data are proved wrong when true data become available. Within this context we find evidence of wrong estimates of output gap in real time data. This is done by comparing estimates of output gap based on real time data with that in the revised data. The quasi real time data are also constructed such that the difference between estimates of output gap from real time data and that from quasi real time data reflects data revision and the difference between estimates of output gap from final data and that from quasi real time data portray other revisions including end sample bias. Moreover, output gap is estimated with the help of five methods namely the linear trend method, quadratic trend method, Hordrick-Prescott (HP) filter, production function method, and structural vector autoregressive method. Results indicate that the estimates of output gap in real time data are different from what have been found in final data but other revisions, compared to data revisions, are found more significant. Moreover, the output gap measured using all the methods, except the linear trend method, appropriately portray the state of economy in the historical context. It is also found that recessions can be better predicted by real time data instead of revised data, and final data show more intensity of recession compared with what has been shown in real time data.

*JEL Classification:* E320
*Keywords:* Data Uncertainty, Measurement Uncertainty, Output Gap, Business Cycle, Economic Activity

## 1. INTRODUCTION

The main limitation of the literature on monetary policy rules is that it ignores uncertainty. Monetary authorities are uncertain regarding transmission channels through which changes in monetary policy instruments affect target variables; about parameter values of structural equations; and regarding the current state of the economy, at the time when policy decisions are taken. These types of uncertainties may cause inappropriate policy actions which have unintended consequences *ex post* for economic activity. Policy-makers may find their decisions—that have been taken in an optimal way based

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on the information available at that time—inappropriate in the future when policy effects are reflected in the economic variables.

The main indicator of current state of the economy is the output gap; positive values of the output gap reflect boom in economic activity while negative values portray recession. So it is considered an important input in the design of monetary policy, as it is evident from the Taylor rule. Despite its importance in the conduct of monetary policy, the true value of the current output gap is difficult to estimate at the time of policy decisions; and output gap estimated from real time data may portray a misleading picture of the economy. Assuming that output gap is autoregressive process, one period ahead forecast may be upward biased in recession and downward biased in boom. The discussion on output gap uncertainty and monetary policy formulation started with the pioneering work of Orphanides and Norden (2002) regarding the unreliability of estimates of the output gap in real time data.

Output gap, which proxies business cycle, is the difference between current level of output in the economy and the potential level that could be supplied without putting upward or downward pressure on inflation. The measurement of output gap goes back to the work of Mitchell (1927) and Burns and Mitchell (1946), which mainly focused on the timing of recessions—episodes which they interpreted to be deviations from full-employment level of output. In macroeconomic models output gap is considered a macroeconomic indicator just like the others but for practitioners the potential output is not directly observable. Therefore it has to be estimated from available information using certain assumptions about path of potential output.

There are at least three reasons why estimates of the current output gap may be inaccurate. First, data of GDP are subject to revisions so revised data may be quite different from what is available to policy-maker at the time of policy decisions. There are technical reasons why final data cannot be released at the end of each year. In Pakistan, for instance, data on GDP are released at the end of each fiscal year but at the time of release data for the last quarter are not available, so estimated figures are used for the last quarter. Second, there are different methods of estimating potential output which may give different estimates. Each method has its own merits and demerits. Some of the methods estimate output gap from data without considering economic theory, while those based on economic theory needs certain assumptions regarding the production technology in the country which may not be true. Some methods are flexible enough that they under-estimate the severity of business cycles while others are so trend dominated that their estimates are subject to end sample bias. Third, assuming that output gap is autoregressive process, one period ahead forecast may be upward biased in recession and downward biased in boom.

Despite importance of uncertainty in the estimates of output gap, researchers in the field have not yet focused on the issue with reference to Pakistan. There are few studies available, like Syed and Shah (2009) and Sherbaz, *et al.* (2010), that estimate output gap for Pakistan using different methodologies but they did not deal with the uncertainty issue. Within this context we will explore the evidence of over and/or under estimation of the output gap based on real time data with that in the revised data.

However, the difference between estimates from these two data sets does not reflect the only data revision. At the start of each period policy-makers have access to different vintages of data, therefore estimates based on these vintages of data are subject to end sample bias. Hence we constructed the quasi real time data in which the final or revised data are considered, but in the same vintages as that of real time data. Difference between estimates of output gap from real time data and that from quasi real time data reflects data revision and the difference between estimates of output gap from final data and that from quasi real time data portray the revisions other than the data revisions including end sample bias. Moreover, output gap is estimated with the help of five methods namely the linear trend method, quadratic trend method, HP filter, production function method, and vector autoregressive method. Furthermore, to analyse the revisions in the output gap, some indicators of revision are also discussed in the study. The list of these indicators include mean revision, mean absolute revision, root mean square error, signal to noise ratio, and autocorrelation function of the estimates.

Rest of the study proceeds as follows: Section 2 highlights the existing literature on the measurement of the output gap with a special focus on real time data; Section 3 explains the methods of estimating the output gap and construction of vintages of real time data and quasi real time data; Section 4 presents and explains detailed empirical results; and Section 5 concludes the study.

## 2. LITERATURE REVIEW

### 2.1. Output Gap: Definition and Measurement

Output gap is defined as the percentage difference between the actual output and its potential level. Different economists define potential level of output in different ways. One school of thought follows Okun's (1962) definition where potential output is the level of output that economy is capable of producing in the absence of shocks. Other economists, who base their macroeconomic models on micro foundations, define potential output as the output in the absence of nominal rigidities [Mankiw and Romer (1991)]. So the potential output can be defined as the output that can be produced in the absence of intervention or external shocks and nominal rigidities. This level of output is also called natural or normal level of output.

The gap between the actual level of output and the potential level can be used as an indicator of economic conditions of a country. If the actual level of output is above its potential, that is, the output gap is positive then there is boom in economic activity which most of the times leads to higher than average inflation rate. Negative output gap, a situation when actual output is below its potential, reflects slowdown of the economic activity and these recessionary phases are mostly associated with low inflation rate but high unemployment.

### 2.2. Measurement Uncertainty in Output Gap

There are different viewpoints regarding the definition and modelling of potential output and output gap. According to pure statistical perspective the potential output is simply the trend output and output gap is the deviation of actual output from this long run trend. According to theoretical viewpoint potential output is the supply side phenomenon and it is the output level where the factors of production are utilised at potential level with current available state of technology. This theoretical idea of potential output reveals that the output gap is due to demand side shocks and these gaps are transitory components of the output. Therefore, the potential output is the stable component of output linked with the long run aggregate supply curve in the absence of nominal rigidities.

There are several studies in the literature that have made an effort to estimate the potential level of output and output gap using different estimation methods. Some of them estimated the potential output using pure statistical approaches while others applied structural or theoretical approaches and attempted to model the output using production function. These different estimation methods of output gap give rise to differences in cyclical component in terms of amplitude, length of gap, range and autocorrelation.

The statistical approaches are based on the assertion that *"let the data speak"* rather than relying on economic theory [Cogley (1997)]. These methods separate the permanent component of output which is non-stationary from transitory component which is stationary and usually consists of cyclical and irregular component [Nelson and Plosser (1982)]. The simplest examples of this approach are linear trend method and quadratic trend method that assume trend output as potential level of output and residuals are a measure of the output gap. Other statistical approaches are Hodrick and Prescott (1997) filter, the Band-pass (BP) filter proposed by Baxter and King (1995), the BN filter proposed by Beveridge and Nelson (1981) and the unobservable-components (UC) time-series approach proposed by Watson (1986) and Clark (1987).

Structural approach makes use of economic theory to estimate the potential output. In this approach different economic variables related to the business cycles, like employment and inflation rate are used and the estimation relies on the particular production function with specific assumption regarding technology. So this approach separates structural and cyclical components of output using economic theory [Saxena and Cerra (2000)]. Another approach estimating the output gap is the mixed approach which combines both the statistical model with economic theory under certain assumptions. Kuttner (1994), for instance, applied unobserved components (UC) model using data on actual output and inflation to estimate the output gap in the USA under the assumption that relationship between these two variables is stable within the sample period. The advantage of structural approach over statistical approach is that the data are not mechanically linked to GDP; rather, this is done with strong theoretical linkages. But the disadvantage is that it requires long time series of key variables which are usually missing for emerging economies. Misspecification of structural model can also be a source of poor output gap estimate through structural approach.

These different measures of potential output and output gap are valued based on how well they present the true picture of economic state of a country. For estimating output gap with statistical approach the simplest model used is linear time trend under the assumption that potential output is a function of time and it grows at constant rate. The percentage deviation of GDP from its trend line is the output gap. The first criticism of the linear trend method is the assumption that potential output grows at a constant rate which implies that the time trend is only demand determined and supply shocks are ignored which may distort resulting cycles and trend [Claus (1999, 2000)]. Secondly, the use of OLS methodology is criticised because GDP contains unit root as Nelson and Plosser (1982) found. Moreover, it does not fulfil another time series property as cyclical output, which is de-trended series, may not be stationary and the property of mean reversion in output gap may not necessarily hold [Gibbs (1995); Diebold and Senhadji (1996); De Brouwer (1998); Billmeier (2004)].

This linear trend model was later replaced with the linear breaking trend model. Perron (1989, 1997) augmented the linear trend with the dummy of structural breaks of 1972 oil crisis and estimated using OLS. Breaking trend approach uses the time trend with restriction of discrete breaks in trend line to avoid the condition of constant potential output growth [Kenny (1995)]. This linear breaking trend is not restricted to only one break rather we can include more than one breaks by introducing dummies. Lots of mixed literature exists on whether the output gap follows a deterministic trend, possibly with breaks, or a stochastic trend [Diebold and Senhadji (1996)].

Another model which is estimated using ordinary least squares method is the one in which potential output is modelled as quadratic trend. The difference between the linear and quadratic trend is that in linear trend the GDP growth rate is assumed to be constant while in quadratic trend this assumption can be relaxed. The quadratic time trend method is more flexible as compared with linear time trend method and it performs better at the end points of data set. The quadratic time trend method may create problem, however, at the start of the sample period.

Other statistical approaches to measuring output gap are smoothing techniques. Despite improvement in structural modelling of the economy, these estimation methodologies are still popular in the macroeconomics literature. One of the smoothing approaches is Hodrick-Prescott (HP) filter [Hodrick and Prescott (1997)]. The HP method is commonly used to estimate potential output from actual output by fitting a smooth curve along a point. The HP filter divides the GDP into trend component and cyclical components. The trend component is the potential output while the cyclical component is the output gap. The HP method is flexible to attain fluctuation in potential output growth by setting different values of smoothing parameter [Correia, *et al.* (1992, 1995) and Cooley and Ohanian (1992)]. Another smoothing approach is the Band-pass filter. In Band-pass filter, as opposed to Hodrick and Prescott filter, we can make use of historical experience with regards to duration of the business cycle. Therefore, we can say that our business cycle has the length that has historically been observed for business cycles. The most important contribution of Baxter and King (1995) is the derivation of a band pass filter to estimate directly the cyclical component.

Although the statistical methods are easy to apply, there are some problems associated with this approach. Firstly, using the univariate approach it is not possible to decompose the output into its components affected by demand and supply shock [Quah (1992)]. Secondly, statistical approaches do not make use of information related to the state of the economy contained in variables related to potential output, while structural methods rely on economic theory [Chagny and Döpke (2001)].

In structural approach two methods which are commonly used for decomposing the output are the production function method and the structural vector autoregressive. In the production function method a specific production function is supposed to capture true production technology in the economy. Mostly the Cobb-Douglas production function is used with two factors of production [Giorno, *et al.* (1995) and Froyland and Nymoen (2000)]. The problem with the production function approach is the assumption about elasticity of substitution between labour and capital which is assumed to be one but it is found to be higher in empirical research. The second problem is that, the capital stock which is used in this method is not directly observed and its data needs to be constructed assuming a constant depreciation rate of capital. Thirdly, data for inputs (like capital, labour, a measure of productivity and sometimes intermediate inputs) are not available, poor in quality or difficult to estimate [Claus (2000)].

Another approach which combines the statistical smoothing along with economic theory is the structural autoregressive models (SVAR). SVAR models allow us to consider all interaction between endogenous variables considering for feedback effects [Sims (1980)]. The SVAR method based on Blanchard and Quah (1989) combines the economic theory with statistical technique to separate the permanent and temporary movements in output. They reconsidered the Beveridge and Nelson (1981) decomposition of Real GNP under the assumption that the demand side shocks have temporary while the supply side shocks have permanent effect on output.

### 2.3. Empirical Literature and the Choice of Method of Measuring Output Gap

Clark (1987) used the multivariate unobserved components model and estimated the output gap for US economy. He applied a bi-variate model using unemployment and real GDP based on Okun's law. Apel, *et al.* (1999) also applied multivariate unobserved components model and estimated the potential output for Canada, US and UK using three variables inflation unemployment and GDP. Scott (2003) used tri-variate model including capacity utilisation, inflation and GDP and projected the output gap for New Zealand. Runstler (2002) applied both multivariate and univariate models for Euro area and provided the real-time valuation of output gap reliability and usefulness of real time output gap for inflation forecasting. Laxton and Tetlow (1992) criticised the HP filter which is based on OLS method and highlighted importance of the theory based models of potential output.

On the same lines, Araujo, *et al.* (2004) used both trended and structural methods of potential output for Brazilian economy and found that all measures have strong short term co-movement. The results indicate that different models of potential output show low and high variance and Beverage-Nelson method performs better at the specific forecast horizons. Dupasquier, *et al.* (1997) estimated the output gap for United States using different estimation methods and show that the VAR based methodology of measuring transitory and long run component of output gap perform better. Saxena and Cerra (2000) used different methods of potential output to estimate the output gap for Sweden. Billmeier (2004) used the data from 1980-2002 for Finland and estimated the output gap using nine different measures. He found that measurement of output gap based on statistical measures may lead to errors as it is unable to capture the high volatility in output.

### 2.4. Output Gap with Real Time Data

There are some problems with the estimation of output gap. Firstly, the output gap estimated using real time data differs from that estimated using revised data, published later. Secondly, different estimation techniques for estimating output gap give different results using same available data. Thirdly, estimated coefficients' magnitude may change over time which leads to wrong estimates of the business cycle [Croushore and Stark (2003)].

Orphanides (2001, 2003) explained that the imperfect information about current state of the economy played a vital role in inflation process during 1970s. The productivity slowdown of that time was interpreted as negative output gap by Federal Reserve which led to expansionary monetary policy. After a long time, the monetary authority realised that the potential output growth rate was lower and eventually adjusted policy to bring inflation down. The author used the real-time estimates of the output gap and proved that the measurement error of the output gap leads to deterioration of the policy outcomes. How a policy-maker estimates current output gap on the basis of available information (real time estimate) is important, since the final information regarding output arrives with some time lags. Kuttner (1992, 1994) highlighted the importance of the output gap for real time and examined the difficulties associated with the real time output gap estimation.

Orphanides (2001) finds the estimates of output gap with official records of final data and compared these with most recent estimates of the output gaps. Orphanides and Van-Norden (2002) explained different phases of the output gap revisions and found that the deviations between the real time estimates of the output gap and final the output gap are on average about 2.6 percent. He also decomposed the output gap revisions into two parts. First, data revision, which is due to the measurement error of GDP series and secondly other revisions which are due to different measures of the output gap named filtering error. This mis-measurement of GDP series explains the extent of revisions in GDP series.

Orphanides (2003) reconstructed the real time GDP series from 1951 and estimated the output gap with this real time series. He compared the output gap of real time series with the final series of GDP and showed persistent underestimation of output gap till 1980s. Nelson and Nikolov (2003) rebuilt a series of output gap in real time for UK, dating from 1965. They found that, in 1970s, the perception about real time output gap which was 7 percent less than what could be quantified at this time and this was the main cause of slowdown as monetary policy was wrongly tightened on the basis of incorrect estimates of the output gap. Kozicki (2004) using U.S. data and Kamada (2005) by using same for Japan show that if policy-makers do not take into account the possibility of data revision at all then the policy actions may be more aggressive. Cayen and Van-Norden (2005) used the data vintages from 1972 for Canada and applied different univariate and multivariate techniques to find out the output gap. They found that revisions in output gap are important and data revision role is not as harmless as it was earlier believed. Bernhardsen, *et al.* (2004) found that total revisions in output gap are greatly influenced by the measurement uncertainty while data revision uncertainty is small in magnitude. Contrary to most of the empirical findings, Crushore and Evans (2006) concluded that the data revision is insignificant for measure of monetary policy shocks, but in simultaneous equation system it is difficult to identify in the presence of data revision. Based on a simulated multivariate filtered real-time output gap series for Australia, Gruen, *et al.* (2002) report revisions below four percentage points of GDP. Moreover, drawing on ex-post data for the Euro area Rünstler (2002) finds revisions to various real-time output gap estimates that do not exceed two percentage points of GDP.

**2.5. Literature Review Related to Pakistan Economy**

A limited number of researchers focused on the measurement of the output gap for Pakistan but they did not estimate the gap using real time data. Sherbaz, *et al.*

(2010) used time series data from 1963–2005 and estimated the output gap by applying production function approach. They determine the factors which cause movement in the output gap. According to their results imports and money supply cause to increase the output gap, while public sector investment and exports lessen the output gap. Syed and Shah (2009) estimated the output gap for Pakistan economy using annual data from 1951 to 2007. They applied different measures of output gap to identify the different spans of excess supply and excess demand. They also show that the economy is facing inflationary pressure since 2005. Haider and Khan (2008) estimated output gap using six different methods. They found that measures of output gap were not identical but they showed some degree of co-movement. Therefore, they constructed a composite index of output gap series measured through all six methods.

## 3. METHODOLOGY

We have used five different methodologies to estimate the output gap using real time data, quasi real time data and revised data. This section presents brief discussion of each method of estimation and explains the method of constructing the series of real time and quasi real time data.

### 3.1. Methodologies for Estimation of Output Gap

#### 3.1.1. *Linear Trend Method*

The simplest way of estimating the potential output is through linear time trend under the assumption that potential output grows at a constant rate and output gap is a percentage deviation of actual output from the fitted trend line. The trend (potential) output is represented by: $\overset{*}{y} = \beta_0 + \beta_1 t + \varepsilon_t$ ; and the cyclical component is given as: $C = y - \overset{*}{y}$ which is a measure of output gap.

#### 3.1.2. *Quadratic Trend Method*

In the quadratic trend method the log of GDP is regressed on time and square of time with constant included which can be written as:

$$y_t = \beta_0 + \beta_1 t + \beta_2 t^2 + \varepsilon_t$$

The cyclical component is again estimated as the difference between actual values of log of the output and the fitted values.

#### 3.1.3. *Hodrick-Prescott Filter*

The Hodrick and Prescott (1997) filter methodology is used under the assumption that the GDP growth, though not constant, is smooth over time. H-P filter divides the GDP into two parts GDP* (potential or trend component) and C (Cyclical component).

$$GDP = GDP^* + C$$

Where GDP* is the sum of squares of its second difference which can be found by minimising the following loss function:

$$MinL = \left\{ \sum_{t=1}^{t} C_t^{\,2} + \lambda \sum_{t=2}^{t} (\Delta GDP_t^{\,*} - \Delta GDP_{t-1}^{\,*})^2 \right\}$$

$$= \left\{ \sum_{t=1}^{t} (GDP_t - GDP_t^{\,*})^2 + \lambda \sum_{t=2}^{t} [(GDP_t^{\,*} - GDP_{t-1}^{\,*}) - ((GDP_{t-1}^{\,*} - GDP_{t-2}^{\,*})]^2 \right\}$$

The lambda is smoothing parameter which is set equal to 1600 for quarterly data, as used by Hodrick and Prescott (1997) and 400 or 100 is used for annual data.

### 3.1.4. *Production Function Method*

Production function method of estimating output gap is mostly associated with the basic structure of the economy which relates the growth of GDP to the growth of factors of production including labour, capital and total factor productivity. This can be captured by Cobb-Douglas production function, where we consider capital and labour (employment) as inputs. Production function of this type can be written as:

$$Y_t = A_t N_t^{\,\alpha} K_t^{\,1-\alpha}$$

Here $Y_t$ is actual output (GDP), $A_t$ is total factor productivity, $N_t$ is employment and $K_t$ is capital, $\alpha$ is the labour share and $1-\alpha$ is the capital share in total output. Here total factor productivity ($A_t$) is un-observable which is usually computed as the Solow residual i.e. by subtracting contribution of capital and labour to GDP from actual GDP. Above equation can be converted into log form as:

$$y_t = A_t + \alpha l_t + (1-\alpha) k_t$$

Now all the variables are in log form and we have information regarding GDP and employment level, while capital stock is constructed using Nehru and Dhareshwar (1993) methodology, explained in data section. Furthermore, we need to know the share of the labour $\alpha$ and share of capital $1-\alpha$. We set value of labour and capital share as 0.56 and 0.44 respectively, used by Khan (2006).

$$y_t^* = A_t^* + 0.56 l_t^* + 0.44 k_t^*$$

The resulting residual from this equation is smoothed using HP filter to get potential level of total factor productivity. After getting all required information and setting the potential capital stock equal to actual capital stock and potential employment equal to labour force we can use above equation to find the potential level of output, deviation of actual output from which is the measure of output gap.

### 3.1.5. Structural Vector Autoregressive (SVAR) Approach

The VAR models allow us to consider all interactions between endogenous variables considering feedback effects [Sims (1980)]. The SVAR method based on Blanchard and Quah (1989) combines the economic theory with statistical technique to separate the permanent and temporary components of output. The BQ method reconsiders the Beveridge and Nelson (1981) decomposition of Real GNP under the assumption that the demand side shocks have temporary while supply side shocks have permanent effects. In order to use BQ technique at least one of the variables must be non-stationary as a stationary variable does not have a permanent component. Here, we want to decompose the real GDP $\{y_t\}$, which is integrated of order 1, into temporary and permanent components and we have another variable, unemployment ($U_t$), which is stationary. The bivariate moving average (BMA) representation of these two variables is:

$$\Delta y_t = \sum_{k=0}^{\infty} c_{11}(k)\varepsilon_{1t-k} + \sum_{k=0}^{\infty} c_{12}(k)\varepsilon_{2t-k}$$

$$U_t = \sum_{k=0}^{\infty} c_{21}(k)\varepsilon_{1t-k} + \sum_{k=0}^{\infty} c_{22}(k)\varepsilon_{2t-k}$$

Here $\varepsilon_{1t}$ and $\varepsilon_{2t}$ are exogenous variables; $\varepsilon_{1t}$ is the aggregate demand shock and $\varepsilon_{2t}$ is the aggregate supply shock.

The demand and supply shocks are not directly observed. Given the variables in the system are stationary, the VAR representation of the variables is given as:

$$X_t = A(L)X_{t-1} + e_t$$

Where

The VAR residuals $e_{1t}$, $e_{2t}$ can be defined as forecast errors and they are composites terms of demand and supply shocks, $\varepsilon_{1t}$ and $\varepsilon_{2t}$ as:

$$e_{1t} = c_{11}(0)\varepsilon_{1t} + c_{12}(0)\varepsilon_{2t} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(i)}$$

$$e_{2t} = c_{21}(0)\varepsilon_{1t} + c_{22}(0)\varepsilon_{2t} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(ii)}$$

If the coefficient matrix of the above system is known we can estimate the structural shocks from estimated forecast errors. These coefficients are, however, unknown and need to be estimated from data. Blanchard and Quah provide the following restrictions to find these four coefficients.

***Restriction 1***

Considering Equation (i) and given that $E\,\varepsilon_{1t}\varepsilon_{2t} = 0$, the normalisation $\text{var}(\varepsilon_1) = \text{var}(\varepsilon_2) = 1$ means that the variance of $e_{1t}$ is $\text{var}(e_1) = c_{11}(0)^2 + c_{12}(0)^2$.

***Restriction 2***

Considering Equation (ii) and given that $E\,\varepsilon_{1t}\varepsilon_{2t} = 0$, the normalisation $\text{var}(\varepsilon_1) = \text{var}(\varepsilon_2) = 1$, means that the variance of $e_{2t}$ is $\text{var}(e_2) = c_{21}(0)^2 + c_{22}(0)^2$.

***Restriction 3***

$$Ee_{1t}e_{2t} = c_{11}(0)c_{21}(0) + c_{12}(0)c_{22}(0),$$

The restriction that $\varepsilon_{1t}$ sequence has no long-run effect on $y_t$ can be written as:

$$\left[1-\sum_{k=0}^{\infty} a_{22}(k)L^{k+1}\right]c_{11}(0)\varepsilon_{1t}+\sum_{k=0}^{\infty} a_{12}(k)L^{k+1}c_{21}(0)\varepsilon_{1t}=0$$

***Restriction 4***

For all realisations of $\varepsilon_{1t}$ sequence, $\varepsilon_{1t}$ shocks will have only temporary effects on $\Delta y_t$ sequence if

$$\left[1-\sum_{k=0}^{\infty} a_{22}(k)\right]c_{11}(0)+\sum_{k=0}^{\infty} a_{12}(k)c_{21}(0)=0$$

Potential output is estimated using only supply side shocks while demand side shocks are ignored. The difference between actual output and the estimated output series is the measure of the output gap.

Each method of estimating the output gap has its own merits and demerits. None of the methods is the one that can solely be relied upon for research or for policy-making. It is therefore better to estimate the output gap with the help of different methods so that results from these methods can be compared.

## 3.2. The Revision Indicator Formulae

The indicators of revisions, used to analyse the magnitude, predictive power and persistence in the output gap are presented in Table 1.

Table 1

*The Revision Indicator*

| | |
|---|---|
| 1. Mean Revision (Mean) $=\frac{1}{n}\sum(y_t^F-y_t^R)$ | Indicator of revision bias but it does not indicate magnitude of the revision |
| 2. Mean Absolute Revision (MAR) = $\frac{1}{n}\sum\left\|y_t^F-y_t^R\right\|$ | Measures the magnitude of revision. And represents the average deviation between the output gap with final data and output gap with real time. |
| 3. Root Mean Square Residual (RMS) = $\sqrt{\frac{1}{n}\sum(Y_t^F-Y_t^R)^2}$ | |
| 4. Noise Signal Ratio (NS) = $\frac{RMS}{SD(Y_t^F)}$ | Ratio between the signal (meaningful information) and noise (not meaningful). High NS indicate significant difference between the real time and final output gap. |
| 5. Correlation Coefficient (COR) = $\frac{COV(Y_t^F,Y_t^R)}{SD(Y_t^F)SD(Y_t^R)}$ | COR is the correlation between the final and real time estimates of output gap. The low COR value implies the significance of revision in size and high COR value indicates the low association between both series. |
| 6. First Order Autocorrelation (AR) $(y_t^F-y_t^R)=\gamma(y_{t-1}^F-y_{t-1}^R)$ Where $\gamma$ shows the degree of persistence | Measure the degree of persistence in the revision. High AR shows persistence in revision which leads the policymaker and other economic agents to make persistent errors about estimation of business cycle movements. |
| 7. Opposite Signs (OPSIGN) = $\frac{1}{n}\sum O_t$ ,Such that $O_t=\begin{cases}1 & if \quad Sign(Y_t^F)\neq Sign(Y_t^R)\\ 0 & otherwise\end{cases}$ | Positive sign of output gap shows inflationary gap while negative signs show deflationary gap. The OPSIGN gives the number of time periods, as ratio of total sample period, when estimates from both types of data have same sign. |

### 3.3. The Components of Output Gap Revision

To analyse the total revisions in output gap and to decompose it into data revision and other revisions we followed Orphanides and van Norden (2002). The output gap is estimated using three types of data sets namely the real time data, quasi real time data and final data. Further, the output gap is estimated using five well known de-trending techniques including linear trend, quadratic trend, HP filter, production function, and vector autoregressive model.

For estimating the output gap in real time we estimated all the five models for every vintage of data available up to a particular year and then constructed a new series of output gap. From each of these series we have taken only the last value and then a new series is constructed that contains all these last values; this new series represents the timeliest estimates of output gap that policy-maker could have accessed in each time period. The output gap from final data is estimated using last vintage of data (taken from POS of 2012) by applying all five de-trending methods. The estimated output gap from final data is the one that is usually used in the research on monetary policy. However, these estimates were not available to policy-maker when (s)he was actually taking the policy decisions.

The difference between final estimates and the real time estimates of the output gap represents the total revision in the output gap. This total revision in the output gap is because of two reasons; first it might be due to the GDP data revision, that is, data revision and secondly it might be due to other reasons, that is, other revisions. These other revisions are due to both end sample bias and parameter instability problem. To decompose the total revision into these two components we have also estimated the output gap in quasi real time data. Quasi-real time estimates of the output gap are constructed using the same approach as that in real time data but using rolling regression in final data. Rolling regression in final data is the same as estimating models in the quasi real time data. Again from estimates of output gap from each of these vintages we have taken only the last value and then the series constructed with these last values represents quasi-real-time estimates of output gap. The difference between quasi-real time and real time estimates of output gap is due to data revision over the sample period and the difference between final and quasi real estimates represents the other revisions that may be due to the end sample bias. So we have three types of revisions:

Total revision in output gap = final series of output gap—real time estimates of output gap.

Data revision = quasi real time estimates of output gap—real time estimates of output gap.

Other revision = final estimates of output gap—quasi real time estimates of output gap.

### 3.4. Data Related Issues

As we are estimating the output gap both from real and revised data the first stage is to develop the real-time data set for those variables which are subject to revision over time. The real time data set is a snapshot of available data that existed prior to subsequent revisions. Following Croushore and Stark (2001, 2003) we designate the last available information set with the most recent revisions, up to specific time as "Vintage" and the collection of these vintages is called "the real time data set".

Data on Real GDP, Labour Force, Real Gross Fixed Capital Formation, Consumer Price Index and Unemployment, over the period 1960 to 2010, have been taken from various issues of *Pakistan Economic Survey* (POS), published by Ministry of Finance, Government of Pakistan. The reason for not taking the data beyond 2010 is the non-availability of revised data after this period. The variables labour force, unemployment and inflation rate are not subject to revision so the annual data, on these variables, from 1960 to 2010 is taken from POS 2012 issue.

The data set for GDP and the fixed capital formation which is further used for construction of the capital stock is subject to revision so real time data set for these two variables is constructed. For the construction of real time data set of these variables we just dig through old sources of data going back to start of that sample period and note down what data sets were available at that point of time. We used different issues of POS from 1974 to 2010 for construction of the real time data series for GDP and gross fixed capital formation. So the first vintage of data, 1960 to 1974, has been taken from the POS published in 1974.

Table 2

*Generic Real-time Data Set for GDP*

| Date to Which Data Pertain | Data Release Date | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | i=1974 | i=1975 | i=1976 | | i=t | i=t+1 | i=t+2 | | i=2009 | i=2010 |
| j=1960 | $y_i$ (j) | $y_i$ (j) | $y_i$ (j) | ……. | $y_i$ (j) | $y_i$ (j) | $y_i$ (j) | …… | $y_i$ (j) | $y_i$ (j) |
| : | $y_i$ (j) | $y_i$ (j) | $y_i$ (j) | ……. | $y_i$ (j) | $y_i$ (j) | $y_i$ (j) | …… | $y_i$ (j) | $y_i$ (j) |
| j=1974 | $y_i$ (j) | $y_i$ (j) | $y_i$ (j) | ……. | $y_i$ (j) | $y_i$ (j) | $y_i$ (j) | …… | $y_i$ (j) | $y_i$ (j) |
| j=1975 | | $y_i$ (j) | $y_i$ (j) | ……. | $y_i$ (j) | $y_i$ (j) | $y_i$ (j) | …… | $y_i$ (j) | $y_i$ (j) |
| j=1976 | | | $y_i$ (j) | ……. | $y_i$ (j) | $y_i$ (j) | $y_i$ (j) | …… | $y_i$ (j) | $y_i$ (j) |
| : | | | | | $y_i$ (j) | $y_i$ (j) | $y_i$ (j) | …… | $y_i$ (j) | $y_i$ (j) |
| j=t | | | | | $y_i$ (j) | $y_i$ (j) | $y_i$ (j) | …… | $y_i$ (j) | $y_i$ (j) |
| j=t+1 | | | | | | $y_i$ (j) | $y_i$ (j) | …… | $y_i$ (j) | $y_i$ (j) |
| j=t+2 | | | | | | | $y_i$ (j) | …… | $y_i$ (j) | $y_i$ (j) |
| : | | | | | | | | | $y_i$ (j) | $y_i$ (j) |
| j=2009 | | | | | | | | | $y_i$ (j) | $y_i$ (j) |
| j=2010 | | | | | | | | | | $y_i$ (j) |

Table 2 explains the procedure of taking different vintages of data from different issues of POS. First of all we present the table of generic real-time data for GDP. The entries in Table 2 are represented by $y_i(j)$, where the subscript $i$ represents the time or year at which data was released and ($j$) in parentheses refers to the data pertaining to period $j$. The diagonal elements at the end of each column represent the provisional data or first release or preliminary data. While the element just above the diagonal of each column represents the revised data and the element above that is the final data of the corresponding year.[1]

[1]In Pakistan data on National Income Accounts are revised twice: first time data are released at the end of fiscal year, after one year data are published again as *Revised Data* and in the third year data are published as *Final Data*.

In Pakistan, the method of measuring GDP has been revised three times in history, so the data on GDP over the period 1960–2010 are available with breaks; three sub-samples are based on three different methodologies. First time, methodology is changed in 1988-89, so the data prior to that period are available with old methodology. Second time the methodology is changed in 1999–2000, so the data on GDP over the period 1989–2003 is based on the second methodology and after that GDP is measured with the third methodology. Before estimating the output gap we have converted all the vintages according to the methodology of 1999-2000 so that a consistent series of output gap can be obtained.

Similarly the GDP data sets are available at three different prices with respect to base year; data for 1960-88 are available at prices of 1959-60, for 1989-2003 it is available at prices of 1980-81 and from 2004-2010 it is on constant prices of 1999-2000. Therefore we converted revised data on GDP and all the vintages of real time GDP on the base price of 1999-2000. Similar procedure has been adopted for the variable, *Gross Fixed Capital Formation*.

The data on *gross fixed capital formation*, however, are not available. Therefore, this variable has been estimated for use in the estimation of the output gap using production function method. Capital stock series is constructed using *Perpetual Inventory Method* which takes capital stock as the accumulation of the stream of past investments or gross fixed capital formation, that is, $K_t = GFCF_t + (1-\sigma)K_{t-1}$ where σ is the depreciation rate. For this purpose we used the Nehru and Dhareshwar (1993) methodology according to which the equation generating capital stock is given as:

$$K_t = (1-\sigma)^t K_0 + \sum_{i=0}^{t-1} GFCF_{t-i}(1-\sigma)^i$$

Where *GFCF* is gross fixed capital formation and $K_0$ is initial capital stock which is calculated by method introduced by Harberger (1978) and is modified further by Nehru and Dhareshwar (1993). To get the initial value of capital stock, log of *GFCF* is regressed on time and the fitted value of *GFCF* is used to calculate initial capital stock using the following equation $K_{t-1} = \frac{GFCF_t}{(g+\sigma)}$, where *g* is the growth rate of GDP for the period *t* and depreciation rate is considered as 4 percent. By applying above mentioned methodology to each vintage of data on gross fixed capital formation we constructed the real time data series for the capital stock.

For GDP and capital stock three types of data sets have been used. First, the final data from 1960 to 2010, which are currently available in POS, published in 2012. Second type of data are the real time data that existed prior to subsequent revisions. Finally, quasi-real time data have been constructed using the same data span as for the real-time but using the rolling final data. This last type of data set is used for comparison of estimated output gap from real time and final data without facing the problems of end sample bias. The commonality between real time data and quasi real time data is that both have same vintage of data in terms of time period. But the difference is that the former contains real time data while the later contains final data. Data on all variables other than

GDP and capital stock are taken from the latest issue of POS as all other variables are not subject to revision overt time.

## 4. EMPIRICAL RESULTS

### 4.1. Output Gap Estimates

Figures 4.1 and 4.2 show the visual comparison between the business cycles measured with five different methods mentioned above, for real-time and final data respectively. From Figures it is clear that the estimates from all the five methods have strong short-term co-movement. The turning points of the output gap, estimated from all methods, are almost the same. However, the estimates generated from Quadratic Trend, HP filter, Production Function method and SVAR are consistent with the historical facts while the estimates generated using linear trend method contradict historical facts. Furthermore, different measures give rise to a wide range of the output gap. The range of estimates from real time data is much wider than that found in the final or revised data. With four measures, Quadratic Trend, HP filter, Production Function method and SVAR, the recessions and booms in real time estimates seem to be more prominent than those found in final data. The linear trend method under-estimates output gap in real time data and over estimates the final data.

The final estimates of the output gap shown in Figure 4.2 are consistent with the economic history of Pakistan. During the time period 1974-1977, the results show that the economy is in recession and reached the trough in 1977. The main cause of this recession is the disintegration of Bangladesh from Pakistan after a civil war. The country was faced with the challenges of recovery from the effects of war, increase in petroleum prices and recession in overall world market. To overcome these problems the government of Pakistan took steps to restructure the economy like land reforms, labour reforms, nationalisation of industries, banks and insurance companies. These reforms were introduced to improve efficiency of manufacturing and agricultural sector but the control of government over the key decisions was proved as the major setback to the economy. The overall economy faced a decline of GDP growth of about 3.6 percent per annum because of decline in share of two major sectors, manufacturing and agriculture.

Significant differences can be found among estimates of the output gaps estimated in two types of data sets. For instance, the real-time estimates of the output gap show that the recovery of economic activity started after 1977 but the final estimates show that the economy remained in recession till 1979 and recovery started after that period.

If we look at final estimates of the output gap the economy is in recovery phase from 1978 to 1992 and the speed of recovery is different with different measures of output gap. When the economy reached its peak in 1992 the output gap value with LT, QT, HP filter, VAR and PF are 9.458 percent, 2.934 percent, 2.798, 1.009 and 3.394 respectively. If we compare these final estimates of output gap with the real-time estimates of the output gap for 1992, the values of real time estimates of the output gap are above those from final estimates. The real time estimates of the output gap show different results. The recovery process started after 1979 and reached the peak point in 1987 with gap values 2.73 percent, 4.05 percent, 3.56 percent, 5.77 percent, and 1.42 for LT, QT, HP, VAR and PF respectively. This recovery phase is consistent with the history of Pakistan. The recovery phase is not due to some fundamental policy changes or reforms rather it was due to large financial assistance, as a result of the Afghan War that improved the balance of payments position and the output that came on stream from large

**Fig. 4.1. Estimates of Output Gap in Real Time Data**

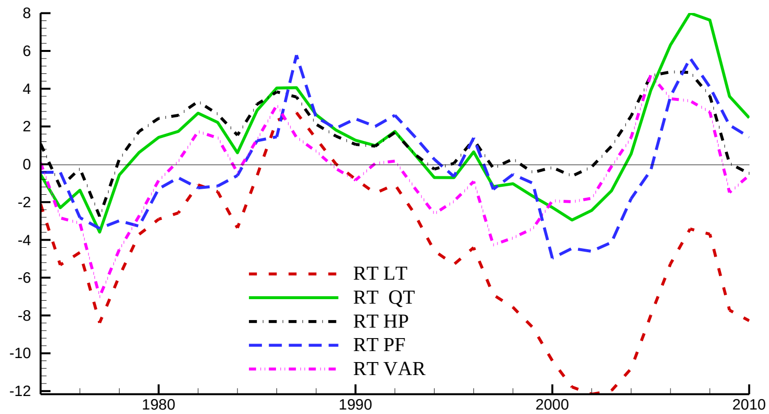
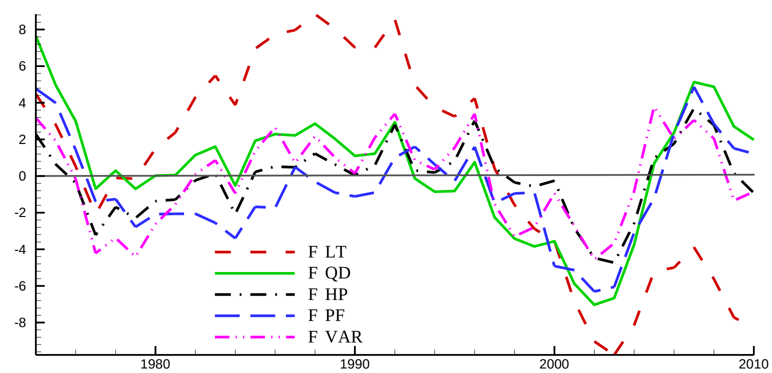



**Fig. 4.2. Estimates of Output Gap in Final Data**




public sector investment made in 1970s. For instance, the *Tarbela Dam* that added significantly to irrigation water availability and hydel power capacity.

The economic performance of Pakistan declined during the 1990s, as the average GDP growth rate was 4.4 percent per annum during this time period. Although different reforms were started in the form of denationalisation, reducing the role of the public sector and introduction of measures to provide better business environment to attract foreign businesses. But due to political instability, frequent changes of government, withdrawl of US aid after the end of Afghan war and sanctions after the nuclear test, the GDP growth rate remained low. The final estimates show that recession in the economy started in 1992 and continued till 2002, with the output gap estimates at a trough in 2002 at –9.02, –7.03, –4.46, –6.30 and –4.55 with LT, QT, HP, VAR and PF methods. Real time estimates of the output gap show the start of recession from 1988, reaching the trough in 2002 with the output gap values of –12.16, –2.439, –0.1323,–4.60, and –1.794 with LT, QT, HP, VAR and PF methods, respectively. With the four measures QT, HP, VAR and PF it is apparent that real time estimates overstate the trough in this period as the gap values are higher in magnitude with real time estimates of the output gap. These output gap values are also different with different measures of the output gap.

After the recession of 1990s the recovery period started in 2002 and continued till 2007. Both real time and final estimates of output show the recovery of economy started in 2002 and reached its peak in 2007. These results are consistent with the actual position of Pakistan economy as the average growth rate of GDP remains 7 percent in this period. This recovery of economy is due to more liberal strategies for enhancing the share of Pakistani exports; privatisation of banking, telecommunication, oil and gas and energy sectors; alliance with coalition forces in the fight against terrorism; and more remittances from abroad after 9/11 event.

At its peak in 2007 the output gap value using real time estimates is –3.41 percent, 8.00 percent, 4.858 percent, 5.61 percent, and 3.35 percent with LT, QT, HP, VAR and PF methods, respectively while the corresponding output gap values of final estimates are 3.89 percent, 5.132 percent, 3.692 percent, 4.86 percent, and 3.05 percent. At its peak, these output gap values vary across different measures of the output gap but, contrary to findings at the trough, less difference is found between real time estimates and final estimates.

The recovery of Pakistan economy that started in 2002 did not last long and the economic activity started to decline in 2008. Both the real time and final estimates of output gap indicate that slowdown started in 2008 and continued till the end of the sample period. However, the intensity of recession is different within each measure of the output gap. The cause of this recession is adverse security condition, large exogenous price shocks, and global financial recession.

It can be concluded from above discussion that the slowdown in the economic activity is indicated first by the real time data and then by the final data. Moreover, the real time estimates of the output gap are higher than those found in final data, both in boom and recession periods. Hence the real time estimates, compared with the final estimates, show a lesser intensity of recession, but greater intensity of boom. Moreover, all the methods except linear time trend model give similar results in both types of data sets.

### 4.2. Output Gap Revision: Size and Persistence

Total revision, which is the difference between the final output gap estimates and the real time estimates of the output gap, is presented in Figure 4.3. The magnitude of the revision with different output gap measures is different. These revisions are relatively high with positive sign in linear time trend based output gap, while the difference is negative, most of the time, in HP filter based output gap. The difference between final estimates and real time estimates is almost zero when output gap is estimated through the production function approach.

Table 3 presents descriptive statistics about various series of output gaps.[2] It can be seen from the first four columns of this table that the output gap series based on the

[2]Although table contains results from final data, real time data, and quasi real time data, the estimates from first two types of data are explained in this section. Estimates of output gap from quasi real time data are given in this table but these estimates are used to decompose total revisions into data revisions and other revisions, which are explained below.

linear time trend has greater amplitude and standard deviation when compared with other output gap methods.

**Fig. 4.3. Total Revision in Output Gap**

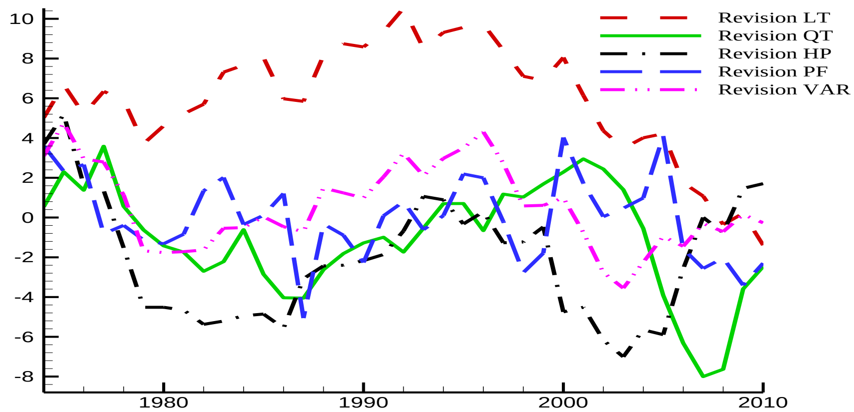



Table 3

*Output-Gap Summary Statistics*

| Method | MEAN | SD | MIN | MAX | COR |
|---|---|---|---|---|---|
| **Linear Trend** | | | | | |
| Final | 1.27 | 5.63 | –9.67 | 9.51 | 1 |
| Quasi-real | –4.66 | 3.99 | –12.17 | 2.73 | 0.87 |
| Real-time | –4.15 | 4.05 | –12.3 | 1.43 | 0.87 |
| **Quadratic Trend** | | | | | |
| Final | 0.37 | 3.27 | –7.03 | 7.65 | 1 |
| Quasi-real | 1.24 | 2.47 | –2.67 | 7.31 | 0.62 |
| Real-time | 1.07 | 2.78 | –3.59 | 8 | 0.58 |
| **Hodrick-Prescott Filter** | | | | | |
| Final | –0.15 | 1.94 | –4.73 | 3.69 | 1 |
| Quasi-real | 1.58 | 1.68 | –0.93 | 5.31 | 0.38 |
| Real-time | 1.37 | 1.82 | –2.76 | 4.89 | 0.42 |
| **Vector Autoregressive** | | | | | |
| Final | –0.71 | 2.7 | –6.3 | 4.86 | 1 |
| Quasi-real | 0.16 | 2.41 | –4.65 | 5.15 | 0.68 |
| Real-time | –0.06 | 2.74 | –4.97 | 5.78 | 0.68 |
| **Production Function** | | | | | |
| Final | –0.08 | 2.46 | –4.56 | 3.79 | 1 |
| Quasi-real | –0.33 | 2.3 | –4.66 | 5.34 | 0.65 |
| Real-time | –0.62 | 2.52 | –7 | 4.73 | 0.65 |

The last column of the Table 3 gives the correlation coefficient of the final estimates of the output gap with other measures to portray the information about the output gap revision. The low correlation value implies the significance of revision. It is shown that the positive and high correlation coefficient between the final and real time gaps is found in linear time trend method, while there is a positive and relatively low correlation for all other estimation methods QT, HP, VAR and PF. Correlation between the real and final estimates is less than 70 percent in four out of five models which suggest that the revision is important in size.

#### 4.2.1. *Revision Statistics*

To analyse the significance of revision, several indicators are used and their values are presented in Table 4. The mean of total revision varies across different measures of the output gap. According to the estimates found in case of quadratic trend, vector autoregressive model, and production function method, revision is quite small while that with the other two methods is quite large. The reason behind this result is that both linear trend method and HP filter give biased estimates at the end of samples. The mean revision is a useful indicator of revision bias but cannot be used for the magnitude of revisions, as the positive revisions offset the negative revisions.

Table 4

*Summery Revision Statistics (Final Minus Real-Time Estimates)*

| Method | MEAN | SD | RMS | MIN | MAX | AR |
|---|---|---|---|---|---|---|
| Linear Trend | 5.94 | 2.95 | 6.61 | –1.39 | 10.53 | 0.91 |
| Quadratic trend | –0.7 | 2.8 | 2.85 | –5.26 | 8.19 | 0.92 |
| Hodrick-Prescott Filter | –1.52 | 2.02 | 2.51 | –5.69 | 1.84 | 0.84 |
| Vector Autoregressive | –0.65 | 2.17 | 2.23 | –5.29 | 5.2 | 0.90 |
| Production Function | 0.53 | 2.07 | 2.11 | –3.55 | 4.75 | 0.84 |

Root mean square (RMS) which is a suitable indicator for capturing the magnitude of total revision in the output gap indicates that total revisions are substantial as RMS values are quite high. Moreover, the RMS obtained from the output gap estimated from linear time trend is way above those found from other methods. The last column of Table 3 reports the estimated first-order autocorrelation coefficients for revision. The results indicate that all revision series are highly persistent, though it differs across different methods. The coefficient ranges from 0.84 for HP and PF model to 0.92 for QT model. The high degree of persistence in the total revision series indicates that real-time output gap estimates may lead policy-makers and other economic agents to make persistent mistakes about the business cycles state.

#### 4.2.2. *Indicators of Reliability*

The statistics given in Table 4 shed some light on the total revision but all these statistics are biased indicators of revision. Therefore, in order to compare the difference between measures of the output gap in different types of data some reliability indicators, which are independent of the size of the gap, are calculated and results are presented in Table 4. The statistics are the indicators of reliability in the sense that they show how real-time estimates of the output gap are different from those found in the final data.

These are not the reliability indicators, however, between different models of the output gap estimation.

First column of the Table 5 presents the correlation between the final and real-time series for each method, which ranges from the lowest value of 0.42 for HP filter method to 0.87 for linear time trend method. As discussed above the low correlation value implies the significance of revision in size but this may understate the relative importance of the revision. This is because the correlation ignores the differences in means of the two series. From Figure 4.1 it is apparent that the linear trend model produces remarkable revision in the output gap but still there is the highest correlation between real time and final gap estimates.

Table 5

*Reliability Indicators*

| Method | COR | NS | NSR | OPSIGN |
|---|---|---|---|---|
| Linear Trend | 0.87 | 0.52 | 1.18 | 0.49 |
| Quadratic trend | 0.58 | 0.85 | 0.87 | 0.22 |
| Hodrick-Prescott Filter | 0.42 | 1.04 | 1.30 | 0.32 |
| Vector Autoregressive | 0.68 | 0.80 | 0.83 | 0.24 |
| Production Function | 0.65 | 0.84 | 0.86 | 0.24 |

The alternative measure to identify the importance of revision and measure of association between the real time and final estimates is OPSIGN (frequency with which the real time and the final estimates have opposite signs). This OPSIGN estimates is of specific importance because the signs of output gap reflects the inflationary or deflationary pressure in the economy, which leads to either loose or tight monetary policy. The results in the last column of Table 4 confirm the unreliability of correlation results because real time estimates from all models give the opposite signs ranging from 22 percent for QT model to 49 percent with linear trend model.

The RMS value given in Table 3 indicates that there is a substantial revision in the output gap, but these indicators do not take account of the variability of the output gaps. Low or high value of RMS may be due to low or high variability in the series rather than the size of revision. Hence, to control this problem another measure of the relative importance of the output gap revision is the Noise to Signal Ratio which is defined as the ratio between the RMS of revision over the standard deviation of revision. This measure captures the effect of downward and upward revisions. The value of NSR ranges from 0.83 for VAR method to 1.30 for HP filter and exceeds 1 for linear time trend and HP filter method. This shows relatively high degree of noise in real time output gap.

### 4.3. Decomposition of the Output Gap Revision

For each model total revision in the output gap can be further decomposed into different factors that account for revision. We decomposed these revisions into data revision (difference between quasi real time and real time estimates) and other revision (difference between final and quasi real time estimates). The data revision is associated with revision in GDP series, while other revisions are related to the inclusion of new observations in the sample, end sample bias etc. In Figure 4.4 panel (a) to (e), we plot the real time estimates of the output gap together with the data revision and total revision. The summary statistics related to this decomposition are presented in Table 4.

As results from the quadratic trend method are more consistent with the historical facts, therefore, we explain the decomposition based on the output gap estimates found with quadratic trend in more detail. Figure 4.4 panel (b) shows the results from quadratic trend. By comparing the real time estimates with total revision it is found that both the series are almost equal in 1979, 1994, and 2001, which indicate that final estimates of the output gap are roughly zero. In 2001, real time estimates indicate extreme recession but final or *ex post* estimates indicate the economy was operating at potential level. The graph also shows the data revision, the difference between the real time estimates of out gap and quasi real time estimates. These data revisions are approximately equal to total revisions for the period year 1987 to 1994, which indicate that nearly all of the revision in our estimated output gap for those years was due to subsequent revisions in the published data. However, considering the whole sample period from 1974 to 2010 the data revision variability tends to be small compared with that of the total revision, so most of these revisions are due to the addition of new sample points in our data or due to the end sample bias. Figure 4.4 panels (a), (c), (d) and (e) show the results for linear trend, HP filter, vector autoregressive and production function methods respectively, which indicate that data revisions seem to play a secondary role in explaining the total revisions.

Although the data revisions are relatively small in magnitude as compared with other revisions even so these revision are significant. The significance of data revision can be confirmed by looking at the results in Table 5 which presents the summary statistics for total revisions, data revisions and other revisions in the output gap estimated using different methods. Total revision in the output gap is negative in QT, HP and VAR models which indicates the downward revision in the gap while it is positive in LT and PF models. The average data revisions, however, are positive in all five models which indicates that final estimates are, in general, above real time estimates. The standard deviation is almost the same in all models which indicate more or less the same spread in revisions.

Figure 4.4(a). Estimated Output Gap-Linear Trend

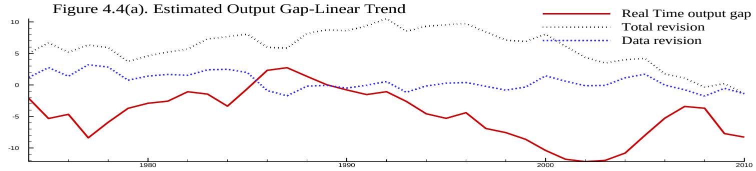



Figure 4.4(b). Estimated Output Gap-QT

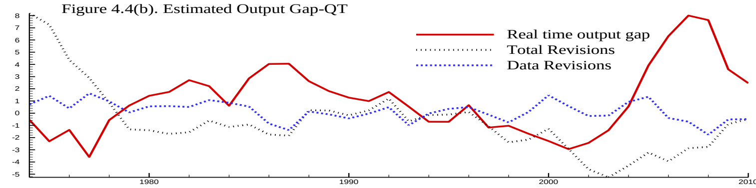



Figure 4.4(c). Estimated Output Gap-HP

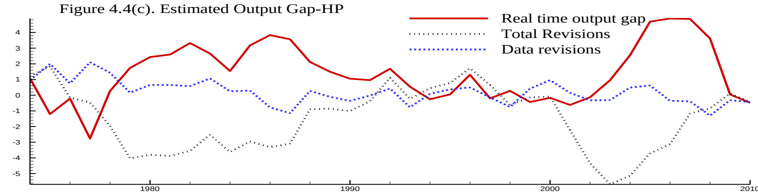



Figure 4.4(d): Output Gap Estimates - VAR Model

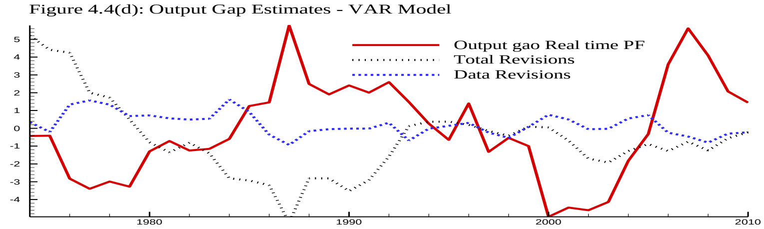
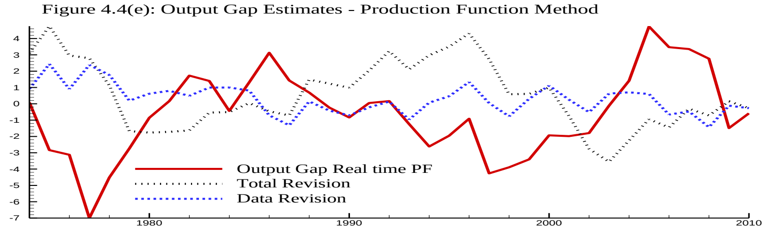



Figure 4.4(e): Output Gap Estimates - Production Function Method




In Table 5 first order autocorrelation coefficient, which measures the degree of persistence, is quite high for total revision series and ranges from 0.84 for HP filter and production function approach to 0.92 for quadratic trend measure. The persistence for other revisions is much higher than the total revision. It ranges from 0.87 for vector autoregressive measures to 0.98 for linear trend method. So the predictability of other revisions is better than total revisions. In the data revision, persistence is very low as compared with total revisions and other revisions. Only in the linear trend model, the data revision of the output gap has the persistence coefficient of 0.64, while in all other measures this coefficient is less than 0.50. This implies the lack of predictability of future data revisions.

Table 6

*Decomposition of Total Revision into Data Revision and Other Revisions*

| Method | MEAN | SD | RMS | MIN | MAX | AR |
|---|---|---|---|---|---|---|
| **Linear Trend** | | | | | | |
| Total Revision= F-RT | 5.94 | 2.95 | 6.61 | –1.39 | 10.53 | 0.91 |
| Other Revisions=F-QR | 5.43 | 2.94 | 6.15 | 0.00 | 9.98 | 0.98 |
| Data Revision= QR-RT | 0.51 | 1.32 | 1.40 | –1.77 | 3.22 | 0.64 |
| **Quadratic trend** | | | | | | |
| Total Revision= F-RT | –0.70 | 2.80 | 2.84 | –5.26 | 8.19 | 0.92 |
| Other Revisions=F-QR | –0.87 | 2.61 | 2.79 | –5.22 | 7.47 | 0.95 |
| Data Revision= QR-RT | 0.17 | 0.80 | 0.80 | –1.76 | 1.62 | 0.43 |
| **Hodrick-Prescott Filter** | | | | | | |
| Total Revision= F-RT | –1.52 | 2.02 | 2.51 | –5.69 | 1.84 | 0.84 |
| Other Revisions=F-QR | –1.73 | 2.03 | 2.65 | –5.62 | 1.22 | 0.91 |
| Data Revision= QR-RT | 0.21 | 0.76 | 0.78 | –1.30 | 2.11 | 0.50 |
| **Vector autoregressive** | | | | | | |
| Total Revision= F-RT | –0.65 | 2.17 | 2.23 | –5.29 | 5.20 | 0.90 |
| Other Revisions=F-QR | –0.87 | 2.07 | 2.22 | –4.43 | 4.85 | 0.87 |
| Data Revision= QR-RT | 0.22 | 0.63 | 0.67 | –0.93 | 1.62 | 0.57 |
| **Production Function** | | | | | | |
| Total Revision= F-RT | 0.54 | 2.07 | 2.11 | –3.55 | 4.75 | 0.84 |
| Other Revisions=F-QR | 0.25 | 1.98 | 1.97 | –4.18 | 3.09 | 0.91 |
| Data Revision= QR-RT | 0.29 | 0.91 | 0.94 | –1.43 | 2.44 | 0.49 |

## 5. CONCLUSION

The objective of this paper is to find evidence of over and/or under estimation of the output gap. This is done by comparing estimates of the output gap based on real time data with that in the revised data. The quasi real time data is also constructed such that the difference between estimates of the output gap from real time data and that from quasi real time data reflects data revision and the difference between estimates of the output gap from final data and that from quasi real time data portray the revisions other than the data revisions including end sample bias. Moreover, the output gap is estimated with the help of five methods namely the linear time trend method, quadratic time trend method, HP filter, production function method, and vector autoregressive method.

The study used data on real GDP, inflation rate, interest rate, gross fixed capital formation, unemployment rate, and the labour force of Pakistan over the period 1960 to 2010 to fulfil the above stated objectives. Results can be summarised as follows.

- Estimates of the output gap in real time data are different from what has been found in the final data. Data revisions, though less than other revisions, are found to be significant. Hence output gap estimated from final or revised data is a poor proxy of the output gap estimate that was actually available to policy-makers at the time of policy decision.
- Output gap measured with linear trend method is a poor proxy of business cycle as it overestimates the intensity of the business cycle and is severely subject to the end sample bias.
- Estimates of the output gap from other four methods portray well the state of the economy. However, results based on quadratic time trend method and

production function method are more consistent with the business cycle facts for Pakistan economy.

- Contrary to the evidence in empirical literature for other countries, it is found that recessions are well predicted by real time data instead of revised data. Slowdown in economic activity is indicated first by real time data and then by final data.
- Despite the predicting power of real time data for recessions, final data shows more intensity of recession compared to what is shown in real time data. Opposite results are found in case of boom periods where real time data shows greater intensity.
- Correlation coefficient between different estimates of the output gap from final data and those from real time data is less than 0.7 which shows that the revision is significant in size.
- All the revision series are highly persistent. However, the persistence differs across different methods. The coefficient ranges from 0.84 for HP filter and PF model to 0.92 for QT model. The high degree of persistence in the total revision series indicates that the real-time output gap estimates may lead policy-makers and other economic agents to persist with false perceptions about the state of business cycles.

**Policy Implications**

The main policy implication of this paper is that the policy-makers in Pakistan should treat estimates of the output gap cautiously. The output gap estimates are a poor proxy for the business cycle and different measures of the output gap give different estimates. As revisions other than data revisions are larger in size, it is suggested that the policy-makers should rely on the methods of estimating the output gap that are less sensitive to end sample observations.

## REFERENCES

Apel, Mikael and Per Jansson (1999) A Theory-consistent System Approach for Estimating Potential Output and the NAIRU. *Economics Letters, Elsevier* 64:3, 271–275.

Araujo, C. H. V., M. B. M. Areosa, and O. T. C. Guillén (2004) Estimating Potential Output and the Output Gap for Brazil. Banco Central do Brazil Working Paper Series.

Baxter, M. and R. G. King (1995) Measuring Business Cycles: Approximate Band-pass Filters for Economic Series. Massachusetts: NBER. (NBER Working Paper No. 5022).

Bernhardsen, T., Ø. Eitrheim, A. S. Jore, and Ø. Røisland (2004) Real-time Data for Norway: Challenges for Monetary Policy. Deutsche Bundesbank. (Discussion Papers 26/2004).

Beveridge, S. and C. R. Nelson (1981) A New Approach to the Decomposition of Economic Time Series into Permanent and Transient Components with Particular Attention to Measurement of the Business Cycle. *Journal of Monetary Economics* 7, 151–174.

Billmeier, A. (2004) Measuring a Roller Coaster: Evidence on the Finish Output Gap. Washington, DC; International Monetary Fund. (IMF Working Paper 04/57).

Blanchard, O. J. and D. Quah (1989) The Dynamic Effect of Aggregate Demand and Supply Disturbances. *American Economic Review* 79:4, 655–673.

Burns, Arthur F. and Wesley C. Mitchell (1946) Measuring Business Cycles. NBER Books.

Cayen, Jean-Philippe and Simon van Norden (2005) The Reliability of Canadian Output-gap Estimates. *The North American Journal of Economics and Finance, Elsevier* 16:3, 373–393.

Chagny, O. and J. Döpke (2001) Measures of the Output Gap in the Euro-Zone: An Empirical Assessment of Selected Methods. Kiel Institute of World Economics. (Kiel Working Paper, 1053).

Clark, P. K. (1987) The Cyclical Components of US Economic Activity. *Quarterly Journal of Economics* 102:4, 797–814.

Claus, Iris (2000) Is the Output Gap a Useful Indicator of Inflation? Reserve Bank of New Zealand. (Discussion Paper Series: DP2000/05).

Claus, Iris (1999) Estimating Potential Output in New Zealand: A Structural Var Approach. Reserve Bank of New Zealand. (Discussion Paper Series: DP2000/03).

Cogley, Timothy (1997) Evaluating Non-structural Measures of the Business Cycle. *Economic Review, Federal Reserve Bank of San Francisco,* 3–21.

Cooley, Thomas J. and Lee E. Ohanian (1992) The Cyclical Behaviour of Prices. *Journal of Monetary Economics* 28, 25–60.

Correia, I., J. C. Neves, and S. Rebelo (1995) Business Cycles in Small Open Economies. *European Economic Review* 39, 1089–1113.

Correia, I., J. C. Neves, and S. Rebelo (1992) Business Cycles from 1850–1950—New Facts about Old Data. *European Economic Review* 36:2, 459–467.

Dean, Croushore and Tom Stark (2000) A Real-Time Data Set for Macroeconomists: Does Data Vintage Matter for Forecasting? Federal Reserve Bank of Philadelphia. (Working Paper 00-6).

Croushore, Dean, and Tom Stark (2001) A Real-Time Data Set for Macroeconomists. *Journal of Econometrics* 105: (November), 111–130.

Croushore, D. and T. Stark (2003) A Real-Time Data Set for Macroeconomists: Does the Data Vintage Matter? *Review of Economics and Statistics* 85, 605–617.

Croushore, Dean and Charles L. Evans (2006) Data Revisions and the Identification of Monetary Policy Shocks. *Journal of Monetary Economics, Elsevier* 53:6, 1135–1160.

De Brouwer, G. (1998) Estimating Output Gaps. Reserve Bank of Australia. (Research Discussion Paper No: 9809).

Diebold, F. X. and A. S. Senhadji (1996) The Uncertain Unit Root on GNP: Comment. *American Economic Review* 86:5, 1291–8.

Dupasquier, Chantal, Alain Guay, and Pierre St-Amant (1997) A Comparison of Alternative Methodologies for Estimating Potential Output and the Output Gap. Bank of Canada. (Working Papers 97-5).

Froyland, E. and R. Nymoen (2000) Output Gap in the Norwegian Economy. Norges Bank. *Economic Bulletin* 71:2, 46–52.

Gibbs, D. (1995) Potential Output: Concepts and Measurements. Labour Market. *Bulletin of New Zealand Department of Labour* 1, 72–115.

Giorno, C., *et al.* (1995) Estimating Potential Output, Output Gaps and Structural Budget Balances. OECD Publishing. (OECD Economics Department Working Papers, No. 152).

Gruen, D., T. Robinson, and A. Stone (2002) Output Gaps in Real Time: Are They Reliable Enough to Use for Monetary Policy? (Reserve Bank of Australia Research Discussion Paper 2002-06).

Harberger, A. (1978) Perspectives on Capital and Technology in Less Developed Countries. In M. J. Artis and A. R. Nobay (eds.) *Contemporary Economic Analysis.*

Haider, Adnan and Sadar Ullah Khan (2008) Estimating Output Gap for Pakistan Economy: Structural and Statistical Approaches. *SBP Research Bulletin* 4:1, 31–60.

Hodrick, R. and E. C. Prescott (1997) Post-War US Business Cycles: An Empirical Investigation. *Journal of Money, Credit and Banking* 29, 1–16.

Kamada, Koichiro (2005) Real-time Estimation of the Output Gap in Japan and its Usefulness for Inflation Forecasting and Policy-making. *The North American Journal of Economics and Finance, Elsevier* 16:3, 309–332.

Kenny, G. (1995) Some Estimates of Potential Output and the Output Gap for Ireland. (Central Bank of Ireland Technical Paper, 5/RT/95).

Khan (2006) Macro Determinants of Total Factor Productivity in Pakistan. *SBP Research Bulletin* 2.

Kozicki, S. (2004) How Do Data Revisions Affect the Evaluation and Conduct of Monetary Policy? *Federal Reserve Bank of Kansas City, Economic Review* (Second Quarter), 5–38.

Kozicki, Sharon and P. A. Tinsley (2005) Permanent and Transitory Policy Shocks in an Empirical Macro Model with Asymmetric Information. *Journal of Economic Dynamics and Control, Elsevier* 29:11, 1985–2015.

Kuttner, K. N. (1994) Estimating Potential Output as a Latent Variable. *Journal of Business and Economic Statistics* 12, 361–368.

Kuttner, K. N. (1992) Monetary Policy with Uncertain Estimates of Potential Output. *Federal Reserve Bank of Chicago Economic Perspectives* 16, 2–15.

Laxton, D. and R. Tetlow (1992) A Simple Multivariate Filter for the Measurement of Potential Output. Bank of Canada. (Technical Report, No. 59).

Mankiw, N. Gregory, and David Romer (1991) *New Keynesian Economics: Coordination Failures and Real Rigidities.* Vol. 2. MIT Press.

Mitchell, Wesley C. (1927) Business Cycles: The Problem and its Setting.

Nehru, V. and A. Dhareshwar (1993) A New Database on Physical Capital Stock: Sources, Methodology and Results. *Revista de Analisis Economico* 8:1, 37–59.

Nelson, C. R. and C. I. Plosser (1982) Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications. *Journal of Monetary Economics* 10, 139–62.

Nelson, Edward and Kalin Nikolov (2003) UK Inflation in the 1970s and 1980s: The Role of Output Gap Mismeasurement. *Journal of Economics and Business, Elsevier* 55:4, 353–370.

Okun, Arthur M. (1962) Potential GNP: Its Measurement and Significance. (Reprinted as Cowles Foundation Paper 190).

Orphanides, A. (2001) Monetary Policy Rules Based on Real-Time Data. *American Economic Review* 91:4, 964–985.

Orphanides, A. (2003) Historical Monetary Policy Analysis and the Taylor Rule. *Journal of Monetary Economics* 50, 983–1022.

Orphanides, A. and S. van Norden (2002) The Unreliability of Real Time Estimates of the Output Gap. *Review of Economics and Statistics* 84: 4, 569–83.

Perron, P. (1997) Further Evidence on Breaking Trend Functions in Macroeconomic Variables. *Journal of Econometrics* 80:2, 355–385.

Perron, P. (1989) The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis. *Econometrica* 57, 1361–1401.

Quah, Danny (1992) The Relative Importance of Permanent and Transitory Components: Identification and Some Theoretical Bounds. *Econometrica* 60:1, 107–118.

Rünstler, G. (2002) Are Real-time Estimates of the Output Gap Reliable? Computing in Economics and Finance 2002 300, Society for Computational Economics.

Saxena, S. Chaman and V. Cerra (2000) Alternative Methods of Estimating Potential Output and the Output Gap—An Application to Sweden. International Monetary Fund. (IMF Working Papers 00/59).

Sherbaz, Sadia, Fatima, Amjad, and Naheed Zia Khan (2010) Output Gap and its Determinants: Evidence from Pakistan. *Journal of Economic Cooperation and Development* 30: 3, 75–82.

Sims, C. A. (1980) Macroeconomics and Reality. *Econometrica* 48, 1–48.

Scott, A. (2000) Stylized Facts from Output Gap Measures. Wellington. (Reserve Bank of New Zealand Discussion Paper No. 2000/07).

Scott, A. (2003) A Multivariate Unobserved Components Model of Cyclical Activity. Reserve Bank of New Zealand.

Syed, Sarfaraz and Ali Shah (2009) Output Gap Measures for Pakistan: Methodologies and Challenges for the Monetary Policy. *Journal of Applied Research in Finance* 1: 2, 206–227.

Watson, M. W. (1986) Univariate Detrending Methods with Stochastic Trends. *Journal of Monetary Economics* 18, 49–75.

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56:3 (Autumn 2017) pp. 221–248

# Spatial Differences and Socioeconomic Determinants of Health Poverty

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The study aims to develop health poverty index (HPI) using the Alkire Foster (AF) Method for Pakistan based on district representative data obtained from Pakistan Social and Living Standards Measurement (PSLM) 2012-13. Using HPI, this study investigates the spatial differences of health poverty at sub-national level and explores the socioeconomic determinants. The analysis reveals that the headcount health poverty is 41 percent in Pakistan. Further, the ratio is very high in rural areas (50 percent) as compared to urban areas (22 percent). Provincial analysis shows that Punjab is the least poor province (36 percent) while Balochistan is the poorest province (62 percent). The majority of the households are deprived in term of cost of health services, post-natal care and child immunisation. Empirical analysis shows that income, regional variation, education and awareness play very important role in explaining health poverty. To eradicate health deprivation, area and dimension specific policies are required to make efficient use of scarce resources.

*JEL Classification:* I12, I32, J18
*Keywords:* Health Poverty, Spatial Analysis, Alkire Foster Method

## 1. INTRODUCTION

It is evident that Pakistan has succeeded in reducing the headcount poverty from 64.4 percent in 2000-01 to 29.5 percent in 2013-14[1] [Pakistan (2016)]. In contrast, there is no significant improvement in social indicators such as health.[2] Pakistan has not succeeded to reduce significantly both the maternal mortality and child mortality rates over time. The maternal mortality ratio is very high as compared with other countries in

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*Authors' Note:* The authors are thankful to Dr Durr-e-Nayab, PIDE, Dr G. M. Arif, PIDE and Dr Shehzad Ali, University of York for their valuable input on proposal. The funding for this study is provided by GIZ under CPHSP Competitive Research Grant. The authors are also thankful to anonymous referee for giving valuable suggestion on the earlier draft to improve the overall quality of paper.

[1]These estimates are based on new poverty line calculated using Cost of Basic Need (CBN) approach. Using CBN approach, the poverty line is Rs 3030 per adult equivalent per month using HIES 2013-14 data. While using old Food Energy Intake (FEI) methodology, poverty has declined from 34.4 percent in 2000-01 to 9.3 percent in 2013-14.

[2]There are many other social factors, such as education, sanitation, clean water, housing, violence and empowerment, which do not show significant improvement. This paper only focuses on health issues for detailed analysis.

the region (178 per 100,000 live births) in 2015 against 100 mentioned in MDG targets.[3] Similarly, infant mortality rate is very high in Pakistan (66 per 1,000 live births). Despite various reforms, Pakistan fails to provide health facilities according to MDGs requirements. Apart from low investment in health sector, rapid population growth is resulting in the inadequacy of health care facilities. The inadequacy of healthcare facilities is reflected as there are estimates of 1,038 persons against one Doctor and one Dentist versus 11,513 persons, while the current ratio of population and availability of hospital beds works out at 1,613 persons per bed in 2015-16 [Pakistan (2016)]. Another notable feature of health sector is the existence of inequalities in the provision of health facilities across Pakistan. For example average distance to reach the Basic Health Unit is 16 KM in KPK, 39 KM in Balochistan, 13 KM in Sindh and 8 KM in Punjab.[4]

Due to lack of health facilities and low investment, health poverty becomes a common phenomenon in developing countries like Pakistan. A wide range of factors determine the health status of a population which may give rise to health inequalities. Recently, the Oxford Poverty and Human Development Initiative (OPHI) developed Multidimensional Poverty Index (MPI) to reflect the multiple deprivations that a poor person faces with respect to education, health, and living standards for Pakistan. Health is quantified using access to health clinic, immunisation, ante-natal care and assisted delivery. This index covers limited dimensions of health poverty.

Literature has shown that health and health inequalities are influenced by various factors grouped into "root causes", "intervening factors" and "situation of health" each of which can be viewed at an individual-household level, local level or on a macro scale [Rolfe and Watson (2006)]. Root causes factors such as wealth, income, gender and education; intervening factors such as access to preventive healthcare, life style and home environment; and situation of health factors such as health capital, physical morbidity and premature mortality etc. are important in determining the overall progress in the health sector. It has been acknowledged widely that to measure health poverty, MPI is not an appropriate choice. To address health issue, there is a need to construct health poverty index which covers all possible dimensions of health in term of health provision as well as affordability of health services. This study addresses this gap by constructing a more comprehensive health poverty index for Pakistan.

This study aims to measure the health poverty in Pakistan at the national and sub-national level. Health poverty is a lack of access to health services. It refers to a situation where a household does not have access or cannot afford to have the basic health or health services to achieve sound health. More specifically, this study attempts to analyse the following objectives:

- To construct health poverty index (HPI) for Pakistan.
- To investigate the spatial differences of health poverty at sub-national level, and
- To explore the socio-economic determinants of health poverty.

The HPI, which is very comprehensive in term of indicator employed, provides useful information to identify the regional disparities in health provision and help to

[3]WHO, UNICEF, UNFPA, World Bank Group, and the United Nations Population Division. Trends in Maternal Mortality: 1990 to 2015. Geneva, World Health Organisation, 2015. [http://data.worldbank.org/indicator/SH.STA.MMRT]

[4]http://www.pbs.gov.pk/sites/default/files/aco/publications/pakistan-mouza-census2008/pakistan-tab15-A.pdf

design targeted measures to improve the health provisions in Pakistan. Vision 2025 highlights the importance of social sector development for the revival of sustainable and inclusive growth. This study helps in better allocation of PSDE to remove health inequalities for sustained and inclusive growth. This index can be used as a baseline to further improve MPI.

The rest of the paper is structured as follow: Section 2 presents important findings from existing literature; Section 3 describes data and methodology; Section 4 explains key findings while the last section spells out the important policy implications.

## 2. LITERATURE REVIEW

The available literature primarily uses human development index (HDI) to measure the wellbeing and living standards of people [Greeley (1994); McGillivray (1991)]. The HDI, however, was criticised for not measuring accurately the poverty and development because of its limited scope in covering various aspects of wellbeing. The HDI only uses one health indicator i.e. longevity while ignores the other health related aspects. Recently, attempts have been made to construct Multidimensional Poverty Index (MPI) to measure poverty [Alkire, Conconi, and Roche (2012); Alkire and Santos (2010); Chakravarty and Silber (2008)]. The MPI uses nutrition and child mortality as health indicators. These measures fail to capture health condition in appropriate manner. The government of Pakistan, in collaboration with OPHI and UNDP has developed MPI for Pakistan using three dimensions; health, education and standard of living. Health dimension is further expanded by including access to health clinic, immunisation, ante-natal care, and assisted delivery. Using PSLM data, the headcount of multidimensional poverty was 38.8 percent in 2014-15. Antony and Laxmaiah (2008) conclude that the HDI is not an appropriate measure to determine development, because despite improvement in the living condition, under-nutrition is still amongst the major health issues in India. To address the health issues, this study concludes that further research is required to developed comprehensive measure of health poverty. Few attempts have been made to construct Health Poverty Index (HPI) using several social, economic, medical and resource factors [Laudicella, Cookson, Jones, and Rice (2009); Spinakis, *et al.* (2011)]. Spinakis, *et al.* (2011) use standardised death rate, life expectancy at birth and self-perceived health to develop health inequality index. Nandi, *et al.* (2008) and Lasser, Himmelstein, and Woolhandler (2008) measured poverty based on the accessibility to health service along with other social and economic indicators like insurance, cost etc. This study further extends the use of indictors in constructing health poverty index including use and cost of health services, quality of health services and maternal and child health.

Empirical literature shows that various socio-economic factors contribute to health poverty, including demographic characteristics, occupation and income status, regional disparities, and infrastructure facilities [Claeson, Bos, Mawji, and Pathmanathan (2000); Drèze and Murthi (2001); Hughes and Dunleavy (2000); Navarro and Shi (2001); Pritchett and Summers (1996); Rutstein, Johnson, and Gwatkin (2000); Wagstaff (2002)]. Education plays significant role in improving health. Mirowsky and Ross (2003) argue that education influences the health outcome through factors of livelihood like occupation and income. Educational attainment leads to high income, better employment and quality living conditions hence improved health outcomes [Bloom (2007)].

Additional, infrastructure of cities, high density of houses, provision of and access to local public facilities and increased reliance on cars is causing population to become physically inactive and thus is the source of poor health [Friel, Chopra, and Satcher (2007)]. Wang (2002) investigated factors that affect health in low income countries disaggregated by geographic location. This study found a significant difference in health services between urban and rural areas, with high rate of mortality in rural areas. Further, evidence suggests that poor are concentrated in rural areas, therefore increase in health expenditure, vaccination and availability of basic necessities can reduce the health related poverty. Ramachandran, Kumar, and Viswanathan (2006) found that nutrition and health status are influenced by various socio-economic factors, include education, social infrastructure and quality of diet. Further this study shows that these factors contribute differently across rural and urban areas.

Poor health in rural areas is due to the fact that cost of seeking treatment is high in rural areas due to large distances, time and travel costs incurred, to reach the nearest health centre [Andersen and Newman (2005); Mwabu (2007)]. Difference in the health poverty level is also due to the regional difference based on the access to medical facilities that depend of the technological, human and drug resources, that are rarely available in the rural area [Barua (2013); Zhang and Kanbur (2005)]. Another study considered the distance and the time need to travel to the nearest health faculty as a contributing factor in increasing the health poverty [Schuurman, Fiedler, Grzybowski, and Grund (2006); Shen and Hsia (2010)]. This shows that geographical difference plays a major role in understanding the dynamics of health, and the causes and spread of disease [Parker and Campbell (1998); Sasaki, Comber, Suzuki, and Brunsdon (2010)]. Quality of health service broadly depends on the infrastructure, location of the health centre, availability of focal person, process and others. Attitude of individual to seek health care is also an important determinant of health poverty. Individual's predisposition also depends on the income and the possession of wealth. Many studies have investigated the effect of income on health seeking behaviour, individual choice for health care and health expenditure, whereas other studies investigated the effect on demand for health due to poverty [Awiti (2014)].

Various studies have used GIS based measure to investigate the geographical and spatial based factors to determine the effectiveness of health based resource allocation [Boulos (2004); McLafferty (2003)]. Ur-Rehman and Zimmer (2010) reveal that health poverty based spatial differences are clearly visible across Pakistan using GIS, even though the information available through internet is limited to certain social classes and groups. It is a general perspective that households with more favourable income situation enjoy better health [Shams (2013, 2014)]. Various studies have investigated the relationship between health and income, and conclude that the income inequality negatively affects health of the lower income group in society [Mellor and Milyo (2002); Shams (2014); Smith (1999); Wagstaff and Van Doorslaer (2000)]. Gerdtham and Johannesson (2004) considered morality as a contributing factor to measure health poverty. Ur-Rehman and Zimmer (2010) measured child health using maternal literacy, poverty, water and sanitation, nutritional level, vaccination coverage and mother's education. A study by Nawaz-ul-Huda, Burke, and Azam (2011) analysed the socio-economic disparities in Balochistan using multivariate analysis. Shams (2013) used various socioeconomic factors like gender, education, income and age to measure health. This study aims to fill the gap in existing literature as few studies measured health poverty. This study explicitly examines the spatial differences across regions focusing on the health deprivation.

## 3. DATA AND METHODOLOGY

### 3.1. Data

To analyse the objectives stated above, this study uses various data sources including Pakistan Social and Living Standards Measurement (PSLM) Survey 2012-13 and MOUZA Statistics 2008. Health indicators have been taken at district level from PSLM Survey 2012-13 conducted by the Pakistan Bureau of Statistics (PBS). The PSLM survey is one of the main mechanisms for monitoring the implementation of the development projects and tracking of the MDGs. It provides a set of district level representative estimates of social indicators. The universe of survey consists of all urban and rural areas of the four provinces and Islamabad excluding military restricted areas. A Two-stage stratified sample design has been adopted in this survey. Population of all provinces is considered as the universal sample. Under the framework of PLSM each city/town was sub divided in to enumeration blocks. Each enumeration block comprises of 200-250 households and categorises into low, middle and high-income groups**.** Urban areas were divided into 26698 blocks and rural areas comprised of 50588 blocks. The sample size is 75,516 households, which is expected to produce reliable results at the district level. The area and province wise distribution is given below in Table 1.

Table 1

*Sample Distribution*

| | Sample SSUs | | |
|---|---|---|---|
| Province/Area | Urban | Rural | Total |
| Punjab | 12937 | 18979 | 31916 |
| Sindh | 8122 | 11358 | 19480 |
| KPK | 3133 | 9340 | 12473 |
| Balochistan | 2406 | 9241 | 11647 |
| Total | 26598 | 48918 | 75516 |

*Source:* PBS (2015).

### 3.2. Methodology

#### 3.2.1. *Construction of Health Poverty Index (HPI)*

To construct HPI, we have used Alkire, *et al.* (2012) methodology—recently used for the construction of MPI. The stepwise brief description of methodology is given below:

***Step 1: The Choice of Appropriate Indicators for Measuring HPI***

To quantify HPI, we have used indicators from five different health dimensions: include D1) use of health services; D2) quality of health services; D3) cost of health services; D4) maternal health; and D5) child health. To measure these dimensions, we have used eight different health indicators.[5] D1 is determined by using two indicators, i.e. IND1) Doctor consulted during sick or injury and IND2) Assisted delivery. D2 is quantified by employing two indicators include IND3) Satisfaction with the use of health services and IND4) Institutional delivery. D3 is measured using one indicator, i.e. IND5) Time cost. D4 is determined using two indicators include IND6) Pre-natal care and IND7) Post-natal care. D5 is measured using one indicator IND8) Immunisation.

### *Step 2: Choosing the Indicators' Deprivation Cut-offs and Assigning the Weight to each Dimension and Indicator*

HPI requires a deprivation cut off for each indicator. The indicators' deprivation cut offs are noted as $z_i$, so that household $i$ is considered deprived if its achievement in that indicator $x_i$ is below the cut off, that is if $x_i < z_i$. Well founded reasons are needed to determine each cut-off. For this purpose global practices, national priorities, culture norms, and empirical evidences are used to define cut-offs. After selecting indicators and their corresponding cut-offs, the next task is to define the weight that each indicator will have in the measure. In the HPI five dimensions are equally weighted, so each of them receives a 1/5 weight. The indicators within each dimension are also equally weighted. Thus, each indicator within the D1, D2 and D4 dimension receives a 1/10 [1/5÷2] weight and each indicator within the D3 and D5 dimension receive 1/5. The Table 2 below provides the definition of each indicator with deprivation cut-off and their relative weights.[6] Here we note the indicator $i$ weight as $w_i$ with $\sum_1^8 w_i = 1$.

Table 2

*Weights and Deprivation Cut-off for each Indicator*

| Dimension | Indicator | Deprivation Cut-off | W |
|---|---|---|---|
| D1: Use of Health Services | IND1: Doctor consulted during sick or injury | Deprived if any person in the hh did not consult doctor during sickness or injury. hh with no sickness or injury non-deprived. | 1/10 |
| | IND2: Assisted delivery | Deprived if any woman has given birth in the hh (last 3 years) with untrained personnel (family member, friend, tba, etc.) or hh with no women that has given birth non-deprived. | 1/10 |
| D2:Quality of health services | IND3: Satisfaction with the use of health services | Deprived if person in hh did not use due to unsatisfactory quality or access constraints of health services. hh with not required is non-deprived | 1/10 |
| | IND4: Institutional delivery | Deprived if any woman has given birth in the hh (last 3 years) with inappropriate facility (home, other) - hh with no women that has given birth non-deprived. | 1/10 |
| D3: Cost of health services | IND5: Time cost | Hh is deprived if more than 30 minutes are required to reach the Health clinic/Hospital | 1/5 |
| D4: Maternal health | IND6: Pre-natal care | Deprived if any woman that has given birth in the hh (last 3 years) did not received prenatal check-ups - hh with no women that has given birth non-deprived. | 1/10 |
| | IND7: Post-natal care | Deprived if any woman that has given birth in the hh Did not receive post-natal care within 6 weeks after this delivery—hh with no women that has given birth non-deprived. | 1/10 |
| D5: Child health | IND8: Immunisation | Deprived if any child under 5 not fully immunised according to vaccinations calendar—hh with no children under 5 non-deprived. | 1/5 |

*Source:* Author's Own.

[5]The choice of indicators is restricted primarily due to availability of indicators from PSLM dataset and qualifying as an outcome variable not an input variable. Nutrition, life expectancy and child mortality are important indicators for measuring health poverty, but due to non-availability of data in PSLM, we did not include these variables in the construction of HPI.

[6]Appendix Table 1 provides the list of questions used in defining each indicator.

***Step 3: Choosing the Poverty Cut-off (to Identify the Poor)***

In this step, we assigned a deprivation score to household according to its deprivations in the component indicators. The deprivation score for each household is calculated by taking a weighted sum of the number of deprivations, so that the deprivation score for each household lies between 0 and 1. The score increase as the number of deprivations of the household increases and reaches its maximum of 1 when the household is deprived in all component indicators. A household, which is not deprived in any indicator, receives a score equal to 0. Formally:

$$c_i = w_1 IND_1 + w_2 IND_2 + w_3 IND_3 + w_4 IND_4 + w_5 IND_5 + w_6 IND_6 + w_7 IND_7 + w_8 IND_8$$

Or

$$c_i = \sum_1^8 w_i IND_i$$

Where $IND_i = 1$ if the household is deprived in indicator $i$ that is if $x_i < z_i$ and $IND_i = 0$ otherwise and $w_i$ is the weight attached to indicator $i$ with $\sum_1^8 w_i = 1$. A cut-off or threshold is used to identify the multidimensionally health poor, which in the AF methodology is called the poverty cut-off. In this study, we define the poverty cut-off as the share of (weighted) deprivations a household must have in order to be considered poor, and we will note it with $k$. Hence, a household is considered poor if its deprivation score is equal or greater than the poverty cut-off i.e. a household is poor if $c_i \geq k$. For those whose deprivation score is below the poverty cut-off, even if it is non-zero, this is replaced by a "0"; what we call censoring in poverty measurement. To differentiate between the original deprivation score from the censored one, we use of the censored deprivation score the notation $c_i\ (k)$. When $c_i \geq k$, then $c_i\ (k) = c_i$, but if $c_i \leq k$, then $c_i\ (k) = 0$. $c_i\ (k)$ is the deprivation score of the poor.

***Step 4: Computing the HPI***

According to this methodology, the HPI combines two key pieces of information: (1) the proportion or incidence of people (within a given population) who experience multiple deprivations, and (2) the intensity of their deprivation: the average proportion of (weighted) deprivations they experience. Formally, the first component is called the Health Poverty headcount ratio:

$$H = \frac{q}{n}$$

Where $q$ is the number of household who are multidimensional health poor and $n$ is the total number of households. The second component is called the intensity (or breadth) of poverty. It is the average deprivation score of the multidimensional health poor and can be expressed as:

$$A = \frac{\sum_{i=1}^{n} c_i(k)}{q}$$

Where $c_i$ ($k$) is the censored deprivation score of household $i$ and $q$ is the number of household who are multidimensional health poor. The HPI is calculated by multiplying the incidence of poverty by the average intensity across the poor:

$$HPI = H * A$$

### 3.2.2. *Spatial Differences based on Geographical Information System (GIS)*

To analyse the spatial difference, Geographical Information System (GIS) is used. The GIS method helps to design targeted policies to eradicate health poverty. Poverty mapping through GIS helps to find the determinants of poverty including natural capital and infrastructure, and access to public services. A district level data has been prepared based on the HPI constructed using AF method in section 3.2.1. Mapping software called ADePT Maps developed by the World Bank is used to produce maps at district level.[7] For GIS analysis, the districts are divided into four groups based on the incidence of health poverty including high deprivation, moderate deprivation, low deprivation and very low deprivation. Following steps are involved in creating the maps:

(i) Construction of district level data: HPI data is converted from households to district level. Similarly distance variable is obtained from MOUZA statistics at the district level. Each district has been assigned unique code similar to the code available in the shape file.

(ii) ADePT Maps operates in Stata for Windows, works with Stata's native datasets and produces the resulting images in a graphic format commonly supported by 'The Office' applications. After loading a Stata dataset, start ADePT Maps,[8] select a shape file (map), specify a regional variable in the data and the shape file and specify the variable of interest like HPI.

### 3.2.3. *Determinants of HPI: Logistic Regression Analysis*

Various factors determine the incidence of health poverty. To measure the effect of these factors, binomial logistic regression model is used in which the dependent variable is dichotomous: 0 when a household is above and 1 when below the health poverty line. The generalised form of the model is given below:

$$P = f\,(\textit{economic factors, social factors, regional factors})$$

where $P$ represents poor household (1 if poor otherwise 0).

Explanatory variables such as income, wealth, gender, education, housing structure, housing services such as gas, telephone, sewerage, electricity, and water supply and occupation are used for analysis. Generalised functional form of the model is as under:

[7] Installation package of ADePT Maps is located at: http://siteresources. worldbank.org/ INTPOVRES/Resources/ADePT_Map.exe. For more details see http://siteresources.worldbank.org/ INTPOVRES/Resources/477227-1184622288835/4002237-1219247341749/ADePT_Maps2.pdf. To produce district level maps, district level *shape file* has been obtained from DIVA-GIS website (http://www.diva-gis.org/datadown).

[8] ADePT Map can be launched by typing *a map* in the Stata command line.

$$P = \alpha + \beta X + \gamma E + \delta R + \pi A + \sigma T + \in$$

Where $X$ represents the matrix of demographic variables include gender, age, education and marital status of the head of the household and overall household size; $E$ represents matrix of variable capture the economic status of the households such as income, number of earners and status of employment of the head of the household; $R$ captures the regional variation such as provincial and rural urban; $A$ indicates the availability of information and $T$ uses to capture the availability of personal transport facility. The Table 3 below provides the detailed definition of each variable. Dependent variable is defined using health poverty index: 1 if household is poor otherwise 0. The results will not be interpreted through the coefficients but we use the odd ratios in logistic regression to see that the occurrence of any particular event will increase or decrease the probability being poor of individual and with what proportion as compared with the reference category.

To further ensure the robustness of results, logistic model with district fixed effect is also estimated. This helps to control the district level heterogeneity which may leads to spatial autocorrelation among explanatory variables and health poverty. Robust standard errors are used in estimation to improve regression outcome.

Table 3

*Variables' Definitions*

| Variables | Definition |
|---|---|
| **Demographic Characteristics** | |
| Gender | Gender of the head of the household: Dummy (1=Male,0= Female) |
| Age | Age of the head of the household: Continuous (number of years) |
| Education | Education is defined as the individual's highest educational attainment. Categorical (Illiterate, Primary, Matric, Bachelor and Master and Above including professional degree: Illiterate is used a reference category): Following dummies are used:<br>Primary [class 1 to class 5] (1 if yes otherwise 0)<br>Matric [class 6 to class 10] (1 if yes otherwise 0)<br>Bachelor [class 11 to class 14] (1 if yes otherwise 0)<br>Master and others [class 15 and above including professional degree] (1 if yes otherwise 0) |
| Marital Status | Marital status of the head of the household: Dummy (1=Married,0= otherwise) |
| Household Size | Total number of persons in the household: Continuous (number) |
| **Economic Status** | |
| Income | Log per capita income which include income from all sources such as from first and second occupation, other work, income in kind, pension, rental income and remittances earned over the last one year: Continues (Rs) |
| Land Ownership | Personal agriculture land: Dummy (1 if yes otherwise 0) |
| Livestock | Livestock in personal possession or Sheep, goat in personal possession: Dummy (1 if yes otherwise 0) |
| No of earners | Total number of persons currently employed: Continuous (number) |
| Employment | Employment status of the head of the household: Dummy (1=Employed,0= otherwise) |
| **Regional Variations** | |
| Province | Provincial dummies. KPK is used a reference category Following dummies are used:<br>1. Punjab (1 if yes otherwise 0)<br>2. Sindh (1 if yes otherwise 0)<br>3. Balochistan (1 if yes otherwise 0) |
| Region | Regional dummies: (1 for Urban and 0for Rural) |
| **Awareness** | |
| Use of Media | Use of TV or other media sources: Dummy (1 if used otherwise 0) |
| **Availability of Personal Transport** | |

| | |
|---|---|
| Transport | Availability of personal transport facilities such as motorcycle, car etc: Dummy (1 if available otherwise 0) |

*Source:* Author's own.

## 4. RESULTS AND DISCUSSION

### 4.1. Incidence of Health Poverty

The Table 4 shows both the incidence or headcount ratio (H) of health poverty and the average intensity (A) of their poverty and health poverty index (HPI) at different poverty K-Cut-off. The results shows that as we move from 10 percent to 100 percent poverty cut-off, the headcount ratio keep on decreasing. The average intensity (A) has the increasing pattern, it is due to the fact that in the Censored Weighted Deprivation Matrix as the percentage of poverty cut-off increases the household with more deprivations are censored as poor, and the Average Intensity of the poverty is the average of the multidimensional (MD) poor people. At the initial poverty cut-offs the A is low and with the increase in poverty cut-off the percentage of A keeps on increasing. The results show that as we move from 10 percent to 100 percent poverty cut-off, the health poverty index keeps on deceasing.

Table 4

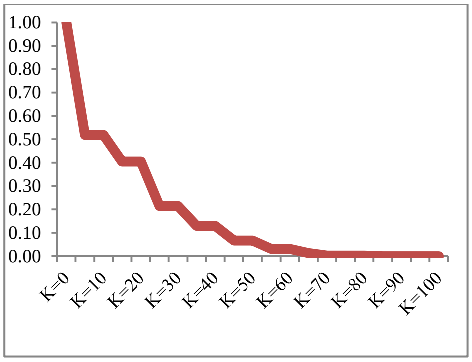
*Headcount, Average Intensity and Health Poverty Index at Different K_Cutoffs*

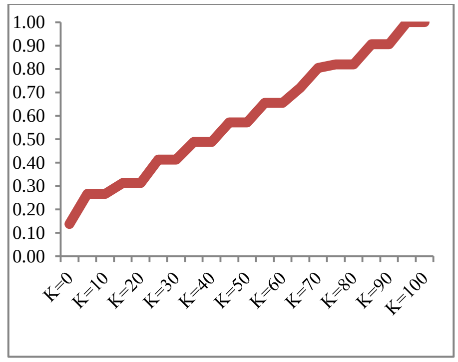
| K- Cutoff (percent) | Headcount (H) | Average Intensity (A) | Health Poverty Index (HPI) |
|---|---|---|---|
| 0 | 1.000 | 0.138 | 0.138 |
| 10 | 0.519 | 0.266 | 0.138 |
| 20 | 0.405 | 0.313 | 0.127 |
| 30 | 0.215 | 0.413 | 0.089 |
| 40 | 0.129 | 0.488 | 0.063 |
| 50 | 0.066 | 0.572 | 0.038 |
| 60 | 0.031 | 0.655 | 0.020 |
| 70 | 0.003 | 0.804 | 0.002 |
| 80 | 0.002 | 0.820 | 0.002 |
| 90 | 0.000 | 0.905 | 0.000 |
| 100 | 0.000 | 1.000 | 0.000 |

Figure 1 graphically shows the trend of H, A and HPI. The figure indicates that as the poverty cut-off goes on increasing, the H has a decreasing trend, A has increasing trend while HPI has also decreasing trend.

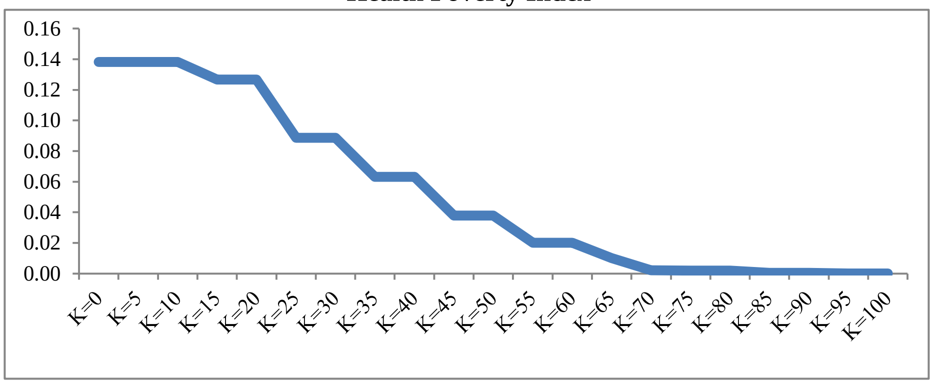
**Fig. 1. Trend in Headcount, Intensity and Health Poverty across Different K-Cutoff**

**Headcount** **Average Intensity**




**Health Poverty Index**




For further analysis, this study set the K-cut-off at 20 percent. We have declared household as a poor household in health if the household has deprived in one dimension out of five dimensions i.e. 5th quintile.[9] The incidence of health poverty for the poverty cut-off K=20 percent is reported in Table 5. The results show that the headcount 41 percent households are below the poverty cut-off across the Pakistan. Further, the ratio is very high in rural area of Pakistan (50 percent) when compared with urban areas of Pakistan (22 percent). Provincial analysis shows that Punjab is the least poor province of Pakistan in term of health poverty (36 percent) while Balochistan is the poorest province in Pakistan (62 percent). The statistics shows that health poverty is high in rural areas in comparison with the urban areas. Similar trends have been observed across all provinces (Table 5).

Table 5

*Health Poverty at 20 Percent Cut-off*

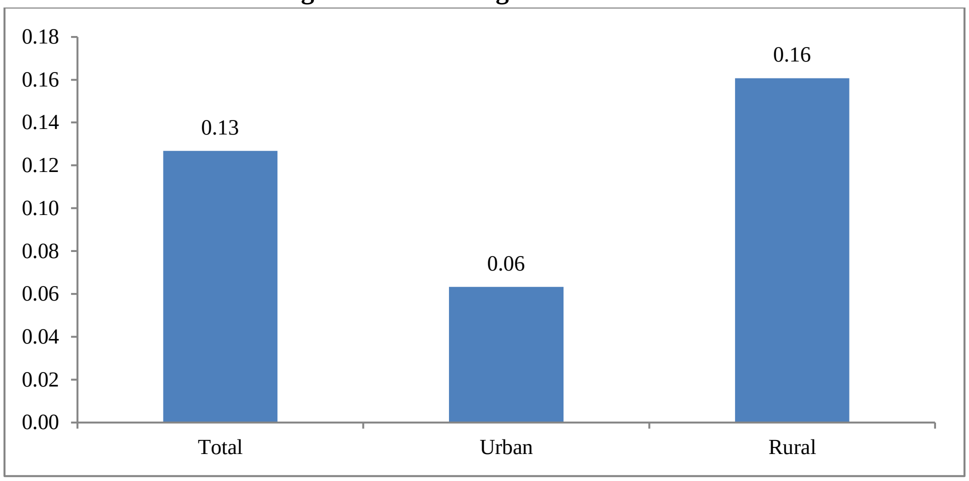
| | Headcount (H) | | | Average Intensity (A) | | | Health Poverty Index (HPI) | | |
|---|---|---|---|---|---|---|---|---|---|
| Region | Total | Urban | Rural | Total | Urban | Rural | Total | Urban | Rural |
| Pakistan | 40.49 | 22.30 | 50.21 | 31.30 | 28.36 | 32.00 | 0.13 | 0.06 | 0.16 |
| KPK | 54.31 | 30.16 | 59.39 | 33.71 | 30.41 | 34.07 | 0.18 | 0.09 | 0.20 |

[9] The definition of health poor (a household is health poor if deprived in at least one dimension) is align with the MPI in which a household is poor is deprived in one dimension.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Punjab | 35.56 | 21.54 | 42.23 | 29.47 | 27.90 | 29.85 | 0.10 | 0.06 | 0.13 |
| Sindh | 41.64 | 21.07 | 64.05 | 32.08 | 28.32 | 33.42 | 0.13 | 0.06 | 0.21 |
| Balochistan | 61.53 | 34.85 | 70.03 | 36.76 | 30.27 | 37.79 | 0.23 | 0.11 | 0.26 |

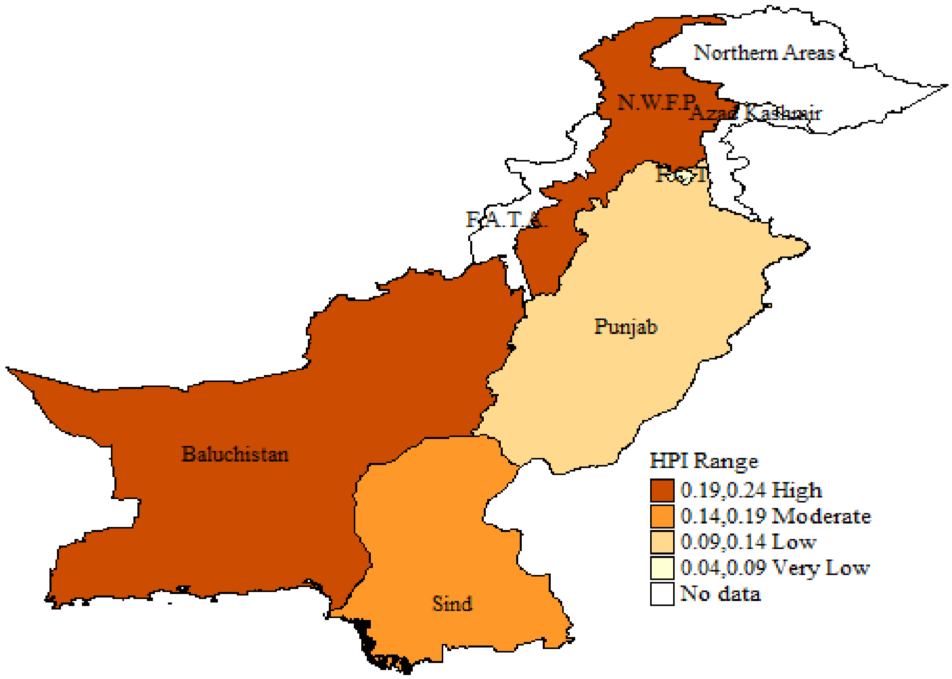
The Figure 2 shows that the value of health poverty index (HPI) is 0.13 which is the product of H and A. It is the percentage of those households which are multidimensional poor as well as being deprived at the same time. This indicates that 13 percent households are multidimensional poor in health across the Pakistan. Regional analysis shows that 16 percent households are multidimensional poor in health in rural areas in comparison with 6 percent in urban areas of Pakistan.

**Fig. 2. HPI and Regional Variations**




To further investigate the depth of health deprivation, we form four categories of health deprivation based on Health Poverty Index (HPI), include (i) very low deprivation; (ii) low deprivation; (iii) moderate deprivation; and (iv) high deprivation. Provincial analysis shows that based on HPI, Punjab falls in the category of low health deprivation, Sindh in moderate health deprivation while KPK and Balochistan are in high health deprivation (Map 1) category.

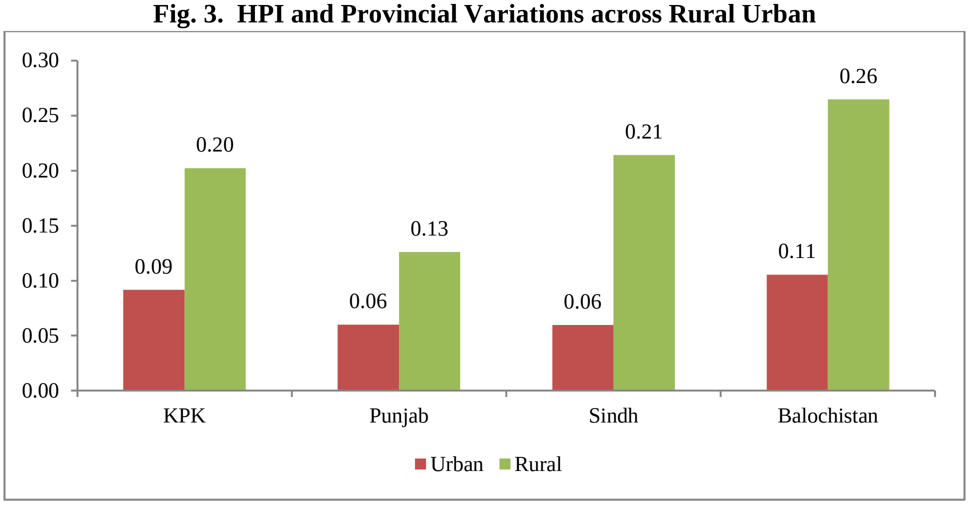
**Map 1. Health Deprivation at Provincial Level**




*Source*: Author's own based on HPI data using ADePT and DIVA-GIS.

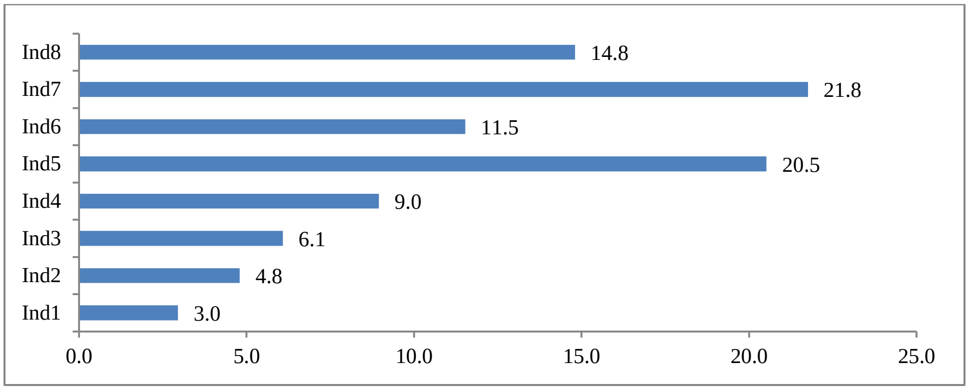
Provincial analysis exhibits similar pattern across rural urban areas. Balochistan is the most deprived as well as multidimensional poor in health province in Pakistan while Punjab is the least deprived as well as multidimensional poor in health (Figure 3).

**Fig. 3. HPI and Provincial Variations across Rural Urban**



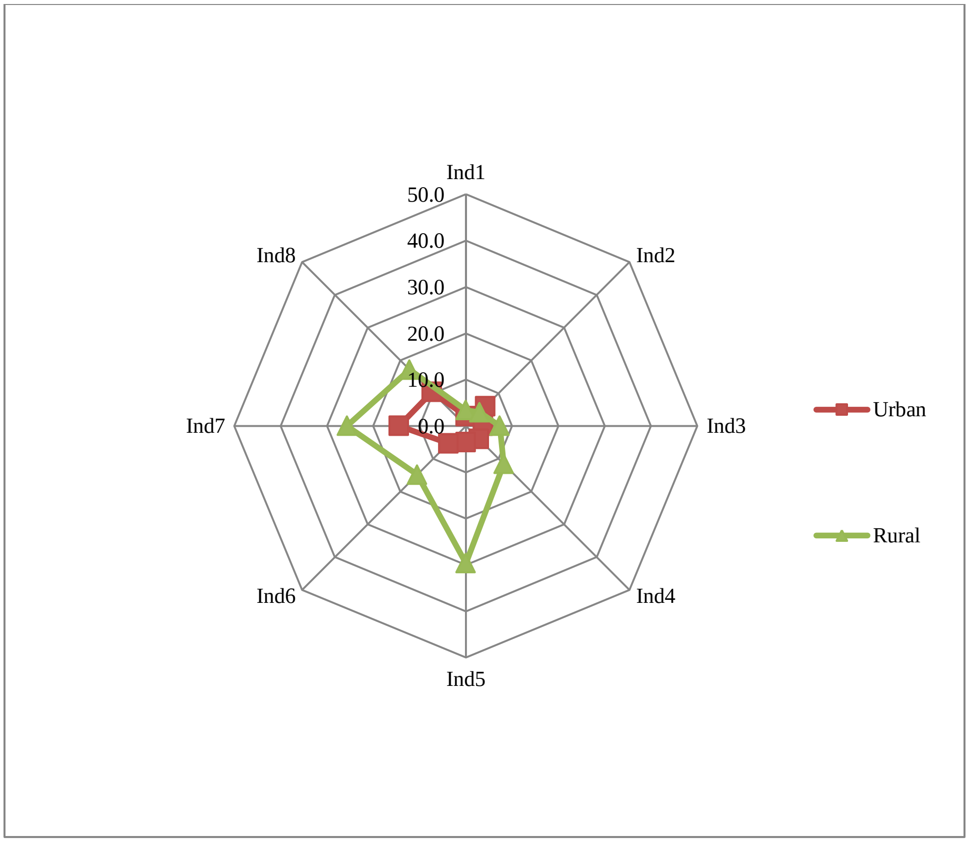

The HPI uses 8 indicators to measure poverty in five dimensions. Figure 4 reports the proportion of the households that are poor and also deprived in each indicator. The results show that only 3.0 and 4.8 percent households deprived in indicator 1—doctor consulted during sick or injury— and indicator 2—assisted delivery —respectively. Around 6.1 and 9 percent are deprived in indicator 3—satisfaction with the use of health services and indicator 4—institutional delivery, respectively. Around 20.5 percent households are deprived in indicator 5 that measures the cost of health facilities in term of time to reach/obtain health facilities. Maternal health situation reveals that around 11.5 percent households are deprived in pre-natal care facilities— indicators 6— and 21.8 percent households are deprived in post-natal care facilities—indicator 7. Child immunisation indicator (IND 8) shows that 14.8 percent households are deprived in child immunisation.

**Fig. 4. Percentage of the Households who are HPI Poor and Deprived in Each Indicator**




The Figure 5 reports the proportion of the households that are poor and also deprived in each indicator across rural urban divide. It compares the performance of rural areas and urban areas with that of the national aggregate. Similar patterns have been observed across rural and urban areas as we explained for the national aggregate. However, the average population deprived in each indicator is low in urban areas as compared to rural areas.

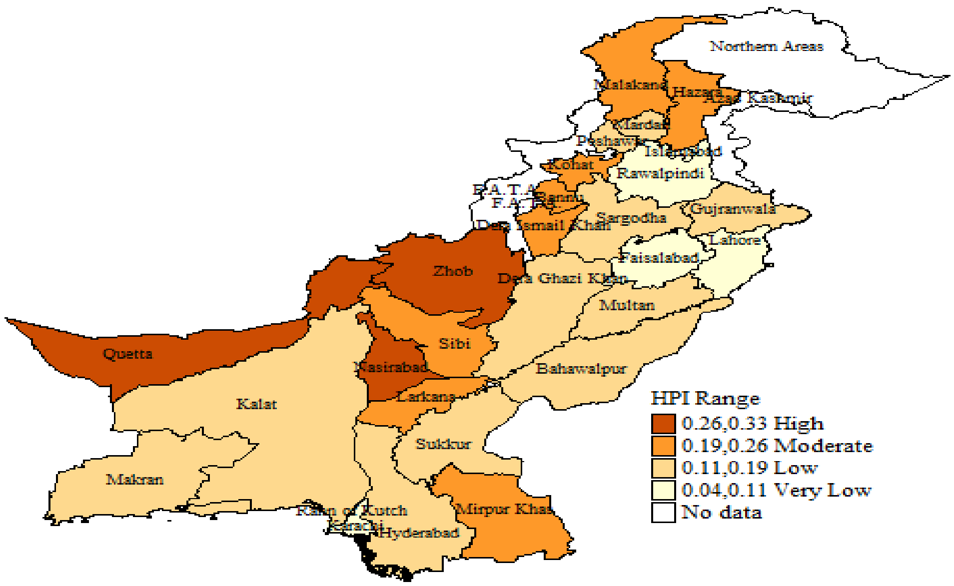
**Fig. 5. Percentage of the Households who are HPI Poor and Deprived in Each Indicator across Rural and Urban Areas**




**4.2. Spatial Differences: A District Level Analysis using Geographical Information System (GIS)**

To further look into the regional differences in health deprivation, we conduct analysis at division and district level. The division level analysis shows that Islamabad, Karachi, Rawalpindi, Lahore and Faisalabad fall in very low health deprivation categories. Multan, Gujranwala, Peshawar, Sargodha, Bahawalpur, Hyderabad, Kalat, Mardan, Dera Ghazi Khan, Sukkur, Makran and Kohat division fall in low health deprivation category. While Mirpur Khas, Dera Ismail Khan, Bannu, Larkana, Hazara, Malakand and Sibi show moderate health deprivation and Zhob, Quetta and Nasirabad show high health deprivation (Map 2).

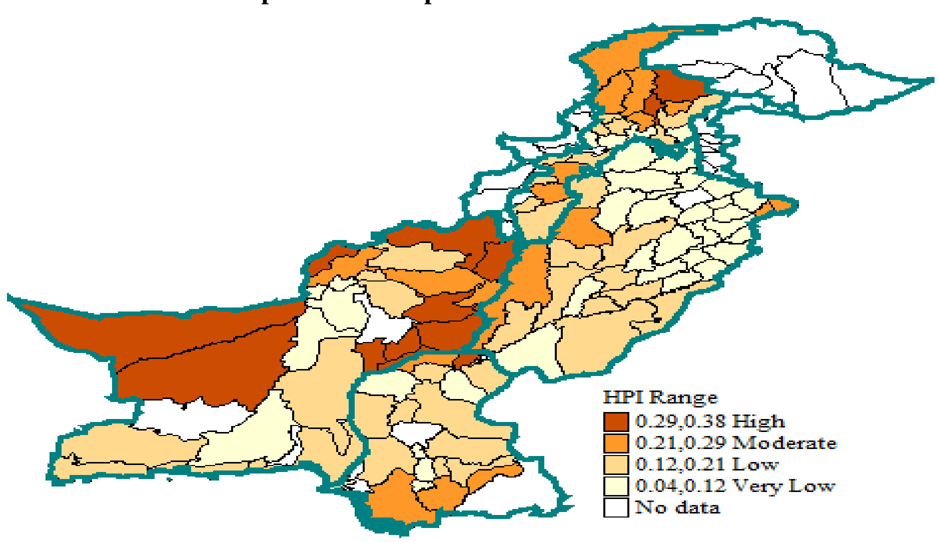
**Map 2. Health Deprivation at Divisional Level**




*Source:* Author's own based on HPI data using ADePT and DIVA-GIS.

Map 3 shows the ranking of districts based on HPI. The district analysis shows that districts from North Punjab including Gujrat, Lahore, Gujranwala, Faisalabad, Chakwal, Sargodha, Rawalpindi and Jhelum are least deprived in health. Most of the districts from Balochistan including Jafarabad, Kharan, Musakhel, Kholu, Zhob, Dera Bugti, Qilla Abdullah, Chagai, Nasirabad and Jhal Magsi and KPK including Shangla and Kohistan categories as highly deprived districts on Pakistan.

**Map 3. Health Deprivation at District Level**




*Source:* Author's own based on HPI data using ADePT and DIVA-GIS.

The obvious question, why are few districts highly deprived as compared with other districts, even in the same division or province? One possible reason could be the unavailability of health services in the vicinity. The MOUZA statistics shows that the average distance from MOUZA to basic health services is very high in highly deprived districts as compared with low deprived districts. The average distance for hospital/dispensary from MOUZA is 17 KM in Pakistan [Punjab (10KM), Sindh (14KM), KPK (12KM), Balochistan (32)]. Similar patterns have been observed for Basic Health Unit (BSU), Rural Health Centre (RHC), Child and Mother Care Centre (CMCC), Population Welfare Centre (PWC), N.G.O. Dispensary (NGOD), Private Doctor and Midwife Facility Centre (MFC) across the provinces (see Appendix Map 1 to Map 6). Distance acts as a binding constraint in availing health facility due to lack of public transport and high cost of private transportation. To reduce health deprivation, availability of health facilities in the vicinity is crucial. Provision of health services at the door step should be the top priority of the government to reduce health poverty.

### 4.3. Determinants of HPI: Logistic Analysis

This section provides the key determinants that explain health deprivation. Various social-economic factors explain the variation in health poverty across the Pakistan as well as at regional level. Table 6 presents the logistic regression results at national and regional level. The results of logistic regression with district fixed effect are reported in Appendix Table 4.

The results show that education of the head of the household plays a significant role in eradicating health poverty. With successive (higher) level of education, the chance to decrease the likelihood of being health poor has an increasing pattern. It is observed that the attainment of primary, matriculation, bachelors and professional (masters or above qualification) will decrease the likelihood of being poor by 17 percent, 29 percent, 36 percent, and 33 percent respectively, compared with their reference category of illiterate. Similar pattern has been observed in urban and rural areas (Table 6). This shows that as we increase the educational qualification of individuals their chances of being non-poor increases or we can say that the probability of being poor declines vigorously. Gender of the head of the household has surprising results. The results indicate that the likelihood of being poor increased by 37 percent as the gender of the head of the household changes from female to male. However, logically, the results are convincing because, the health of the household members especially children and mother is primarily influenced by the active role played by the female. Males, primarily are concerned with earning, to smooth the consumption of households, while female, especially wife of the head of the household manage the use of basic facilities like health and education. In this way, the role of female is very important in improving the health conditions of the household. Increasing the household size increases the chances to fall into poverty (Table 6). This is because distribution of limited resources among the household members causes shortage of resources to obtain health services.

Economic status of the household has a significant role in determining the health outcomes. Per capita income has a negative and significant impact on the health poverty. The results have shown that the likelihood of being poor is decreased by 25 percent income level increased by one percent. This association holds for both rural and urban areas. Number of earner and employment status of the head of the household is also negatively related to the health deprivation (Table 6). Availability of household assets like land ownership and livestock, on the other hand, are not supportive of removing health deprivation and can even increase health deprivation. The obvious question is: why assets fail to reduce health poverty? Agriculture land and livestock are primarily owned by the rural households. These households use these assets as the prime source of their income to finance their livelihood. The income generated from these sources is seasonal. This creates the problem of shortage of income during off seasons. Hence, these households are less prone to finance their health needs, because their prime focus is to finance their basic need such as food and cloths etc. This pushes the household into the health poverty.

Regional variations have a significant impact of health poverty. We have used three dummies to capture provincial variations and one dummy to capture rural urban variation. The results show that that the likelihood of being health poor is decreased by 41 and 10 percent in Punjab and Sindh respectively when compared with their reference KPK. On the other hand, the likelihood of being health poor is increased 38 percent in Balochistan in compared with their reference KPK. Similar pattern has been observed in rural and urban areas. Movement from rural to urban areas has decreased 62 percent, the likelihood of being health poor.

Information availability has a very important role in eradicating health poverty. To gauge the role of information in removing poverty, we have used “use/availability of media” as a proxy. The results show that the availability of media has a significant impact on health poverty. Awareness about the use and importance of health facilities creates the demand for health services. The results show that that the likelihood of being health poor is decreased by 25 among the household using different media sources in comparison with the household not using media at aggregate level. Similar behaviour has been observed at sub-national level i.e. rural and urban levels.

Role of transportation is very important in availing health facilities. Availability of personal transport not only reduces the transportation cost but also reduces the waiting time involved in the arranging public transport especially in rural areas. To quantify the impact of availability personal transport, we use the “availability of motorcycle, car etc. in the household” as a proxy. We find that the availability personal transport has a significant impact on health poverty. The results show that that the likelihood of being health poor is decreased by 8 among the households having personal transport facility in comparison with the households not having this facility. Similar behaviour has been observed at sub-national level i.e. rural and urban levels

To further gauge the role these socio-economic variables on health poverty, we bifurcate the national sample into sub-national units i.e. provinces. We estimate the impact of these variables on health poverty for each province. The results are reported in the Table 7. Most of the outcomes remains same as reported and discussed at national level. In sum, socio-economic variables such as the income, regional variation, education and awareness play a very important role in explaining health poverty.

Table 6

*Determinants of HPI: Logistic Regression Analysis*
*(Dependent Variable HPI: 1 if Household Poor Otherwise 0)*

| Variables | National | Urban | Rural |
|---|---|---|---|
| **Demographic Characteristics** | | | |
| Gender of HH | 1.370*** | 1.389*** | 1.325*** |
| | (0.05) | (0.11) | (0.06) |
| Age of HH | 0.970*** | 0.964*** | 0.972*** |
| | (0.00) | (0.00) | (0.00) |
| Education of HH | | | |
| Primary | 0.827*** | 0.893** | 0.809*** |
| | (0.02) | (0.04) | (0.02) |
| Matric | 0.710*** | 0.755*** | 0.704*** |
| | (0.02) | (0.03) | (0.02) |
| Bachelor | 0.642*** | 0.656*** | 0.657*** |
| | (0.02) | (0.03) | (0.03) |
| Master and above | 0.672*** | 0.581*** | 0.976 |
| | (0.06) | (0.07) | (0.14) |
| Marital Status of HH | 1.194*** | 1.276*** | 1.175*** |
| | (0.04) | (0.08) | (0.05) |
| HH Size | 1.212*** | 1.291*** | 1.176*** |
| | (0.00) | (0.01) | (0.01) |
| **Economic Status** | | | |
| Income | 0.752*** | 0.811*** | 0.737*** |
| | (0.01) | (0.02) | (0.01) |
| Land Ownership | 1.159*** | 1.072 | 1.193*** |
| | (0.03) | (0.06) | (0.03) |
| Livestock | 1.495*** | 1.391*** | 1.524*** |
| | (0.03) | (0.08) | (0.03) |
| No of Earner | 0.969*** | 0.959** | 0.969*** |
| | (0.01) | (0.02) | (0.01) |
| Employment of HH | 0.804*** | 0.684*** | 0.867*** |
| | (0.02) | (0.04) | (0.03) |
| **Regional Variations** | | | |
| Province | | | |
| Punjab | 0.598*** | 0.794*** | 0.523*** |
| | (0.01) | (0.04) | (0.01) |
| Sindh | 0.908*** | 0.798*** | 0.984 |
| | (0.02) | (0.04) | (0.03) |
| Balochistan | 1.380*** | 1.081 | 1.463*** |
| | (0.04) | (0.07) | (0.05) |
| Urban | 0.465*** | | |
| | (0.01) | | |
| **Awareness** | | | |
| Use of Media | 0.744*** | 0.791*** | 0.743*** |
| | (0.01) | (0.03) | (0.02) |
| **Personal Transport** | | | |
| Use of Personal Transport | 0.936*** | 0.873*** | 0.961 |
| | (0.02) | (0.03) | (0.02) |
| Constant | 43.32*** | 6.877*** | 59.23*** |
| | (7.10) | (2.09) | (11.74) |
| Observations | 75,321 | 26,538 | 48,783 |
| Wald chi2 (Prob > chi2) | 12199.98 (0.00) | 2369.95 (0.00) | 5564.18 (0.00) |

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table 7

*Determinants of HPI at Sub-National Level (Dependent Variable HPI: 1 if Household Poor Otherwise 0)*

| Variables | KPK | Punjab | Sindh | Balochistan |
|---|---|---|---|---|
| **Demographic Characteristics** | | | | |
| Gender of HH | 1.261*** | 1.304*** | 0.890 | 1.265 |
| | (0.09) | (0.07) | (0.13) | (0.33) |
| Age of HH | 0.971*** | 0.975*** | 0.965*** | 0.961*** |
| | (0.00) | (0.00) | (0.00) | (0.00) |
| Education of HH | | | | |
| Primary | 0.735*** | 0.886*** | 0.780*** | 0.806*** |
| | (0.05) | (0.03) | (0.04) | (0.05) |
| Matric | 0.616*** | 0.740*** | 0.722*** | 0.737*** |
| | (0.03) | (0.02) | (0.03) | (0.05) |
| Bachelor | 0.561*** | 0.702*** | 0.633*** | 0.598*** |
| | (0.04) | (0.04) | (0.04) | (0.05) |
| Master and above | 0.627** | 0.565*** | 0.564*** | 1.253 |
| | (0.12) | (0.10) | (0.10) | (0.22) |
| Marital Status of HH | 1.314*** | 1.111** | 1.553*** | 1.141 |
| | (0.10) | (0.05) | (0.14) | (0.14) |
| HH Size | 1.175*** | 1.248*** | 1.209*** | 1.169*** |
| | (0.01) | (0.01) | (0.01) | (0.01) |
| **Economic Status** | | | | |
| Income | 0.826*** | 0.738*** | 0.727*** | 0.728*** |
| | (0.03) | (0.02) | (0.02) | (0.03) |
| Land Ownership | 1.262*** | 1.215*** | 1.325*** | 0.789*** |
| | (0.06) | (0.04) | (0.06) | (0.04) |
| Livestock | 1.965*** | 1.369*** | 1.343*** | 1.575*** |
| | (0.09) | (0.05) | (0.05) | (0.08) |
| No of Earner | 1.108*** | 0.949*** | 0.993 | 0.897*** |
| | (0.03) | (0.01) | (0.02) | (0.02) |
| Employment of HH | 0.888** | 0.820*** | 0.766*** | 0.448*** |
| | (0.05) | (0.04) | (0.06) | (0.04) |
| **Regional Variations** | | | | |
| Urban | 0.491*** | 0.614*** | 0.354*** | 0.305*** |
| | (0.02) | (0.02) | (0.01) | (0.02) |
| **Awareness** | | | | |
| Use of Media | 0.887*** | 0.697*** | 0.653*** | 0.835*** |
| | (0.04) | (0.02) | (0.03) | (0.04) |
| **Personal Transport** | | | | |
| Use of Personal Transport | 0.818*** | 1.022 | 0.980 | 0.905** |
| | (0.05) | (0.03) | (0.04) | (0.04) |
| Constant | 10.58*** | 22.77*** | 110.7*** | 433.3*** |
| | (3.96) | (5.31) | (38.46) | (246.63) |
| Observations | 12,420 | 31,809 | 19,454 | 11,638 |
| Wald chi2 (Prob > chi2) | 1837.09 | 3616.94 | 3715.32 | 1537.43 |
| | (0.00) | (0.00) | (0.00) | (0.00) |

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

## 5. CONCLUDING REMARKS AND POLICY OPTIONS

The present study has constructed the health poverty index (HPI) for Pakistan using households data from Pakistan Living and Standard Measurement (PSLM) survey 2012-13 based on the Alkire Foster (AF) Method. Five different dimensions and eight different indicators with equal weights have been used in the construction of HPI. To further find the regional disparities in the health poverty, district level analysis has been carried out using GIS. To find the socio-economic determinants of health poverty, this study has employed logistic regression model.

The results have shown that the headcount health poverty is 41 percent in Pakistan. Further, the ratio is very high in rural area (50 percent) as compared with urban areas (22 percent). Provincial analysis has shown that Punjab is the least poor province (36 percent) while Balochistan is the poorest province (62 percent). The value of health poverty index is 0.13 which is the product of the headcount and average intensity. It is the percentage of those households which are multidimensional poor as well as being deprived at the same time. This indicates that 13 percent of households are multidimensional poor in health across the Pakistan. Regional analysis has shown that 16 percent households are multidimensional poor in health in rural areas, compared to 6 percent in urban areas of Pakistan. Provincial analysis has exhibited similar patterns across rural and urban areas. Balochistan is the most deprived as well as multidimensional poor province in Pakistan while Punjab is the least deprived as well as multidimensional poor province. The results have shown that 20.5 percent of households are deprived in indicator that measures the cost of health facilities in terms of time to reach/obtain health facilities. Maternal health situation has revealed that around 11.5 percent households are deprived in pre-natal care facilities and 21.8 percent households are deprived in post-natal care facilities. Child immunisation indicator has shown that 14.8 percent households are deprived in child immunisation. Empirical analysis has shown that various socio-economic variables such as income, regional variation, education and awareness play very important roles in explaining health poverty.

To eradicate health deprivation, areas specific and dimension specific policies are required. More specifically following important policy implications have emerged from the study:

(1) The GIS analysis reveals that most of the districts from Balochistan, KPK, interior Sindh and Southern Punjab lack availability of basic healthcare services. Provincial governments should focus on these districts as their top priority to increase basic health facilities. Based on district ranking, it can be identified which district lack which facility, hence targeted framework may be designed to meet the area specific needs.

(2) Analysis reveals that females can play pivotal role in eliminating health poverty. It is suggested that government should focus females in their health policies/interventions for better outcome of health interventions. There is evidence that empowering females can improve the social indicators of the households. Benazir Income Support Programme (BISP) is the best example of this. BISP provides financial assistance to females only. The evidence shows that BISP is associated with an increase in expenditure on health.[10]

[10] http://www.bisp.gov.pk/Others/BISPFirstImpactEvaluationReport.pdf

(3) There are two reinforcing outcome of the analysis; one, significant contribution of education in eliminating health poverty and two, awareness of the use of health facilities in breaking health deprivation nexus. Improvement in literacy will also help to create awareness among the poor segment of the society of the use of health services. Education can also induce people to use better food and medical services to keep them healthy. Provision of education should be the prime focus of national and sub-national governments. Following the 18th Constitutional Amendment, it is the duty of provincial governments to ensure 100 percent literacy not only to improve health conditions but also to achieve Sustainable Development Goals (SGDs).

(4) Well targeted communication strategies should be devised to highlight the importance of health. For this media can play very significant role. Health deprivation is very high in underdeveloped regions of the country as noted in spatial analysis. Communication strategy should target these areas with strong social mobilisation. Radio, TV and mobile messages can be used to create awareness in these regions.

(5) Availability of transportation system will also help to eliminate health poverty. Efforts are required to promote public transport especially in rural areas of Balochistan and Southern Punjab.

In essence, targeted efforts are required to increase the provision of services especially public transport, availability of affordable medical facilities in the vicinity, qualified doctors, proper physical infrastructure and awareness about the use of health services to eliminate health poverty in Pakistan.

## APPENDIX

Appendix Table 1

*List of Questions Used in Defining Each Indicator*

| Indicator | Questions from HIES/PSLM | Q Code in Data |
|---|---|---|
| IND1: Doctor consulted during sick or injury | Section D. Health<br>1.Had he/she been sick or injured during the last two weeks?<br>2.Did anyone consulted for this illness? | sdq01<br>sdq02 |
| IND2: Assisted delivery | Section I. Ever Married women (age 15 to 49 years)<br>1.Did she given birth to a child during last 3 years?<br>9.Who assisted with delivery? | siq01<br>siq09 |
| IND3: Satisfaction with the use of health services | Section D. Health<br>5.Did he/she faced any problem at time of visit____?<br>6.Why he/she did not seek medicines/medical facilities during the last two weeks? | sdq05<br>sdq06 |
| IND4: Institutional delivery | Section I. Ever Married women (age 15 to 49 years)<br>1.Did she given birth to a child during last 3 years?<br>8.Where did she give birth (Last Pregnancy)? | siq01<br>siq08 |
| IND5: Time cost | Section: G. Detail of the Family<br>10. How much time is spent in reaching to the most near place of facility:<br>Option: Health clinic/Hospital | sgq10_71 |
| IND6: Pre-natal care | Section I. Ever Married women (age 15 to 49 years)<br>1.Did she given birth to a child during last 3 years?<br>2. Did she receive any pre-natal care during this pregnancy? | siq01<br>siq02 |
| IND7: Post-natal care | Section I. Ever Married women (age 15 to 49 years)<br>1.Did she given birth to a child during last 3 years?<br>10.Did she receive post-natal care within 6 weeks after this delivery? | siq01<br>siq10 |
| IND8: Immunisation | Section: H. Vaccination and Diarrhoea (for children under 5)<br>3. Has the child ever been immunised? | shq03==2 |

Appendix Table 2

*Divisional Ranking*

| Division | Region/Province | HPI |
|---|---|---|
| | **Very Low Health Deprivation** | |
| Islamabad | F.C.T. | 0.040 |
| Karachi | Sindh | 0.053 |
| Rawalpindi | Punjab | 0.083 |
| Lahore | Punjab | 0.084 |
| Faisalabad | Punjab | 0.097 |
| | **Low Health Deprivation** | |
| Multan | Punjab | 0.118 |
| Gujranwala | Punjab | 0.119 |
| Peshawar | KPK | 0.122 |
| Sargodha | Punjab | 0.140 |
| Bahawalpur | Punjab | 0.146 |
| Hyderabad | Sindh | 0.155 |
| Kalat | Balochistan | 0.157 |
| Mardan | KPK | 0.160 |
| Dera Ghazi Khan | Punjab | 0.176 |
| Sukkur | Sindh | 0.180 |
| Makran | Balochistan | 0.183 |
| Kohat | KPK | 0.189 |
| | **Moderate Health Deprivation** | |
| Mirpur Khas | Sindh | 0.204 |
| Dera Ismail Khan | KPK | 0.206 |
| Bannu | KPK | 0.208 |
| Larkana | Sindh | 0.213 |
| Hazara | KPK | 0.214 |
| Malakand | KPK | 0.231 |
| Sibi | Balochistan | 0.243 |
| | **High Health Deprivation** | |
| Zhob | Balochistan | 0.266 |
| Quetta | Balochistan | 0.269 |
| Nasirabad | Balochistan | 0.335 |

Appendix Table 3

*District Ranking*

| District | Region/Province | HPI | District | Region/Province | HPI |
|---|---|---|---|---|---|
| **Very Low Health Deprivation** | | | **Low Health Deprivation** | | |
| Islamabad | F.C.T. | 0.040 | Sialkot | Punjab | 0.122 |
| Karachi | Sindh | 0.053 | Layyah | Punjab | 0.129 |
| Gujrat | Punjab | 0.056 | Khuzdar | Balochistan | 0.133 |
| Lahore | Punjab | 0.057 | Sibi | Balochistan | 0.134 |
| Gujranwala | Punjab | 0.058 | Khanewal | Punjab | 0.138 |
| Faisalabad | Punjab | 0.058 | Kohat | KPK | 0.140 |
| Chakwal | Punjab | 0.059 | Mardan | KPK | 0.141 |
| Hyderabad | Sindh | 0.064 | Vehari | Punjab | 0.141 |
| Sahiwal | Punjab | 0.070 | Jhang | Punjab | 0.142 |
| Rawalpindi | Punjab | 0.071 | Haripur | KPK | 0.142 |
| Kasur | Punjab | 0.075 | Charsadda | KPK | 0.144 |
| Hafizabad | Punjab | 0.077 | Bahawalpur | Punjab | 0.145 |
| Khushab | Punjab | 0.083 | Jamshoro | Sindh | 0.145 |
| Sheikhupura | Punjab | 0.084 | Dadu | Sindh | 0.146 |
| Pakpattan | Punjab | 0.086 | Muzaffargarh | Punjab | 0.156 |
| Jhelum | Punjab | 0.088 | Malakand P.A. | KPK | 0.156 |
| Toba Tek Singh | Punjab | 0.091 | Mianwali | Punjab | 0.162 |
| Okara | Punjab | 0.094 | Mansehra | KPK | 0.163 |
| Multan | Punjab | 0.099 | Ziarat | Balochistan | 0.166 |
| Abbottabad | KPK | 0.099 | Kech | Balochistan | 0.173 |
| Nankana Sahib | Punjab | 0.100 | Hangu | KPK | 0.174 |
| Sargodha | Punjab | 0.100 | Lodhran | Punjab | 0.176 |
| Peshawar | KPK | 0.104 | Tando M. Khan | Sindh | 0.176 |
| Awaran | Balochistan | 0.105 | Bahawalnagar | Punjab | 0.178 |
| Kalat | Balochistan | 0.108 | Qilla Saifullah | Balochistan | 0.179 |
| Matiari | Sindh | 0.109 | Shikarpur | Sindh | 0.180 |
| Tando Allahyar | Sindh | 0.112 | Lasbela | Balochistan | 0.187 |
| Attok | Punjab | 0.112 | Sanghar | Sindh | 0.189 |
| Quetta | Balochistan | 0.113 | Gwadar | Balochistan | 0.193 |
| Mastung | Balochistan | 0.113 | Naushahro Firoz | Sindh | 0.195 |
| Rahimyar Khan | Punjab | 0.116 | Mirphurkhas | Sindh | 0.199 |
| Sukkur | Sindh | 0.117 | Khairpur | Sindh | 0.201 |
| Swabi | KPK | 0.118 | Rajan Pur | Punjab | 0.203 |
| Nowshera | KPK | 0.119 | Bannu | KPK | 0.205 |
| Larkana | Sindh | 0.120 | Tank | KPK | 0.206 |
| **Moderate Health Deprivation** | | | **Dera Ismail Khan** | **KPK** | **0.206** |
| Bhakkar | Punjab | 0.213 | Ghotki | Sindhh | 0.206 |
| Dera Ghazi Khan | Punjab | 0.215 | Lakki Marwat | KPK | 0.210 |
| Chitral | KPK | 0.216 | High Health Deprivation | | |
| Swat | KPK | 0.216 | Jafarabad | Balochistan | 0.295 |
| Buner | KPK | 0.220 | Kharan | Balochistan | 0.297 |
| Umerkot | Sindh | 0.225 | Kashmore | Sindh | 0.302 |
| Barkhan | Balochistan | 0.229 | Musakhel | Balochistan | 0.313 |
| Narowal | Punjab | 0.231 | Kholu | Balochistan | 0.326 |
| Dir | KPK | 0.237 | Zhob | Balochistan | 0.327 |
| Thatta | Sindh | 0.242 | Shangla | KPK | 0.328 |
| Badin | Sindh | 0.243 | Dera Bugti | Balochistan | 0.345 |
| Jakobabad | Sindh | 0.250 | Qilla Abdullah | Balochistan | 0.349 |
| Karak | KPK | 0.254 | Chagai | Balochistan | 0.349 |
| Pishin | Balochistan | 0.264 | Nasirabad | Balochistan | 0.353 |
| Loralai | Balochistan | 0.283 | Jhal Magsi | Balochistan | 0.356 |
| Battagram | KPK | 0.285 | Kohistan | KPK | 0.379 |

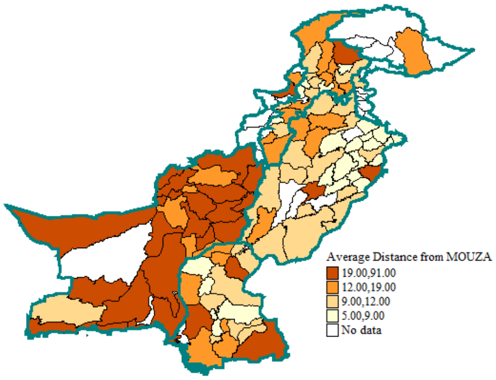
Appendix Table 4

*Determinants of HPI: Logistic Regression Analysis*
*(Dependent Variable HPI: 1 if Household Poor otherwise 0) with District Fixed Effect*

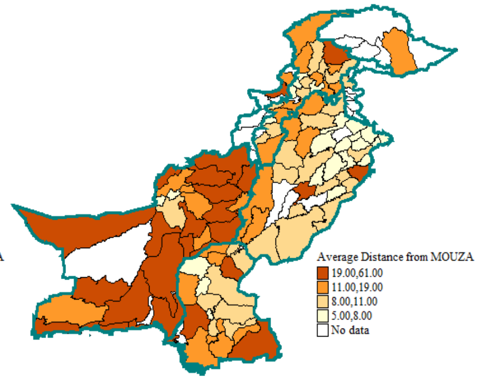
| Variables | National | Urban | Rural | KPK | Punjab | Sindh | Balochistan |
|---|---|---|---|---|---|---|---|
| | | | ***Demographic Characteristics*** | | | | |
| Gender of HH | 1.370*** | 1.432*** | 1.326*** | 1.194** | 1.409*** | 0.935 | 1.246 |
| | (0.06) | (0.11) | (0.06) | (0.09) | (0.08) | (0.13) | (0.34) |
| Age of HH | 0.970*** | 0.962*** | 0.973*** | 0.975*** | 0.974*** | 0.964*** | 0.954*** |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| Education of HH | | | | | | | |
| Primary | 0.803*** | 0.909** | 0.805*** | 0.726*** | 0.835*** | 0.756*** | 0.845** |
| | (0.02) | (0.04) | (0.02) | (0.05) | (0.03) | (0.03) | (0.06) |
| Matric | 0.683*** | 0.746*** | 0.731*** | 0.630*** | 0.706*** | 0.635*** | 0.753*** |
| | (0.02) | (0.03) | (0.02) | (0.04) | (0.02) | (0.03) | (0.05) |
| Bachelor | 0.575*** | 0.638*** | 0.628*** | 0.531*** | 0.624*** | 0.554*** | 0.557*** |
| | (0.02) | (0.03) | (0.03) | (0.04) | (0.03) | (0.03) | (0.05) |
| Master and above | 0.536*** | 0.545*** | 0.834 | 0.586*** | 0.461*** | 0.424*** | 0.901 |
| | (0.05) | (0.07) | (0.12) | (0.12) | (0.08) | (0.08) | (0.17) |
| Marital Status of HH | 1.209*** | 1.242*** | 1.135*** | 1.306*** | 1.076 | 1.586*** | 1.423*** |
| | (0.04) | (0.08) | (0.05) | (0.10) | (0.05) | (0.14) | (0.18) |
| HH Size | 1.216*** | 1.300*** | 1.196*** | 1.196*** | 1.247*** | 1.204*** | 1.174*** |
| | (0.00) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| | | | ***Economic Status*** | | | | |
| Income | 0.748*** | 0.812*** | 0.781*** | 0.805*** | 0.750*** | 0.688*** | 0.747*** |
| | (0.01) | (0.02) | (0.01) | (0.03) | (0.02) | (0.02) | (0.03) |
| Land Ownership | 1.223*** | 1.002 | 1.110*** | 1.258*** | 1.256*** | 1.475*** | 0.899* |
| | (0.03) | (0.06) | (0.03) | (0.06) | (0.04) | (0.07) | (0.05) |
| Livestock | 1.608*** | 1.177*** | 1.273*** | 1.650*** | 1.442*** | 1.667*** | 2.020*** |
| | (0.03) | (0.07) | (0.03) | (0.08) | (0.05) | (0.07) | (0.11) |
| No of Earner | 0.976*** | 0.969* | 0.957*** | 1.069*** | 0.952*** | 0.996 | 0.964 |
| | (0.01) | (0.02) | (0.01) | (0.03) | (0.01) | (0.02) | (0.02) |
| Employment of HH | 0.789*** | 0.689*** | 0.864*** | 0.826*** | 0.809*** | 0.808*** | 0.543*** |
| | (0.02) | (0.04) | (0.03) | (0.05) | (0.04) | (0.06) | (0.06) |
| | | | ***Awareness*** | | | | |
| Use of Media | 0.680*** | 0.791*** | 0.759*** | 0.714*** | 0.723*** | 0.585*** | 0.702*** |
| | (0.01) | (0.03) | (0.02) | (0.03) | (0.02) | (0.02) | (0.04) |
| | | | ***Personal Transport*** | | | | |
| Use of Personal Transport | 0.951** | 0.907*** | 0.952* | 0.948 | 0.975 | 1.011 | 0.872*** |
| | (0.02) | (0.03) | (0.02) | (0.05) | (0.03) | (0.04) | (0.04) |
| Constant | 30.90*** | 4.545*** | 23.28*** | 9.937*** | 14.79*** | 83.23*** | 215.3*** |
| | (6.17) | (1.81) | (5.60) | (4.09) | (3.75) | (30.47) | (130.25) |
| Observations | 75,321 | 26,538 | 48,783 | 12,420 | 31,809 | 19,454 | 11,638 |

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

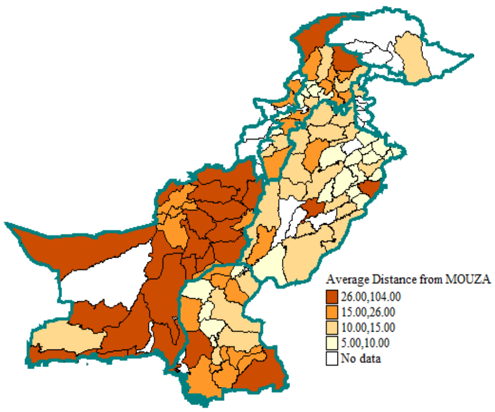
**Appendix Map 1: Mean Distance (Hospital)**



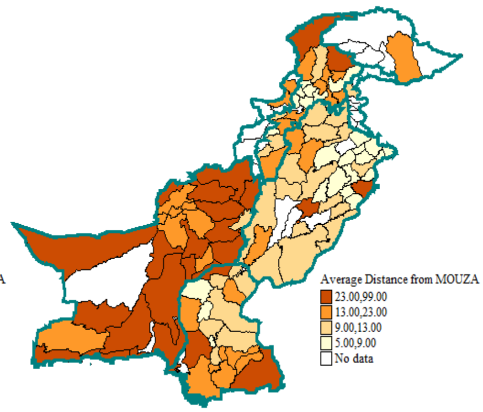

**Appendix Map 2: Mean Distance (BHU)**



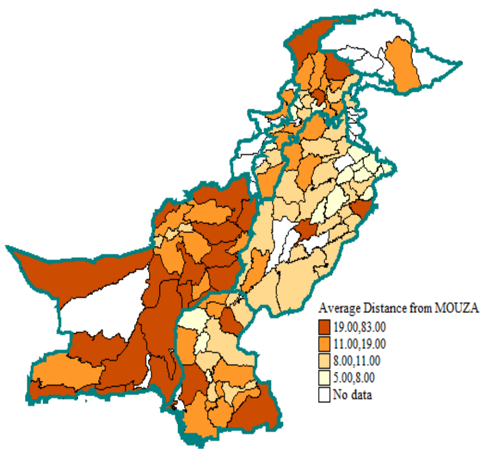

**Appendix Map 3: Mean Distance (CMCC)**



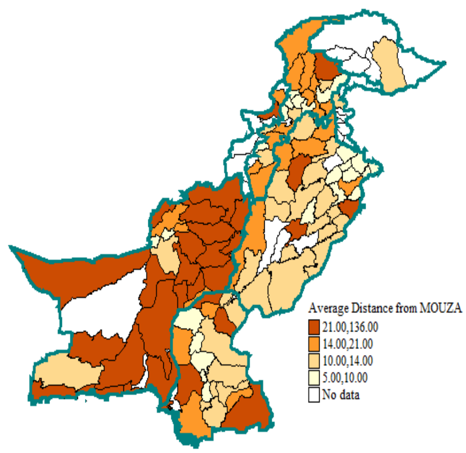

**Appendix Map 4: Mean Distance (PWC)**




**Appendix Map 5: Mean Distance (RHC)**




**Appendix Map 6: Mean Distance (MFC)**



**REFERENCES**

Alkire, S. and M. E. Santos (2010) Multidimensional Poverty Index: 2010 Data. Retrieved August, 14, 2010.

Alkire, S., A. Conconi, and J. M. Roche (2012) Multidimensional Poverty Index 2012: Brief Methodological Note and Results. University of Oxford, Department of International Development, Oxford Poverty and Human Development Initiative, Oxford, UK.

Andersen, R. and J. F. Newman (2005) Societal and Individual Determinants of Medical Care Utilisation in the United States. *The Milbank Quarterly* 83:4.

Antony, G. M. and A. Laxmaiah (2008) Human Development, Poverty, Health and Nutrition Situation in India. *Indian Journal of Medical Research* 128:2, 198.

Awiti, J. (2014) A Multilevel Analysis of Prenatal Care and Birth Weight in Kenya. *Health Economics Review* 4:1, 1–16.

Barua, B. (2013) *Provincial Healthcare Index 2013.* Fraser Institute.

Bloom, D. E. (2007) *Education, Health, and Development.* Cambridge, MA: American Academy of Arts and Sciences.

Boulos, M. N. K. (2004) Towards Evidence-based, GIS-driven National Spatial Health Information Infrastructure and Surveillance Services in the United Kingdom. *International Journal of Health Geographics* 3:1, 1.

Chakravarty, S. R. and J. Silber (2008) Measuring Multidimensional Poverty: The Axiomatic Approach. *Quantitative Approaches to Multidimensional Poverty Measurement* 192–209.

Claeson, M., E. R. Bos, T. Mawji, and I. Pathmanathan (2000) Reducing Child Mortality in India in the New Millennium. *Bulletin of the World Health Organisation* 78:10, 1192–1199.

Drèze, J. and M. Murthi (2001) Fertility, Education, and Development: Evidence from India. *Population and Development Review* 27:1, 33–63.

Friel, S., M. Chopra, and D. Satcher (2007) Unequal Weight: Equity Oriented Policy Responses to the Global Obesity Epidemic. *BMJ: British Medical Journal* 335:7632, 1241.

Gerdtham, U.-G. and M. Johannesson (2004) Absolute Income, Relative Income, Income Inequality, and Mortality. *Journal of Human Resources* 39:1, 228–247.

Greeley, M. (1994) Measurement of Poverty and Poverty of Measurement. *IDS Bulletin* 25:2, 50–58.

Hughes, G. and M. Dunleavy (2000) Why do Babies and Young Children Die in India? The Role of the Household Environment. The World Bank.

Lasser, K. E., D. U. Himmelstein, and S. Woolhandler (2008) Access to Care, Health Status, and Health Disparities in the United States and Canada: Results of a Cross-national Population-based Survey. *Health Policy: Crisis and Reform in the US Health Care Delivery System* 379.

Laudicella, M., R. Cookson, A. M. Jones, and N. Rice (2009) Health Care Deprivation Profiles in the Measurement of Inequality and Inequity: An Application to GP Fundholding in the English NHS. *Journal of Health Economics* 28:6, 1048–1061.

McGillivray, M. (1991) The Human Development Index: Yet another Redundant Composite Development Indicator? *World Development* 19:10, 1461–1468.

McLafferty, S. L. (2003) GIS and Health Care. *Annual Review of Public Health* 24:1, 25–42.

Mellor, J. M. and J. Milyo (2002) Income Inequality and Health Status in the United States: Evidence from the Current Population Survey. *Journal of Human Resources* 510–539.

Mirowsky, J. and C. E. Ross (2003) *Education, Social Status, and Health.* Transaction Publishers.

Mwabu, G. (2007) Health Economics for Low-income Countries. *Handbook of Development Economics* 4, 3305–3374.

Nandi, A., S. Galea, G. Lopez, V. Nandi, S. Strongarone, and D. C. Ompad (2008) Access to and Use of Health Services among Undocumented Mexican Immigrants in a US urban Area. *American Journal of Public Health* 98:11, 2011.

Navarro, V. and L. Shi (2001) The Political Context of Social Inequalities and Health. *Social Science and Medicine* 52:3, 481–491.

Nawaz-ul-Huda, S., F. Burke, and M. Azam (2011) Socio-economic Disparities in Balochistan, Pakistan—A Multivariate Analysis. *Geografia: Malaysian Journal of Society and Space* 7:4, 38–50.

Pakistan, Government of (2016) *Economic Survey of Pakistan 2015-16.* Islamabad: Ministry of Finance, Government of Pakistan.

Parker, E. B. and J. L.Campbell (1998) Measuring Access to Primary Medical Care: Some Examples of the Use of Geographical Information Systems. *Health and Place* 4:2, 183–193.

Pritchett, L. and L. H. Summers (1996) Wealthier is Healthier. *The Journal of Human Resources* 31:4, 841–868.

Ramachandran, M., K. S. K. Kumar, and B. Viswanathan (2006) *Vulnerability to Chronic Energy Deficiency: An Empirical Analysis of Women in Uttar Pradesh, India* (Vol. 12).

Rolfe, L. and J. Watson (2006) Health Poverty Index: An Atlas for the South East. UK.

Rutstein, S., K. Johnson, and D. Gwatkin (2000) Poverty, Health Inequality, and its Health and Demographic Effects. Paper presented at the Annual Meeting of the Population Association of America, Los Angeles, California.

Sasaki, S., A. J. Comber, H. Suzuki, and C. Brunsdon (2010) Using Genetic Algorithms to Optimise Current and Future Health Planning—the Example of Ambulance Locations. *International Journal of Health Geographics* 9:1, 4.

Schuurman, N., R. Fiedler, S. Grzybowski, and D. Grund (2006) Defining Rational Hospital Catchments for Non-urban Areas Based on Travel-time. *International Journal of Health Geographics* 5:1, 1–11.

Shams, K. (2013) Socio-economic Determinants of Health in Rural Pakistan: Relative or Absolute Standards? *International Journal of Humanities and Social Science* 3:12, 313–326.

Shams, K. (2014) Income and Health Satisfaction: Evidence from Rural Pakistan. *Journal of Happiness Studies* 1–20.

Shen, Y.-C. and R. Y. Hsia (2010) Changes in Emergency Department Access between 2001 and 2005 among General and Vulnerable Populations. *American Journal of Public Health* 100:8, 1462–1469.

Smith, J. P. (1999) Healthy Bodies and Thick Wallets: The Dual Relation between Health and Economic Status. *The Journal of Economic Perspectives: A Journal of the American Economic Association* 13:2, 144.

Spinakis, A., G. Anastasiou, V. Panousis, K. Spiliopoulos, S. Palaiologou, and J. Yfantopoulos (2011) Expert Review and Proposals for Measurement of Health Inequalities in the European Union—Summary Report. Luxembourg: European Commission Directorate General for Health and Consumers.

Ur-Rehman, K. and A. Zimmer (2010) Spatial Patterns of Child Health Inequalities in the Province of Punjab, Pakistan. The Advantages of GIS in Data Analysis. *Geographica Helvetica* 2010:1, 36–47.

Wagstaff, A. (2002) Poverty and Health Sector Inequalities. *Bulletin of the World Health Organisation* 80:2, 97–105.

Wagstaff, A. and E. Van Doorslaer (2000) Income Inequality and Health: What does the Literature Tell Us? *Annual Review of Public Health* 21:1, 543–567.

Wang, L. (2002) *Health Outcomes in Low-income Countries and Policy Implications: Empirical Findings from Demographic and Health Surveys.* World Bank, Environment Department.

Zhang, X. and R. Kanbur (2005) Spatial Inequality in Education and Health Care in China. *China Economic Review* 16:2, 189–204.

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56:3 (Autumn 2017) pp. 249–264

# Parental Effects on Primary School Enrolment under Different Types of Household Headship: Evidence from Pakistan

TARIQ MAHMOOD, NAJAM US SAQIB, and MUHAMMAD ALI QASIM

Previous studies in Pakistan have established the number of pupil, parents, household, and community characteristics as determinants of primary school enrolment. However, treatment of the role of the household power structure in these studies is limited to the inclusion of a single dummy variable for female headship. Present study estimates separate probit regressions for different types of headships, hence allowing for an analysis of the power structure of the household and its impact on other explanatory variables. In addition to confirming the findings of previous studies, this study concludes that mother's headship results in greater positive influence of her own education and the economic status of the household on child's primary school enrolment. Father's headship in this regard has only limited influence.

*JEL Classification:* C25, J16, I21
*Keywords:* Probit Models, School Enrolment, Gender Issues

## 1. INTRODUCTION

Education plays an important role in a society. Its function as an agent of economic growth is well established in economics literature [Mankiw, Romer, and Weil (1992)]. At micro level it is a potent force behind social and economic mobility. It transforms a raw human being into a valuable human resource. Benefits of education extend far beyond private returns reaped by the individual who gets education. A social rate of return is also associated with education in the form of positive externalities, hence making a classical case for government intervention. In view of the above, it is not surprising that all the member state of the United Nations committed themselves to achieving universal primary education as one of the eight Millennium Development Goals (MDG's) following the Millennium Summit of the United Nations held in 2000 [United Nations (2015)]. Quality education and gender equality are also included among Sustainable Development Goals (SDGs), passed by United Nations in 2015. Primary education, being the first and arguably very crucial rung of the educational ladder, has been a focus of all the education policies of Pakistan since the creation of this country.

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*Authors' Note:* The views expressed in this paper do not necessarily reflect the views and policies of the institute.

More recently, Pakistan's Vision 2025 has envisaged increasing the primary school enrolment and completion rate to 100 percent in 2025.[1]

A study of the determinants of primary school enrolment is crucial for understanding the role of various factors that influence decision to enrol in a primary school and for devising policies necessary to achieve enrolment related goals set by the policy-makers. However, influence of these determinants may vary across types of households depending upon headship of the family. Female headed households usually have a widow or divorcee household head. This situation may create certain socio-economic conditions which are usually absent in other households. Joint family system makes the matter more complicated as an elder brother, uncle, or some other relative may become household head. In fact, it is household head who makes important family decisions including children's enrolment. So these decisions are very likely to influence the causal chain of almost all of the important explanatory variables in the model. Usually a single multiple regression equation is used with a dummy variable for female household head. Such analysis would give effect of female household headship on state of enrolment, whereas, we want to estimate the effects of all relevant variables e.g. income, education, region etc. on enrolment under three different types of household headship. For this purpose, we use three separate regressions for each type of household head, namely, (a) father as a household head, (b) mother as a household head, and (c) neither mother nor father as a household head. This would enable us to quantify effects of all determinants of primary school enrolment under different headships. Recent drive of gender empowerment makes the issue of headship more relevant to empirical research as well as policy actions.

The rest of the study is divided as follows. In the next section a brief overview of state of primary education in the country in the light of Millennium Development Goals is presented. A brief review of the relevant literature is presented in Section 3. Section 4 discusses methodology and data. Section 5 presents and discusses estimated results. Section 6 ends the paper with concluding remarks.

## 2. STATE OF PRIMARY EDUCATION IN THE COUNTRY IN THE LIGHT OF MILLENNIUM DEVELOPMENT GOALS

Millennium Development Goals (MGDs) were established in 2000 following the Millennium Summit of the United Nations, All the United Nations member states committed to achieve these goals by the year 2015. These are:

(1) To eradicate extreme poverty and hunger.
(2) To achieve universal primary education.
(3) To promote gender equality and empower women.
(4) To reduce child mortality.
(5) To improve maternal health.
(6) To combat HIV/AIDS, malaria, and other diseases.
(7) To ensure environmental sustainability.
(8) To develop a global partnership for development.

[1]Government of Pakistan, Planning Commission, Ministry of Planning, Development and Reform, "Pakistan 2025: One Nation-One Vision. Executive Summary". http://www.pc.gov.pk/wp-content/uploads/2015/05/Vision-2025-Executive-Summary.pdf (Accessed May 20, 2015)

The Second Millennium Development Goal promotes universal primary education. One hundred percent enrolment of children in primary education in the age group of 5-9, 100 percent completion of education from grade 1-5, and 88 percent overall literacy rate were decided to be the indicators to check the performance of a country in achieving this goal. The Third Millennium Development Goal aims to promote gender equality in education. It was committed that the gender disparity at all level of education will be eliminated by 2015.

Pakistan's National Education Policy (2009) gives great emphasis to the second and third MDGs. Increasing enrolment rates and improving retention and completion rates are main focus of the policy. The policy aims for strengthening education facilities, encouraging private sector participation, and removal of urban, rural and gender imbalances, developing social and human capital and empowering women. First pillar of the Vision 2025 aims at developing social and human capital and empowering women. So in essence it encompasses the Second Millennium Development Goal. Government took a number of initiatives to achieve the targets set by the MDGs. National Education Assessment System at a cost of Rs 319.4 million. Its aim was to improve the quality of education at all levels. A project for reform of Madaris was launched with a capital cost of Rs 5759.4 million. Its aim was to provide financial assistance to introduce formal subjects in the curricula of Deeni Madaris. Initiatives were launched at Federal and provincial levels to provide free textbooks. Funds were allocated in Public Sector Development Programmes to improve the capacity of teacher training institutions.

While these efforts are commendable, the fact remains that outcomes achieved in Pakistan lag much behind the objectives. Lack of funds, poor governance, corruption, inefficiency, and law and order situation in many parts of the country are some of the main reasons. Public expenditure on education has remained almost stagnant during first decade of the millennium (Table 1).

Table 1

*Public Expenditure on Education*

(Million Rupees)

| Year | Current | Development | Total Expenditure | As % of GDP |
|---|---|---|---|---|
| 2006-07 | 130,313 | 31,771 | 162,084 | 1.75 |
| 2007-08 | 155,622 | 32,034 | 187,656 | 1.76 |
| 2008-09 | 197,723 | 42,655 | 240,378 | 1.82 |
| 2009-10 | 219,933 | 39,592 | 259,525 | 1.75 |
| 2010-11 | 276,239 | 46,572 | 322,811 | 1.77 |
| 2011-12 | 330,228 | 63,295 | 393,523 | 1.96 |
| 2012-13 | 428,944 | 50,909 | 479,853 | 2.14 |
| 2013-14 | 453,735 | 83,863 | 537,598 | 2.14 |
| 2014-15 July - Dec | 219,880 | 17,556 | 237,436 | – |

*Source:* Pakistan Economic Survey 2014-15.

Another reason for poor performance in this regard is the fact that higher education has been the top priority during the last two decades, which resulted in neglect of primary level education. In the year 2000-01 there were 147.7 thousand primary schools in the whole country, whereas for the year 2014-15 the figure is estimated to be 158.7 thousand. This gives an annual growth rate of about 0.5 percent. Whereas during the same period, total number of universities increased from 59 to 161 (Table 2). The state of primary enrolment is also not very impressive. In the year 2000-01 14.105 million children were enrolled in primary schools, whereas for the year 2014-15 the figure is 19.935 million, an annual growth rate of about 2.75 percent (Table 2).

Table 2

*State of Primary Education, 2000-01 to 2014-15*

| | Number of Primary Schools (In Thousands) | | Enrolment in Primary Education(In Millions) | | Number of Universities |
|---|---|---|---|---|---|
| Years | Total | Female | Total | Female | Total |
| 2000-01 | 147.7 | 54.3 | 14,105 | 5,559 | 59 |
| 2001-02 | 149.1 | 55.3 | 14,560 | 5,871 | 74 |
| 2002-03 | 150.8 | 56.1 | 15,094 | 6,132 | 96 |
| 2003-04 | 155.0 | 57.6 | 16,207 | 6,606 | 106 |
| 2004-05 | 157.2 | 58.7 | 18,190 | 7,642 | 108 |
| 2005-06 | 157.5 | 59.8 | 17,757 | 7,710 | 111 |
| 2006-07 | 158.4 | 60.9 | 17,993 | 7,848 | 120 |
| 2007-08 | 157.4 | 64.9 | 18,360 | 8,032 | 124 |
| 2008-09 | 156.7 | 63.4 | 18,468 | 8,144 | 129 |
| 2009-10 | 157.5 | 60.6 | 18,772 | 8,320 | 132 |
| 2010-11 | 155.5 | 58.2 | 18,063 | 7,971 | 135 |
| 2011-12 | 154.6 | 57.0 | 18,667 | 7,905 | 139 |
| 2012-13 | 159.7 | 60.1 | 18,790 | 8,278 | 147 |
| 2013-14 (Estimated) | 157.9 | 59.7 | 19,441 | 8,567 | 161 |
| 2014-15 (Provisional) | 158.7 | 60.1 | 19,935 | 8,780 | – |

*Source:* Pakistan Economic Survey (2014-15).

Consequently, there appear huge gaps between the objectives and actual achievements. Net primary enrolment which was 46 percent in 1990-91 crept up to 57 percent in 2013-14 against the target of 100 percent for 2015. Completion/survival rate showed small improvement for some initial years, but for later years it remains almost stagnant against the target of 100 percent. Some improvement has been achieved in literacy rate as it increased from 1990-91 benchmark of 35 percent to 58 percent in 2013-14. However, it still misses the MDG target of 88 percent by a wide margin of 30 percent (Table 3).

Table 3

*Progress towards Universal Primary Education*

(Percentage)

| Indicators | 1990-91 (BenchMark) | 2001-02 | 2004-05 | 2007-08 | 2010-11 | 2013-14 | MDG Target 2015 |
|---|---|---|---|---|---|---|---|
| Net Primary Enrolment Ratio (5-9 Years) | 46 | 42 | 52 | 55 | 56 | 57 | 100 |
| Completion/Survival Rate Grade 1 to 5 | 50 | 57 | 67 | 52 | 49 | – | 100 |
| Literacy Rate (%) 10 Years and above | 35 | 45 | 53 | 56 | 58 | 58 | 88 |

*Source:* Pakistan Social and Living Standards Measurement (PSLM) Survey 2013-14.

These facts indicate the severity of the problems faced by our education sector. There is an urgent need to recognise the root-cause of the problems, and take appropriate remedial measures.

In September 2015 United Nations passed a new set of goals with 169 targets to be achieved in 15 years. These are named as Sustainable Development Goals (SDGs). These goals are based upon broader concept of development, and include environment, sustainability, justice, and reduced income inequality. In addition, quality education and gender equality are explicitly included among these goals. Present study may provide an important insight regarding factors influencing primary enrolment under different family structures. This could be helpful in formulating strategies to fulfil the SDGs.

## 3. REVIEW OF LITERATURE

A number of studies have been conducted to analyse the determinants of primary school enrolment in Pakistan. A detailed review of the studies on this subject by Chishti and Lodhi (1988), Sathar and Lloyd (1994), Burney and Irfan (1991, 1995), and Alderman, *et al.* (1996, 2001) can be found in Saqib (2004). These studies are based on a variety of databases with diverse coverage. While coverage of the data used by Chishti and Lodhi (1988) and Alderman, *et al.* (2001) are limited to a single city, the other studies cited above use datasets like IFPRI's longitudinal survey of rural Pakistan, Pakistan Integrated Household Survey (PIHS) and Pakistan Labour Force and Migration Survey that cover much broader areas of Pakistan and therefore are more representative of the country as a whole.

More recent work on this subject, in addition to updating the previous one, adds variety to the contexts, methodologies, and datasets that have been used to study the determinants of the primary school enrolment. While exploring the question whether gender differences in school enrolment are due to underinvestment in female education or due to lower returns to female education, Qureshi (2012) reports maximum likelihood Logit estimates of the probability of being enroled in school using the Pakistan Social and Living Standards Measurement Survey (PSLMS), 2005-06. In another study, Qureshi, *et al.* (2014) look at the determinants of the probability of being enrolled in school in the context of the broader question of child enrolment/work decision of the household. Their school enrolment probit estimates are based on Pakistan Panel Household Survey, Round 2010. Though main focus of Sathar, *et al.* (2013) is the influence of poverty, gender, and access to school on secondary schooling for girls in Pakistan, they also present an in-depth analysis of net primary school enrolment rates for girls based on PSLMS data from various rounds. In addition, they estimate logistic regression models to calculate odds ratios for school attendance of girls. Baluch and Shahid (2008) study determinants of gross and net enrolment rates in various localities in the district of Lahore employing primary data collected from 2520 urban and 800 rural households. The 1997 dataset used by Lloyd, *et al.* (2005), though limited in coverage to six rural communities in three districts each in Punjab and present day Khyber Pakhtunkhwa (KP), is supplemented by the data from all 26 public and 12 private primary schools located within 12 villages. This allows them to estimate nested multinomial logit models to study the decision to enrol in a school and making a choice between public and private schools. Rosati and Rossi (2003) look at the simultaneous decision of going to school and supplying work hours to the labour market. Their data came from a 1996 survey which was carried out under the Statistical Information and Monitoring Programme on Child Labour led by the International Labour Organisation (ILO) as part of its International Programme for the Elimination of Child Labour (IPEC). The probit estimates of Hazarika (2001) are based on PIHS 1991 data and include school access and school quality as measured by a number of proxy variables as the determinants of primary school enrolment.

Although the specific variables used as the factors that influence probability of primary school enrolment vary considerably from study to study depending on their scope, focus, and data availability, it is possible to group them in four broad categories namely pupil, parents, household, and in a few cases, community characteristics. Importance of parents' education as one of the most important determinant of primary school enrolment, along with household characteristics such as income and composition of the household as captured by the distribution of household members by age and/or by type of activities such as education and work is a common theme that resonates through almost all the studies mentioned above. However two important points that get little attention in this literature are the importance of the power structure of the household in addition to its composition, and interaction of this structure with parental characteristics, particularly education.

The studies that address the issue of household power structure, both in Pakistan and abroad, are mainly focused on the role of female headship, especially on its relationship with poverty.[2] A number of studies have also investigated the relationship between female headship and educational outcomes of the children. In the social context of the developed countries such as the United States, cause of concern is a possible negative effect of single-parenthood on children, and research on this topic has produced mixed results.[3] On the other hand, research on the developing countries has traditionally concentrated on the potentially positive role of female headed households in this regard

[2]See for example, Mohiuddin (1989), Buvinić and Gupta (1997), Ray (2000a), Chant (2004), Villarreal and Shin (2008) and Khalid and Akhtar (2011).

[3]Based on the analysis of data from four national surveys and more than a decade of research, McLanahan and Sandefur (1994) show that children living in s single-parent household suffer disadvantage at school even after controlling for income and race. Painter and Levine (2000), on the other hand, use data from the National Education Longitudinal Study of 1988 (NELS) to argue that much of the difference in the schooling outcomes of the fractured family children comes from the pre-existing disadvantages of these families.

and the results are mixed in this case too. Using data from seven African countries, Lloyd and Blanc (1996) find out that children in the female headed households are more likely to have attended school and completed grade 4 despite the fact that these households are economically disadvantaged as compared to male-headed households. Pong's (1996) research based on data from peninsular Malaysia discerns that Malaysian children of widowed mothers have similar school participation rates as children of two-parent families, when other demographic and socioeconomic factors are controlled, whereas divorce and separation have direct negative effect on their schooling. Johsi (2004) uses data from Matlab, Bangladesh to estimate the impact of female-headship on children's schooling and finds out that children residing in households headed by married women have stronger schooling attainments than children in other households. Evidence from four Latin American countries, Brazil, Ecuador, Nicaragua, and Panama suggests that the adolescents (age 14-16) who live in single mother households have lower school attendance and attainment as compared to those living with both parents [Arends-Kuenning and Duryea (2006)].

The role of female household headship on education of children has attracted considerable interest in Pakistan as well. This interest dates back at least to early 1990s when Hamid (1993) used a simple cross-tabulation analysis to find out that percentage of households sending their children to school was higher for those with a female head, as compared to other households. Maitra and Ray (2000) provide multinomial logit estimates for schooling and/or employment choices of Pakistani children based on data from PIHS 1991. Using a dummy for the gender of the head of the household, they conclude that it does not have a significant influence on these choices in Pakistan. Another study by Ray (2002) that recognises the joint endogeneity of child labour, child schooling and child poverty, and employs a three-stage estimation procedure to estimate years of schooling equation, confirms this finding. However, when data for male and female children is analysed separately, and the issue of sample selection bias has been taken care of, it turns out that though gender of the household head does not matter for boys, a female head exerts a positive and significant influence on school enrolment of girls, Ray (2000). If we believe the logit estimates of Toor and Parveen (2004) based on PIHS 2001-02 data for girls alone, this positive effect is limited to the female students living in the rural areas of the country and in the provinces of Punjab and Sindh only. While examining the impact of temporary economic migration of a member of a rural household in Pakistan on child schooling, Mansuri (2006) discovers no protective effect of migration-induced female headship on the schooling outcomes for girls. Contrary to that, such household heads seem to protect boys at the cost of girls. Their data comes from Pakistan Rural Household Survey (PRHS) 2001-02.

It is evident from the above review that the investigation of the role of the household power structure in the context of the primary school enrolment is essentially limited to the study of female headship alone and the efforts to capture this role are often limited to the introduction of a single dummy variable, hence ignoring the possibility of interaction of household headship with other explanatory variables. First of all, there are at least three possible headship scenarios that are of interest in the context of enrolment decisions, namely, when father is the head of the household, when mother heads the household, and when some other member of the household has this status. Therefore, even if dummy variables are to be used, there should be at least two dummies. Moreover, if the influence of the head on school enrolment is reflected through his/her characteristics such as income and education, even dummy variables will not suffice. One possible way, used in this study, is to estimate separate regressions for different types of headships. The purpose of this study is to analyse the determinants of primary school enrolment in Pakistan keeping in mind the considerations discussed above. In particular, separate probit functions for school enrolment are estimated for different headship scenarios. This allows us to study the effects of household headship on the magnitude of influence that head's personal characteristics such as income and education exert on primary school enrolment.

## 4. METHODOLOGY AND DATA

Binomial probit regression model is the estimation procedure used in this paper. It is customary to motivate the probit model in the present context in terms of a continuous latent variable that measures unobservable propensity of parents to enrol their child in a school. Let us call it $Y^*$. It is assumed to depend on a vector $X$ of explanatory variables, $\beta$ a vector of parameters, and $\varepsilon$ an independently and identically distributed random disturbance such that:

$$Y^*_i = \beta' X_i + \varepsilon_i \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (1)$$

While $Y^*$ is unobservable, we observe $Y$, a dichotomous realisation of $Y^*$. It takes the value 1 if the parents enrol the student in a school and is equal to 0 otherwise. In Symbols, $Y$ is defined as follows:

$$Y_i = 1 \text{ if } Y^*_i > 0$$
$$Y_i = 0 \text{ otherwise.} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (2)$$

The probability of school enrolment, therefore, may be expressed as:

$$\text{Prob. (school enrolment)} = \text{Prob. } (Y_i = 1)$$
$$= \text{Prob. } (Y^*_i > 0)$$
$$= \text{Prob. } (\varepsilon_i > -\beta' X_i)$$
$$= 1 - F(-\beta' X_i) \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (3)$$

$$= F(\beta' X_i) \text{ (if the distribution of } \varepsilon_i \text{ is symmetric)} \qquad \ldots \quad \ldots \quad \ldots \qquad (4)$$

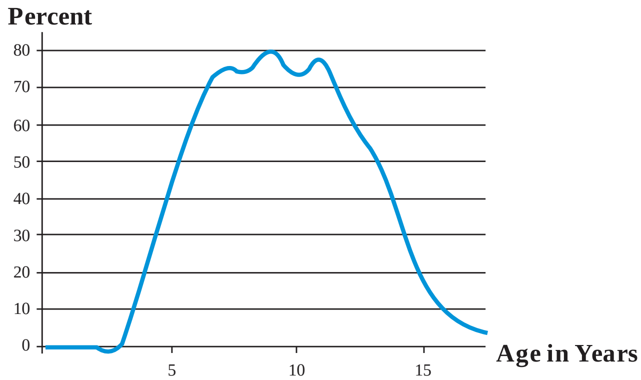
where $F$ is the cumulative distribution function of $\varepsilon_i$. The probability of not enrolling in a school can be determined residually as $1-F(\beta' X_i)$. Assuming normal distribution for $\varepsilon_i$, the probability of school enrolment can be estimated by using probit model with the school enrolment dummy as the dependent variable.

However, this conceptualisation of the probit model entails at least two problems. One, the idea of the propensity to enrol which cannot be empirically observed is not intuitively appealing. Two, any attempt to compare coefficients as implied by this interpretation of the model is complicated by the potential presence of the heterogeneity in the unknown variance of the residual variation among groups and subsamples [Mood (2010)]. Fortunately, there is a simple way out of these complications. Instead of postulating the dependent variable as an obscure propensity to enrol a child in school, we may straightforwardly interpret the predicted values of the dummy dependent variable of probit model as measuring the predicted probability of school enrolment in the sample [Buis (2015)]. By assuming a normal distribution for $\varepsilon_i$ we ensure that this probability lies between zero and one. Throughout this paper we follow this interpretation.

Pakistan Social and Living Standards Measurement Survey (PSLM) data for the year 2010-11 has been used in this study. This is a nationally representative survey based on stratified random sampling, which is carried out at irregular intervals. The survey is conducted by the Pakistan Bureau of Statistics, Pakistan's official data collecting organisation.

The probit estimates reported below are based on all the children covered in the survey who are between the ages of 4 and 14 years. Since our purpose is to analyse primary enrolment, we exclude children in the age group 4-14 who are enrolled in higher classes. In Figure 1 below percentage of children enrolled in primary schools is plotted against their age. It is clearly evident from the plotted curve that 4-14 is the age group in which most of the primary school attending students fall, except for 22 percent of the sample who are enrolled in higher classes. The dummy dependent variable of our probit regressions is equal to 1 for the children enrolled in primary schools while its value is zero for those who are not.

**Fig. 1. Percentage of Students Enrolled in Primary Schools by Age**




*Source:* Estimates based on the data from (PSLM) for the year 2010-11.

## 5. RESULTS

State of the sampled households in terms of the classification used in this paper is as follows. There are total 28511 children in the age group 4-15. These children are either enrolled in class 1-5 or not enrolled. Out of these, 21864 children have father as household head, 1516 children have mother as household head, and 5131 children have neither father nor mother as household head. The group of children with mother as household head turns out to be smallest among the three groups. Three separate probit regressions have been estimated for the three mutually exclusive and exhaustive groups of households, namely, the households headed by the father, those headed by the mother and the remaining households which are headed by someone other than child's father or mother. Estimation results are reported in Table 4 and Table 5.

Table 4

*Probit Regression Results*

| Independent Variables | Father as HH Head Coefficients | Father as HH Head Standard Errors | Mother as HH Head Coefficients | Mother as HH Head Standard Errors | Neither Mother nor Father as HH Head Coefficients | Neither Mother nor Father as HH Head Standard Errors |
|---|---|---|---|---|---|---|
| Age | 1.3046*** | 0.0224 | 1.2939*** | 0.0874 | 1.4380*** | 0.0469 |
| Age Square | –0.0722*** | 0.0013 | –0.0732*** | 0.0049 | –0.0794*** | 0.0027 |
| Number of Children | –0.0604*** | 0.0065 | –0.1016*** | 0.0289 | –0.0438*** | 0.0093 |
| Dummy for Male | 0.3953*** | 0.0195 | 0.4086*** | 0.0770 | 0.3524*** | 0.0414 |
| Dummy for Urban | 0.2631*** | 0.0219 | 0.1631* | 0.0951 | 0.2750*** | 0.0467 |
| Sindh | –0.5470*** | 0.0255 | –0.8208*** | 0.1487 | –0.7340*** | 0.0592 |
| Khyber Pakhtunkhwa | –0.0981*** | 0.0298 | –0.2003** | 0.0873 | –0.2443*** | 0.0568 |
| Balochistan | –0.4822*** | 0.0281 | –0.8235*** | 0.2400 | –0.7641*** | 0.0642 |
| Quintile 2 | 0.2536*** | 0.0268 | 0.5326*** | 0.0999 | 0.0853 | 0.0902 |
| Quintile 3 | 0.2834*** | 0.0287 | 0.7052*** | 0.1134 | 0.3048*** | 0.0861 |
| Quintile 4 | 0.3395*** | 0.0322 | 0.4332*** | 0.1306 | 0.2844*** | 0.0838 |
| Quintile 5 | 0.3835*** | 0.0406 | 0.5509*** | 0.2239 | 0.5138*** | 0.0844 |
| *Father's Education* | | | | | | |
| Education=Grade (1–5) | 0.3312*** | 0.0273 | | | 0.3032*** | 0.0702 |
| Education=Grade (6–10) | 0.5698*** | 0.0266 | | | 0.3195*** | 0.0526 |
| Education>=Grade 11 | 0.6846*** | 0.0369 | | | 0.5012*** | 0.0751 |
| *Mother's Education* | | | | | | |
| Education=Grade (1–5) | 0.5706*** | 0.0409 | 0.9270*** | 0.1558 | 0.6054*** | 0.0754 |
| Education=Grade (6–10) | 0.6703*** | 0.0458 | 0.8493*** | 0.1427 | 0.6875*** | 0.0775 |
| Education>=Grade 11 | 0.7777*** | 0.0763 | 0.6034** | 0.2735 | 0.8657*** | 0.1143 |
| Constant | –5.4443*** | 0.0969 | –4.9281*** | 0.3768 | –5.7754*** | 0.1970 |
| | LL = –11087.4 | | LL = –720.6 | | LL = –2443.7 | |
| | N = 21864 | | N = 1516 | | N = 5131 | |

'***', '**', and '*' indicate that the variable is significant at the level of 0.01, 0.05, and 0.10 respectively.

Table 5

*Marginal Effects*

| Independent Variables | Father as HH Head Marginal Effects | Father as HH Head Standard Errors | Mother as HH Head Marginal Effects | Mother as HH Head Standard Errors | Neither Mother nor Father as HH Head Marginal Effects | Neither Mother nor Father as HH Head Standard Errors |
|---|---|---|---|---|---|---|
| Age | 0.3736*** | 0.0048 | 0.3455*** | 0.0179 | 0.3862*** | 0.0088 |
| Age Square | –0.0207*** | 0.0003 | –0.0195*** | 0.0010 | –0.0213*** | 0.0005 |
| Number of Children | –0.0173*** | 0.0018 | –0.0271*** | 0.0076 | –0.0118*** | 0.0025 |
| Dummy for Male | 0.1132*** | 0.0054 | 0.1091*** | 0.0201 | 0.0946*** | 0.0110 |
| Dummy for Urban | 0.0753*** | 0.0062 | 0.0436* | 0.0253 | 0.0738*** | 0.0124 |
| Sindh | –0.1566*** | 0.0071 | –0.2192*** | 0.0386 | –0.1971*** | 0.0153 |
| Khyber Pakhtunkhwa | –0.0281*** | 0.0085 | –0.0535** | 0.0232 | –0.0656*** | 0.0152 |
| Balochistan | –0.1381*** | 0.0079 | –0.2199*** | 0.0634 | –0.2052*** | 0.0166 |
| Quintile 2 | 0.0726*** | 0.0076 | 0.1422*** | 0.0259 | 0.0229 | 0.0242 |
| Quintile 3 | 0.0812*** | 0.0082 | 0.1883*** | 0.0292 | 0.0818*** | 0.0230 |
| Quintile 4 | 0.0972*** | 0.0092 | 0.1157*** | 0.0345 | 0.0764*** | 0.0224 |
| Quintile 5 | 0.1098*** | 0.0116 | 0.1471*** | 0.0594 | 0.1380*** | 0.0224 |
| *Father's Education* | | | | | | |
| Education=Grade (1–5) | 0.0948*** | 0.0077 | | | 0.0814*** | 0.0188 |
| Education=Grade (6–10) | 0.1632*** | 0.0074 | | | 0.0858*** | 0.0140 |
| Education>=Grade 11 | 0.1961*** | 0.0103 | | | 0.1346*** | 0.0200 |
| *Mother's Education* | | | | | | |
| Education=Grade (1–5) | 0.1634*** | 0.0116 | 0.2475*** | 0.0404 | 0.1626*** | 0.0199 |
| Education=Grade (6–10) | 0.1920*** | 0.0130 | 0.2268*** | 0.0371 | 0.1846*** | 0.0204 |
| Education>=Grade 11 | 0.2228*** | 0.0217 | 0.1611** | 0.0729 | 0.2325*** | 0.0303 |

'***', '**', and '*' indicate that the variable is significant at 0.01, 0.05, and 0.10 level of significance respectively.

Table 4 reports estimated coefficients of these models. Highly nonlinear nature of the probit model makes its coefficients impervious to ready interpretation. Therefore estimated marginal effects implied by these coefficients have also been reported in Table 5. All variable are statistically significant except Quintile 2 which turns out to be small and insignificant in case of either Mother or Father as Household Heads. This might be an indication of higher threshold level for income in joint families.

Estimation results for the three categories of household heads presented in this study lead to interesting insights about the role of household headship in the decision to enrol a child in primary school. The results indicate that the marginal effects of income and mother's education are much higher when mother is head of the household. The mother's headship effect seems more pronounced for lower quintiles as well as lower mother's education levels.

The most noticeable and consistent effect of the mother household head on child's school enrolment is observed to take shape through the channel of the economic status of the household. This impact is particularly pronounced in the 2nd and 3rd quintiles that are supposed to constitute the middle class of the society. The school enrolment probability of children belonging to the households in these two income quintiles is respectively 7 and 11 percentage points higher for the mother headed households, as compared to the father headed households. This advantage with reference to the households headed by someone other than the parents is respectively 12 and 11 percentage points. The role of father's headship of the household in this respect is much smaller and inconsistent across income quintiles.

Another important channel through which mother's household headship influences child's school enrolment is her education. Mother's primary education is the most important in this regard. When a primary school educated mother becomes head of the household, the probability of primary school enrolment of her children gets a boost of 9 percentage points as compared to other forms of household headship. In this respect, the father does not seem to have very substantial advantage over a non-parent head of the household.

When the mother's education is greater than or equal to grade 11, the marginal effect of mother headship case turns out to be lower than that of other two categories. One possible reason could be that highly educated mothers especially when they are also head of the household are more likely to be intensively involved in domestic, economic and social activities. This, so called "time poverty" is found to be more prevalent among females [Saqib and Arif (2012)]. Time poverty among females is also found to increase with the level of education [Lawson (2007)]. This time poverty may render the effect of mothers' education relatively less pronounced when they are the household head. However, the marginal effect is still positive and significant. Though headship of parents is not enough to reduce gender gap in school enrolment, the disadvantage of living in rural areas declines by 3 percentage points as mother of the potential student becomes head of the household.

Overall picture that emerges from these results is that of great conformity with the findings of the previous studies. Even a cursory look at the estimates points to the presence of substantial provincial and gender disparity in the country in terms of primary school enrolment. In this respect, provinces of Sindh and Balochistan are particularly worse off as compared to the base province of Punjab. In these two provinces children are between 14 to 22 percent less likely to enrol in a primary school than those living in Punjab, depending on the nature of household headship. Khyber Pakhtunkhwa is also behind the base province in this regard, but if is still far ahead of Sindh and Balochistan. Female children in Pakistan are about 10 percent less likely to enrol in school when compared with boys. Rural-urban gap in primary school enrolment is also evident from these estimates. Children living in urban areas are 4 to 7 percent more likely to enrol in a primary school.

This study also confirms the key role played by mother's education in the school enrolment of the children, though father's role is also very important. The school enrolment probability of the children having an educated mother is between 16 and 25 percentage points higher as compared to the children of uneducated mothers, whereas the corresponding figures for father's education are 8 and 20 percentage points. The policy implication of these results is that increasing female enrolment in schools today will not only reduce the school enrolment gap between male and female children today, but it will also have substantial positive influence on future school enrolment trends when todays the girls will become tomorrow's mothers.

Well-off households are more likely to send their children to school as compared to the poorest 20 percent households. Depending upon the income quintile and the nature of household headship, this difference ranges between 7 and 19 percentage points.[4] This finding indicates that a possible beneficial side effect of the poverty reduction policies would be an increase in primary school enrolment rate. This provides another reason for increasing scope and coverage of the existing poverty alleviation programmes.

There is a quadratic relationship between age and school enrolment such that the probability of school enrolment increases with the child's age and, after reaching a maximum, starts declining. This is also evident from Figure 1 above. A possible reason for this enrolment behaviour could be availability of more attractive child labour opportunities for children beyond a certain age. This pattern highlights the importance of early childhood for educational outcomes of a child. Thus policies that incorporate steps for early intervention to get children enrolled in a primary school are more likely to bear fruit as compared to those which miss this opportunity.

Demographic composition of the household also plays a role in school enrolment of children. Present study confirms the finding of earlier studies that the households inhabited by more school age children are less likely to send them to school though this difference in terms of probability is relatively small—of the order of 1 to 3 percentage points. The reasons for this phenomenon may be diverse. Possible explanations often offered in the literature on this subject include more pressure on the given resources of the household due to an additional child or a trade-off between quality and number of children. Marginal effects of this variable may appear small, but these are comparable with those found in earlier studies, see for example, Rosati and Rossi (2003).

[4]Current income is not a good measure of the long-term purchasing power of a household as it fluctuates significantly from period to period. This is particularly true for the rural areas where such volatile factors as weather changes and outbreak of disease in crops and livestock can influence the level of income. Current consumption expenditure is considered a reasonable proxy for the permanent income of the household. Hence we use current consumption rather than nominal income to generate dummy variables for income quintiles.

This study seems to confirm the conventional wisdom that mother's lap is the nursery for raising educated children. Society can help mother in this invaluable effort by recognising significance of her role and enabling her to play a more active part in making decisions about allocation of household resources for education of children. Policy-makers can do their little bit by ensuring more education for women which better equips them to positively influence their children's educational future.

## 6. CONCLUSIONS

Study of the determinants of primary school enrolment is a popular theme among researchers in Pakistan and abroad. Such studies shed light on the nature and strength of various factors that influence the decision to enrol in a primary school and help devise policies to achieve universal primary education, a coveted goal of governments and other stake holders. Previous studies in Pakistan on this subject have established the number of pupil, parents, household, and community characteristics as significant influences on the primary school enrolment. However, two important points that get little attention in this literature are the importance of the power structure of the household in addition to its composition, and interaction of this structure with parental and household characteristics. The role of the household power structure in these studies is essentially limited to the study of female headship alone and the efforts to capture this role are often limited to introduction of a single dummy variable, hence ignoring the possibility of interaction of household headship with other explanatory variables.

There are at least three possible headship scenarios that are of interest in the context of school enrolment decisions, namely, when father is the head of the household, when mother heads the household, and when some other member of the household has this status. Moreover, the influence of the head on school enrolment may also reflect itself through explanatory variables such as household income and parent's education. This calls for estimating separate regressions for different types of headships. Present study analyses the determinants of primary school enrolment in Pakistan by estimating separate probit functions for the three headship scenarios.

Estimation results for the three categories of household heads presented in this study lead to important insights about the role of household headship in making decision to enrol a child in a primary school, which conventional studies do not offer. Though headship of parents is not enough to reduce gender gap in school enrolment, it leads to some decline in the disadvantage arising from living in the rural areas. The most noticeable and consistent effect of mother's household headship on child's school enrolment shows itself through the greater positive influence of the economic status of the household on the latter. This impact is particularly pronounced in the middle income groups. The role of father headed household in this respect is much smaller and inconsistent across income quintiles. Another important channel through which mother's household headship influences child's school enrolment is her education. Mother's primary education is the most important in this regard. Father's headship on the other hand, does not seem to have a very substantial advantage in this respect over the headship of a non-parent member of the household.

Results of this study generally conform well to the findings of previous studies. The study confirms presence of substantial provincial and gender, and some rural-urban disparity in the country in terms of primary school enrolment. Mother's education plays a key role in the school enrolment of the children, though father's role is also important. Therefore increasing female enrolment in schools will not only reduce school enrolment gap between male and female children today, it will also have a substantial positive influence on future school enrolment trends when todays girls will become tomorrow's mothers. Well-off households are more likely to send their children to school as compared to the poorest 20 percent households. Thus a possible beneficial side effect of the poverty reduction policies would be an increase in primary school enrolment rate. Households with more school age children are less likely to send them to school, probably due to the pressure on limited household resources or due to a tradeoff between the number and quality of children. The probability of school enrolment increases with the child's age and after reaching a maximum, starts declining, perhaps due to availability of more attractive child labour opportunities in the later years. This highlights the importance of early intervention to get children enrolled in a primary school.

This study clearly demonstrates that mothers' role is of critical importance in raising educated children. Enabling them to play a more active role in making decisions about allocation of household resources for education can make crucial difference in the children's educational outcomes. Ensuring more education for women through policy intervention can better equip them to ensure the educational future of the next generation.

## REFERENCES

Alderman, H., Behrman, R. Jere, Khan, S. Ross, R. David, and R. Sabot (1996) Decomposing the Regional Gap in Cognitive Skills in Rural Pakistan. *Journal of Asian Economics* 7, 49–76.

Alderman, H., J. R. Behrman, D. R. Ross, and R. Sabot (1996) Decomposing the Gender Gap in Cognitive Skills in a Poor Rural Economy. *Journal of Human Resources* 31, 229–254.

Alderman, H., P. F. Orazem, and E. M. Paterno (2001) School Quality, School Cost, and the Public/Private School Choices of Low-Income Households in Pakistan. *Journal of Human Resources* 36, 304–326.

Ali, Karamat and Rana Ejaz Ali Khan (2004) Simultaneous Decision Making of Child Schooling and Child Labour in Pakistani Urban Households. *The Lahore Journal of Economics* 9, 127–148.

Arends-Kuenning, Mary, and Suzanne Duryea (2006) The Effect of Parental Presence, Parents' Education, and Household Headship on Adolescents' Schooling and Work in Latin America. *Journal of Family and Economic Issues* 27, 263–286.

Baluch, Mazhar ul Haq and Saima Shahid (2008) Determinants of Enrolment in Primary Education: A Case Study of District Lahore. *Pakistan Economic and Social Review* 46, 161–200.

Becker, G. S. (1965) A Theory of the Allocation of Time. *The Economic Journal* 75, 493–517.

Buis, Maarten L. (2015) Logistic Regression: Why We Often Can Do What We Think We Can Do Presented at the 19th UK Stata Users Meeting. London.

Buvinić, M. and Geeta Rao Gupta (1989) Female-Headed Households and Female-Maintained Families: Are They Worth Targeting to Reduce Poverty in Developing Countries? *Economic Development and Cultural Change* 45, 259–280.

Chant, S. (2004) Dangerous Equations? How Female-headed Households Became the Poorest of the Poor: Causes, Consequences and Cautions. *IDS Bulletin* 35,19–26.

Desforges, C. and A. Abouchaar (2003) The Impact of Parental Involvement, Parental Support and Family Education on Pupil Achievements and Adjustment: A Literature Review. Department for Education and Skills, London, UK. (Research Report No. 433).

Hamid, Shahnaz (1993) A Micro Analysis of Demand-side Determinants of Schooling in Urban Pakistan. *The Pakistan Development Review* 32, 713–723.

Joshi, S. (2004) Female Household-Headship in Rural Bangladesh: Incidence, Determinants and Impact on Children's Schooling, Economic Growth Centre, Yale University, New Haven, Connecticut. (Centre Discussion Paper No. 894).

Kabubo-Mariara jane and Domisiano K. Mwabu (2007) Determinants of School Enrolment and Education Attainment: Empirical Evidence from Kenya. *South African Journal of Economics* 75, 5,l72–593.

Khalid, U. and Sajjad Akhtar (2011) Poverty Dynamics of Female-headed Households in Pakistan: Evidence from PIHS 2000-01 and PSLM 2004-05. Pakistan Institute of Development Economics, Islamabad. (PIDE Working Papers 2011: 80).

Lawson, David (2007) A Gendered Analysis of Time Poverty: The Importance of Infrastructure Economic and Social Research Council, UK. (GPRG-WPS-078).

Lincove, J. A. (2009) Determinants of Schooling for Boys and Girls in Nigeria under a Policy of Free Primary Education. *Economics of Education Review* 28, 474–484.

Lloyd, Cynthia B. and Ann K. Blanc (1996) Children's Schooling in Sub-Saharan Africa: The Role of Fathers, Mothers, and Others. *Population and Development Review* 22, 265–298.

Lloyd, Cynthia B., Cem Mete, and Zeba A. Sathar (2005) The Effect of Gender Differences in Primary School Access, Type, and Quality on the Decision to Enrol in Rural Pakistan. *Economic Development and Cultural Change* 53, 685–710.

Mankiw, N. G., D. Romer, and D. N. Weil (1992) A Contribution to the Empirics of Economic Growth. *Quarterly Journal of Economics* 107, 407–421.

McLanahan, Sara and Gary Sandefur (1994) *Growing Up With a Single Parent: What Hurts, What Helps.* Cambridge, Massachusetts: Harvard University Press.

Maitra, P. and Ranjan Ray (2002) The Joint Estimation of Child Participation in Schooling and Employment: Comparative Evidence from Three Continents. *Oxford Development Studies* 30, 41–62.

Mansuri, Ghazala (2006) Migration, School Attainment, and Child Labour: Evidence from Rural Pakistan. The World Bank, Washington, D. C. (World Bank Policy Research Working Paper 3945).

Memon, Ghulam Rasool (2007) Education in Pakistan: The Key Issues, Problems and the New Challenges. *Journal of Management and Social Sciences* 3, 47–55.

Mohiuddin, Y. (1989) Female-headed Households and Urban Poverty in Pakistan. *The Pakistan Development Review* 28, 759–775.

Mood, Carina (2010) Logistic Regression: Why We Cannot Do What We Think We Can Do, and What We Can Do About It. *European Sociological Review* 26, 67–82.

Pong, Suet-Ling (1996) School Participation of Children from Single-Mother Families in Malaysia. *Comparative Education Review* 40, 231–249.

Painter, Gary and David I. Levine (2000) Family Structure and Youths' Outcomes: Which Correlations are Causal? *The Journal of Human Resources* 35, 524–549.

Qureshi, M. Gohar (2012)The Gender Differences in School Enrolment and Returns to Education in Pakistan. Pakistan Institute of Development Economics, Islamabad. (PIDE Working Papers 2012: 84).

Qureshi, M. Gohar, Saman Nazir, and Hafsa Hina (2014) Child Work and Schooling in Pakistan: To What Extent Poverty and Other Demographic and Parental Background Matter? Pakistan Institute of Development Economics, Islamabad. (PIDE Working Paper No. 105).

Ray, R. (2000) Child Labour, Child Schooling, and Their Interaction with Adult Labour: Empirical Evidence for Peru and Pakistan. *The World Bank Economic Review* 14, 347–367.

Ray, R. (2000a) Poverty and Expenditure Pattern of Households in Africa: A Comparative Study. *Journal of International Development* 12, 241–256.

Ray, R. (2002) Simultaneous Analysis of Child Labour and Child Schooling: Comparative Evidence from Nepal and Pakistan. *Economic and Political Weekly* 37, 5215–5224.

Rosati, Furio Camillo and Mariacristina Rossi (2003) Children's Working Hours and School Enrolment: Evidence from Pakistan and Nicaragua. *The World Bank Economic Review* 17, 283–295.

Saqib, Najam us (2004) Willingness to Pay for Primary Education in Rural Pakistan. *The Pakistan Development Review* 43:1, 27–51.

Saqib, Najam us and G. M. Arif (2012) Time Poverty, Work Status and Gender: The Case of Pakistan. *The Pakistan Development Review* 51:1, 23–46.

Sathar, Zeba A., Asif Wazir, and Maqsood Sadiq (2013) Struggling against the Odds of Poverty, Access, and Gender: Secondary Schooling for Girls in Pakistan. *The Lahore Journal of Economics* 18: SE (September 2013), 67–92.

Toor, Imran Ashraf and Rizwana Parveen (2004) Factors Influencing Girls' Primary Enrolment in Pakistan. *The Lahore Journal of Economics* 9:2, 141–161.

United Nations (2015) *The Millennium Development Goals Report 2015*. New York: United Nations.

Villarreal, A. and Heeju Shin (2008) Unravelling the Economic Paradox of Female-Headed Households in Mexico: The Role of Family Networks. *The Sociological Quarterly* 49, 565–595.

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56:3 (Autumn 2017) pp. 265–289

# Spatial Differences in Rice Price Volatility: A Case Study of Pakistan 1994–2011

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Prices of agricultural commodities tend to be more volatile in comparison to other commodities. Volatility can result in inefficient allocation of the resources by the farmers, traders and consumers. Rice is the second major staple and export item of Pakistan. This study presents the trends in volatility of regional rice markets of Pakistan and analyses spatial differences in volatility across regional rice markets in Pakistan from 1994 to 2011, and also draws comparison of volatility with the international market. ARCH-LM tests are applied to check the presence of volatility and volatility clustering is found in all the markets. Tests for equality of variance and dynamic conditional correlations (DCC) GARCH model are employed to analyse the spatial differences across the regional rice markets of Pakistan. The results indicate the presence of spatial differences in volatility. Positive conditional correlations in the dynamic conditional correlations (DCC) GARCH model are found which indicate positive association of volatility across markets. Spatial differences in volatility and its persistence reflect the differences in market forces, infrastructure and information flow which leads to varying degree of risk across markets and some regions are exposed to higher risk. The study found out that Hyderabad and Sukkur are the most volatile markets and their volatility levels are highly persistent and require highest time to return to its long-term mean which makes them the riskiest rice markets. Investments in infrastructure, particularly in transportation and controlling the market power of middlemen may reduce price risk across markets particularly in the most risky markets.

*JEL Classification*: C22, C32, Q11, Q13, Q18
*Keywords:* Rice Prices Volatility, Regional Markets, Pakistan. DCC-GARCH-models

## 1. INTRODUCTION

Commodity prices are generally volatile and agricultural commodity prices are typically more volatile than those for example, of metals [Deaton and Laroque (1992); Pindyck (2004); Newbery (1989)]. High volatility poses difficulties in the prediction of agricultural commodity price changes which might exert large impacts on developing economies relying on the agricultural production, export and import of food commodities. Price risk raises problems for the macroeconomic as well as the microeconomic policy [Deaton and Laroque (1992); Stigler (2011)]. The prolonged periods of high volatility raise concerns for the governments, traders, producers and

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*Authors' Note:* The earlier version of this article was presented in the conference Forskemøte 2014 at Norwegian Business School (BI) Norway. We are thankful to the discussant of the paper Dagfinn Rime, for his comments. Thanks are also due to Daumantas Bloznelis for his comments and detailed discussion on the methods.

consumers [Kroner, *et al.* (1995)]. Persistent high price volatility can increase economic inequality and strengthen poverty traps, particularly in the presence of inadequate liquidity and asset resources [Zimmerman and Carter (2003) in Rapsomanikis ( 2011)].

High food price volatility became a hot issue during and after the 2007-08 food crises, claiming an extra attention of researchers and policy-makers. The World Bank [World Bank (2009)] stated that "*high volatility in the food prices combined with the impact of financial crisis, threatens to further increase food insecurity*". In times of crisis, volatility may be self-leading, i.e., generating cascades of volatility. Such a phenomenon can lead to "herd-like" behaviour where market agents make decisions, following the price trends instead of sticking to market fundamentals [Rapsomanikis (2011)]. Hence, a better understanding of the price volatility is a prerequisite for developing strategies to reduce the negative effects from high volatility and also to devise policies aiming at stabilising commodity prices.

In this article, we analyse price volatility in Pakistan's rice markets, focusing on the regional differences. These differences may convey important information to decision makers at political levels. Bottlenecks in the distribution of goods may be one of the major factors behind spatial differences in price volatility. Hence, the information on price volatility, in general, and on the regional differences in volatility, in particular, can be an important input in view of the political decisions on interventions in transportation and trading infrastructure and policies aiming at the improved functioning of markets.

In Pakistan, rice production is an important part of agriculture, rice being the second largest staple food after wheat and the second largest export item after cotton and cotton products. Rice production covers about 20 percent of the total cropped area under food grains in the country and the rice crop accounts for almost 3.1 percent of the value added in agriculture, contributing to 0.7 percent of GDP [Pakistan (2014); Pakistan (2013)]. Pakistan is a net exporter of rice and earns about 15 percent of its foreign exchange from rice exports [Siddique (2008)]. Paddy rice production in Pakistan contributes 1.3 percent to the global production volume entailing Pakistan to have an 11 percent share of exports of milled rice in the world rice export levels [UN FAO (2010)].

Given the economic importance of the rice sector in Pakistan's economy, it is important to understand the way the rice markets are functioning and the behaviour of prices. In particular, we seek the answers for the following questions:

(1) What is the general trend in rice price volatility in Pakistan's domestic (regional) markets?
(2) Are there any spatial differences in volatility in rice markets across Pakistan?
(3) Are volatilities among the markets correlated?

Two main varieties of rice i.e. Basmati and IRRI are produced in Pakistan. Basmati rice is a long grain fine rice variety having nice aroma and it is produced is mainly in the Punjab province of Pakistan. On the other hand, IRRI rice is a coarse grain variety which is mainly produced in Sindh province of Pakistan [Abdullah, *et al.* (2015)]. Domestic consumption of Basmati rice is higher than IRRI rice while yield, production and exports of IRRI[1] rice are higher than that of Basmati rice [Ahmad and Gjølberg

[1]IRRI6 and IRRI9 coarse rice varieties were developed at the International Rice Research Institute (IRRI) in the Philippines. IRRI9 was developed by crossing the IRRI6 and Basmati rice.

(2015); Pakistan (2013); FAO (2010)]. This study employs monthly wholesale price data from 1994 to 2011 of six major wholesale markets of IRRI rice in Pakistan. In order to enable us to draw international comparisons, the price of Thai 5 percent broken rice is also included in the analysis. Thai 5 percent broken rice is a coarse grain variety similar to IRRI rice and is a close substitute to IRRI rice. Its price has been used as a benchmark price in many studies [Ahmad and Gjølberg (2015)].

There are eight major domestic wholesale rice markets in Pakistan; i.e. Karachi, Lahore, Rawalpindi, Multan, Sukkur, Hyderabad, Peshawar and Quetta. Six of these markets are included in this study. Karachi and Lahore are not included due to lacking of access to data on complete price series. However, the markets included can be considered a representative sample of the four provinces and are situated close to surplus as well as in deficit production regions. Moreover, some of these markets are also involved in exports. Hyderabad, included in the sample, lies close to Karachi with a port from which rice is shipped to other countries. Rice is also exported from Quetta and Peshawar to Iran and Afghanistan which, both regions included in our sample as is Rawalpindi close to Lahore in the Punjab province which is a deficit region of IRRI.

For several reasons, the behaviour of prices in these regions may differ, which may lead to spatial differences in the volatility. For instance, Fang and Sanogo (2014) described that the rise in prices of IRRI rice in the Lahore market was higher than in other markets during October 2006–April 2007. This may result in more variation of volatility in the Lahore market, which may lead to a higher difference in the spatial volatility in IRRI rice markets of Pakistan. The present study focuses on finding these differences. The results of the study indicate that spatial differences in volatility exist across regional markets of rice in Pakistan. However, there are high expectations that including these markets could strengthen the findings of this study. The greatest impediment to cover these markets for the time being has already been mentioned above that there is a lack of access to data on complete price series in both these markets. Moreover, these markets, given their cosmopolitan dimensions hold so great an attraction for people that they prefer, sometimes, to ignore their neighbouring markets in view of greater business prospects in these markets. However, equally neutralising argument to this market trend is that markets like Lahore and Rawalpindi, being equally attractive options for the people provide a good case of comparison, as the generalisations regarding volatility, for instance drawn from the study of one market can easily be applied to the other market. The same argument applies in the case of Hyderabad-Karachi markets. So, for their relative relevance or conversely for disadvantage, either of these markets were considered to be left out of purview in this project. Future studies can take up these markets also.

Earlier studies on rice markets in Pakistan, such as by Mushtaq, *et al.* (2006) and Ghafoor and Aslam (2012), focused mainly on measuring market integration of Basmati rice markets in the Punjab province, whereas Ahmad and Gjølberg (2015) measured market integration of IRRI rice markets in the four provinces of Pakistan through employing co-integration techniques of time series econometrics. Fang and Sanogo (2014) focused on measuring the effects of price and climate shocks on household wheat and rice consumption. In the first place, they identified the areas and corresponding livelihood groups, that were relatively more vulnerable to potential shocks. In the second place, they identified the most vulnerable markets of wheat and rice to domestic and international price shocks through a market integration analysis by employing co-integration technique. Finally, they performed simulations to investigate the effects of shocks on household consumption through shock impact modelling system (SISMOD). Abdullah, *et al.* (2015) analysed the marketing system of Basmati and non-Basmati rice in Pakistan not only to identify marketing problems faced by different market players but also to determine the marketing margins. However, all of the above research endeavours have left an important research gap to examine the trends in price volatility and spatial difference in volatility among rice markets of Pakistan. Therefore, present study has been specifically designed to identify spatial differences in regional rice markets of Pakistan. For the said purpose, pair wise tests of equality of variances, ARCH-LM tests and multivariate dynamic conditional correlations (DCC) GARCH models are applied. Moreover, conditional correlations across markets are also determined through DCC-GARCH model.

## 2. RICE PRODUCTION AND VALUE CHAIN SYSTEM IN PAKISTAN

Production area and volume, annual percentage changes in area and volume, and yield per hectare of both varieties of rice, Basmati and IRRI, are presented in Table 1. The Punjab province is a major producer of Basmati rice, while Sindh of IRRI rice.[2] Punjab shares about 90 percent of total Basmati production and Sindh about 65 percent of total IRRI production in Pakistan. Until 2008, there was no area under production of Basmati in the province of Sindh, and a very small area was allocated afterwards. The

Table 1

*Production Area, Volume and Yield of Rice Crop in Pakistan*

| | Area (000, Hectares) | | | | Production (000, Tons) | | | | Yield (Kg/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Basmati | % Change | IRRI | % Change | Basmati | % Change | IRRI | % Change | Basmati | IRRI |
| 93-94 | 1104 | | 961 | | 1267 | | 2524 | | 1148 | 2627 |
| 94-95 | 1145 | 3.8 | 865 | –10.0 | 1352 | 6.7 | 1927 | –23.7 | 1180 | 2226 |
| 95-96 | 1148 | 0.2 | 895 | 3.4 | 1488 | 10.1 | 2282 | 18.4 | 1296 | 2550 |
| 96-97 | 1174 | 2.3 | 952 | 6.4 | 1564 | 5.1 | 2528 | 10.8 | 1372 | 2656 |
| 97-98 | 1106 | –5.8 | 952 | 0.1 | 1439 | –8.0 | 2468 | –2.4 | 1302 | 2592 |
| 98-99 | 1216 | 10.0 | 989 | 3.8 | 1687 | 17.2 | 2593 | 5.1 | 1387 | 2623 |
| 99-00 | 1296 | 6.5 | 1016 | 2.7 | 1871 | 10.9 | 2912 | 12.3 | 1444 | 2867 |
| 00-01 | 1158 | –10.6 | 927 | –8.8 | 1701 | –9.1 | 2556 | –12.2 | 1468 | 2759 |
| 01-02 | 1332 | 15.0 | 667 | –28.0 | 1999 | 17.6 | 1695 | –33.7 | 1501 | 2539 |
| 02-03 | 1377 | 3.4 | 722 | 8.2 | 2304 | 15.3 | 1942 | 14.6 | 1673 | 2690 |
| 03-04 | 1521 | 10.4 | 718 | –0.6 | 2522 | 9.4 | 1901 | –2.1 | 1659 | 2648 |
| 04-05 | 1558 | 2.5 | 678 | –5.6 | 2555 | 1.3 | 1908 | 0.4 | 1639 | 2816 |
| 05-06 | 1659 | 6.4 | 750 | 10.7 | 2920 | 14.3 | 2214 | 16.0 | 1761 | 2952 |
| 06-07 | 1589 | –4.2 | 757 | 0.9 | 2736 | –6.3 | 2238 | 1.1 | 1721 | 2958 |
| 07-08 | 1467 | –7.7 | 747 | –1.3 | 2643 | –3.4 | 2284 | 2.1 | 1801 | 3058 |
| 08-09 | 1697 | 15.7 | 915 | 22.5 | 2901 | 9.8 | 2984 | 30.6 | 1710 | 3261 |
| 09-10 | 1544 | –9.0 | 894 | –2.3 | 2732 | –5.8 | 2790 | –6.5 | 1770 | 3120 |
| 10-11 | 1413 | –8.5 | 617 | –30.9 | 2445 | –10.5 | 1490 | –46.6 | 1731 | 2413 |

*Source: Agricultural Statistics of Pakistan 2011-12.*

[2]A table with detailed data on province wise and period wise area and production of rice is provided in Appendix.

area of Basmati rice varied between 1.3 and 1.7 million hectares while its production fluctuated between 1.2 and 3.1 million tons. The variation in the area and production of IRRI rice ranged from 0.6 to 9.2 million hectares and from 0.3 to 3.0 million tons, respectively [Pakistan (2013)]. The fluctuations in area and production primarily depend on timely availability of fertiliser and pesticides, water availability, access to credit, weather conditions, price fluctuations, market power of the middlemen and the effect that unstable farm income has on the timing of sowing, the purchase of inputs and the ability to respond to external shocks [Abdullah (2015); Iqbal, *et al.* (2009)]. More details on rice economy of Pakistan can be found in Salam (2009), Ahmad and Garcia (2012) and Ahmad and Gjølberg (2015).

Over time, Pakistan has been enacting a wide range of government policies and regulations influencing the domestic and export rice markets. These include privatisation of exports in 1988-89; export subsidies during 2002-04; minimum export price policy during 2007-08; decreasing import tariffs and a price support policy until 2001-02 [Salam (2009); REAP (2010); WTO (2011)]. After 2002, the government occasionally and irregularly announced an indicative support price [Salam (2009)]. This essentially is often intended to generate a floor price during the period of abundant supply, but is not a proper substitute of market-determined prices and is intended to correct shortcomings in the marketing system [Anwar (2004)], such as controlling the market power of middlemen. Moreover, there have been no government purchases of rice since 1996. The situation before that procurement, level of government procurement, was too low to affect the prices in the wholesale markets as well as decisions making of the producers and other stakeholder. Farooq, *et al.* (2001) and Mushtaq and Dawson (2001) found a low level of responsiveness from the farmers to the support prices and suggested its discontinuity.

The data for total rice exports as well as exports of Basmati and non-Basmati (mainly IRRI6 and IRRI9) from Pakistan for the period 2001-11 are given in Table 2. During this period, the total exports varied between 2.7 million tons and 4.2 million tons for IRRI, while such variations for Basmati rice are 0.8–1.2 million tons and 1.7–3.2 million tons, respectively. For the last few years, however, exports of non-Basmati rice that mainly consist of IRRI6 and IRRI9 varieties have been greater than that of Basmati

Table 2

*Variety Wise and Total Rice Exports from Pakistan during 2001-11*

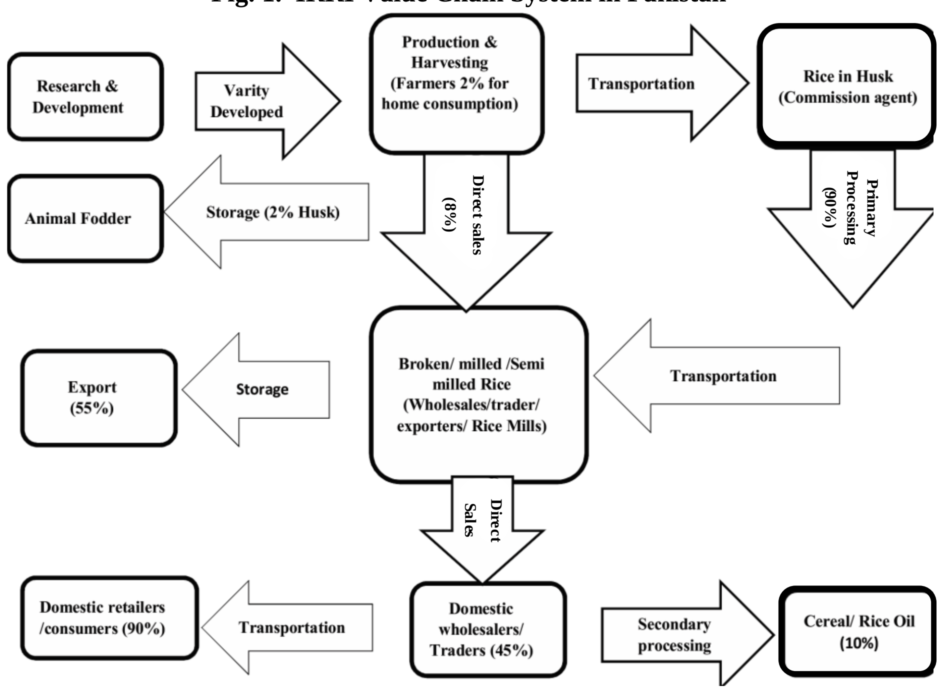
| Year | Rice (all) M. tons | Rice (all) Billion Rs | Basmati M. tons | Basmati Billion Rs | Non-Basmati M. tons | Non-Basmati Billion Rs |
|---|---|---|---|---|---|---|
| 2001-02 | 1.68 | 27.51 | 0.55 | 15.86 | 1.13 | 11.65 |
| 2002-03 | 1.82 | 32.43 | 0.72 | 21.08 | 1.10 | 11.36 |
| 2003-04 | 1.82 | 36.53 | 0.82 | 24.28 | 1.01 | 12.25 |
| 2004-05 | 2.89 | 55.39 | 0.81 | 26.07 | 2.08 | 29.32 |
| 2005-06 | 3.69 | 69.33 | 0.84 | 28.71 | 2.85 | 40.61 |
| 2006-07 | 3.13 | 68.29 | 0.91 | 33.73 | 2.22 | 34.55 |
| 2007-08 | 2.81 | 117.09 | 1.14 | 68.23 | 1.67 | 48.86 |
| 2008-09 | 2.73 | 154.76 | 0.97 | 83.25 | 1.76 | 71.51 |
| 2009-10 | 4.18 | 183.37 | 1.03 | 71.77 | 3.15 | 111.60 |
| 2010-11 | 3.67 | 184.67 | 1.17 | 82.31 | 2.50 | 102.36 |

*Source: Agricultural statistics of Pakistan* (Various Issues).

rice and this changing trend reflects the increasing importance of IRRI rice for export purposes. Exports of both the varieties decreased during the food crisis of 2007-08, probably due to the minimum export price policy during this period. After the crisis period and withdrawal of the policy, exports of both varieties increased. The increase in non-Basmati rice exports was larger than in Basmati.

Mapping of the IRRI rice value chain system in Pakistan is presented in Figure 1. Mapping of the Rice value chain comprises of the fundamentals of product flow system which takes into account various players and the subsequent key activities they performed at their specific level. For example Research and Development (R&D) Institutions such as Rice Research Institute and Ayub Agriculture Research Institute (AARI) are responsible to introduce varieties which are compatible to the existing production system and generate a substantial yield for the farmers. Rice producing farmers are mainly located into two provinces, Sindh and the Punjab. However, IRRI rice is mainly grown in the Sindh that is about 65 percent of its total produce in the country. Majority of the farmers possess small and medium size holdings and mainly depend on the middlemen for marketing of their produce. The Middlemen, located in the main grain markets, control the supplies through village dealers/contractors. An estimated proportion of 10-15 percent of husk is generated from the overall produce that is used as fodder for animals and sometime is also procured by the paper making industry. Rice after husk removal is called brown rice, a stage referred to as primary processing. The husk so obtained is procured by wholesalers/rice mills from the farmers/contractors [Pakistan (2013); TDAP (2016); Abdullah, *et al.* (2015) and Rehman, *et al.* (2012)].

**Fig. 1. IRRI Value Chain System in Pakistan**




*Source:* TDAP (2016), Abdullah, *et al.* (2015), Pakistan (2013) and author's intuition.

Milling is a very important step in the post-production phase of rice wherein edible white rice is produced after completely removing the husk and bran layers. Broken rice is also produced during the milling process; however, depending upon the demand of the customers its quantity should be minimum broken kernel. In the rice processing industry usually rice mills are privately owned enterprises, owned by rice exporters. However, some rice growers also have established their rice mills in the vicinity. Total milled rice contains whole grains or head rice, and broken rice while rice hull, rice germ and bran layer and fine broken rice are the by-products which are mainly procured by oil and cereal making companies. In IRRI rice, 65-70 percent white rice is produced which is transported to consumers in both the domestic and export market. About 90 percent IRRI exports are directed to Middle East, Africa and South and Central Asia. The whole value chain is dominantly handled the Middle men and in this case the mill owners are the key chain player [Pakistan (2013); TDAP (2016); Abdullah, *et al.* (2015); Rehman, *et al.* (2012)].

Regarding domestic markets, another issue is that a traditional marketing system is still in practice in which traders, wholesalers and distributors are the main stakeholders, hence their interests determine the market mechanism. They assert their own terms and conditions for the growers. Therefore, strict hold of the middle men and less price of rice in markets is perceived as the major problem in the overall IRRI rice value chain system. In addition, some of the marketing factors such as extra commission, high market committee fee, high carriage and other handling charges, late payment by dealers, high storage cost and lack of storage facilities create a lot of wattage which affects the overall value of the produce. Distant markets, shortage of transport and improper roads were also rated as the major product flow barriers in the IRRI rice value chain system which may lead to price volatility and spatial difference in volatility across regions [Pakistan (2013); TDAP (2016); Abdullah, *et al.* (2015); Rehman, *et al.* (2012)].

Market intermediaries such as traders and commission agents are based in the grain markets and are involved in the wholesale trade. Grain markets exist in most of the cities, however, eight markets are mentioned in the introduction section and six of them are selected for the present study. The distances between the selected markets in this study are given in the Table 3. Among the selected markets for the present study, Peshawar and Quetta are the provincial capitals of Khyber Pakhtunkhwa and Balochistan provinces, respectively. The distance between the two is roughly 850km. Quetta and Peshawar are relatively far from the production regions, with populations of about 0.84 and 1.3 million, respectively. Peshawar is situated close to the border of Afghanistan while Quetta is located close to the borders of Iran and Afghanistan. Rawalpindi is the neighbouring city of Islamabad, the capital of Pakistan, and is situated 183km away from Peshawar. Rawalpindi has about 1.83 million inhabitants and it lies between Peshawar and Multan. Multan is located in South Punjab at a distance of 549 km from Rawalpindi and has a population of about 1.55 million. Sukkur is located in Sindh province and it is 468km from Multan. Hyderabad is located close to Karachi, the provincial capital of Sindh and it is a port city. Hyderabad and Sukkur are 323km apart from each other with populations of about 10.4 and 0.40 million, respectively. These are located relatively closer to the production regions as Sindh is the largest producing province of IRRI rice. The respective distance of Quetta from Sukkur is 400km and from Hyderabad 722km.

Table 3

*Equality of Variance Test and Distance between Domestic Market Pairs*

| Market Pairs | Equality of Variance /SD (1994-2011) | Distance (Km) |
|---|---|---|
| Rawalpindi – Peshawar | Yes | 183 |
| Hyderabad –Sukkur | No | 323 |
| Quetta – Sukkur | No | 399 |
| Sukkur – Multan | Yes | 468 |
| Multan – Rawalpindi | No | 548 |
| Quetta – Multan | Yes | 625 |
| Multan – Peshawar | No | 689 |
| Quetta– Hyderabad | No | 721 |
| Hyderabad –Multan | No | 781 |
| Quetta – Peshawar | No | 846 |
| Sukkur – Peshawar | No | 884 |
| Quetta – Rawalpindi | Yes | 902 |
| Sukkur – Rawalpindi | No | 1012 |
| Hyderabad – Peshawar | No | 1206 |
| Hyderabad – Rawalpindi | No | 1325 |
| Average–International Market | No | 7595[a] |

[a] Sea distance between Karachi and Bangkok.

Logistics or distances from the production area to the market are characterised as critical operational or supply chain strategic planning components which involve ensuring product delivery to the right place, at the right time, and at the right price [Christopher (2005); Ballou (2004)]. Dunne (2010) identified that an effective logistic planning can improve the overall efficiency of the marketing system. Therefore, selection of the mode of transport, rout, product handling and storage provisions can also enhance the product value at the market place. An important consideration to mark here is that all of the above identified markets in Pakistan are connected with motorways, highways or railways. Cargo transportation is carried out mostly through highways. Infrastructure, in general, is relatively more developed in the Punjab province compared with other provinces. National highway and motorway network spans around 9600km, forming about 3.7 percent of total road network, accounting for about 95 percent of freight of all goods. So, road transport is the backbone of the transport sector of Pakistan. Road infrastructure has improved in Pakistan as percentage of paved roads increased from about 53 percent of total roads in 1991 to about 72 percent in 2010. This percentage is greater than in China, India, Indonesia, and Vietnam but lesser than in Thailand and Malaysia. However, about half of Pakistan’s national highways are in a poor condition and poor road safety is a major concern along with low productivity of the transportation system. Trucks usually travel at a speed of less than 50km per hour mainly because of being overloaded and in poor quality. Railway freight accounts for only 5 percent of the total freight services. Pakistan’s railways freight productivity is considered to be significantly inferior and lower than the productivity of railways in India and Thailand. Moreover, the storage system of Pakistan railways has been so sub-standard that it cannot ensure the product quality at the desired level. Low productivity can result in it being uncompetitive when compared with the road network [World Bank (2013)]. Another problem is the high cost of transportation which is mainly dependent on the prices of fuel. Fuel is one of the major import items of Pakistan and its imports are levied high tax which provides an important source of revenue to the government [Afia (2008)]. Imposition of tariff on oil imports is one of the reasons for increase in the domestic prices of oil and ultimately in the cost of transportation. However, for the last one to two years, oil prices have experienced a declining trend because of the decline in prices in the international market. Overall, poor logistic management system in Pakistan has endangered the rice value chain efficiency and effectiveness, and this situation is likely to affect the prices and its volatility in different markets.

## 3. DATA AND METHODS

The data for monthly IRRI rice prices in the six domestic markets: Rawalpindi, Multan, Peshawar, Hyderabad, Sukkur and Quetta, were taken from the agricultural statistics of Pakistan [Pakistan (2013)]. Staff members of PBS collect data on wholesale prices of 463 items, rice being one of them, included in wholesale price index (WPI) from the wholesale markets in 21 cities regularly on monthly basis. One Statistical Officer in every Regional/Field office is responsible for the technical supervision of work done by the price collectors. He is required to ensure that the technical aspects of price collection are clearly understood and the laid down instructions are generally followed by the price collectors. For this purpose, he is required to visit the markets for random checking of the prices. The Chief Statistical Officers of Regional offices also undertake field checking of the price data collected by the price collectors. Senior Officers from the Head Office also carryout surprise field inspections/visits to ensure authenticity of data. Collected data are entered in computers located at 34 Regional/Field Offices. Price data are checked and scrutinised at the headquarters to ensure its accuracy. In case of any doubt or abnormal variations, the concerned price reporting centres are contacted immediately for clarifications and necessary corrections [Pakistan (2013a)]. The data for Thai prices are downloaded from World Bank’s pink sheet [World Bank (2012)]. Thai prices are converted to Pakistan rupees for comparison with the domestic markets using exchange rate from Oanda (2012) web page.

The present study employs the dynamic conditional correlation generalised autoregressive conditionally heteroskedastic (DCC)-GARCH approach of multivariate GARCH models developed by Engle (2002) to examine the spatial differences in volatilities of prices among the six major markets of IRRI rice of Pakistan. Multivariate GARCH models are employed very often in the studies examining the volatilities in prices in time series data analysis and their transmission across markets. DCC-GARCH, in particular, is designed to analyse the dynamics of volatility of a time series under analysis and measures conditional correlations among the various time series under study and transmissions among them. In DCC-GARCH model, the conditional variances are modelled as univariate generalised autoregressive conditionally heteroskedastic (GARCH) models and the conditional co-variances are modelled as nonlinear functions of the conditional variances. The conditional quasi correlation parameters that weight the nonlinear combinations of the conditional variances follow the GARCH-like process specified in Engle (2002). The (DCC) GARCH model is about as flexible as the closely related varying conditional correlation (VCC) GARCH model, rather more flexible than the constant conditional correlation (CCC) GARCH model and similarly more parsimonious than the diagonal (VECH) GARCH model [Engle (2002); Göt, *et al.* (2013)].

The mean equation in the DCC GARCH model for domestic rice market of Pakistan can be written as:

$$Y_t = a_0 + \sum_{i=1}^{p} a_i Y_{t-1} + \varepsilon_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Where $Y_t$ is a 6x1 vector of prices in the six domestic markets, $\alpha_0$ is a 6x1 vector of drifts, and $\varepsilon_t$ is a 6x1 vector of error terms. Error term ($\varepsilon_t$) has the following conditional variance-covariance matrix:

$$H = D_t R_t D_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

Where $D_t$ is a diagonal 6x6 matrix of conditional variances ($\sigma_{it}^2$) in which each $\sigma_{it}^2$ is generated according to a univariate GARCH model of the following form for each price series.

$$\sigma_t^2 = \alpha_0 + \sum_{l}^{m} \alpha_l \mu_{t-l}^2 + \sum_{k}^{s} \beta_k \sigma_{t-j}^2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

A typical GARCH (1,1) can be written as follows:

$$\sigma_{t|}^2 = \alpha_0 + \alpha_1 \mu_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

Where $\sigma^2$ is the conditional variance from the conditional mean equation, $\mu_t^2$ is the squared error term from the equation for conditional mean, *i* indexes markets and t indexes time periods. The lambda ($\lambda$) denotes the sum of alphas and betas and for GARCH (*m*,*s*) can be written as $\lambda = \sum_{l}^{m} \alpha_l + \sum_{k}^{s} \beta_k$ and for GARCH(1,1) it can be written as $\lambda = \alpha_1 + \beta_1$. Lambda $\lambda$ is termed as persistence parameter and measures the persistence in volatility. A close to 1 value of Lambda indicates that it will take longer time for the conditional variance to revert to its long-term mean. If $\lambda = 1$ then the conditional variance can increase with no bounds and no tendency to revert to its long-term value of the mean. The greater than one value lambda ($\lambda > 1$) exhibits an explosive growth. Theoretical support for the last two cases is lacking, hence value of the lambda is presented as less than 1. Moreover, the speed with which the conditional mean return to the value of its long term mean can be calculated by measuring the time required for conditional mean to fill half of the gap between the value of the long term mean and the present value of the conditional mean. This time period is called half-life and can be represented by $K$ which is computed as $K = \frac{\ln(0.5)}{\ln(\lambda)}$. For instance, 0.8 value of $\lambda$ calculates as $K = 3.1$, indicating that the initial gap between the current value of the conditional variance and the value of its long-term mean is covered in about 3 time periods. If $\lambda = 1$, then the value $K$ will be infinity, meaning the existence of the gap for an infinitely long time periods. In other words conditional mean will not revert to its long term mean [Bloznelis (2016)].

$R_t$ represents a 6x6 symmetric dynamic correlations matrix that is defined in the following form:

$$R_t = (\text{diag}(Q_t))^{-1/2}\, \bar{Q}_t\, (\text{diag}(Q_t))^{-1/2} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

Where

$$Q_t = \{q_{ij,t}\} = (1-\alpha-\beta)\, \bar{Q}_t + \beta\, Q_{t-1} + \alpha\, (\mu_{t-1}\, \mu'_{t-1}) \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

GARCH-DCC model primarily focuses on obtaining conditional correlations in $R_t$ written as follows:

$$\rho_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ii,t}}\sqrt{q_{jj,t}}}$$

In the above Equation 6, $Q_t = \{q_{ij,t}\}$ is the time varying covariance matrix of standardised residuals from (1), $\bar{Q}_t$ is unconditional variance-covariance matrix obtained by estimating a univariate GARCH in Equation (3), and $\alpha$ and $\beta$ are vectors of non-negative adjustment parameters satisfying $\alpha + \beta < 1$. Parameter $\alpha$ indicates the impact of the lagged error term (or, in other words, the role of the previous shocks) on the series' volatility in the current period. Parameter $\beta$ represents the effect of price volatility in the previous period on volatility in the current period [Bloznelis (2016); Got, *et al.* (2013)].

These models are widely applied on financial data series such as stock prices, exchange rate and interest rate, etc. A number of applications of these models on the monthly prices data on agricultural commodities do exist also. Valadkhani, *et al.* (2005) investigated Australia's export price volatility by employing GARCH models and presented the evidence that Australia's export prices significantly vary with world prices. Fredy, *et al.* (2008) investigated the effects of policies of market reforms on maize price volatility in Tanzania and identified the factors responsible for spatial price volatility using an autoregressive conditional heteroskedasticity in mean (ARCH-M) model. They found that the reforms resulted in an increase in the farm-gate prices and volatility. They also found higher volatility in the less developed regions; surplus areas of maize; and the regions not having the borders with the neighbouring countries. They suggested investments for improving transportation infrastructure and communication to reduce the spatial price volatility in the long run. Baharom, *et al.* (2009) found that Thailand's rice export price had been volatile during 1961–2008. They also found asymmetry in volatility, indicating that positive shocks lead to larger increases in volatility than the negative shocks. Apergis and Rezitis (2003) in their study of volatility transmission the markets of Greece discovered that the agricultural input and retail food prices wield positive and highly significant effects on the volatility of agricultural output prices by employing multivariate GARCH models. They also illustrated that output prices exert significant positive effects on their own volatility. Rapsomanikis (2011), employing multivariate GARCH models, found that wheat market in Peru and maize markets in Mexico were not showing an increasing trend in price volatility while the world wheat and maize markets showed increasing price volatility. He also found volatility clustering in all the markets during 2008 on account of food crises. He added that domestic price volatilities are more responsive to domestic shocks compared with shocks in the international market prices. He also found that India's power in the international rice market led to bidirectional causality between Indian and international market prices. A similar relationship existed between the volatilities in Indian and international market prices. However, Indian price stabilisation policies such as restrictions on exports on account of the price surge during 2007-08 reduced the volatilities in the domestic markets and raised volatility in the international market.

## 4. SALIENT FEATURES OF REGIONAL RICE PRICES VOLATILITY

To visualise price volatility, monthly percentage price changes in domestic price (average of all markets) and international market prices are plotted in Figure 3. Large fluctuations reflecting high volatility can be viewed particularly after 2008. As an alternative measure of volatility, rolling 48-month standard deviations of logarithmic prices returns are depicted in Figure 4. Increases in rolling standard deviations have been observed since 2008, falling in line with the preceding argument. The argument was further validated by Gilbert and Morgan (2010) found that rice price volatility was higher compared with other food grains during and after the food crisis period 2007-08. They also added that evidence was weak for the perception of increasing grain price volatility.

**Fig. 2. Logarithmic Price Returns in Pakistan's Domestic (Average) and International Rice Markets**

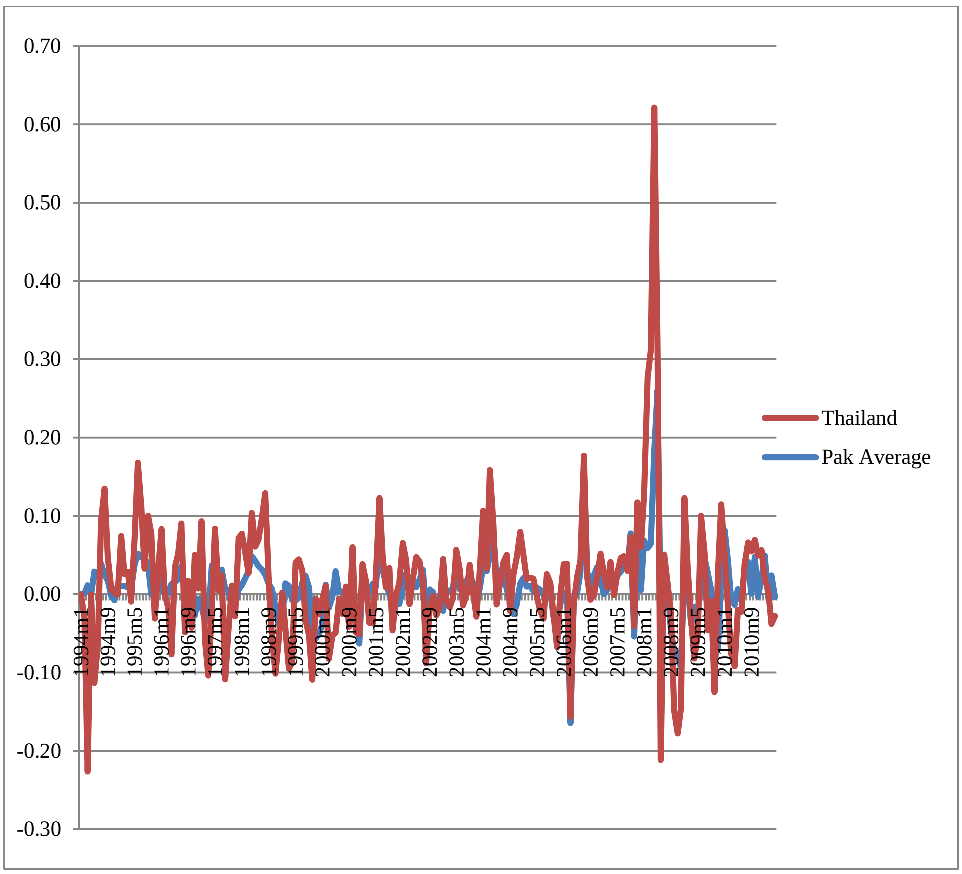
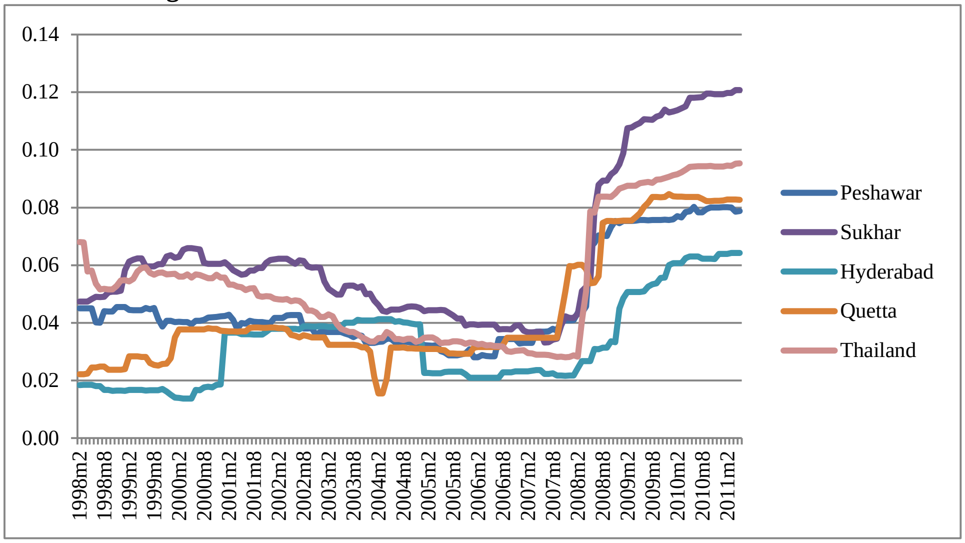
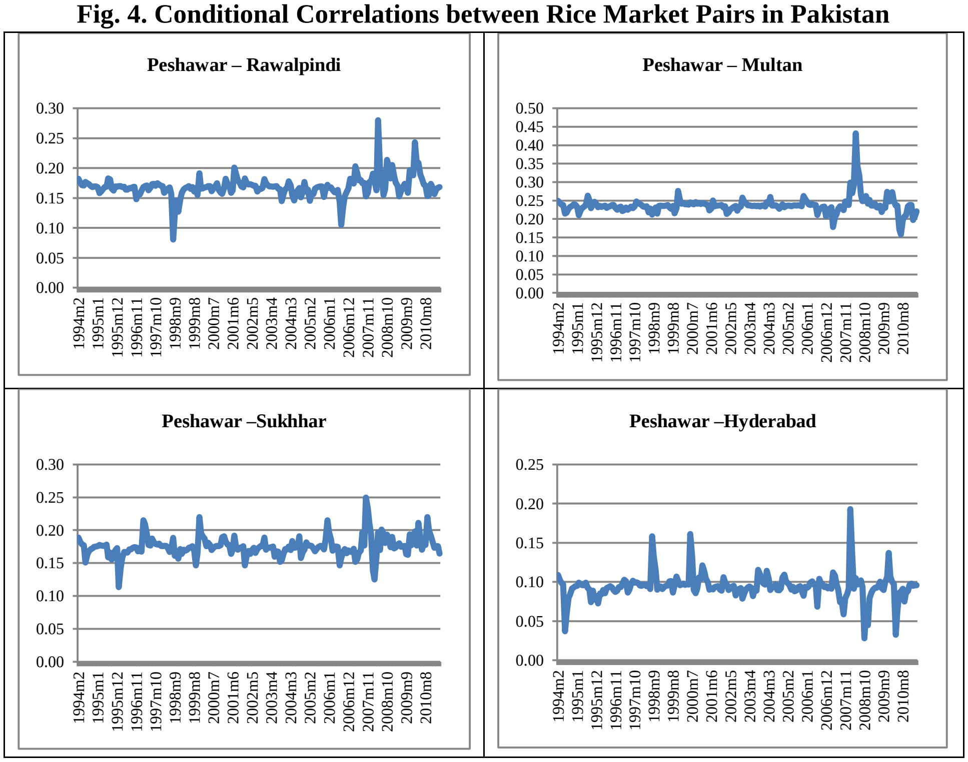


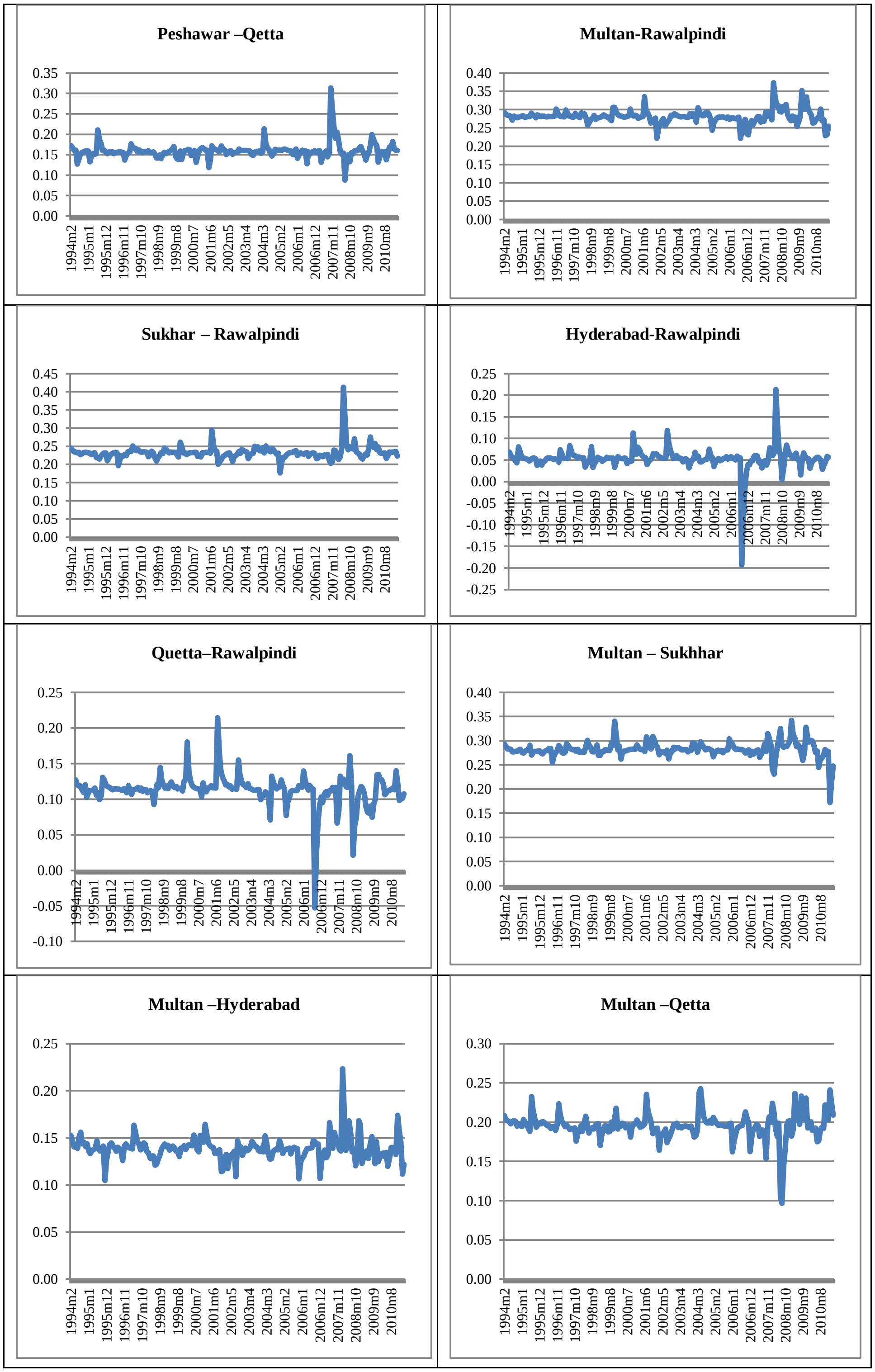
**Fig. 3. Standard Deviations of Logarithmic Price Returns in Pakistan's Domestic and International Rice Markets Over 48-Month Rolling Windows during 1994–2011**

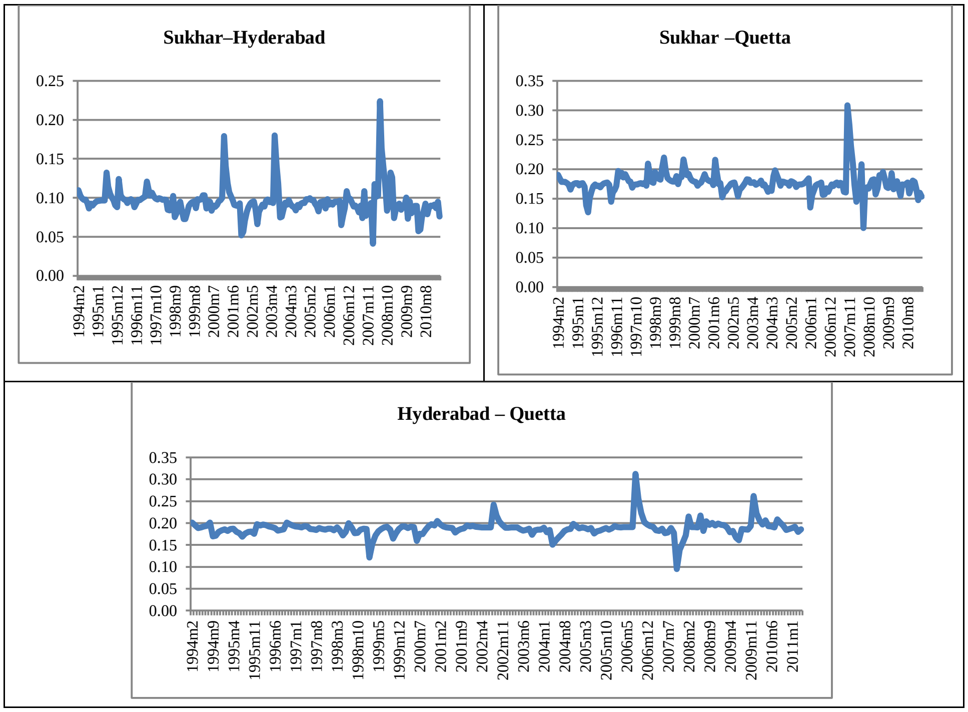



*Note:* Thailand's prices were converted into Pakistan's rupees before estimations of rolling standard deviations.

**Fig. 4. Conditional Correlations between Rice Market Pairs in Pakistan**




Peshawar –Qetta
0.35 0.30 0.25 0.20 0.15 0.10 0.05 0.00
Multan-Rawalpindi
0.40 0.35 0.30 0.25 0.20 0.15 0.10 0.05 0.00
Sukhar – Rawalpindi
0.45 0.40 0.35 0.30 0.25 0.20 0.15 0.10 0.05 0.00
Hyderabad-Rawalpindi
0.25 0.20 0.15 0.10 0.05 0.00 -0.05 -0.10 -0.15 -0.20 -0.25
Quetta–Rawalpindi
0.25 0.20 0.15 0.10 0.05 0.00 -0.05 -0.10
Multan – Sukhhar
0.40 0.35 0.30 0.25 0.20 0.15 0.10 0.05 0.00
Multan –Hyderabad
0.25 0.20 0.15 0.10 0.05 0.00
Multan –Qetta
0.30 0.25 0.20 0.15 0.10 0.05 0.00
1994m2 1995m1 1995m12 1996m11 1997m10 1998m9 1999m8 2000m7 2001m6 2002m5 2003m4 2004m3 2005m2 2006m1 2006m12 2007m11 2008m10 2009m9 2010m8




In view of answering the second research question in the study i.e. to visualise the spatial differences in the volatility among rice among pairs of markets, F-tests of equal variances are performed and the results are given in Table 3. Pair-wise test results show mixed picture demonstrating that some market pairs possess statistically equal volatility while other pairs exhibit differences in volatility. Volatilities of average domestic and international market price are also found to be different. Among domestic markets, markets that are located far from each other possess statistically different volatilities while volatility in neighbouring markets is similar with few exceptions. For instance the results for Sukkur and Hyderabad markets pair show dissimilar volatility despite the fact that these markets are not far from each other. A possible reason for this difference could be the exposure of these markets to the production area and international market as they are located in the surplus production region which is a source of supply to both the domestic and international markets. Hyderabad is located close to the Karachi port and therefore exposed to the international markets while Sukkur is located close to the production areas and act as a source of supply to both the domestic as well as international markets. Quetta and Peshawar are located far from each other and possibly, though there is no direct flow between them, they show a similar behaviour of volatility, again possibly due to their exposure to international markets. Peshawar is located close to the border of Afghanistan while Quetta is situated close to the borders of Afghanistan and Iran. Peshawar may also have been affected by the war against terrorism after the 9/11 incident, while Quetta has poor law and order situation. Quetta and Rawalpindi are also situated far from each other but possess statistically equal variance, which can be attributed to the fact that they are deficit regions as situated far from the production areas.

Although there is no direct trade between Quetta and Rawalpindi, their geographical location with respect to the supply area may lead to similarities in the operations of market forces and resulting behaviour of price volatility. Quetta-Sukkur and Multan-Peshawar market pairs, situated relatively far from each other, also showed statistically similar variance which, possibly, is because of expected higher trade between them. The actual data for trade is not available; however, we can expect this result as Sukkur and Multan are located relatively close to the production regions and product moves from Sukkur and Multan.

The volatility in all the regions and in the international market, measured by moving window of standard deviations of logarithmic price returns over 48 months (Figure 3) shows a rising trend in particular after the boom-and-bust period 2007-08. To further visualise the trends in volatility, the data set is divided into three sub-sets, 1994-1999; 2000-2005 and 2006-2011. Volatility is measured in terms of standard deviations of logarithmic price returns over the selected period. Results are shown in Table 4. These results, in general, support a rising trend in volatility. The highest level of volatility occurred in 2006-2011. During this period, volatility almost doubled in all the regions and even more than doubled in some markets. However, the level of volatility differs across markets during these sub-periods. Three markets, i.e. Rawalpindi, Multan and Hyderabad, showed an increase in volatility from 1994-1999 to 2000-2005 while Sukkur, Peshawar and Quetta showed a decrease in volatility during the same sub-periods.

Table 4

*Standard Deviations of Logarithmic Price Changes*

| Years | Peshawar | Rawalpindi | Multan | Sukkur | Hyderabad | Quetta |
|---|---|---|---|---|---|---|
| 1994-1999 | 0.044 | 0.034 | 0.043 | 0.056 | 0.017 | 0.033 |
| 2000-2005 | 0.033 | 0.039 | 0.049 | 0.043 | 0.035 | 0.028 |
| 2006-2011 | 0.072 | 0.081 | 0.092 | 0.104 | 0.057 | 0.073 |
| 1994-2011 | 0.052 | 0.051 | 0.064 | 0.071 | 0.039 | 0.048 |

## 5. ECONOMETRIC RESULTS

Augmented Dickey-Fuller and Phillips-Perron unit root tests applied on the logarithmic prices indicated non-stationarity while the test results on first-difference of log prices (i.e. logarithmic price returns) show that these are stationary. The results of unit root tests are reported in Appendix. ARCH-LM tests were applied on the logarithmic price returns to examine the presence of volatility clustering, or ARCH effects. The results (Table 5) support the hypothesis of presence of ARCH effects in the domestic as well as in the international markets. This evidence is weak for Rawalpindi and Hyderabad, where the test statistic is significant at 10 percent level. The results of univariate[3] part of DCC- GARCH models are reported in Table 6. All models included a first-order autoregressive term (lagged logarithmic price returns) in the conditional mean equation to control for the predictability of conditional mean. The coefficients on AR (1)

[3]Prices for Thai rice are not included in the DCC-estimations as the focus of the present study is to identify the spatial differences across domestic markets and estimating conditional correlations among them. However, separate univariate GARCH model is estimated for Thai prices for comparison.

in all the markets are positive and statistically significant at 1 percent level suggesting that specification of GARCH models without its AR term in any model for conditional mean would not be appropriate. Ljung-Box test for autocorrelation and ARCH-LM test for remaining ARCH effects were applied on standardised model residuals as diagnostics tests after the estimation of DCC-GARCH. The results show that the residuals do not have autocorrelation and conditional heteroskedasticity.

Table 5

*ARCH-LM Test on Price Returns in the Domestic Rice Markets in Pakistan*

| Year | Thailand | Peshawar | Rawalpindi | Multan | Sukkur | Hyderabad | Quetta |
|---|---|---|---|---|---|---|---|
| Skewness | 1.0 | 0.9 | 7.6 | 0.8 | 0.6 | 0.4 | 0.8 |
| Kurtosis | 2.9 | 2.6 | 2.6 | 2.8 | 2.5 | 2.2 | 2.8 |
| ARCH- LM[a] | 15.3 | 5.5 | 2.9 | 30.1 | 26.0 | 2.6 | 12.9 |

*Source:* Author's calculations.
*Notes:* [a] All the coefficients are significant at 1 percent level of significance except for Rawalpindi and Hyderabad which are significant at 10 percent level of significance

Table 6

*Univariate Part of DCC-GARCH Model*

| DlnP | Thailand | Hyderabad | Sukkur | Multan | Rawalpindi | Peshawar | Quetta |
|---|---|---|---|---|---|---|---|
| Constant | 0.005 | 0.009[a] | 0.01[a] | 0.009[b] | 0.01[a] | 0.009[b] | 0.01[a] |
| AR(1) | 0.33[a] | 0.23[a] | 0.21[a] | 0.38[a] | 0.48[a] | 0.29[a] | 0.23[a] |
| ARCH (1) | 0.15 | 0.17[c] | 0.20[b] | 0.32 | 0.72[c] | 0.21 | 0.97[a] |
| GARCH(1) | 0.43[b] | 0.81[a] | 0.72[c] | – | – | 0.51[a] | – |
| Lambda | 0.58 | 0.98 | 0.92 | | | 0.72 | |
| K | 1.27 | 34.31 | 8.31 | | | 2.11 | |
| Constant | 0.0003 | 0.00006[c] | 0.0004[b] | 0.003[a] | 0.001[a] | 0.0006[a] | 0.0006[a] |
| ARCH(2) | 0.28[b] | | | | | | |
| [d]Ljung-Box(3) | 4.95[c] | 1.22 | 0.96 | 2.62 | 2.19 | 0.06 | 3.00 |
| ARCH-LM(3) | 4.25 | 0.49 | 0.77 | 1.20 | 0.13 | 1.12 | 0.90 |

*Notes:* [a/b/c] statistically significant at the 1 percent, 5 percent, and 10 percent levels, respectively.
[d] Ljung-Box (3 lags) and ARCH-LM (3 lags) tests' statistics for standardised model residuals.

The ARCH coefficients in domestic markets are positive and statistically significant, except for Multan and Peshawar. These coefficients are significant at 10 percent level in Hyderabad and Multan while at 5 percent and 1 percent in Sukkur and Quetta, respectively. Their magnitudes range from around 0.2 in Hyderabad and Sukkur to around 0.7 in Rawalpindi and almost 1.0 in Quetta. In the international market, ARCH (1) coefficient is not significant while ARCH (2) coefficient is significant at 5 percent level; the sum of the two is 0.4. Significant ARCH (1) coefficients imply that the most recent shock to logarithmic price returns significantly affects the current volatility in the prices of rice markets. A relatively large ARCH coefficient (e.g. in Rawalpindi and Quetta) implies that the most recent shock has a sizeable impact of increasing the current period's volatility. A relatively small ARCH coefficient (as in Hyderabad and Sukkur) indicates that shocks to logarithmic price returns have a little impact on subsequent period's volatility.

The GARCH coefficients are not significant in Multan, Rawalpindi and Quetta markets while these are significant in Sukkur, Hyderabad and Quetta at 1 percent level of significance. The GARCH coefficient in the international market is significant at 5 percent level. Significant GARCH coefficients indicate autoregressive memory in conditional variance, that is, current conditional variance depends on past conditional variances. In other words, volatility in the past periods affects the current period's volatility of prices in the market. A relatively large GARCH coefficient implies that current volatility tends to remain close to its most recent value rather than at its basic level. Such a pattern is the strongest in Hyderabad and Sukkur (GARCH coefficient values of around 0.8 and 0.7 respectively) and less pronounced in Peshawar (around 0.5). The international market has the least pronounced autoregressive memory in conditional variance with a GARCH coefficient of around 0.4, indicating relatively smaller effects of past period's volatility on current period's volatility.

Significant GARCH effects together with significant ARCH effects indicate that volatility depends on both previous shocks and previous volatility. The sum of the ARCH and GARCH coefficient value measures the persistence in volatility, and values close to unity reflect high persistence [Verbeek (2008)]. This sum for international market is 0.86, which is relatively high. Persistence in Hyderabad and Sukkur amounts to 0.98 and 0.89, respectively, even higher than that of the international market. The value of K, half-life, is also the highest in Hyderabad and Sukkur markets which are 34 and 8 respectively. This indicates that the initial gap between current volatility and its long-term mean would be covered in 34 periods in Hyderabad and 8 periods in Sukkur. Differences in the significance and magnitude of ARCH and GARCH coefficients reflect spatial differences in behaviour of the volatility across the regional rice markets in Pakistan. Hyderabad and Sukkur are the only two markets in Pakistan having both significant ARCH and GARCH effects and high values of K. Hence both of these can be regarded as the riskiest markets.

The results of the equality of variance tests, volatility trends measured by rolling window of the standard deviations and 5-years standard deviations of differenced logarithmic prices and ARCH/GARCH models reveal spatial differences in volatility across the regional markets in Pakistan. It is reasonable to assume that these spatial differences reflect the differences in infrastructure such as the cost of transportation and communication services, storages and possibly also the existence of market power by the market intermediaries. In particular, the domestic value chain where the intermediaries drive the whole chain, commission agents have inter-regional wholesale market contacts and they possess accurate market information. Therefore, they hold an important position in the market to influence prices. Moreover, the price surge during the 2007-08 food crises also affected the volatility in the regional markets. Inventory holders would intend to store more in a volatile environment resulting in increase in the inventories. Buildup in inventories can create shortage in domestic supply that in turn can increase the demand and ultimately prices. Increased price could negatively affect the food security. Differences in the volatility across markets can result in regional differences in decision making by the inventory holders, generating increased volatility. This is similar to the power structure of the middlemen in the existing supply chain system, generally in developing countries and particularly in Pakistan that govern the whole system according their vested interest [Dunne (2010)].

Other part of the DCC-Model is comprised of time-varying conditional correlations between market pairs which are presented in Figure 4. Figure 4 depicts that each market has a different correlation with the other market and over-time values of the conditional correlations vary across markets pairs. In general, these conditional correlations are low. These facts reflect that spatial differences exist across markets and market pairs which can also be explained by poor logistic and supply chain system that increases the information gap among the trading partners. The average dynamic conditional correlations during 1994-2011 are given in Table 7. The highest conditional correlation exists between Multan and Sukkur, 0.29. This is as was expected given the fact that these two markets are relatively close. Multan and Rawalpindi possess the second highest conditional correlation, 0.28, which are located in the same province. Both these markets have a relatively better road infrastructure and more trade can be expected from Multan to Rawalpindi as Multan is relatively closer to production/supply areas.

Table 7

*Time-varying Conditional Correlations from DCC-GARCH Model in Domestic Rice Markets of Pakistan*

| Market Pairs | Average Conditional Correlation | Distance (km) |
|---|---|---|
| Rawalpindi – Peshawar | 0.17 | 183 |
| Hyderabad –Sukkur | 0.09 | 323 |
| Quetta – Sukkur | 0.18 | 399 |
| Sukkur – Multan | 0.29 | 468 |
| Multan – Rawalpindi | 0.28 | 548 |
| Quetta – Multan | 0.20 | 625 |
| Multan – Peshawar | 0.24 | 689 |
| Quetta– Hyderabad | 0.19 | 721 |
| Hyderabad –Multan | 0.14 | 781 |
| Quetta – Peshawar | 0.16 | 846 |
| Sukkur – Peshawar | 0.18 | 884 |
| Quetta – Rawalpindi | 0.11 | 902 |
| Sukkur – Rawalpindi | 0.23 | 1012 |
| Hyderabad – Peshawar | 0.09 | 1206 |
| Hyderabad – Rawalpindi | 0.05 | 1325 |

Average conditional correlation between Rawalpindi and Sukkur is 0.23 which reflects the fact that there is direct trade between Sukkur and Rawalpindi as the former is located closer to the supply areas. However, this trade proportion seems lower than between Multan and Rawalpindi possibly due to larger distance. Average conditional correlation between Peshawar and Rawalpindi is relatively lower, 0.17, in spite of the fact that they are located closer, although in different provinces, and have good infrastructure. This reflects that there is more direct trade between Peshawar and Multan, having higher average conditional correlation, 0.33, as it is of a little difference to travel between Multan and Peshawar or Multan and Rawalpindi. This also suggests that good infrastructure and information flow promotes direct trade between the different markets. The conditional correlation between Hyderabad-Sukkur markets pair is relatively low, which is somewhat counterintuitive since these markets are situated close to each other. The test of equality of variance also showed a difference in price volatility between the two markets as described earlier. Relatively low correlation can be attributed to the differences in the demand structure in both the markets. Both have effects of derived demand from the other markets. In Hyderabad market effects of derived demand are from the Karachi which in turn has the demand from international market.

In general, it can be said that there is a higher degree of association in volatility between closer markets than between distant markets although exceptions exist. Distance is a proxy measure of infrastructure such as roads, transportation, communication and geopolitical conditions of the markets and operations of market forces differ across markets. These can be the possible reasons for differences in volatility and the varying degrees of conditional correlations across rice markets in Pakistan. Hence, investments on infrastructure and transportation can reduce the spatial differences in volatility across markets in Pakistan. Improving the efficiency of the railways would reduce the transportation cost and possibly price uncertainty across markets.

## 6. SUMMARY AND CONCLUSIONS

In the introduction, we presented three research questions on the general trend in rice price volatility in Pakistan's domestic markets, possible presence of spatial differences in volatility and presence of correlation between volatilities in different markets. To answer these questions, we analysed volatility trends and patterns by applying standard tests for equality of variance and GARCH-DCC models.

We found a rising trend in rice price volatility in regional markets of Pakistan as well as in the international market during the period 1994-2011. As for producers, higher volatility can result in inefficient allocation of resource. Inventory holders most likely tend to store more in a volatile environment resulting in an increase in inventory costs. Inventories can contribute to reduced price volatility. However, this depends on inventory holders being good at forecasting future prices. If not, building up inventory volumes may actually contribute to larger price variations.

Furthermore, we found differences in volatility across regional markets. In general, markets situated far from each other show statistically significant differences in variances while the markets located relatively closer to each other possess statistically equal variance, although exceptions exist. ARCH-LM tests on logarithmic price returns in individual markets show the presence of ARCH effects in all domestic markets and the international market. The significance and magnitude of ARCH and GARCH coefficients vary across markets reflecting spatial differences in volatility. The highest persistence in volatility is found in Sukkur and Hyderabad. Coupled with its high unconditional variance, Sukkur can be regarded as the most risky domestic market.

Analysis of conditional correlations using DCC model reveals positive association of volatility across markets. It also elucidates spatial differences since correlations are inversely related to distance between markets. Differences in volatile behaviour across markets reflect differences in infrastructure, transportation and communication services, and possibly the market power exercised by the market intermediaries. Given the poor quality of national highways, slow driving freight vehicles and inefficient railway freight, investments in infrastructure and particularly in transportation may reduce the price risk across markets. Hyderabad and Sukkur are found to be the risky markets and Sukkur the riskiest, hence, infrastructural investments in this region should be prioritised.

Improving the way markets function generally reduces price volatility. Such improvements can be achieved by investments in physical infrastructure, i.e. roads, railroads and telecommunications. But perhaps even more important, the open access of market information to both producers and consumers can balance the power structure in the existing chain and will possibly improve the overall supply chain profitability. The econometric results presented in this paper suggest that investments aiming at improving the way Pakistan's rice markets are functioning may yield good returns.

## APPENDIX

*Unit Root Tests*

| | Levels | | | | First Difference | |
|---|---|---|---|---|---|---|
| | Augmented Dickey Fuller (ADF) | | Phillips-Perron (Pperron) | | ADF | Pperron |
| Variables | No Rend | With Trend | No Trend | With Trend | No Trend | No Trend |
| Thailand fob | –1.15 | –1.70 | –1.27 | –1.98 | –7.06 | –2.88 |
| Avg. Dom. Price | –0.88 | –1.71 | –0.48 | –1.32 | –6.65 | –9.00 |
| **IRRI Rice** | | | | | | |
| Hyderabad | –0.45 | –2.82 | –0.30 | –2.50 | –7.39 | –10.39 |
| Sukkur | –0.52 | –2.35 | –0.46 | –2.31 | –8.08 | –13.26 |
| Multan | –0.83 | –2.40 | –0.77 | –2.22 | –7.32 | –9.97 |
| Rawalpindi | –0.59 | –2.27 | –0.48 | –2.03 | –7.31 | –9.33 |
| Peshawar | –0.56 | –1.73 | –0.43 | –1.60 | –7.10 | –10.89 |
| Quetta | –0.31 | –1.88 | –0.03 | –1.43 | –7.34 | –12.14 |

*Source:* Author's calculations.

Appendix Table 1

*Area, Production and Yield of Rice Crop in Pakistan*

| | | Area (000, hectares) | | | Production (000, tons) | | | Yield (Kg / ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Prov. | Basmati | IRRI | Total | Basmati | IRRI | Total | Basmati | IRRI | Total |
| 93-94 | Punjab | 1074.0 | 218.5 | 1300.6 | 1215.9 | 361.5 | 1588.2 | 1132.0 | 1654.0 | 1221.0 |
| | Sindh | – | 630.1 | 702.9 | – | 1840.6 | 1954.9 | – | 2921.0 | 2781.0 |
| | Total | 1103.5 | 961.0 | 2187.1 | 1266.7 | 2524.3 | 3994.7 | 1148.0 | 2627.0 | 1826.0 |
| 94-95 | Punjab | 1107.6 | 222.6 | 1338.7 | 1295.9 | 376.3 | 1684.0 | 1170.0 | 1690.0 | 1257.0 |
| | Sindh | – | 535.6 | 598.3 | – | 1324.7 | 1406.7 | – | 2473.0 | 2351.0 |
| | Total | 1145.4 | 865.3 | 2124.6 | 1351.6 | 1926.6 | 3446.5 | 1180.0 | 2226.0 | 1622.0 |
| 95-96 | Punjab | 1109.2 | 214.5 | 1327.7 | 1415.1 | 381.9 | 1803.0 | 1276.0 | 1780.0 | 1358.0 |
| | Sindh | – | 570.9 | 642.3 | – | 1592.9 | 1697.2 | – | 2790.0 | 2642.0 |
| | Total | 1147.8 | 894.9 | 2161.7 | 1487.5 | 2281.9 | 3966.5 | 1296.0 | 2550.0 | 1835.0 |
| 96-97 | Punjab | 1133.1 | 216.5 | 1354.5 | 1486.6 | 369.8 | 1864.0 | 1312.0 | 1708.0 | 1376.0 |
| | Sindh | – | 625.5 | 701.8 | – | 1846.8 | 1961.5 | – | 2953.0 | 2794.0 |
| | Total | 1173.9 | 951.8 | 2251.1 | 1563.7 | 2527.9 | 4304.8 | 1372.0 | 2656.0 | 1912.0 |
| 97-98 | Punjab | 1055.0 | 221.4 | 1409.9 | 1342.9 | 396.9 | 1948.0 | 1273.0 | 1793.0 | 1382.0 |
| | Sindh | – | 614.4 | 689.3 | – | 1733.6 | 1840.9 | – | 2822.0 | 2671.0 |
| | Total | 1105.8 | 952.3 | 2317.3 | 1439.3 | 2468.0 | 4333.0 | 1302.0 | 2592.0 | 1870.0 |
| 98-99 | Punjab | 1162.2 | 236.8 | 1492.9 | 1584.3 | 422.2 | 2176.0 | 1363.0 | 1783.0 | 1458.0 |
| | Sindh | – | 628.7 | 704.1 | – | 1813.6 | 1930.3 | – | 2885.0 | 2742.0 |
| | Total | 1216.0 | 988.5 | 2423.6 | 1687.1 | 2593.3 | 4673.8 | 1387.0 | 2623.0 | 1928.0 |
| 99-00 | Punjab | 1246.8 | 266.7 | 1609.4 | 1764.0 | 534.8 | 2481.0 | 1415.0 | 2005.0 | 1541.0 |
| | Sindh | – | 616.9 | 690.4 | – | 1994.9 | 2123.0 | – | 3234.0 | 3075.0 |
| | Total | 1295.5 | 1015.5 | 2515.4 | 1870.8 | 2911.7 | 5155.6 | 1444.0 | 2867.0 | 2050.0 |
| 00-01 | Punjab | 1113.7 | 313.2 | 1627.2 | 1601.0 | 592.4 | 2577.0 | 1438.0 | 1891.0 | 1584.0 |
| | Sindh | – | 481.4 | 540.1 | – | 1580.3 | 1682.3 | – | 3283.0 | 3115.0 |
| | Total | 1158.2 | 926.5 | 2376.6 | 1700.6 | 2555.9 | 4802.6 | 1468.0 | 2759.0 | 2021.0 |
| 01-02 | Punjab | 1293.8 | 147.7 | 1475.9 | 1913.8 | 284.8 | 2266.0 | 1479.0 | 1928.0 | 1535.0 |
| | Sindh | – | 413.6 | 461.1 | – | 1102.1 | 1159.1 | – | 2665.0 | 2514.0 |
| | Total | 1331.8 | 667.3 | 2114.2 | 1999.3 | 1694.5 | 3882.0 | 1501.0 | 2539.0 | 1836.0 |
| 02-03 | Punjab | 1316.8 | 146.5 | 1512.3 | 2175.5 | 289.7 | 2579.7 | 1652.0 | 1977.0 | 1706.0 |
| | Sindh | – | 438.3 | 488.3 | – | 1240.6 | 1299.7 | –.0 | 2830.0 | 2662.0 |
| | Total | 1377.3 | 721.9 | 2225.2 | 2304.2 | 1941.9 | 4478.5 | 1673.0 | 2690.0 | 2013.0 |
| 03-04 | Punjab | 1426.1 | 138.0 | 1687.9 | 2309.2 | 287.6 | 2871.4 | 1619.0 | 2084.0 | 1701.0 |
| | Sindh | – | 495.3 | 551.2 | – | 1368.7 | 1432.8 | – | 2763.0 | 2599.0 |
| | Total | 1520.5 | 717.8 | 2460.6 | 2521.9 | 1900.5 | 4847.6 | 1659.0 | 2648.0 | 1970.0 |
| 04-05 | Punjab | 1466.5 | 108.1 | 1754.3 | 2347.9 | 236.4 | 2980.3 | 1601.0 | 2187.0 | 1699.0 |
| | Sindh | – | 484.9 | 543.9 | – | 1428.4 | 1499.7 | – | 2946.0 | 2757.0 |
| | Total | 1558.4 | 677.7 | 2519.6 | 2554.6 | 1908.1 | 5024.8 | 1639.0 | 2816.0 | 1994.0 |
| 05-06 | Punjab | 1535.0 | 131.9 | 1762.4 | 2641.8 | 314.8 | 3179.6 | 1721.0 | 2387.0 | 1804.0 |
| | Sindh | – | 527.4 | 593.2 | – | 1639.5 | 1721.0 | – | 3109.0 | 2901.0 |
| | Total | 1658.5 | 750.0 | 2621.4 | 2920.4 | 2214.1 | 5547.2 | 1761.0 | 2952.0 | 2116.0 |
| 06-07 | Punjab | 1474.3 | 138.8 | 1728.4 | 2493.6 | 334.4 | 3075.5 | 1691.0 | 2409.0 | 1779.0 |
| | Sindh | – | 534.3 | 598.1 | – | 1667.7 | 1761.8 | – | 3121.0 | 2946.0 |
| | Total | 1589.2 | 756.5 | 2581.2 | 2735.7 | 2238.0 | 5438.4 | 1721.0 | 2958.0 | 2107.0 |
| 07-08 | Punjab | 1377.1 | 159.8 | 1723.5 | 2453.1 | 414.4 | 3286.0 | 1781.0 | 2593.0 | 1907.0 |
| | Sindh | – | 531.1 | 594.0 | – | 1716.5 | 1817.7 | – | 3232.0 | 3060.0 |
| | Total | 1467.0 | 746.8 | 2515.4 | 2642.7 | 2283.9 | 5563.4 | 1801.0 | 3058.0 | 2212.0 |
| 08-09 | Punjab | 1548.3 | 202.3 | 1977.7 | 2601.7 | 517.7 | 3643.0 | 1680.0 | 2558.0 | 1842.0 |
| | Sindh | 88.8 | 560.3 | 733.5 | 133.3 | 1949.3 | 2537.1 | – | 3479.0 | 3459.0 |
| | Total | 1696.8 | 915.1 | 2962.6 | 2900.8 | 2983.9 | 6952.0 | 1710.0 | 3261.0 | 2347.0 |
| 09-10 | Punjab | 1414.0 | 218.9 | 1931.5 | 2475.4 | 532.2 | 3713.0 | 1751.0 | 2431.0 | 1922.0 |
| | Sindh | 74.3.0 | 518.9 | 707.7 | 103.2 | 1728.2 | 2422.4 | 1389.0 | 3331.0 | 3423.0 |
| | Total | 1543.5 | 894.0 | 2883.1 | 2731.7 | 2789.6 | 6882.8 | 1770.0 | 3120.0 | 2387.0 |
| 10-11 | Punjab | 1333.8 | 182.5 | 1766.8 | 2365.2 | 445.8 | 3384.0 | 1773.0 | 2443.0 | 1915.0 |
| | Sindh | 28.0 | 274.6 | 361.1 | 42.5 | 919.4 | 1230.3 | 1517.9 | 3348.1 | 3407.0 |
| | Total | 1412.6 | 617.4 | 2365.2 | 2445.1 | 1490.0 | 4803.5 | 1731.0 | 2413.0 | 2031.0 |

*Source*: Agricultural statistics of Pakistan 2011.

**REFERENCES**

Abdullah, M., J. Li, S. Ghazanfar, I. Khan, M. N. Ishaq, and J. Ahmed (2015) Domestic Rice Marketing Structure and Marketing Margins in Pakistan. *Journal of Economics and Sustainable Development* 6:12, 226–238.

Afia, M. (2008) How Pakistan is Coping with the Challenge of High Oil Prices. Munich Personal RePEc Archive (MPRA). (MPRA Paper No. 8256). Munich Personal RePEc Archive (MPRA).

Ahmad, B. and R. J. Garcia (2012) Measuring Commodity-Specific Trade Determinants and Export Potential: A Gravity Model of Pakistan's Rice Exports. *Journal of International Agricultural Trade and Development* 2:8, 125-148

Ahmad, B., and O. Gjølberg (2015) Are Pakistan's Rice Markets Integrated Domestically and With the International Markets? *SAGE Open* 5:3, 1–15.

Anwar, S. (2004) Comparative Advantage and Competitiveness of Major Agricultural Crops in Indus Basin: Price Risk Analysis. PhD dissertation, University of Agriculture Faisalabad, Pakistan.

Apergis, N. and A. Rezitis (2003) Agricultural Price Volatility Spillover Effects: The Case of Greece. *European Review of Agricultural Economics* 30:3, 389-406.

Baharom, A. H, A. Radam, M. S. Habibullah, and M. T. Hirnissa (2009) The Volatility of Thai Rice Price. *Integration and Dissemination* 4, 70–76.

Ballou, R. H. (2004) Business Logistics/Supply Chain Management: Planning, Organising, and Controlling the Supply Chain. Pearson Prentice Hall.

Bloznelis, D. (2016) Salmon Price Volatility: A Weight-Class-Specific Multivariate Approach. *Aquaculture Economics and Management* 20: 1, 24-53

Bollerslev, T. (1986) Generalised Autoregressive Conditional Heteroskedasticity. *Journal of Econometrics* 31:3, 307–327.

Christopher, M. (2005) Logistics and Supply Chain Management: Creating Value-added Networks. Financial Times Prentice Hall.

Deaton, A. and G. Laroque (1992) On the Behaviour of Commodity Prices. *The Review of Economic Studies* 59:1, 1-–23.

Dunne, A. and P. Johnson (2010) The Rapid Supply Chain Appraisal Approach: A Case Study of Pakistan Mangoes to the United Kindom. In P. J. Batt (ed.) Third International Symposium on Improving the Performance of Supply Chains in the Transitional Economies, July 4-8, 2010, Kuala Lumpur, Malaysia, pp. 107–12.

Engle, R. F. (1982) Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation. *Econometrica* 50: 4, 987–1007.

Engle, R. F. (2002) Dynamic Conditional Correlation: A Simple Class of Multivariate Generalised Autoregressive Conditional Heteroscedasticity Models. *Journal of Business and Economic Statistics* 20:3, 339–350.

Exporters Association of Pakistan (REAP) (2010) Introduction. Rice Exporters Association of Pakistan's. web page. http://www.reap.com.pk/links/introduction.asp.

Fang, C. and I. Sanogo (2014) Food Price Volatility and Natural Hazards in Pakistan Measuring the Impacts on Hunger and Food Assistance. Food and Agriculture Organisation of the United Nations. http://www.fao.org/3/a-i3808e.pdf

Farooq, U., T. Young, N. Russell, and M. Iqbal (2001) The Supply Response of Basmati Rice Growers in Punjab, Pakistan: Price and Non-price Determinants. *Journal of International Development* 13:2, 227–237.

Fredy, K., C. Chung, P. Kenkel, and E. R. Mbiha (2008) Impacts of Market Reform on Spatial Volatility of Maize Prices in Tanzania. *Journal of Agricultural Economics* 59:2, 257–270.

Ghafoor, A. and M. Aslam (2012) Market Integration and Price Transmission in Rice Markets of Pakistan. Dhaka, Bangladesh: South Asia Network of Economic Research Institutes. (SANEI Working Paper Series No. 12-08).

Gilbert, C. L. and C. W. Morgan (2010) Food Price Volatility. *Biological Sciences* 365:1554, 3023–3034.

Got, L., K. Goychuk, T. Glauben, and W. H. Meyers (2013) The Dynamics of Ukrainian Farm Wheat Prices Volatility: Evidence from a Dynamic Conditional Correlation GARCH Model Development. Proceedings of the NCC-134 Conference on Applied Commodity Prices Analysis, Forecasting, and Market Risk Management. St. Louis, MO. [http/www.farmdoc.illinois.edu/nccc134].

Iqbal, A., I. Ashraf, S. Muhammad, and K. M. Chaudhry (2009) Identification and Prioritisation of Production, Protection and Marketing Problems Faced by the Rice Growers. *Pakistan Journal of Agricultural Sciences* 46:4, 290–293.

Kroner, K. F., K. P. Kneafsey, and S. Claessens (1995) Forecasting Volatility in Commodity Markets. *Journal of Forecasting* 14:2, 77–95.

Mushtaq, K. and P. J. Dawson (2002) Acreage Response in Pakistan: A Co-integration Approach. *Agricultural Economic* 27, 111–121.

Mushtaq, K., F. Abbas, Abedullah, and A. Ghafoor (2006) Testing the Law of One Price: Rice Market Integration in Punjab, Pakistan. *Pakistan Journal of Agricultural Sciences* 43, 213–216.

Newbery, D. M. (1989) The Theory of Food Price Stabilisation. *The Economic Journal* 99:398, 1065–1082.

Oanda (2012) Oanda. Retrieved from http://www.oanda.com/

Pakistan, Government of (2013) *Agricultural Statistics of Pakistan (2011-12).* Islamabad: Federal Bureau of Statistics of Pakistan.

Pakistan, Government of (2013a) *Methodology of Price Collection and Computing Price Indices*. Islamabad: Federal Bureau of Statistics of Pakistan.

Pakistan, Government of (2014) *Economic Survey of Pakistan (2013-14).* Islamabad: Economic Advisor's Wing, Finance Ministry.

Pindyck, R. S. (2004) Volatility and Commodity Price Dynamics. *Journal of Futures Markets* 24:11, 1029–1047.

Rapsomanikis, G. (2011) Price Transmission and Volatility Spillovers in Food Markets, In Adam Prakash (ed.) Safeguarding: Food Security in Volatile Global Markets. Food and Agricultural Organisation of the United Nations, Rome, Italy.144–163.

Rehman, A., S. Muhammad, K. M. Chaudry, M. A. Aulakh, and Z. Ahmed (2012) Identification and Prioritisation of Problems Faced by Rice Growers: A Case Study of Tehsil Daska, Sialkot. *Pakistan Journal of Agricultural Sciences* (Pakistan) 49:3, 385–390.

Salam, A. (2009) Distortions in Incentives to Production of Major Crops in Pakistan: 1991-2008. *The Journal of International Agricultural Trade and Development* 5:2, 185–207.

Siddique, R. (2008) Welfare and Poverty Implications of Global Rice and Agricultural Trade Liberalisation for Pakistan. In M. A. Razzaque (ed.) *Global Rice and Agricultural Trade Liberalisation: Poverty and Welfare Implications for South Asia*. Commonwealth Secretariat, London, The United Kingdom.

State Bank of Pakistan (2010) Balance of Trade. Handbook of Statistics on Pakistan Economy 2010. http://www.sbp.org.pk/departments/stats/PakEconomy_HandBook/Chap-8.1.pdf

Stigler, M. (2011) Commodity Prices: Theoretical and Empirical Properties. In Adam Prakash (ed.) Safeguarding: Food Security in Volatile Global Markets. 25–44. Food and Agricultural Organisation of the United Nations, Rome, Italy.

Trade Development Authority of Pakistan (TDAP), European Union Funded Trade Related Technical Assistance (EU TRTA II) (2016) Sectoral Competitiveness and Value Chain Analysis.

Tripathy, T. (2008) Volatility and Price Integration in Primary Commodities Market: A Strategic Direction in India. *The ICFAI Journal of Business Strategy* 5:1, 7–20.

United Nations, Food and Agriculture Organisation (UN FAO) (2010) On line data base, www.fao.org

Valadkhani, A., A. P. Layton, and N. D. Karunaratne (2005) Sources of Volatility in Australia's Export Prices: Evidence from ARCH and GARCH Modelling. *Global Business and Economics Review* 7:4, 295–310.

Verbeek, M. (2008) *A Guide to Modern Econometrics.* (3rd edition). John Wiley & Sons ltd., the Atrium, Southern Gate, Chichester, West Sussex, England.

World Bank (2009) Global Food Crises at a Glance. Issue Briefs, The World Bank.

World Bank (2012) Pink Sheet Data. http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTDECPROSPECTS/0,,contentMDK:21574907~menuPK:7859231~pagePK:64165401~piPK:64165026~theSitePK:476883,00.htm

World Bank (2013) Pakistan's Transport Sector. The World Bank. http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/EXTSARREGTOPTRANSPORT/0,,contentMDK:20699058~menuPK:869060~pagePK:34004173~piPK:34003707~theSitePK:579598,00.html

World Trade Organisation (WTO) (2011) Pakistan's Domestic Support Notifications, WTO on line data base, www.wto.org.

Zimmerman, F. J., and M. R. Carter (2003) Asset Smoothing, Consumption Smoothing and the Reproduction of Inequality under Risk and Subsistence Constraints. *Journal of Development Economics* 71:2, 233–260.

## *Book Review*

**Floor Brouwer (ed.)** *Sustaining Agriculture and the Rural Environment: Governance, Policy and Multifunctionality*. Cheltenham, UK: Edward Elgar. 2004 (Reprinted 2016). Xi+360 pages. U.K. £98.10 (Hardback).

The edited book, "Sustaining Agriculture and the Rural Environment", is largely a European contribution to the Ecological Economics. It provides a useful review of 'multifunctionality' as the central attribute of the European Model of Agriculture (EMA) and its applied value to other developing countries. Brouwer introduces the book (in Chapter 1) with a premise that jointly with food and fibre, the European farmers also produce 'public goods' such as landscapes and biodiversity management, cultural heritage, and viable rural communities. He warms up the reader to digest what follows in the book with a quick overview of the market for these positive externalities and strategies for their continuous supply in the European Union's Common Agriculture Policy. This paves the way for rest of the book, which is organised into four parts and seventeen chapters.

Part I consists of three chapters. Chapter 2 by Clive Potter unpacks the idea of 'multifunctionality', its conceptual and contextual roots, underlying assumptions, linkages with European Model of Agriculture (EMA) and its implications for and vulnerability to the WTO negotiations. The key message, which also emerges from various empirical chapters, is as follows: owing to the high chances of market failure to reward positive externalities, the governments' support for agriculture under the EU's 'Common Agriculture Policy' (CAP) is merely rewarding farmers for the continuous supply of these positive externalities. Chapter 3 by Peter L. Nowicki basically gives a cost and benefit comparison of EU's approach to multifunctional agriculture with its alternatives in 'market-oriented approaches'. The author points towards the limits to procure public goods through tax-money, proposes to rely on consumer demand for public good (as if it exists or can be created and is free of commons problems), and reminds that a rational farmer would automatically capture such market and maintain the quality of their land, if they intend to remain in the business. Chapter 4 by Eirik Romstad brings in a theoretical discussion about the nature of public and private goods, production possibility frontiers of public goods in terms of their relative prices. Based on his analysis and quite contradictory to Nowicki's suggestion, he warns that compliance with WTO prescriptions may cause a major drop in the relative commodity prices of public goods produced through agriculture and thereby may justify price support.

The contributions in the first part together develop a strong conceptual basis to comprehend the various manifestations of 'multifunctionality' in Part II, elaborated through eight regional and country-specific empirical case studies chapters. In Chapter 5, Karlheinz Knickel and colleagues assess the socioeconomic relevance of multifunctionality in European agriculture and recommend developing linkages of agriculture and rural change with various functions of agriculture, including agri-tourism and nature and landscape management, and impact assessments of policy changes across the diversity of European farms. Chapter 6 by Erling Andersen and colleagues also has a regional focus and provides both conceptual and empirical insights on multifunctionality of the European livestock systems. They also identify the diversity of EU's livestock systems and highlight data limitation to appreciate this it in policy processes. The remaining six chapters in this part provide country cases studies. Chapter 7 by Thomas Dax and Gerhard Hovorka and Chapter 8 by Leonidas Louloudis and colleagues give somewhat similar analysis of multifunctional agriculture in naturally sensitive mountain regions of Austria and Greece, respectively. They advocate for policy support to local survival and production of public goods in these marginalised and remote regions. Chapter 9 by Pierre Dupraz and Pierre Rainelli discuss the French way of dealing with multifunctional agriculture and elaborate societal values and the political and institutional arrangement that govern it. Their message is to introduce simple and manageable schemes to encourage farmers to diversify their farming activities and joint production of public goods. Chapter 10 by Roel Jongeneel and Louis Slangen report Dutch farmers' strategies and willingness to produce green services, but warns that in the absence of appropriate incentive structure the supply of green services may be limited. Chapter 11 by Joke Luttik and Bareld van der Ploeg brings in a sociological aspect to examine the declining levels of joint production of agriculture due to urbanisation in the Netherlands and advocate a transformation from economies of scale to economies of scope, and a broader orientation in agricultural production of green services and rural amenities to support the declining incomes of farmers. Chapter 12 by Lourdis Viladomiu and Jordi Rosell examines non-agricultural functions of olive gardens in Spain and shows the impact of incentive structure on multifunctionality of production systems.

Four chapters in Part III of the book are devoted to emerging perspectives on multifunctionality of agriculture outside the EU. Chapter 13 by Franz Gatzweiler shares the experience of EU candidate countries with institutional engineering for sustainable agriculture and shows how Central and Eastern European countries compromised over environmental goals in their hurry to join the EU. Chapter 14 by Jørgen Primdahl and Simon Swaffield provides a defence against neoliberal attack on EMA, and shows how spatial segregation policies and political disinterest in agriculture-environment integration cause the underperformance of the most monofunctional landscapes in New Zealand. In Chapter 15 Fabrizio Bresciani and colleagues compare FAO and OECD approaches to multifunctional agriculture and argues that policymakers in developing countries increasingly appreciate the role of agriculture such as employment generation, poverty alleviation, hunger prevention, and direct linkages with other sectors of economic growth, but still discriminate against it in their preference for industrialisation. Chapter 16 by Chantal Carpentier, *et al*. reveals that despite multifunctionality, never has been a formal theme in agricultural policy debate in North America, the principles underling the concept can be traced in the case of trade and environment. They appreciate the multifunctional role of agriculture, but demand a more transparent and less trade-distortive implementation.

Part V has just one chapter (Chapter 17) that synthesises and concludes the book. Ian Hodge emphasises on the need to choose agri-environmental policies based on economic rationalities and concludes that both agricultural sustainability and agricultural multifunctionality offer a narrow outlook for future policy development. He convincingly argues that public goods are provided through countryside multifunctionality rather than agricultural multifunctionality and give new directions to the conceptualisation of multifunctionality.

This book is a highly informative collection of material related to policy and governance of agricultural multifunctionality in the EU context and beyond, yet has left some grey areas for the reader. The book pays inadequate attention on identifying the actual beneficiaries of public goods produced by multifunctional agriculture. Oftentimes, it is not merely an issue of production of public good, but also one of who pays and who benefits from these public goods. Even in terms of the production of public goods, the book does not evaluate any alternatives to farmers as producers of pubic goods. Furthermore, the book hardly talks about negative externalities generated by multifunctional agriculture. With similar observations, a reader would perceive the ‘multifunctionality of agriculture’ as a power discourse generated within EU merely to defends its agricultural support and prevent WTO progress on agricultural deregulation. I would highly recommend this book to those having interest in ecological and natural resource economics not only because of the theoretical and empirical understanding of multifunctional landscapes but also for understanding the politics and discourse that shape our understanding of these interesting concepts.

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## *Shorter Notice*

**Luc J. A. Mougeot (editor).** *Putting Knowledge to Work—Collaborating, Influencing, and Learning for International Development.* Warwickshire, U.K.: Practical Action Publishing. 2017. 200 pages. U.K. £18.95 (Paperback).

The book, "Putting Knowledge to Work" is a collection of essays that address various aspects of the role of civil society in international development. Although the book is written from the perspective of the Canadian civil society organisation (CSOs), it is useful for the practitioners and academics located in the other countries in the Global North. The contributors of the book are professionals who have experience of working in academia and for NGOs, lending the book diversity and richness. In general, the book argues for more knowledge-driven role of the civil society to remain relevant for international development. The book gives a comprehensive overview of how the different relationships (funding, collaboration, influence) between development actors (donors, recipients, partners, stakeholders, and beneficiary communities) interact with one another to affect how knowledge is generated and applied. One of the key messages of the book is that knowledge is only useful if it is timely, relevant, and practicable. Apart from an introductory and a concluding chapter, the book comprises of four chapter. After the introductory chapter, chapter 2 examines the Global North donors' influence on the agenda-setting of Global-South recipients. It presents a comprehensive appraisal of the political economy of North-South development research partnerships. Chapter 3 looks at how collaboration between non-governmental organisations (NGOs) and universities can be nurtured. The analysis in the chapter reveals that working together, NGOs and universities collaborate prudently and take their collaboration to the next level only when it is mutually beneficial. The focus of chapter 4 is on the strategies that international NGOs use, with Global South NGOs to apply knowledge to influence attitudes, practices, and policies. The role of learning is also stressed in this chapter. It argues that for CSOs and funders to support innovation, there needs to be more exchange between domestic and internationally engaged organisations and a more explicit recognition and communication by CSOs to others, funders included, of the role of research throughout their strategy for change. Chapter 5 takes this discussion further and emphasises the role of small- and medium-sized NGOs in this regard. The chapter identifies the elements required for effective learning, planning, and processes at the headquarters level that support fieldwork and knowledge capture. The concluding chapter synthesises the findings of the essays and it also identifies gaps that need to be filled through further exploration. For example, the concluding chapter highlights that there is a growing range of disciplinary fields whose curriculum now includes international development issues and we need to know how the students and faculty from the diverse fields, such as journalism, technology, and engineering, among others, engage with development CSOs. [*Omer Siddique*].