ISSN 1608-6627

ECONOMIC REVIEW

Occasional Paper April 2006 Number 18

NEPAL RASTRA BANK

Number 18 April 2006 ECONOMIC REVIEW Occasional Paper

The Editorial Board*, Economic Review: Occasional Paper* (ISSN 1608-6627), has the pleasure of releasing this eighteenth issue of the Review on the occasion of the 51st Anniversary of the Nepal Rastra Bank (NRB). This issue incorporates analytical articles from the staff of the NRB on contemporary issues of the economy.

Though the articles are reviewed by the Editorial Board, the Board does not guarantee the accuracy of the data and analytical results along with their implications. Moreover, the views and interpretations included in the articles are those of the authors' and do not necessarily reflect and represent the views and policies of the NRB. The Editorial Board would also like to acknowledge the valuable comments and suggestion of Dr. Nephil Matangi Maskay, in the review of the articles published in this issue.

The Editorial Board invites applications of quantitative, econometric, and analytical tools and techniques as developed by the authors of the articles to draw on conclusions and suggestions to be most useful to the readers. Those interested in contributing analytical articles to the Review on any pertinent subject of the economy such as money, banking and finance, trade and balance of payments, government finance, broad-based and sustained economic growth, socio-economic development, poverty reduction, etc. are requested to submit the articles for consideration in the forthcoming issues.

Any comments, queries, suggestions, and correspondence should be directed to the Editorial Board.

Finally, for the information of the interested readers, this issue onwards the past contents of the Review will also be included at the end of each issue.

GUIDELINES FOR ARTICLE SUBMISSION

The *Economic Review: Occasional Paper* (ISSN 1608-6627) is a publication of the Nepal Rastra Bank. Submission of a paper to the Review will be taken to imply that it represents original work not previously published, that it is not being considered elsewhere for publication, and that if accepted for publication it will not be published anywhere without the consent of the Editorial Board. Further, the articles so received are subject to approval by the Editorial Board; however, the ideas and opinions expressed in the articles published in the Review are solely those of authors. The contents of articles in no way represent views and policies of the Nepal Rastra Bank or that of the Editorial Board.

Submitted articles should be written in English, typed in double spacing with wide margins (3 cm) on one side of standard paper. The title page should contain the title, the name, institutional affiliation(s), full postal address, telephone/fax number and E-mail of each author, and, if there are more than one author, indicate which author is responsible for correspondence. Footnotes, if any, should be numbered consecutively with superscript arithmetic numerals at the foot of each page. Figures and tables should be on separate sheets and have descriptive titles. References in the text should follow the author-date format and followed, if necessary, by the page numbers; for example, Hemphill (1974, 637). References should be listed alphabetically in the following style:

- Anderson, T.W., and C. Hsiao. 1982. "Formulation and Estimation of Dynamic Models Using Panel Data." *Journal of Econometrics* 18: 47–82.
- Chu, K., E. C. Hwa, and K. Krishnamurty. 1983. "Export Instability and Adjustment of Imports, Capital Inflows, and External Reserves: A Short Run Dynamic Model." In David Bigman and T. Taya, eds., *Exchange Rate and Trade Instability*. Cambridge, Mass.: Ballinger.
- Goldstrein, Morris, and Mohsin Khan. 1985. "Income and Price Effects in Foreign Trade." In R. W. Joners and P. B. Kenen, eds., *Handbook of International Economics*, vol. II. New York: Elsevier.
- Hemphill, William. 1974. "The Effect of Foreign Exchange Receipts on Imports of Less Developed Countries." *IMF Staff Papers* 21: 637–77.

The article should be accompanied by an abstract of not more than 100 words, and the preferred maximum length of a submission is 30 typed pages.

Author(s) submitting to the Review should provide their article both in hard copy and on a computer diskette. This latter should be labeled with the title of the article, the name(s) of the author(s) and the word processing software, the preferred word processing software for the Review being Microsoft Word. Submission should be sent to:

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Testing for Unit Roots in Nepalese Macroeconomic Data

Dr. Min Bahadur Shrestha[1]

Unit root test is viewed as mandatory on time series data since these data may possess specific properties like memory, trend and structural break. The results obtained by employing conventional regression methods without testing for the unit root in time series data might be misleading. This paper presents an overview of various unit root test methods and conducts the unit root test on Nepalese key macroeconomic data allowing one endogenous structural break. The test results show that out of the 18 macroeconomic variables, 10 have unit roots and the remaining 8 are stationary. An analysis of the structural break dates of these variables suggests that the Nepalese economy has gone through a structural change after mid-1980s.

I. BACKGROUND

Most of the applied economic research works use time series data. The reliability of findings of such works depends heavily upon the model specification and selection of statistical or econometric methods. As time series data may posses some specific properties such as memory, trend and structural break, the methods that are commonly used to analyse other data may not be appropriate for time series data.

The ordinary least square (OLS) method is widely used to analyse the pattern of effect of one variable on another variable. The test statistics may often show a significant relationship between variables in the regression model even though no such relationship exists between them. This type of regression is known as 'spurious regression'. The suitability and the reliability or the goodness of fit of a regression model is determined by checking the coefficient of determination (R^2) and the value of Durbin-Watson (DW). The value of R^2 close to 1 and the value of DW close to 2 shows that the goodness of fit of the model is high and the regression results are reliable. However, when R^2 is greater than the DW value, it is a good rule of thumb to suspect that the estimated regression is spurious (Granger and Newbold 1974).

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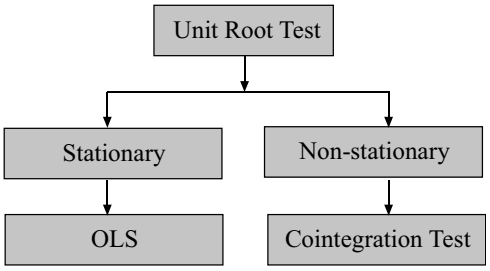
The case of spurious regression is frequently encountered while dealing with the time series data. Spurious regression occurs mainly because of the non-stationarity in the time series. To solve such a problem of spurious regression, the stationarity of the time series is examined by conducting unit root test.

A time series is considered to be stationary if its mean and variance are independent of time. If the time series is non-stationary, *i.e.*, having a mean and or variance changing over time, it is said to have a unit root. The regression analysis done in a traditional way will produce spurious results, if the time series is non-stationary. Therefore, in order to examine stationarity of the time-series, the unit root test is conducted first. The standard procedure for analysing the time series data can be explained by the following schematic diagram:

DIAGRAM 1: Procedure for Analysing Time Series Data



Most of the past empirical studies conducted on various aspects of Nepalese economy have used OLS method. The results obtained by employing time series data without considering unit roots in data may be misleading. Therefore, this paper conducts a comprehensive unit root test on key macroeconomic data of Nepal and presents the unit root results for these time series.

The subsequent section reviews various unit root test methods with and without structural change. In section 3, the nature and sources of data of this study are discussed. The unit root test results obtained by following a sequential test procedure are presented and discussed in section 4. Finally, the concluding remarks are presented in section 5.

II. UNIT ROOT TEST METHODS

There are several methods available for conducting unit root test. Dickey-Fuller (DF), Augmented Dickey-Fuller (ADF), and Phillip-Perron (PP) test methods are commonly used to examine the stationarity of a time series.

The Dickey-Fuller (DF) model is as follows:

$$y_t = \sigma + \zeta y_{t-1} + e_t \qquad (1)$$

Where σ is an intercept and e_t is a white noise. In this model, the null hypothesis is $\zeta = 1$ (nonstationary series) against the alternative hypothesis of $\zeta < 1$ (stationary series).

The error term in DF test might be serially correlated. The possibility of such serial correlation is eliminated in the following Augmented Dickey-Fuller model:

$$\div y_t \mid \sigma 2\, \iota y_{t41} 2 \sum_{i\mid 1}^{k} \eta_i \div y_{t4i} 2\, e_t \qquad (2)$$

where $\iota \mid \zeta 41$

The null hypothesis of ADF is $\iota = 0$ against the alternative hypothesis of $\iota < 0$. Non-rejection of the null hypothesis implies that the time series is non-stationary, whereas rejection means the time series is stationary.

Phillips and Perron (1988) have suggested a non-parametric test as an alternative to the ADF test. Although the ADF test has been reported to be more reliable than the Philips-Perron test, the problem of size distortion and low power of test make both these tests less useful (Maddala and Kim 2003).

Perron (1989) argues that the structural break is common in the time series data and creates problem in determining the stationarity of that time series. He shows that in the presence of a structural break in the time series, many perceived non-stationary time series may be in fact stationary. The structural break may occur due to regime change, change in policy direction, external shocks, war, etc. Perron (1989) re-examined Nelson and Plosser (1982) data and found that 11 of the 14 US macroeconomic variables were stationary when known exogenous structural break was included. Perron (1989) allows one time structural change occurring at a time T_B ($1<T_B<T$).

Following are the models developed by Perron (1989) for three different cases:

Null Hypothesis:

Model (A) $y_t \mid \sigma 2\, dD(TB)_t 2\, y_{t41} 2\, e_t \qquad (3)$

Model (B) $y_t \mid \sigma_1 2\, y_{t41} 2\, (\sigma_2 4\, \sigma_1) DU_t 2\, e_t \qquad (4)$

Model (C) $y_t \mid \sigma_1 2\, y_{t41} 2\, dD(TB)_t 2\, (\sigma_2 4\, \sigma_1) DU_t 2\, e_t \qquad (5)$

Where $D(TB)_t = 1$ if $t = T_B + 1$, 0 otherwise, and
$DU_t = 1$ if $t > T_B$, 0 otherwise.

Alternative Hypothesis:

Model (A) $y_t \mid \sigma_1 2\, \eta t 2\, (\sigma_2 4\, \sigma_1) DU_t 2\, e_t \qquad (6)$

Model (B) $y_t \mid \sigma 2\, \eta_1 t 2\, (\eta_2 4\, \eta_1) DT_t^* 2\, e_t \qquad (7)$

Model (C) $y_t \mid \sigma_1 2\, \eta_1 t 2\, (\sigma_2 4\, \sigma_1) DU_t 2\, (\eta_2 4\, \eta_1) DT_t 2\, e_t \qquad (8)$

where $DT_t^* = t - T_B$, and
$DT_t = t$ if $t > T_B$, 0 otherwise.

The first model (Model A) permits an exogenous change in the level of the series whereas the second model (Model B) permits an exogenous change in the rate of growth. The third model (Model C) allows change in both.

Perron (1989) models include one known structural break. These models cannot be applied where such breaks are unknown. Therefore, this procedure is criticised for assuming known break date which raises the problem of pre-testing and data-mining regarding the choice of the break date (Maddala and Kim 2003).

Zivot and Andrews (1992), Perron and Vogelsang (1992), and Perron (1997) have developed unit root test methods which include one unknown structural break.

Zivot and Andrews (1992) models are as follows:

Model with Intercept

$$y_t = \sigma + \chi DU_t(\varsigma) + \eta t + \zeta y_{t-1} + \sum_{j=1}^{k} \epsilon_j \Delta y_{t-j} + e_t \quad (9)$$

Model with Trend

$$y_t = \sigma + \eta t + \nu DT_t^*(\varsigma) + \zeta y_{t-1} + \sum_{j=1}^{k} \epsilon_j \Delta y_{t-j} + e_t \quad (10)$$

Model with Both Intercept and Trend

$$y_t = \sigma + \chi DU_t(\varsigma) + \eta t + \nu DT_t^*(\varsigma) + \zeta y_{t-1} + \sum_{j=1}^{k} \epsilon_j \Delta y_{t-j} + e_t \quad (11)$$

where $DU_t(\varsigma) = 1$ if $t > T\varsigma$, 0 otherwise;

$DT_t^*(\varsigma) = t - T\varsigma$ if $t > T\varsigma$, 0 otherwise.

The above models are based on the Perron (1989) models. However, these modified models do not include DT_b. On the other hand, Perron and Vogelsang (1992) include DT_b but exclude t in their models. Perron and Vogelsang (1992) models are given below:

Innovational Outlier Model (IOM)

$$y_t = \sigma + \iota DU_t + \chi D(T_b)_t + \zeta y_{t-1} + \sum_{i=1}^{k} \epsilon_i \Delta y_{t-i} + e_t \quad (12)$$

Additive Outlier Model (AOM)– Two Steps

$$y_t = \sigma + \iota DU_t + \tilde{y}_t \quad (13)$$

and

$$\tilde{y}_t = \sum_{i=0}^{k} w_i D(T_b)_{t-i} + \zeta \tilde{y}_{t-1} + \sum_{i=1}^{k} \epsilon_i \Delta \tilde{y}_{t-i} + e_t \quad (14)$$

Perron (1997) includes both t (time trend) and DT_b (time at which structural change occurs) in his Innovational Outlier (IO1 and IO2) and Additive Outlier (AO) models.

Innovational Outlier Model allowing one time change in intercept only (IO1):

$$y_t = \sigma + \chi DU_t + \eta t + \iota D(T_b)_t + \zeta y_{t-1} + \sum_{i=1}^{k} \epsilon_i \Delta y_{t-i} + e_t \quad (15)$$

Innovational Oulier Model allowing one time change in both intercept and slope (IO2):

$$y_t = \sigma + \chi DU_t + \eta t + \nu DT_t + \iota D(T_b)_t + \zeta y_{t-1} + \sum_{i=1}^{k} \epsilon_i \Delta y_{t-i} + e_t \quad (16)$$

Additive Outlier Model allowing one time change in slope (AO):

$$y_t = \sigma + \eta t + \iota DT_t^* + \tilde{y}_t \quad (17)$$

where $DT_t^* = 1(t > T_b)(t - T_b)$

$$\tilde{y}_t = \zeta \tilde{y}_{t-1} + \sum_{i=1}^{k} \epsilon_i \Delta \tilde{y}_{t-i} + e_t \quad (18)$$

The Innovational Outlier models represent the change occurring gradually whereas Additive Outlier model represents the change occurring rapidly.

More recently, some new methods have been proposed for unit root test allowing multiple structural breaks (Lumsdaine and Papell 1997; Bai and Perron 2003).

From the above discussion it is clear that there are several methods for unit root test. Different models are suggested for the time series with intercept only, with trend only, and with both. Similarly, different models are prescribed for the time series with structural break and with time trend. In such a case, certain judgement has to be applied based on economic theory in order to make assumptions about the nature of the time series under consideration. But such assumptions may not be always true and may lead to misspecification and totally wrong inferences. To solve this problem, Shrestha and Chowdhury (2005) have proposed a sequential test procedure to select an optimal method of the unit root test allowing one endogenous structural break in data. They argue that different type of test methods or models may be appropriate for different time series. In such a case, sticking to only one method for all the time series could be inappropriate when one is dealing with a large number of time series in a single research. The Shrestha-Chowdhury sequential procedure is as follows:

Stage 1. Run Perron (1997): Innovational Outlier Model (*IO2*)

As mentioned earlier, this model includes t (time trend) and DT_b (time of structural break), and both intercept (DU) and slope (DT).

- Check *t* and DT_b statistics
- If both *t* and DT_b are significant, check *DU* and *DT* statistics
- If both *DU* and *DT* are significant, select this model
- If only *DU* is significant, go to Perron (1997): *IO1* model.
  This model includes t (time trend) and DT_b (time of structural break), and DU (intercept) only.
- If only *DT* is significant, go to Perron (1997): Additive Outlier model (*AO*)

This model includes t (time trend) and DT_b (time of structural break), and slope (DT) only.

In some cases, *t* and DT_b may be insignificant in IO2 but significant in IO1 or AO. Therefore, IO1 and AO tests should be conducted after IO2 in order to check the existence of such condition.

Stage 2. If only *t* is significant in stage 1, go to Zivot and Andrews (1992) models:

Zivot and Andrews (1992) models include t but exclude DT_b.

- Run Zivot and Andrews test with intercept, trend, and both separately and compare the results. Select the model that gives the results consistent with the economic fundamentals and the available information.

Stage 3. If only DT_b is significant in stage 1, go to Perron and Vogelsang (1992) models:

Perron and Vogelsang (1992) models include DT_b but exclude t.

- Run *IOM* and *AOM*. Compare the statistics and select the appropriate model.

Stage 4. If both *t* and DT_b are not significant in stage 1, this implies that there is no statistically significant time trend and or structural break in the time series. In such a case, certain judgement has to be used to select the test method.

The rationale behind employing the above sequential procedure is that the inclusion of irrelevant information and the exclusion of relevant information may lead to misspecification of the model. Following the above procedure, a set of mixed methods or models is selected for the unit root test in this study. The results given by such a set of the mixed methods would be more realistic and consistent with the economic fundamentals and known facts.

III. THE DATA

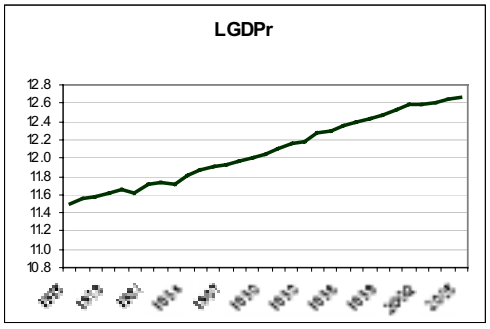
The data analysed in this paper consists of 18 macroeconomic time series of Nepal. These include 5 real sector time series, 4 money and credit time series, 3 government finance time series, 3 external sector time series, and 3 rate related time series. The sources of the data include various issues of Economic Survey published by His Majesty's Government of Nepal, Ministry of Finance, and Quarterly Economic Bulletin published by Nepal Rastra Bank. The money and credit data are available from 1960 but most of the real sector data, the government finance data and the external sector data are available from 1975 only. Out of the 3 rate related time series, the data for 2 series are available from 1965 and the data for one time series is available from 1973. For the consistency purpose, the data range covered in this study is 1975 to 2005.

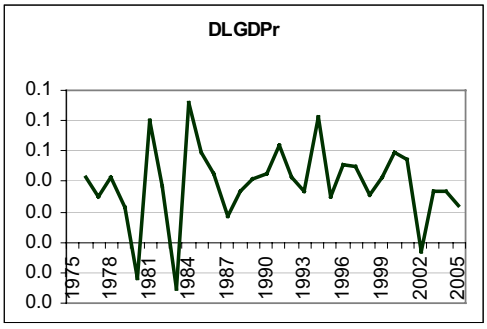
The annual data of the 16 time series for the above period have been transformed into natural log form. However, the annual data of inflation and real interest rate have not been transformed into natural log form, as some of the data of these time series are negative. The data are plotted in the graph at level as well as at first difference. The description of the data and their graphs are given below.

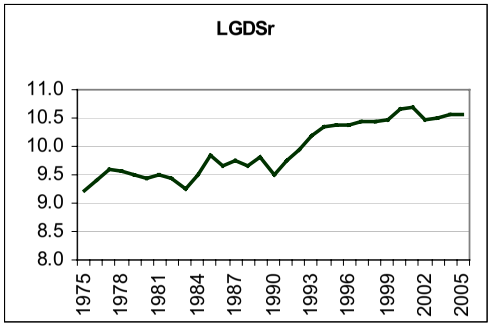
A. Real Sector Data

1. Natural Log of the Real Gross Domestic Product (*LGDPr*)
2. Natural Log of the Real Gross Domestic Saving (*LGDSr*)
3. Natural Log of the Real Investment (*LINVESTr*)
4. Natural Log of the Real Total Consumption (*LCONSUMr*)
5. Natural Log of the Real Gross Fixed Capital Formation (*LCAPFORMr*)

Level *First Difference*



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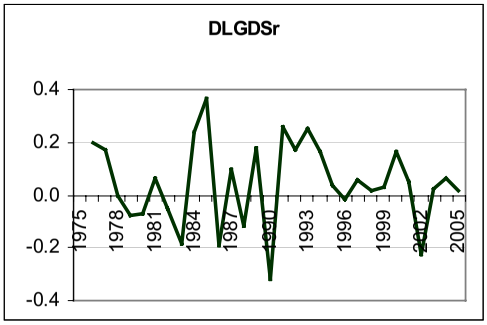
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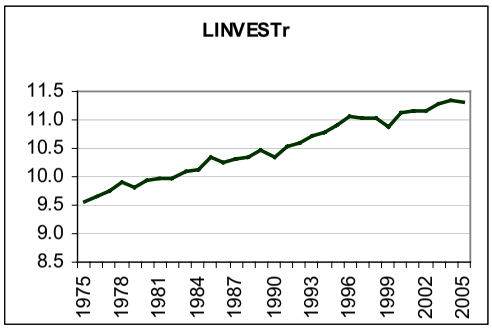
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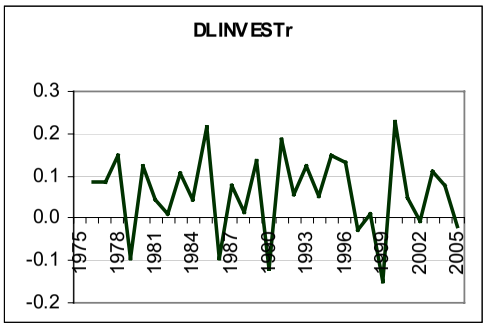
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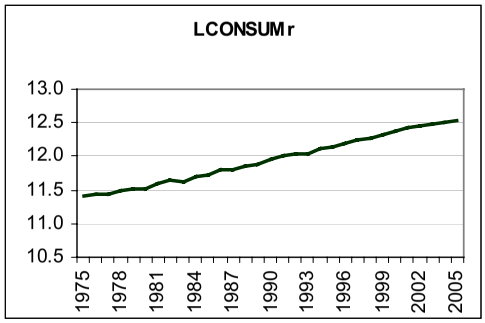
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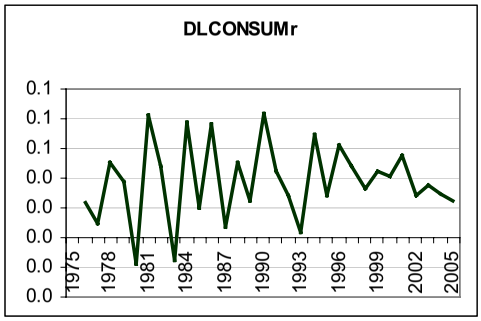
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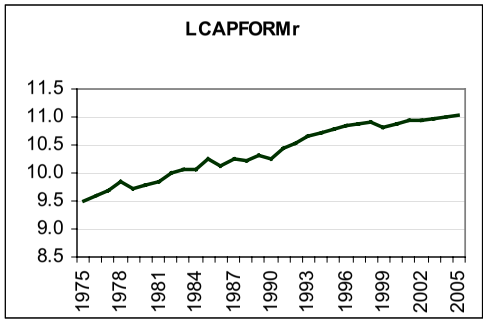
LCAPFORMr
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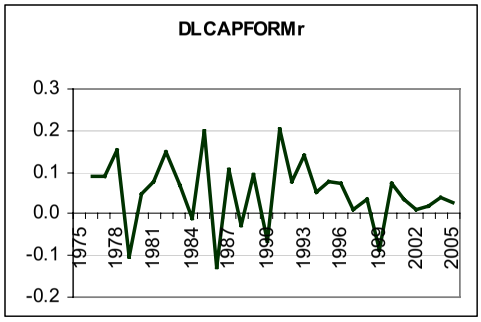
DLCAPFORMr
0.3
0.2
0.1
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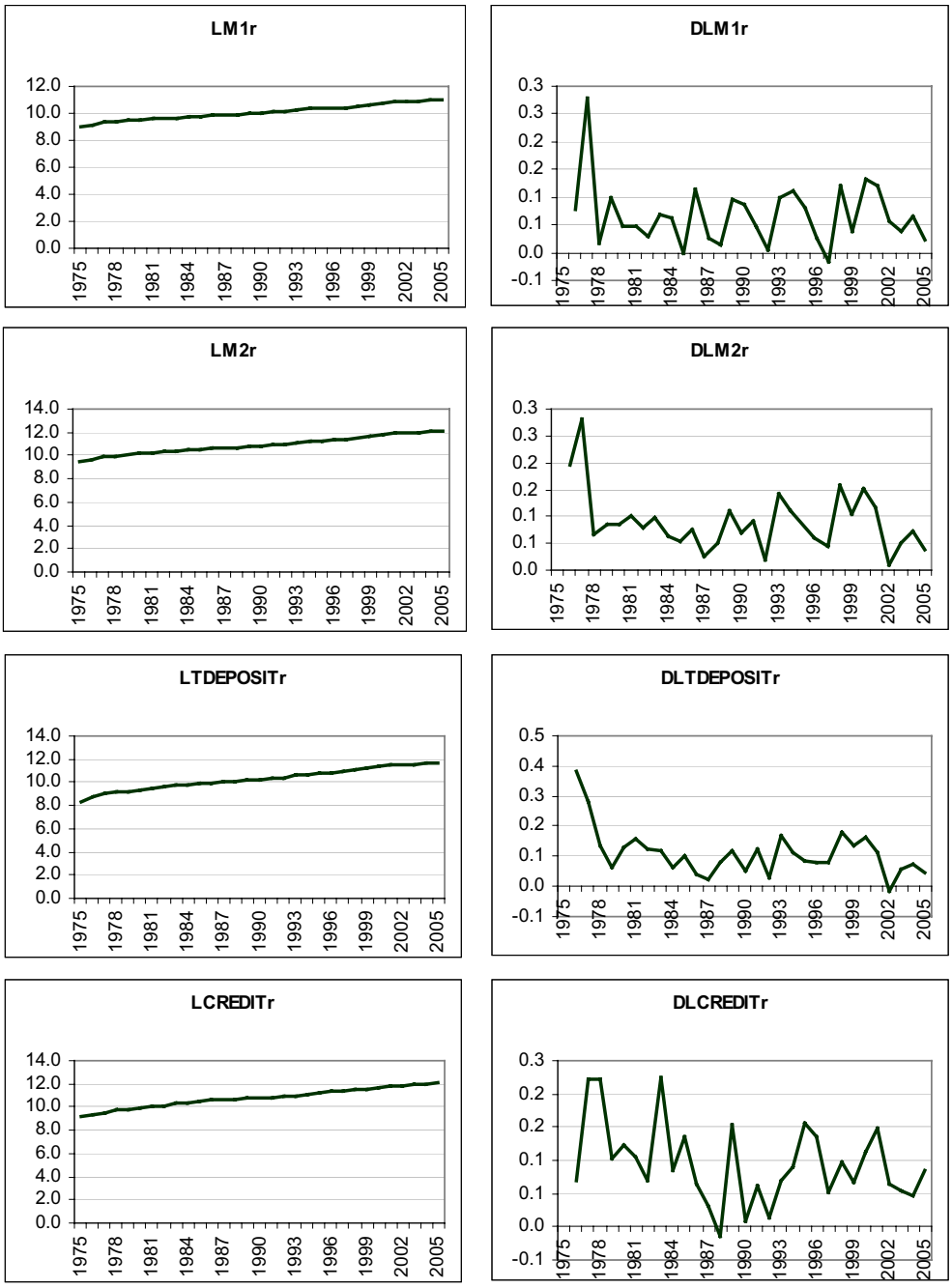
-0.1
-0.2
1975 1978 1981 1984 1987 1990 1993 1996 1999 2002 2005

B. Money and Credit Data

6. Natural Log of the Real Money Supply (*LM1r*)
7. Natural Log of the Real Broad Money (*LM2r*)
8. Natural Log of the Real Time Deposits (*LTDEPOSITr*)
9. Natural Log of the Real Domestic Credit (*LCREDITr*)

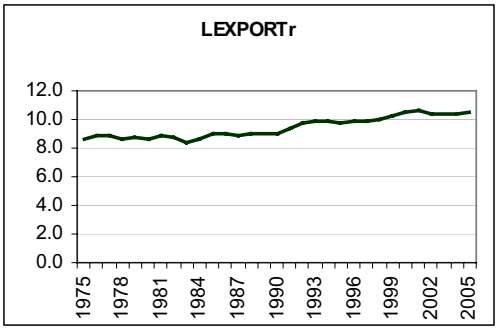
Level *First Difference*

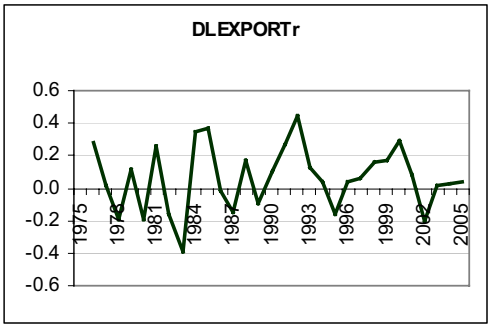


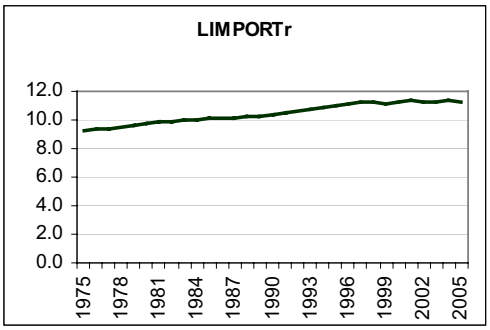
C. External Sector Data

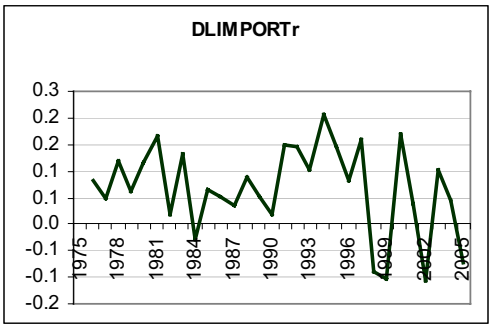
10. Natural Log of the Real Total Exports (*LEXPORTr*)
11. Natural Log of the Real Total Imports (*LIMPORTr*)
12. Natural Log of the Real Gross Forex Reserves (*LRESERVEr*)

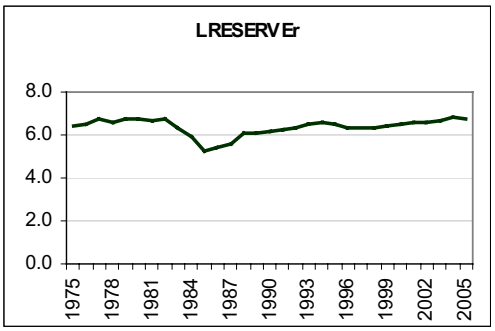
Level *First Difference*

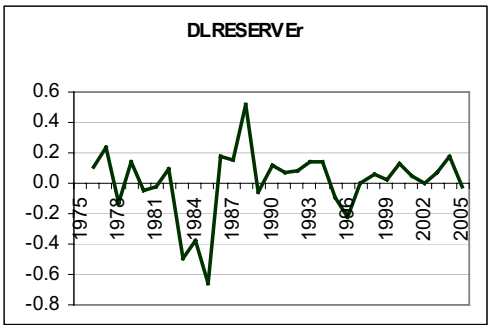








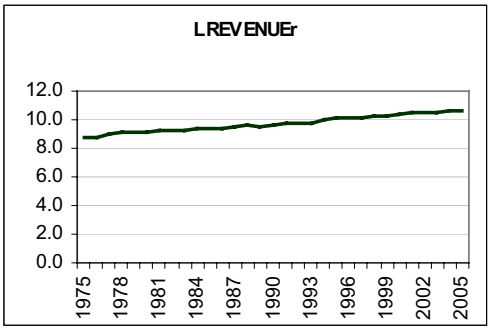


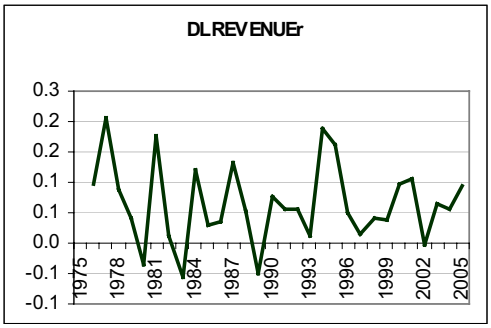


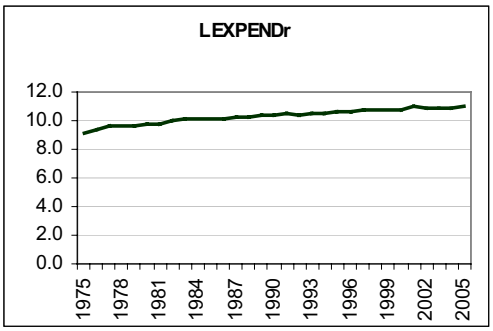
D. Government Finance Data

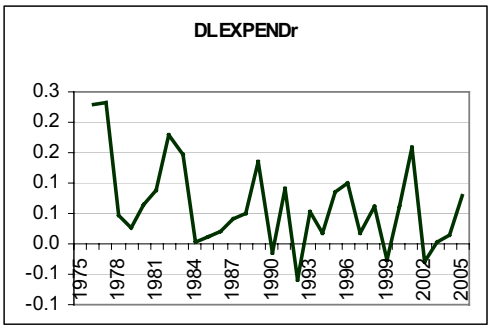
13. Natural Log of the Real Government Revenue (*LREVENUEr*)
14. Natural Log of the Real Government Expenditure (*LEXPENDr*)
15. Natural Log of the Real Government Budgetary Deficits (*LDEFICITr*)

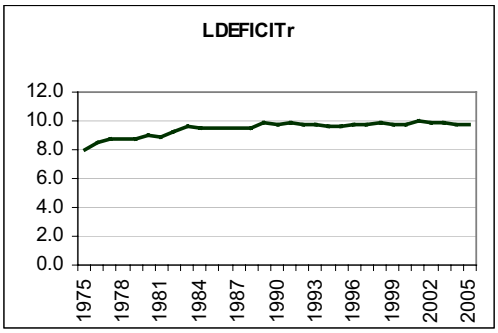
Level *First Difference*

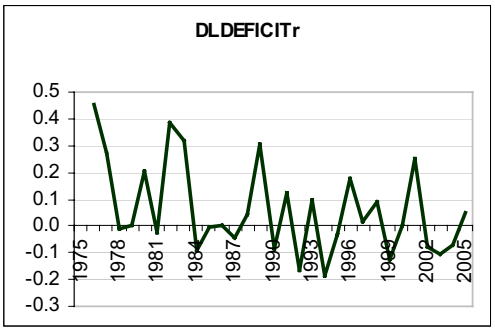






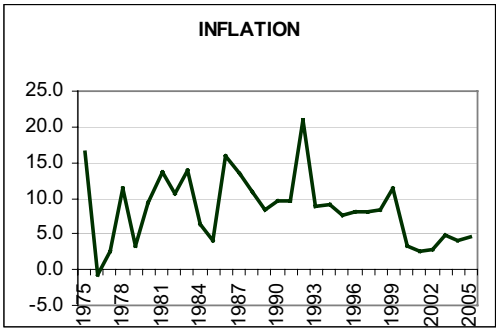


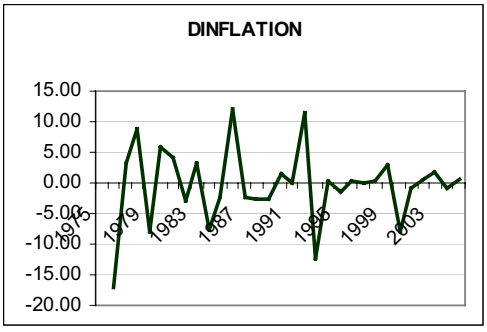


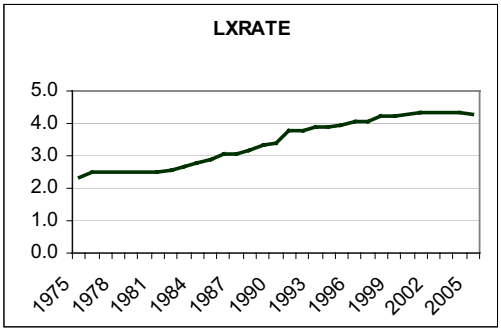


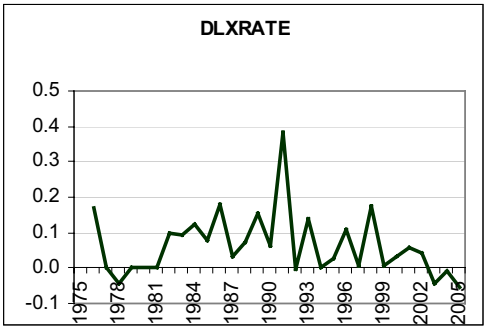
E. Rate Related Data

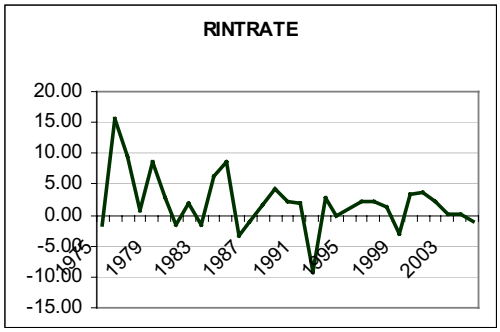
16. Inflation Rate (*INFLATION*)
17. Natural Log of the Exchange Rate (*LXRATE*)
18. Real Interest Rate (*RINTRATE*)

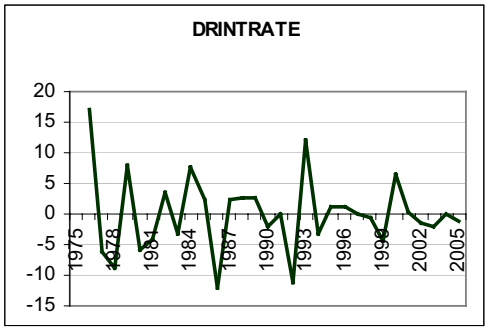












IV. UNIT ROOT TEST RESULTS

The summary test statistics given by various unit root test models using RATS programme are presented in Tables 1 to 7 below[1]. The results are compared in Table 8 and a list of selected models for each time series and their results are presented in Table 9.

[1] The coefficients and respective T-statistics of *t*, *DTb*, *DU*, and *DT* have not been reported.

TABLE 1. Perron 1997 – IO2 Model Statistics

Variables	*Tb*	*k*	*t*	DT_b	*DU*	*DT*	$T_\zeta \mid 1$		*Result*
LGDPr	1992	0	*				-3.1163		Non-stationary
LGDSr	2002	11					-9.9510	*	Stationary
LINVESTr	1999	9					-4.8947		Non-stationary
LCONSUMr	1975	12					-7.1383	*	Stationary
LCAPFORMr	2001	11					-13.7312	*	Stationary
LM1r	1999	0	*				-4.3601		Non-stationary
LM2r	2004	12					-7.3510	*	Stationary
LTDEPOSITr	1997	0	*			*	-7.5297	*	Stationary
LCREDITr	1996	11					-11.2852	*	Stationary
LIMPORTr	1997	11				*	-15.2759	*	Stationary
LEXPORTr	2004	12					-66.9656	*	Stationary Ö
LRESERVEr	1990	11					-19.2465	*	Stationary
LREVENUEr	1990	11					-12.7410	*	Stationary
LEXPENDr	1981	2					-5.9988	*	Stationary
LDEFICITr	1999	10					-9.5095	*	Stationary
INFLATION	1990	11					-17.7838	*	Stationary
LXRATE	1999	2	*				-3.8787		Non-stationary
RINTRATE	1990	11					-17.9944	*	Stationary

Critical value for $T_\zeta \mid 1$ at 5% is –5.59

* Significant at 5% level (in the case of *t, DT_b, DU*, and *DT* coefficient close to zero and T-statistics significant at 5% level)

The above unit root test statistics given by Perron 1997- IO2 model shows that the set of all the first four features (values for *t, DT_b, DU*, and *DT*) is significant for none of the series. From this, it can be inferred that this model does not best fit for any of the time series.

TABLE 2. Perron 1997 – IO1 Model Statistics

Variables	*Tb*	*k*	*t*	DT_b	*DU*	$T_\zeta \mid 1$		*Result*
LGDPr	1986	7	*			-4.1452		Non-stationary
LGDSr	1991	0	*			-4.6917		Non-stationary
LINVESTr	8[[<	89				48; 38: 79	1	Stationary
LCONSUMr	1997	12				-147.2858	*	Stationary
LCAPFORMr	2002	5	*			-3.7412		Non-stationary
LM1r	1992	12				-15.8375	*	Stationary
LM2r	2004	12	*			-7.3510	*	Stationary
LTDEPOSITr	1996	0	*		*	-6.5028	*	Stationary
LCREDITr	1995	9		*		-6.0823	*	Stationary
LIMPORTr	2002	12				-33.0881	*	Stationary
LEXPORTr	2004	12				-66.9656	*	Stationary
LRESERVEr	1998	12				-44.9903	*	Stationary
LREVENUEr	1990	11				-14.6378	*	Stationary
LEXPENDr	1980	0	*			-6.1981	*	Stationary
LDEFICITr	1994	12		*		-27.6697	*	Stationary
INFLATION	1998	0				-6.0074	*	Stationary
LXRATE	2002	2	*			-3.0857		Non-stationary
RINTRATE	2001	12				-9.9212	*	Stationary

Critical value for $T_\zeta \mid 1$ at 5% is –5.23

* Significant at 5% level (in the case of *t, DT_b*, and *DU* coefficient close to zero and T-statistics significant at 5% level)

The above table shows that all the three features (*t*, DT_b, and *DU*) are significant for none of the time series. This implies that Perron 1997 – IO1 model also is not suitable for any of the variables under consideration.

TABLE 3. Perron 1997 – AO Model Statistics

Variables	*Tb*	*k*	*t*	*DT*	$T_\zeta \mid 1$		*Result*
LGDPr	1980	10	*	*	-4.0852		Non-stationary
LGDSr	1983	0		*	-3.1833		Non-stationary
LINVESTr	8[[>	7			4; 5>>: ?		Non-stationary
LCONSUMr	1981	0	*	*	-6.0760	*	Stationary
LCAPFORMr	2001	5			-4.6699		Non-stationary
LM1r	1996	0			-4.2608		Non-stationary
LM2r	1993	1			-3.7446		Non-stationary
LTDEPOSITr	2004	8			-3.6478		Non-stationary
LCREDITr	1989	6		*	-4.5807		Non-stationary
LIMPORTr	2001	3			-4.2794		Non-stationary
LEXPORTr	1982	1			-3.9595		Non-stationary
LRESERVEr	2000	12			-7.6631	*	Stationary
LREVENUEr	1990	1		*	-4.6790		Non-stationary
LEXPENDr	1983	2			-6.4830	*	Stationary
LDEFICITr	1986	1			-4.4572		Non-stationary
INFLATION	1996	0			-6.1113	*	Stationary
LXRATE	1991	11			-3.4958		Non-stationary
RINTRATE	1995	0			-6.5870	*	Stationary

Critical value for $T_\zeta \mid 1$ at 5% is –4.83

* Significant at 5% level (in the case of *t* and *DT* coefficient close to zero and T-statistics significant at 5% level)

The AO model statistics reported in the above table reveals that this model is relevant for LGDPr and LCONSUMr only as *t* and DT_b are significant for these variables.

TABLE 4. Zivot and Andrews 1992 Model Statistics (With both intercept and trend)

Variables	*Tb*	*k*	*t*	$T_\zeta \mid 1$		*Result*
LGDPr	1980	0	*	-3.6382		Non-stationary
LGDSr	1993	0	*	-4.3934		Non-stationary
LINVESTr	8[[<	7	1	4<5 [9?	1	Stationary
LCONSUMr	1980	0	*	-6.0472	*	Stationary
LCAPFORMr	1993	0		-4.8340		Non-stationary
LM1r	2001	0	*	-4.3732		Non-stationary
LM2r	2000	0		-5.1305	*	Stationary
LTDEPOSITr	1998	0	*	-7.4465	*	Stationary
LCREDITr	1987	0	*	-3.0651		Non-stationary
LIMPORTr	1994	0		-3.8302		Non-stationary
LEXPORTr	1991	0	*	-3.3140		Non-stationary
LRESERVEr	1983	2		-6.7149	*	Stationary
LREVENUEr	1994	0	*	-5.1127	*	Stationary
LEXPENDr	1982	0		-5.5227	*	Stationary
LDEFICITr	1982	0		-5.5402	*	Stationary
INFLATION	1994	0		-6.9840	*	Stationary
LXRATE	1991	0		-2.7365		Non-stationary
RINTRATE	1984	0		-7.6789	*	Stationary

Critical value for $T_\zeta \mid 1$ at 5% is -5.08

* Significant at 5% level (in the case of *t*, coefficient close to zero and T-statistic significant at 5% level)

TABLE 5. Zivot and Andrews 1992 Model Statistics (With intercept only)

Variables	*Tb*	*k*	*t*	T_{ζ} | 1	*Result*
LGDPr	1993	0	*	-4.6514	Non-stationary
LGDSr	1993	0	*	-5.0477 *	Stationary
LINVESTr	8[[:	7	1	4<57; >> 1	Stationary
LCONSUMr	1980	0	*	-5.9782 *	Stationary
LCAPFORMr	1999	0		-3.7762	Non-stationary
LM1r	2000	0	*	-4.7259	Non-stationary
LM2r	1998	0		-5.3235 *	Stationary
LTDEPOSITr	1998	0	*	-6.6856 *	Stationary
LCREDITr	1990	0	*	-3.1506	Non-stationary
LIMPORTr	2001	0		-1.9247	Non-stationary
LEXPORTr	1992	0	*	-3.5272	Non-stationary ä
LRESERVEr	1983	2		-6.7990 *	Stationary
LREVENUEr	1994	0	*	-4.9619 *	Stationary
LEXPENDr	1982	0		-6.1248 *	Stationary
LDEFICITr	1982	0		-6.1338 *	Stationary ä
INFLATION	1981	0		-6.2987 *	Stationary
LXRATE	1989	0		-2.2136	Non-stationary
RINTRATE	1980	0		-7.1215 *	Stationary

Critical value for T_{ζ} | 1 at 5% is –4.80

* Significant at 5% level (in the case of *t*, coefficient close to zero and T-statistic significant at 5% level)

TABLE 6. Zivot and Andrews 1992 Model Statistics (With trend only)

Variables	*Tb*	*k*	*t*	T_{ζ} | 1	*Result*
LGDPr	1983	0	*	-3.5685	Non-stationary
LGDSr	1983	0	*	-3.2532	Non-stationary
LINVESTr	8[?8	7	1	4<5=7< 1	Stationary
LCONSUMr	1997	0	*	-4.5542 *	Stationary
LCAPFORMr	1998	0		-3.9576	Non-stationary
LM1r	1993	0	*	-4.2780	Non-stationary
LM2r	1993	0		-4.5651 *	Stationary
LTDEPOSITr	2001	0	*	-5.6907 *	Stationary
LCREDITr	1979	0	*	-3.5910	Non-stationary
LIMPORTr	1998	0		-2.4638	Non-stationary
LEXPORTr	1984	0	*	-3.6375	Non-stationary
LRESERVEr	1986	2		-4.7334 *	Stationary
LREVENUEr	1991	0	*	-4.0304	Non-stationary
LEXPENDr	1984	0		-5.0671 *	Stationary
LDEFICITr	1984	0		-4.4678 *	Stationary
INFLATION	1993	0		-6.9417 *	Stationary
LXRATE	1999	0		-2.2189	Non-stationary
RINTRATE	1982	0		-7.7936 *	Stationary

Critical value for T_{ζ} | 1 at 5% is –4.42

* Significant at 5% level (in the case of *t*, coefficient close to zero and T-statistic significant at 5% level)

The test statistics given by the Zivot and Andrews 1992 models are presented in Table 4, 5, and 6 above. Three different models (*viz*. with both intercept and trend, with

intercept only, and with trend only) return identical *t* values[2] and number of *k*. But the structural break (*Tb*) date and values for $T_\zeta \mid 1$ are different for these three models. Regarding the stationarily of the time series, these models agree in the case of 16 time series except for LGDSr and LREVENUEr.

TABLE 7. Perron and Vogelsang 1992 Model Statistics (Innovational Outlier Model)

Variables	*Tb*	*k*	DT_b	*DU*	$T_\zeta \mid 1$	*Result*
LGDPr	1982	2		*	-1.7582	Non-stationary
LGDSr	1991	0			-4.0878	Non-stationary
LINVESTr	8[[7	8			495 88[[	Non-stationary
LCONSUMr	1984	2			-1.0416	Non-stationary
LCAPFORMr	1989	1			-3.4777	Non-stationary
LM1r	1992	0			-2.2811	Non-stationary
LM2r	1992	0			-3.9607	Non-stationary
LTDEPOSITr	8[[:	7			4;5 7;>1	Stationary
LCREDITr	1993	0			-3.7263	Non-stationary
LIMPORTr	1989	3			-3.3513	Non-stationary
LEXPORTr	1989	0			-3.0950	Non-stationary
LRESERVEr	1988	2			-3.5535	Non-stationary
LREVENUEr	1992	2			-2.5022	Non-stationary
LEXPENDr	8[[;	;			4;5 97<1	Stationary
LDEFICITr	1980	0			-5.5703	* Stationary
INFLATION	1991	0			-5.8141	* Stationary
LXRATE	1987	4			-2.9876	Non-stationary
RINTRATE	1984	0			-6.3814	* Stationary

Critical value for T_ζ at 5% is -4.19

* Significant at 5% level (in the case of DT_b, coefficient close to zero and T-statistic significant at 5% level)

As mentioned earlier, the Perron and Vogelsang model includes DT_b. In the above table, DT_b is found to be statistically significant for none of the time series, while *DU* is significant for LGDPr only.

[2] Not reported here.

TABLE 8. Unit Root Test Result Comparison

	Perron 1997			Zivot & Andrews 1992			Perron & Vogelsang 1992	
Series	IO2	IO1	AO	Both	Intercept	Trend	IOM	Result
LGDPr	N	N	N*	N*	N*	N*	N	N*
LGDSr	S	N	N	N*	S*	N*	N	N*
LINVESTr	K	S	K	S1	S1	S1	K	S*
LCONSUMr	S	S	S*	S*	S*	S*	N	S*
LCAPFORMr	S	N	N	N	N	N	N	?
LM1r	N	S	N	N*	N*	N*	N	N*
LM2r	S	S	N	S	S	S	N	?
LTDEPOSITr	S	S	N	S*	S*	S*	S	S*
LCREDITr	S	S	N	N*	N*	N*	N	N*
LIMPORTr	S	S	N	N	N	N	N	?
LEXPORTr	S	S	N	N*	N*	N*	N	N*
LRESERVEr	S	S	S	S	S	S	N	?
LREVENUEr	S	S	N	S*	S*	N*	N	S*
LEXPENDr	S	S	S	S	S	S	S	?
LDEFICITr	S	S	N	S	S	S	S	?
INFLATION	S	S	S	S	S	S	S	?
LXRATE	N	N	N	N	N	N	N	?
RINTRATE	S	S	S	S	S	S	S	?

N = Non-stationary, S = Stationary

* Significant (All the given features, i.e., *t, DT_b*, *DU*, and *DT*, whichever relevant, have coefficient close to zero and T-statistics significant at 5% level)

The results given by various models are summarised in Table 8 above. It can be seen from the table that Perron 1997:AO model is optimal for 2 time series: LGDPr and LCONSUMr. The Zivot & Andrews 1992 models are the best models for 9 time series, *viz.* LGDPr, LGDSr, LINVESTr, LCONSUMr, LM1r, LTDEPOSITr, LCREDITr, LEXPORTr and LREVENUEr. However, there is no such a match for half of the time series under consideration, which include LCAPFORMr, LM2r, LIMPORTr, LRESERVEr, LEXPENDr, LDEFICITr, INFLATION, LXRATE and RINTRATE. Some judgement based on the economic fundamentals has to be used to select the optimal model for these 9 time series.

Regarding the power of test, the Perron and Vogelsang 1992 model is robust. The testing power of Perron 1997 models and Zivot and Andrews models are almost the same (Wilson 2004). On the other hand, Perron 1997 model is more comprehensive than Zivot & Andrews 1992 model as the former includes both *t* and DT_b while the later includes *t* only. Therefore, Perron 1997:AO model is selected for LGDPr and LCONSUMr and Zivot and Andrews 1992 model is selected for 7 time series. As there is no matching model for 9 time series, the Perron and Vogelsang 1992 model is selected for these series based on its robustness.

The selected models for all the 18 time series and their test results are presented in Table 9 below.

TABLE 9. Selected Models and Results

Series	Selected Model	Tb	$T_{\zeta} \mid 1$		Result
LGDPr	Perron 1997: AO	1980	-4.0852		N
LGDSr	Zivot & Andrews 1992: Both	1993	-4.3934		N
LINVESTr	Zivot & Andrews 1992: Both	1995	-5.4928	*	S
LCONSUMr	Perron 1997: AO	1981	-6.0760	*	S
LCAPFORMr	Perron & Vogelsang 1992	1989	-3.4777		N
LM1r	Zivot & Andrews 1992: Both	2001	-4.3732		N
LM2r	Perron & Vogelsang 1992	1992	-3.9607		N
LTDEPOSITr	Zivot & Andrews 1992: Both	1998	-7.4465	*	S
LCREDITr	Zivot & Andrews 1992: Both	1987	-3.0651		N
LIMPORTr	Perron & Vogelsang 1992	1989	-3.3513		N
LEXPORTr	Zivot & Andrews 1992: Both	1991	-3.3140		N
LRESERVEr	Perron & Vogelsang 1992	1988	-3.5535		N
LREVENUEr	Zivot & Andrews 1992: Both	1994	-5.1127	*	S
LEXPENDr	Perron & Vogelsang 1992	1994	-4.4205	*	S
LDEFICITr	Perron & Vogelsang 1992	1980	-5.5703	*	S
INFLATION	Perron & Vogelsang 1992	1991	-5.8141	*	S
LXRATE	Perron & Vogelsang 1992	1987	-2.9876		N
RINTRATE	Perron & Vogelsang 1992	1984	-6.3814	*	S

Critical values for $T_{\zeta} \mid 1$ at 5% level: Perron 1997:AO = -4.83, Perron & Vogelsang 1992 = -4.19, and Zivot & Andrews 1992:Both = -5.08.
N = Non-stationary, S = Stationary

The results given by the selected models (Table 9) show that 10 of the 18 macroeconomic variables of Nepal are non-stationary and the remaining 8 are stationary. The structural break dates show that, 15 macroeconomic time series have undergone through a structural break in or after 1984, while 3 time series, *viz*. LGDPr, LCONSUMr, and LDEFICITr had gone through a structural break before 1984. As Nepal started implementing various economic and financial liberalisation measures since 1984, it can be argued that Nepalese economy has gone through a structural change as a result of the implementation of liberalisation policy.

V. CONCLUDING REMARKS

Due to the specific properties possessed by the time series data, the traditional methods of regression may not be appropriate for analysing these data. The stationarity of the time series should be determined first by conducting unit root test before running any regression. There are several methods and models available for unit root test, which differ in their emphasis on one or more of the time series properties. The researcher has to apply certain judgement based on economic theory in order to make assumptions about the nature of the time series under consideration. But such assumptions may not be always true and may lead to misspecification of models and totally wrong inferences. For this reason, researchers face some practical problem in selecting appropriate methods and models of unit root test for the time series data. Against this backdrop, a sequential

procedure proposed by Shrestha and Chowdhury (2005) have been followed in this study to select an optimal method of unit root test.

The results of the unit root test conducted employing the Shrestha-Chowdhury sequential procedure allowing one unknown structural break in the time series suggest that out of the 18 Nepalese macroeconomic variables considered in this study, 10 are non-stationary, while the remaining 8 are stationary. The results would be misleading if the ordinary least square (OLS) or similar traditional regression method were applied to analyse these non-stationary data. The results also show that 15 time series have undergone a structural change in or after 1984, while only three variables have gone through such a break before 1984. The structural break date of a time series also should be taken into account to correctly specify the model.

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Remittance Inflows to Nepal: Economic Impact and Policy Options

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Remittances are generally thought to contribute to savings and investments thus leading to economic growth. In 2004, officially recorded remittances flows to developing countries were greater than US$ 125 billion. The rise in remittances, that are less affected by economic cycles in the recipient country, are taking place at a time of declining official development assistance which adds more significance to the remittance debate and research. The various uses of the remitted funds vary in their potential to reduce poverty and create economic security for the household and community. In Nepal's case, in more recent years, remittances have been playing a pivotal role in the country's economic development by relaxing the foreign exchange constraints and strengthening the balance of payments, among others. Although a gamut of policy measures have been taken by the concerned authorities for encouraging remittances through the banking channel, more needs to be done.

I. INTRODUCTION

Development economics has traditionally taken into account foreign savings as the key to augmenting a nation's capital output ratio. Factors such as foreign direct investment (FDI), official development assistance (ODA), foreign trade, the transfer of technology and, more recently, remittances have been incorporated into these studies.

The macroeconomic effects of remittances enjoy a strong theoretical tradition dating back to Adam Smith, David Ricardo and the labor theory of value and comparative advantage. It advanced right up to the endogenous growth innovation in the 1980s assigning human capital a crucial role in modern production and exchange.

Generally, remittances refer to that portion of migrants' earnings sent from the migration destination to the place of origin. Even though they can also be sent in kind, the term 'remittances' is normally limited to denote monetary and other cash transfers transmitted by migrant workers to their families and communities.

International migrant remittances have become an important source of external finance in developing countries. Remittances to developing countries from overseas

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resident and nonresident workers are estimated to have risen by 8 percent in 2004, reaching US$ 125.8 billion, making them the second largest source of development finance after FDI. That rise followed a 17 percent increase in 2003. Much of the 8 percent increase in 2004 happened in low-income countries, where remittances soared by 18 percent. Since 2001, remittances to developing countries have augmented by almost 50 percent. Low-income countries constitute almost half of the increase: the share of remittances flowing to low-income countries catapulted from 28 percent in 2001 to 35 percent in 2004.[1]

The major portion of the $41 billion increase in remittances to developing countries from 2001 to 2004 was concentrated in South Asia ($17 billion), Latin America and the Caribbean ($13 billion), and to a lesser degree, East Asia and the Pacific ($7 billion). The increases in remittance flows have been especially strong in China, India, Mexico, Pakistan and the Philippines.[2]

The upsurge in remittances flows over the past couple of years can be ascribed to a variety of causes. There have been noticeable reductions in remittance sending costs in some countries—for example, by 60 percent in the U.S.—Mexico corridor since 1999. Growing migration also play crucial roles. The sizable depreciation of the dollar against most other major currencies over the past three years has raised the dollar value of nondollar remittances over time. Some portion of the rise in remittance flows can be attributed to improvements in data recording by central banks.

While the development community continues the search for additional resources to finance the Millennium Development Goals, remittances—pro-poor and cyclically stable, compared to other capital flows—seem to be a promising source. In this context, a number of remittance initiatives are underway.[3]

Against the foregoing background, this paper first attempts to summarize some concepts and measurement pertaining to remittances followed by an investigation into the

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[1] These data taken from World Bank (2005) denote officially recorded remittances, which are sometimes estimated. Flows through informal channels, such as hundi, are not captured in the official statistics but are assumed to be rather large.

[2] The remittance flows to these countries are presented below:

(US$ billion)

Country	2001	2003
China	1.2	4.6
India	11.1	17.4
Mexico	9.9	14.6
Pakistan	1.5	4.0
Philippines	6.2	7.9

Source: World Bank (2005).

[3] For instance, the Sea Island G-8 Summit in June 2004 called for better coherence and coordination of international organizations working to enhance remittance services and increase the development impact of remittance earnings. The World Bank, the International Monetary Fund (IMF) and the United Nations have constituted an interagency, intergovernmental technical group to improve remittance statistics. The Bank for International Settlements and the World Bank have set up a special task force on international retail payment systems to improve transparency in remittance transactions. Regional development banks, bilateral aid agencies and other international agencies have also begun ambitious programs to collect information and facilitate remittance flows. For more on the remittance initiatives, see Maimbo and Ratha (2005).

different theories for remitting. This is preceded by the general impact of remittances together with the use of remittance income. The impact of remittances on the Nepalese economy is then scrutinized followed by an analysis of the various initiatives undertaken by the concerned officials for encouraging remittance inflows through the official channel.[4] Before concluding, the paper attempts to provide some policy options for increasing remittances through the official channel as well as some measures to use remittance income productively.

II. CONCEPTS AND MEASUREMENT

Remittances fall under the group of items classified as transfers in the balance of payments (BOP). In the fifth edition of the balance of payments manual (BPM5), transfers are defined as offsetting entries for real sources or financial items provided, without a *quid pro quo*, by one economy to another. Putting it in another way, whenever an economy does not receive or provide recompense in the form of real resources of financial items for goods, services or financial items supplied to or received from another economy, it becomes a transfer for the purposes of BOP accounting.

Two kinds of transfer are identified in the BPM5: current transfers and capital transfers. While current transfers are recorded in the current account, capital transfers are recorded in the capital account.

Current transfers are categorized on the basis of the sector of the compiling economy into two main groups: general government and other sectors. General government transfers encompass current transfers, in cash or in kind, between governments and international organizations. Current transfers between other private sectors of the economy and non-residents consist of those occurring between individuals, between non-governmental institutions or organizations (or between the two groups) or between non-resident government institutions and individuals or non-governmental institutions. Moreover, the category of workers' remittances encompasses current transfers by migrants who are employed in other economies and considered residents there.

Standard measures on remittances are based on three items in the BOP reports (as incorporated in the IMF Balance of Payments Statistical Yearbooks). These are in the form of : a) workers' remittances (money sent by workers living abroad for greater than one year); b) compensation of employees (gross earnings of foreigners living abroad for less than one year; and c) migrant transfer (net worth of migrants moving from one country to another.

[4] It should be mentioned at the outset that internal remittances (defined as the money and/or goods sent to rural areas from urban areas by migrant workers) are equally important from a development perspective. For instance, Adams (1997) has demonstrated that in Pakistan while external remittances have a positive and significant impact on the accumulation of land, internal remittances have a significant and positive effect on the accumulation of agricultural capital. DeWind and Holdaway (2005) have also made a comprehensive analysis on the importance of internal remittances.

III. MOTIVES FOR REMITTING

According to the literature on remittances, a number of theories have emerged to explain the causes behind the migrants' decisions to send funds (cash and goods) to their relations back home.[5] An important research on the motivations to remit has been developed under the framework of the 'new economics of labor migration' or NELM.[6] Families in migrant-sending areas, particularly rural communities, have indulged in migration by sending one or more members off as migrants (normally, sons and daughters of the household head), who subsequently share part of their earnings with the rural household, through remittances. The NELM theory states that imperfections in rural credit and risk markets (for instance, farmers' inability to obtain credit and insure against income loss) generate incentives to participate in migration by sending family members to work in the city or abroad. Migrants function as financial intermediaries, substituting for the missing rural bank or insurance institution. Once they are set up at their destinations, migrants provide the family members at the origin with required capital through remittances, and with income insurance, or simply the promise to remit if the origin household suffers an adverse income shock.

Generally, the motives behind remittances can be grouped under three headings: a) the altruistic motive, b) the self-interest motive, and c) implicit family contract: loan repayment and co-insurance.

Altruistic Motive

According to the altruism or livelihoods school of thought, remitting is an obligation to the household. A model of pure altruism would envisage that as migrant incomes rise, a portion of the incremental income is passed on to the origin household through remittances. Remittances are dispatched owing to affection and responsibility towards the family. The altruistic model states that sending remittances brings satisfaction to the migrant out of a concern for the welfare of his family. When motivated by altruism, remittances can vary based on the number of household members that migrate and the poverty status of the receiving household, although it has been shown that poorer households obtain a larger proportion of their total income from remittances than do non-poor ones.

Self-Interest Motive

A divergent motivation is to assume that the migrant is primarily stimulated by an economic and financial self-interest, when sending remittances to the home country. The argument supporting this line of theory is that at every point in time, the successful migrant in the foreign country saves. Subsequently, the migrant wants to know how (in which assets) and where (in which country) to accumulate his wealth. The home country is the obvious place to invest, at least part of his assets, by purchasing property, land and

[5] For an elaborated discussion, see Addison (2004) and Solimano (2003).
[6] The NELM theory is examined in Stark and Bloom (1985).

financial assets, among others. These assets could generate a higher rate of return than assets in the host country though their risk profile can also be greater.

Implicit Family Contract: Loan Repayment and Co-Insurance

Economic theory has devised explanations of the remittances process that take the family—rather than the individual—as the major unit of analysis.[7] According to this theory, families seem to develop an implicit contract among those who opt to reside abroad, the migrant, and those who stay at home. The implicit contract consists of an inter-temporal dimension, which could last for many years or even decades, as a time horizon.

The contract is a combination of the elements of investment and repayment. As per the loan repayment theory the family invests in the education of the migrant and usually finances the costs of migrating (travel and subsistence costs in the host country). This is the loan (investment) element of the theory. The repayment part happens after the migrant settles in the foreign country and his income profile begins to rise over time and is in a position to begin repaying the loan (principal and interest) back to the family in the form of remittances. This implicitly connotes that the family invests in a higher yield 'asset' (the migrant) who obtains a higher income level in the foreign country than other family members that live and work at home. The amount to be remitted will however be governed by various factors such as the income profile of the migrant.

A variant of the theory of remittances as an implicit family contract between the migrant and those at home is based on the notion of risk diversification. If it is assumed that economic risks between the sending and foreign country are not positively correlated, then it becomes an opportune strategy for the family as a whole to send some of its members abroad (often the most educated) to diversify economic risks. The migrant can then help to support his family in worsening times at home. Conversely, for the migrant, having a family in the home is insurance as bad periods can also take place in the foreign country. In this model, migration is a co-insurance strategy with remittances playing the part of an insurance claim. Analogous to any contract there exists a potential problem of enforcement (for instance, ensuring that the terms of the contract are respected by the parties). Still, enforcement seems to be simpler, in principle owing to the fact that these are implicit family contracts, helped by considerations of family trust and altruism.

Whatever the motivation to migrate and remit, the different uses to which the remitted funds are applied vary in their potential to reduce poverty and create economic security for the household and community. Remittances that form part of productive investment seem to have an effect on long-term poverty reduction, leading to less vulnerability at both the household and the community level. There could also be a reduction in inter-household inequality. Conversely, if remittances are utilized in domestic consumption, the impact could be only of short duration and may lead to a rise in inter-household inequality.[8]

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[7] For an extensive illustration on this issue, see Poirine (1997).

[8] It should be noted that the theories pertaining to the motives for remittance transfers indicate that it is only in the altruistic case that there is a no '*quid pro quo*.' Transfers take place solely out of concern for the family and fits into the standard definition of transfers in the BOP sense. The other

IV. ECONOMIC IMPACT OF REMITTANCES

Remittances can generate a positive effect on the economy through various channels such as savings, investment, growth, consumption, and poverty and income distribution. Workers' remittances flow in as a component of foreign savings and as such complements national savings by increasing the total pool of resources available for investment.

Remittances constitute an integral part of household livelihood strategies. They make a direct contribution to raising household income, while broadening the opportunities to increase income. They also permit households to increase their consumption of local goods and services.

At the community level, remittances create multiplier effects in the domestic economy, producing employment opportunities and spurring new economic and social infrastructure and services, especially where effective structures and institutions have been set up to pool and direct remittances. Where these have been set up and encouraged, and where the state is cooperative, remittances can bring about a change, especially in remote rural areas where state resources have not been effective.

The poverty reducing and income distribution effect of remittances is also significant.[9] This case is based on the fact that the recipients of remittances are often low-income families whose offspring left the country to work abroad. In this situation, migration is taken as a response to escape poverty at home and improve the income-earning capacity of the migrant by attempting to enter foreign labor markets in richer countries. Again, remittances assist in alleviating poverty of the family of migrants in the home country by supporting their income through transfers.

Remittances assist in augmenting national income by providing foreign exchange and raising national savings and investment as well as by providing hard currency to finance essential imports hence curtailing any BOP crisis.[10] Since they bear no interest, do not have to be repaid, and their utilization is not tied to specific investment projects with high import content, they have a more positive effect on BOP than other monetary flows such as direct investments or loans.

V. USES OF REMITTANCES: PRODUCTIVE VERSUS NON-PRODUCTIVE

It has been shown through a community- and family-level approach that remittances enable better health care, nutrition, housing and education.[11] However, spending patterns are governed by a host of factors such as the strength of the migrant's kinship ties and intent to return to the country of origin. Migrants who wish to return tend to remit than those who are permanently integrated into the host countries; hence, remittances may slow as ties weaken with time. Still, this argument supporting the remittance decay

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motives behind transfers indicate that there may be a *quid pro quo* as in the case of implicit family contract, though this may not be immediate or binding.

[9] For a comprehensive explanation, see Barham and Boucher (1998).

[10] This aspect is delineated in Buch *et. al* (2002).

[11] This has been illustrated by Chimhowu, Piesse and Pinder (2005).

hypothesis remains anecdotal.[12] Although it is true that the propensity to remit, that is, the proportion of income remitted by a migrant, may go down over time, it rarely vanishes, since first-generation migrants (and often even second-generation migrants) continue to send money to their original communities. Even if the propensity to remit declines, the remittance volume rises with the sharp increase in income levels of migrants over time.

In many countries, a large portion of remittances are invested in real estate, demonstrating both a desire of migrants to provide housing to families left behind and a paucity of other investment instruments in the recipient. Whether remittances are utilized for consumption or purchasing houses, or other investments, they produce positive impact on the economy by stimulating demand for other goods and services. Moreover, the positive macroeconomic or development impact of remittances could become more effective if migrants form associations and their commitment to their home country becomes 'institutionalized'.[13]

While the contributions of remittances can be significant with positive growth impacts, the very act of the citizens migrating can also generate some negative growth impacts. This adverse growth effect will, however, depend largely on the type of migrant that left home, the state of the labor market and the productivity of the migrant. If the migrant was an unskilled worker of low productivity, or an unemployed person, demonstrating slack or excess supply in the labor market, it can safely be argued that the impact of migration on output in the home country will be meager. On the other hand, if the emigrant is a highly skilled worker, such as a medical doctor or an information technology professional with a high direct and indirect contribution to output for instance, then the negative growth impact will definitely be large. The permanency of remittance flows together with the macroeconomic importance would imply, however, that the negative effects of migration might only be a short-term phenomenon.

Still, some argue that remittances are utilized basically for non-productive purposes, and have concluded that they do little to stimulate development in the countries of origin. A few studies undertaken relating to the uses of remittances show that savings produced by remittances are frequently directed to purchases of non-productive assets.[14] Remittances were also seen to increase dependency. These inflows are quite volatile in the sense that countries that rely too much on them may encounter economic shocks when the flow is disrupted.[15]

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[12] The 'remittance decay' hypothesis indicates that the amount of remittances sent by migrants to their countries of origin declines through time. For details, see Greico (2004).

[13] An example of such migrant associations is the Home Town Associations in the US, where organized migrants from various Latin American countries such as El Salvador, Guatemala, Honduras, Mexico and the Dominican Republic come together and dispatch donations to finance investment for community projects in their home countries. For more on this, see Ellerman (2003).

[14] Evidences from microeconomic surveys demonstrate that purchases of land, housing and other real assets, are the most common uses of remittances in the country of origin. In some instances this led to ballooning prices of these real assets.

[15] The Gulf war, for instance, put Jordan, Sudan and Yemen, among others, in difficulty owing to the massive return of emigrants. For details, see El-Sakka (1997).

The emergence of remittances as a central issue for development policy has generated some backlash and confusion among politicians and academicians pertaining to the nature of remittances. Some have cited remittances as promoting migration from poor countries, and hence leading to reduced labor pools, lower per capita incomes, increased income inequality, and negative 'demonstration effects'.

Others have associated remittances with the so-called 'Dutch Disease'.[16] This term has been loosely used to diagnose the exchange rate volatility, inflation, loss of competitiveness on international markets, and other effects, such as real estate appreciation, owing to an influx of foreign exchange (including remittances) into a country. Some are of the view that remittances enable governments to avoid reforms, to overspend on the bet of growing future inflows. Still, other researchers are of the view that geographic distance and asymmetric information between remittance senders and receivers lead to problems of moral hazard, whereby recipients may engage in activities contrary to the wishes or interests of senders.[17]

Nevertheless, many of the research studies that question the benefits of remittances seem to minimize several basic issues. In the first place, while remittances are no cause for celebration, they are not responsible for underdevelopment. The hard reality is that remittances exist since many countries cannot provide sufficient employment and income for their citizens. Thus, people move 'North' by the millions, and money flows towards 'South' by the billions. These flows have become a primary source of income for a large number of families. Indeed, it is impossible to envision social conditions in the absence of these resources.

Two, remittances do not typically produce optimal economic outcomes in recipient countries—but neither do other flows and economic activities in environments where poor economic incentives and weak institutions discourage households, businesses, and investors from saving, investing and undertaking risks.

Still, there are certain regulatory factors that can contribute to attracting or discouraging remittance flows and their investment.[18] The factors that hinder the sending of remittances, particularly through the formal channels include (a) monetary policies, such as foreign exchange restrictions or the channeling of all foreign exchange dealings through the central bank or a state bank and (b) financial sector regulations that impact the availability or outreach of financial services.[19] The factors that obstruct the investment of remittances comprise (a) restrictions on foreign exchange holdings, such as foreign

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[16] This term is named for the economic effect on the Netherlands emanating from the discovery of natural gas in the North Sea. According to the Dutch Disease theory, the effects of capital inflows on resource allocation are traced through their effects on the real exchange rate. More precisely, it states that large inflows of capital can give rise to an appreciation of the real exchange rate and eventually a deterioration of the competitiveness of the sectors exposed to international competition, thus preventing the development of a dynamic export sector. For more on the Dutch Disease, refer to Bourdet and Falck (2004).

[17] For details, see Chami, Fullenkamp and Jahajah (2003).

[18] The regulatory issues pertaining to remittances are discussed at length in Sander and Maimbo (2005).

[19] Examples include regulations that require banks to operate full branches rather than allowing for less costly service points or restrictive licensing of money transfer operators that ties money transfer operator services exclusively to banks.

exchange-denominated bank accounts, (b) denial of repatriation of savings, c) indirect taxation of remittances through exchange rate controls or by withholding portions of remittances; and d) administrative hurdles to setting up a business.

VI. REMITTANCE INFLOWS AND IMPACT ON NEPAL'S ECONOMY

In Nepal, much of early migrations were the result of push factors like excessive tax burden, exploitative agrarian relations and political instability. The more formal and temporary migration began after people started to work in the British army following the Sugauli Treaty that was signed on December 2, 1815. This Treaty permitted Britain to recruit Gurkhas for military service.[20]

While both the First and the Second World War created a huge demand for young army personnel from Nepal, in recent times the scope for out-migration for military services has declined and more and more people have migrated for other types of job. It was only after the 1990s that policy makers and academicians began to fully acknowledge the importance of remittances send by Nepalese employed abroad for enhancing the livelihoods of the households, including those in the rural regions.

There are basically three methods of measuring remittance inflows. The first technique is through the BOP estimates. The second mechanism is the household surveys of recipients of such flows, for instance, the Nepal Living Standards Survey (NLSS). The third technique is through banks or financial institutions in origin countries, that is, focusing on resource transfer institutions. The size of remittance flows examined in this paper refer to the workers' remittances under the current account of the BOP data compiled by the Research Department of the Nepal Rastra Bank [21]

Conclusions relating to the impact of remittances can vary depending on the analytical approach adopted. Regardless of the approach employed, studies on the poverty impact of remittances have demonstrated that apart from possibly increasing inequality and dependency, remittances make a pivotal contribution to reducing poverty and vulnerability in most households and communities. In Nepal's case, the impact of remittances on poverty has been positive as revealed by the *Nepal Living Standards Survey (2003-2004)* which showed that the poverty level, defined in terms of absolute head counts, declined from 42 percent in 1995/96 to 31 percent in 2003/04.[22] Other studies have also supported the government's findings on the significance of remittances.[23]

Remittances have helped to boost individual household consumption and provide temporary financial relief at the household level. A small study conducted by the Research Department of the Nepal Rastra Bank a few years ago, covering 10 districts and

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[20] A historical perspective on foreign employment in Nepal is also provided by Singh (2006).

[21] Since remittances are transmitted through different channels, it is an arduous task to capture the full amount in the BOP statistics. As a result, it is sometimes difficult to come up with strong and valid conclusions on the role of remittances in the economic development of the country.

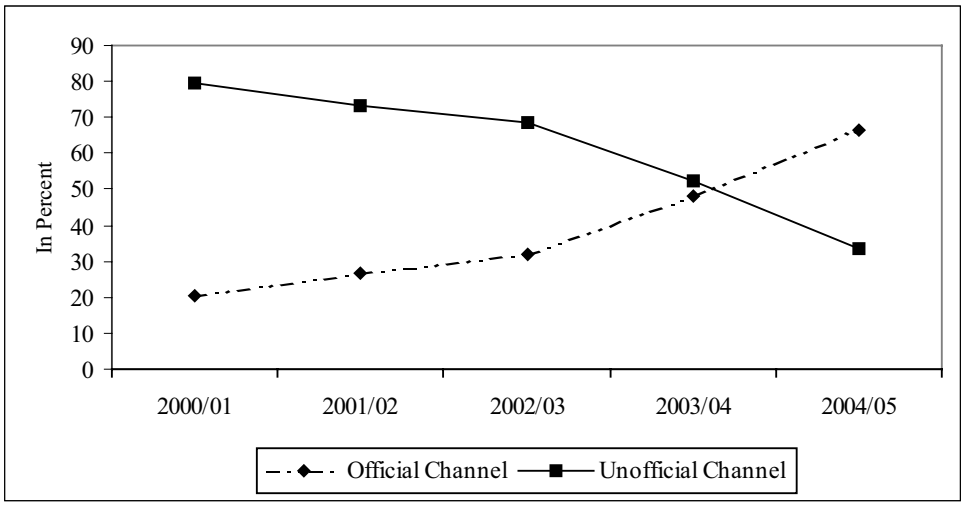
[22] Besides remittances, the other factors responsible for the decline in poverty included, among others, rise in agriculture wages, rise in non-agriculture wages and income, rise in urbanization and a drop in dependency ratio owing to a decline in fertility.

[23] For instance, according to the Asian Development Bank (ADB), in FY 2003/04, the economic recovery was led by remittance-driven consumption expenditure. For details, see ADB (2005).

160 sample households, disclosed that the remittance earnings were primarily invested for household purposes, purchase of real estate and house, paying off the loan, purchase of jewellery and as bank deposits.[24]

Currently, due to the widespread conflict in the country, many workers view foreign employment as their only viable option. Again, paucity of economic opportunities at home and growing employment prospects abroad have also tempted Nepalese to seek employment abroad.[25] According to the latest statistics of the Department of Labor and Employment Promotion, the number of workers going abroad for employment has increased by 14.7 percent in 2004/05 as compared to 2003/04.[26] With the increase in the number of workers, the inflow of remittances has also taken an upswing. Moreover, due to policy initiatives undertaken by the concerned authorities for enhancing the inflow of remittances through the official mechanism, the share of remittances incoming through the official channel has been going up.[27] For instance, in 2000/01, out of total remittance income of Rs. 47.2 billion, just about 20 percent flowed into the country through the official channel and 80 percent is estimated to have come through the unofficial channel. In 2004/05, on the other hand, out of total remittance income of Rs. 65.4 billion, 67 percent entered through the official channel and 33 percent is estimated to have flowed in through the unofficial channel (Fig. 1).

FIGURE 1 : Remittances Inflow: Official and Unofficial Channels



[24] Details of this study are provided in NRB (2002). Seddon *et al*. (2000) also elaborate on the investment aspect of remittances.

[25] These causes have been discussed at length by Seddon (2005).

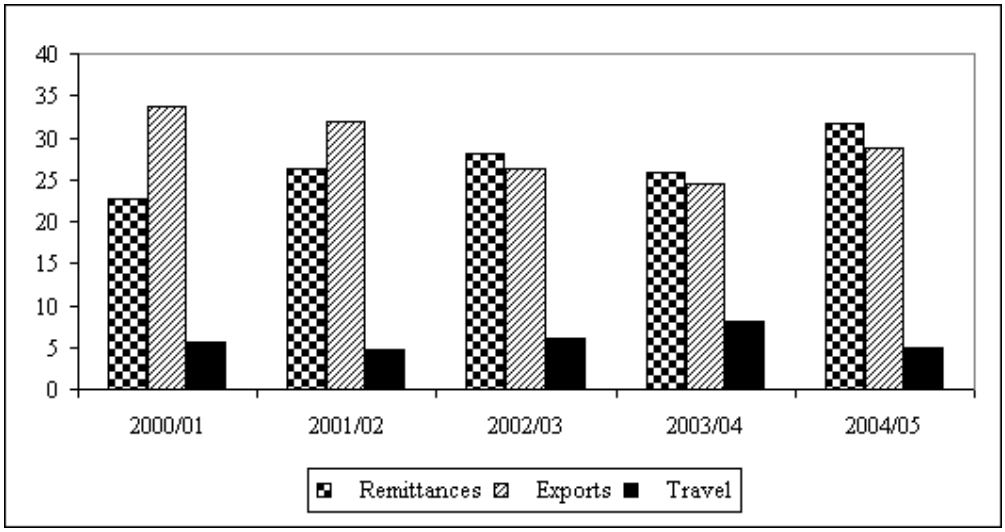
[26] The number of persons granted institutional permission for foreign employment was 121,769 in 2003/04. This figure was 139,696 for 2004/05. Country-wise data discloses that in 2004/05 Malaysia (47 percent) was the major destination for foreign employment followed by Qatar (30 percent) and Saudi Arabia (10 percent).

[27] These policy measures are discussed in the next section.

The growing remittances have led to a surplus in the current account, thereby strengthening the overall balance of payments position. The share of remittances in total current account receipts, excluding grants, soared from 27.4 percent in 2000/01 to 38.2 percent in 2004/05. Remittances have relaxed foreign exchange constraints of the country. One of the prime causes for the 6.0 percent growth of convertible currency reserves of the banking system in 2004/05 compared to the previous year has been the rise in remittances. The strong external position has allowed the NRB to build official reserves to high levels, reducing its vulnerability to external shocks.

The impact of remittances on national economy can also be illustrated by the fact that it has surpassed exports as the top contributor in the foreign exchange earnings of the country after 2001/02. While the share of remittances in total foreign exchange receipts was 28.0 percent, 25.9 percent and 31.5 percent in 2002/03, 2003/04 and 2004/05, respectively, the corresponding share of exports was 26.2 percent, 24.4 percent and 28.8 percent. The share of travel receipts in total foreign exchange receipts, on the other hand, went down to 5.0 percent in 2004/05 from 5.7 percent in 2000/01 (Figure 2). Likewise the remittances to GDP ratio increased from 11.5 percent in 2000/01 to 12.3 percent in 2004/05. These illustrations clearly denote that any significant decline in receipts from remittances could disturb the structure of the economy from the macro level, say, exchange rate of Nepali rupee *vis-à-vis* other currencies of the world to the domestic consumption of a family.

FIGURE 2: Share in Foreign Exchange Receipts: Remittances, Exports and Travel (In Percent)



VII. NEPAL'S EFFORTS TO HARNESS REMITTANCES

Owing to the potential positive effect of remittances, the country has accorded priority in promoting overseas employment and mobilizing remittances so as to maximize the benefits from these transfers. In this respect, effective March 29, 2002, the Nepal Rastra Bank (NRB) had begun granting licenses to private sector organizations interested in remittance-transfer business. As of March 31, 2006, 31 firms excluding the commercial banks are undertaking money transfer businesses as agents. Additionally, in order to make the money transfer business more competitive, the letter of intent has been granted to 83 other firms to conduct this business directly as well as to act as agents.

Other policy initiatives have also been undertaken so that remittances could be directed through the banking channel. For instance, as per its Monetary Policy and Program for FY 2002/03, the NRB had arranged to provide 15 paisa per US dollar as commission to licensed private firms in addition to the prevailing buying rate.[28] Moreover, permission was granted to manpower agencies, engaged in sending Nepalese nationals to work overseas, to open foreign currency account in the Nepalese commercial banks out of the foreign currency income that they realized under the prevailing rules.

Beginning from 2004/05, if a Nepal-based licensed agent/representative of any money transfer company located overseas requires bank guarantee for the purpose of receiving advance payment from the principal company, a policy arrangement of making such facility available, within the stipulated limits, directly from the commercial banks has been introduced.[29] This measure has facilitated the licensed agents in making instant payments of the remittance to the related parties.

As an increase in foreign employment generally leads to an increase in remittances, arrangement for employment is to be made by making the required provisions of training and loans to tackle the problem of unemployment by exploring foreign employment opportunities in FY 2005/06. Training programs that fall under the Council for Technical Education and Vocational Training (CTEVT), Ministry for Labor and Transport Management, Ministry of Industry, Commerce and Supplies and Ministry of Women, Children and Social Welfare would be undertaken to avoid duplication. These programs would be assessed to make them compatible to the requirements of foreign employment opportunities. Moreover, to further encourage foreign employment in FY 2005/06, provisions are to be made to provide loans from the commercial banks for those seeking overseas employment on the guarantee of Credit Guarantee Corporation.[30]

For FY 2005/06, continuity has been made to the arrangement of seed money for foreign employment loan programs targeted at providing loan for those seeking foreign employment. The program will bear up to 80 percent of the total expenditure incurred when seeking foreign employment.

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[28] See NRB (2002a) for details on this incentive.
[29] This is elaborated in NRB (2004).
[30] For details, see Ministry of Finance (2005).

VIII. POLICY OPTIONS

Policies are needed to encourage the use of remittances to promote longer-term growth and income security. Nepal needs to further devise policies that (i) send more remittances through official rather than unofficial mechanisms; (ii) increase the levels of remittances by encouraging migrants to hold their savings in financial assets in the country rather than holding them abroad (or spending their savings on consumer goods); or (iii) encourage migrants to become investor in productive assets in the country. Elsewhere, governments of labor-exporting countries have introduced a variety of schemes with these policy objectives in mind, namely (a) repatriable foreign exchange accounts to encourage the greater use of official channels, (b) foreign currency denominated bonds to encourage more use of financial assets in the home country[31], and (c) self-employment investment schemes to stimulate more direct investment in productive assets.

A favorable interest rate policy, a market-determined and realistic exchange rate and limited restrictions on withdrawals are also important. In building these products, policymakers should keep in mind that migrants and their families form a diverse group, ranging from white-collar workers to the illiterate and poor. Moreover, policies formulated to mobilize remittances should also be preceded by policies to promote other sources of foreign exchange to relieve the pressure on the foreign exchange pools and maintain stable exchange rates. Consistent interest rates should also be accompanied by policies to curb inflationary pressures.[32]

The opportunity to promote self-employment and small business formation amongst returning migrants and their relations back home needs to be recognized by the government and schemes must be targeted to assist investment in business activities. In order to promote investment of remittances in business enterprises, there is a dire need for the government to provide adequate incentives for migrant workers to invest in productive activities in Nepal. In this context, micro-finance institutions in Nepal could also expand their micro and small business portfolio, whereas government and NGOs could render services like training, business advice and marketing assistance for micro and small entrepreneurs to facilitate matching of funds for development projects.

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[31] For instance, foreign currency denominated bonds for development purposes were issued by the Egyptian Government to which Egyptians residing abroad were invited to subscribe on advantageous terms and conditions. One of the most successful techniques to encourage formal remittances of hard currencies earned by emigrants was the introduction of a special import system called Own Exchange Import System (OEIS). As per this system, importers were provided an import permit if they were able to demonstrate that they could provide the necessary foreign exchange on their own, that is, outside the official foreign exchange pool. The principal source of foreign exchange to the importers was the savings of emigrants. The OEIS was a very successful way of encouraging emigrants to utilize their savings to finance the country's needed imports from overseas. For more, see El-Sakka (1997).

[32] In this context, domestic interest rates need to be quite competitive with those of the outside world. Lower interest rates in the country will provide incentives for the emigrants to put their savings abroad, or to direct their remittances towards non-productive uses with higher speculative intentions, such as investing in land and other real assets.

One of the biggest hurdles to private sector growth in Nepal is the paucity of credit for seed capital and working capital for enterprises, especially small and medium-size enterprises. Pooled remittances can provide such credit, thus supporting the growth of enterprises. Although residing abroad, many Nepalese migrants want to invest in enterprises in their home country, either to employ family members at home, earn additional income or to prepare for their retirement or eventual return. These types of investments on the part of remitters can lower poverty by expanding businesses in their home communities and generating jobs and income that would not otherwise exist.

Pre-departure training for labor migrants is not only important to reduce the human and economic costs of migration, it can also be a powerful tool in raising awareness about remittance methods and utilization. The involvement of a variety of actors (migrant associations, NGOs and governmental bodies) is instrumental in the success of these initiatives.

To end this section, a few suggestions are made for improving the remittance market in terms of the roles to be played by each of the remittance market players: (a) remittance institutions, (b) public authorities; (c) civil society. [33]

Institutions conducting remitting business such as banks and money transfer companies should (a) disseminate all the information on total costs and transfer conditions, including all commissions and fees, foreign exchange rates applied, and execution time in a fully transparent way (b) compete on the basis of fair and non-discriminatory contractual arrangements and refrain from indulging in unfair pricing and applying high exchange rate margins, (c) use cost effective technology and deploy innovative platforms to slash costs, improve speed and security, and develop new products, (d) look for partnerships and alliances, including linkages between money transfer companies and financial institutions, in order to leverage capabilities and promote 'cash to accounts' services, and other forms of financial intermediation and e) deepen financial markets through inclusive and integrated services for remittance customers, such as current account services, savings, credit and mortgage products, *inter alia.*

The government and/or the NRB need to (a) facilitate remittance market and avoid attempts to tax, over-regulate or otherwise take actions that retard the remittances flow; (b) improve systems for collecting and reporting remittance market data and help to devise international standards for computing such data; (c) facilitate the mainstreaming of remittances into financial institutions by improving regulatory and financial sector frameworks; and (d) arouse awareness of the benefits of savings and other financial products.

The civil society and private sector organizations, on the other hand, should (a) systematically identify hurdles to leveraging the development impact of remittances, and engage and cooperate with all relevant stakeholders to address and eliminate such hurdles; and (b) support the social and financial inclusion of transnational families into their communities and build up innovative partnerships to promote training and domestic productive opportunities.

[33] A list of suggestions is also delineated in Terry, Wilson and De Vasconcelos (2005).

IX. CONCLUSIONS

Remittances are potentially important stimuli to economic growth. Despite the lack of accurate data on the real volume of funds transferred, there is ample evidence that remittance flows are substantial, stable relative to other forms of development finance, and well-targeted to vulnerable families, both as support during a crisis and as an income-smoothing mechanism.

In Nepal, during the last few years, remittances have been an important avenue of support for family members remaining at home. As the number of workers going abroad for employment continues to rise, the corresponding growth of remittances has become a critical flow of foreign currency into Nepal. This has been partly the result of measures undertaken by the concerned officials to streamline financial systems, dismantling controls and creating incentives, with the aim of attracting remittances particularly through the official channels.

Economic growth, interest rate and exchange rate policies are crucial determinants of remittance inflows. In order to further encourage the inflow of remittances to the country through official channels, and to promote the tendency to exchange these remittances of foreign exchange into local currency, it is imperative that these policies be conducive to the inflow of remittances.

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Some Measures of Core Inflation and Their Evaluations in Nepal

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This paper measures core inflation and evaluates their performance in Nepal. Concept of core inflation and survey of methodologies as well as international experiences and empirical evidence have been reviewed and analysed before measuring the core inflation in Nepal. An existence of asymmetric price distribution necessitates the alternative measure of inflation in place of traditional CPI-based headline inflation. Ultimately, by using exclusion method and stochastic measures, nine different types of core inflations have been computed. Empirical results show that core inflations perform better than the headline inflation in several aspects such as having less volatility, highly relating to money supply growth, and capturing the permanent component of headline inflation. Better core inflation is selected with the help of different performance criteria such as observing statistical properties, tracking trend inflation, finding the relationship with money supply, and the analysing the ability of capturing permanent component and forecasting capacity. However, no single core measure performs better in all aspects. Hence, a set of core inflation measures, namely exclusion based, weighted median and trimmed mean should be analysed in conducting the monetary policy in Nepal.

I. INTRODUCTION

A conduct of monetary policy requires the information on inflation, among others. The relationship between monetary policy and inflation can be traced out from the classical quantity theory of money i.e. the famous Fisherian equation[1]. Past experiences and empirical studies in the world also suggest that high inflation distorts the decision of private sector on investment, saving and production, which ultimately lead to slower economic growth (Barrow, 1995). As such, price stability has been considered as a main objective of monetary policy during the recent years and a most important yardstick to

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[1] MV = PY, where, M = money stock, V = velocity of circulation, P = general price and Y = output

measure the success of monetary policy. Taking a sole objective of price stability, a growing number of countries have been adopting the inflation-targeting regime[2] to achieve this goal and have succeeded in achieving it to the larger extent (Duebelle, 1998 and Waiquamdee, 2001).

There are several methods of measuring inflation in the economy, for example, GDP deflator, Wholesale price index (WPI), Consumer Price Index (CPI) and so on. Among others, a widely used and easily understood measurement of inflation is the CPI-based inflation. In fact, the CPI measures the cost of living index of people and it is constructed by collecting the prices of goods and services included in the consumption basket, assigning the appropriate weight to each items based on the expenditure pattern of people. Many countries calculate inflation figure based on the change in CPI as; $(\phi) = CPI_t\text{-}CPI_{t-1}/CPI_{t-1}$. However, the consumption basket differs from one country to the other.

Though CPI-based inflation is commonly used, it tends to have noises, being influenced by the transient shocks. Inflation may result due to cost-push or demand-pull factors in the economy. Hence, the conduct of the monetary policy on the basis of the inflation information from the CPI may distort the final outcome of it. As a result, to make monetary policy accountable and credible, there should be the alternative measures of inflation by eliminating the supply shocks and transitory shocks from the CPI inflation. Such measures are termed as "core inflation" or "underlying inflation". They would serve as a way to monitor progress of monetary policy towards the goal of price stability.

In Nepal, as per the Nepal Rastra Bank (NRB) Act 2002, the main objectives of monetary policy also incorporate the price stability in addition to balance of payments consolidation. To keep the accountability and credibity of monetary policy towards the objective of price stability, NRB also needs to focus on the computation and analysis of core inflation because various studies (Khatiwada, 1994; NRB, 2001, Pandey, 2005) have revealed that inflation in Nepal is highly influenced by the supply shocks, existing Indian prices and the government administered price. For example, very recently (particulary since the mid-half of 2004/05), after witnessing consecutive low inflation for couples of years, the upward trend in CPI based inflation has been observed due mainly to hike in petroleum prices and VAT rate by the government as well as rise in food price because of bad weather.

In fact, the conventional measurement of price changes by computing CPI does not provide with adequate insight into the differential impact of demand and supply influences on the measured inflation rate. Thus, the identification of sources of inflationary pressure is essential for the formulation of appropriate monetary policy responses. This has necessitated to find the way for the refinement of the measurement of inflation for which the concept of estimating core inflation by eliminating transitory noises or distortionary effects of supply shocks has come up in widespread uses.

On this backdrop, this paper is the extension and updated version of the paper published earlier (Shrestha, 2002) expanding the coverage of the subject matter and

[2] Inflation targeting framework evolved in 1990s after the failure of both the money-growth targeting framework in the developed countries and the exchange rate targeting framework in the emerging economies. In this framework, inflation target is taken as both final goals and intermediate goals. Any deviation of forecast of inflation from inflation target demands the change in monetary instruments.

sample period. There has not been any other attempts made to measure core inflation in the Nepalese context, though some interest has been shown on the matter of core inflation recently by NRB, particularly to defend the monetary policy from rising inflation. Hence, this paper has again attempted to compute core inflation measures extending the coverage till 2004/05 in Nepal to identify the best measures of core inflation which extracts the generalized and persistent part of CPI[3] price change in Nepal.

This paper is organized as follows. First of all, this paper highlights the concept of core inflation and its uses in the second section followed by the methodological discussion in the section third. The section four will examine international experience and empirical evidence related to measuring core inflation. Then, data coverage and methodology applied in this paper are discussed in the section five. The section six will analyse the nature of distribution of price change in Nepal, followed by the empirical measures of core inflation in the section seven. The section eight evaluates the performance of different core measures. Finally, the discussion will be concluded in the section nine.

II. Core Inflation: Concept and Its Uses

Inflation is generally defined as a persistent rise in price in the economy. However, price change is measured commonly by the weighted arithmetic mean (Laspeyers index), among others. It is argued that this conventional price measure does not distinguish the differential impact of demand and supply shocks because it includes both the inflation generated by demand-pull and cost-push factors. Therefore, the concept of core inflation emerged as an inflation, which is directly related to the demand factors.

The term core inflation has widespread used but it appears to have no clear definition though early attempts to define core inflation can be found in Eckstein (1981) and Blinder (1982) (cited in Bryan and Cecchetti, 1993). As mentioned in Rich and Steindel (2005), the more familiar core inflation measures as aggregate price growth excluding food and energy appears to have first been analysed in a systematic fashion in a 1975 paper by Robert Gordon.

In the economic literature, however, there are six broad concepts of core inflation. The first definition is of Eckstein (1981) which defines the core inflation as an inflation that is related to the concept of output neutral inflation. Quay and Vahey (1995) also define the core inflation in line with Eckstein. The second concept defines core inflation as an expected inflation from different price index series, while the third one considers core inflation as the persistent component of measured inflation. The fourth assumes that price changes in any individual commodity consist of two components -a common trend and a relative price shock- and core inflation tries to estimate the common trend. The fifth one identifies a list of commodities which are likely to be prone to supply shocks (outside the preview of monetary policy) and compiles the price index by excluding these commodities from the basket with a view to capturing the demand related (or core)

[3] Some may argue for taking WPI or GDP deflator for measuring core inflation. However, since the ultimate concern of the monetary policy is the welfare maximization of final consumers, it is most relevant for monetary policy to focus on the CPI, and core inflation measures should be based on the CPI (Tahir, 2003).

inflation (Samanta, 1999). Lastly, Bryan and Ceccetti (1993) define the core inflation as a money-induced inflation, which is expected to persist over medium-run horizons of several years, in which core inflation (ϕc) = money growth.

In the mathematical equation form, as per the second concept, actual inflation is represented by (Roger, 1998)

$$M_t = \phi_t^e + g(X_t) + V_t$$

where,

M_t = aggregate inflation rate in period 't'

ϕ_t^e = expected inflation

$g(X_t)$ = measure of excess demand pressure

V_t = measure of supply disturbance

Then, core inflation M_c is,

$M_c = M_t - g(X_t) - V_t = \phi_t^e$ = the expected inflation rate

while non-core inflation, M_{nc}, is

$M_{nct} = g(X_t) + V_t$

As per the third and fourth concept, the observed price change M_t is (Wynne, 1999)

$M_t = \phi_t + X_t$

This expression defines the rate of change of the price of an individual commodity $M_t = \ln(P_t) - \ln(P_{t-1})$, as consisting of an aggregate inflation component (persistent) ϕ_t and a transient price change component X_t. The objective of core inflation is to find out ϕ_t - the persistent component of all prices.

As per the fifth concept, the conventional measured inflation is

$M_t = M_d + M_s$

where,

M_d = inflation generated by demand factor

M_s = supply shocked inflation.

Core inflation takes 'M_d' under consideration by excluding supply- affected inflation.

Though many define the core inflation differently, but monetary policy operation should consider the core inflation as the one which is highly influenced by demand side rather than supply side. Moreover, that should be the core inflation which excludes the temporary influences on inflation due to one-off shift in the price level resulting from a change in tax rate or due to extreme change in weather conditions, or rise in international oil price due to political crisis.

With regard to uses of core inflation, many central banks, in recent years, have highlighted the measures of core inflation in the course of policy formulation and communication. Although the concept of core inflation emerged in the 1970's, a renewed interest has emerged in the 1990's, because of its importance especially with the introduction of inflation targeting regime in many countries. While the headline inflation is often volatile and unreliable predictor of the true inflationary trend, core inflation can be a more accurate measure of underlying inflation and can be a useful weapon in the quest for price stability. Even countries that do not explicitly adopt inflation targeting as a policy regime often publish their measures of core inflation and use them as monitoring tool such as USA and Pakistan.

It is a well-established fact that monetary policy affects the price after a long lag. As such, monetary policy responses to CPI based inflation may be inappropriate, because of containing relative price shocks. Non-monetary events such as sector-specific shocks and the government policy can temporarily produce noise in the price data that substantially affects the aggregate price indices. The core inflation attempts to extract the persistent part of the headline inflation, useful to make monetary policy decision. A rationale for focusing on core inflation is that there is a significant amount of transient noise in the movement of aggregate CPI. Temporary shocks, despite impacting the headline index, can reverse. Therefore it does not demand a policy response from the monetary authority. In the event of supply disturbances, policy actions to counter the impact on the aggregate price level will lead to accentuate the output effects of the disturbance (Roger, 1998). Hence, a primary use of core inflation is to find a measure that is highly correlated with money growth (Bryan and Ceccheti, 1993).

An appropriate measure of inflation is essential for taking monetary policy decisions since the price stability is the main objective of monetary policy and the money supply is the most important determinant of inflation. Moreover, Marianne (1999) argues that core inflation would be (a) a good indicator of current and future trend in inflation, (b) a good measure of inflation for empirical work and (c) the most importantly, a viable target for monetary policy, very essential particularly in inflation targeting regime. Core inflation measures assist the monetary authority to separate the noise and the short-run fluctuations in the data from its more persistent trend. Moreover, core inflation can be useful to make *ex post* assessment of the effectiveness of monetary policy and helpful to maintain its accountability and credibility in public. Further, core inflation would aid in the communication or transparency of monetary policy to the public. In similar line, Roger (1998) mentions that a measure of core inflation has three distinct uses for monetary policy purpose: setting or formulation of policy, providing policy accountability, and in econometric estimation and forecasting.

In Nepal, a priori rational for the use of core inflation emerges from the inflation experience. During the period of 1996/97 to 2004/05, inflation (y-o-y) rose as high as 14.55 percent in mid-November 1998 while as low as 0.45 percent in mid-July 2000. Such a peak and tough of inflation movement was due to rise and fall of price of certain goods, mainly agricultural products. For example, in the month of mid-November 1998, the prices of vegetable increased by 66 percent, the price of oil and ghee increased by 46.0 percent, and the price of rice and rice products increased by 10.78 percent over the previous year. Contrary, in mid-July 2000, the prices of these goods declined by 12.65 percent, 15.22 percent and 13.27 percent respectively. Recently also, particularly after the second half of 2004/05, inflation experienced a rising trend due mainly to hike in VAT rate and the prices of petroleum products. An unfavourable weather conditions, resulting in supply shock in paddy production, further aggravated the inflationary situation. In this context, monetary policy should respond cautiously otherwise it can be counter productive. Hence, the use of core inflation cannot be ruled out in Nepal as in other countries.

III. METHODOLOGICAL DISCUSSION

Though there is a widespread consensus that monetary policy should focus on underlying inflation, there is no unique way of measuring underlying inflation similar to its definition. It is not a variable that can be observed directly, but it has to be estimated (Landau, 2000). In the literature, there are broadly following methods found[4].

(a) Core inflation as expectation (Jefferies, 1990),
(b) Univariate methods – moving average technique, Hodrick-Prescott (HP) filter, and Kalman filter
(c) Multivariate method-Structural Vector Auto-Regression (SVAR) framework (Quah and Vahey, 1995),
(d) Stochastic measures – mean, weighted median and trimmed mean, also called limited influence estimator
(e) Exclusion based measures

An ideal measure of core inflation should be efficient in distinguishing between persistent and transient movement in inflation. It should be unbiased to the headline inflation, otherwise it undermines credibility in providing public accountability for inflation performance. It is also important that the estimates of core inflation to be as robust as possible on different factors: sample size as well as variables used. Timely availability of core inflation estimates helps initiate corrective policy measures in time. Core inflation measure should be easily understood and readily verifiable (see Roger 1998). However, each method has their own pros and cons.

Jefferis (1990) argues that the expected inflation, based on different models and time series can track a common trend which can be considered as a core inflation. For the implementation of the *Jefferis's (1990) expectation based core inflation*, it is necessary to build up forecasting models. Subjectivity is involved in the choice of forecasting models, as such the accountability and variability of core inflation are practically lost. The model specification and estimated parameters may also vary over time depending upon both the number of observations and the time structure of data. This method lacks the timeliness and robustness of the estimated core measures.

The univariate method is based on the smoothing or filtering techniques. This process tends to eliminate the unwanted component from measured inflation. A popular and simple way is to apply the moving average technique and Hodrick-Prescott (HP) filter. A more sophisticated smoothing technique involves the use of fixed or moving seasonal adjustment factors and Kalman filters. The use of moving averages for inflation does tend to reduce the volatility of the resultant series, and may better reflect the persistent element of inflation. But, it also reduces the timeliness of information on core inflation, since the averaged series will be dominated by past rather than current inflation (Roger, 1998).

Quah and vahey (1995) suggested estimation of core inflation in a SVAR framework which decomposed the measured inflation into two uncorrelated components: core inflation and an unwanted component (noise). *The SVAR-based multivariate method* is appealing from a policy perspective because it attempts to estimate the output neutral component of measured inflation similar to the definition of Eckstein (1981). Samanta (1999) argues that a serious drawback of this technique is that it considers only two variables viz. price and output in the SVAR model. In absence of other related variables such as money, interest rates etc, the reliability and credibility of the estimates is under

[4] See Samanta (1999) for a detail discussion of methodologies of core inflation and Roger (1998).

questionable. Application of this method in the developing countries is hindred by the lack of availability of related data in a higher frequency.

Several recent studies (Bryan and Ceccheti, 1993, Roger 1998) have argued in favour of *stochastic measures viz. trimmed mean, weighted median,* etc of the cross sectional distribution of price changes as a measure of core inflation to be more efficient. These methods are also called *Limited Influence Estimators*. It is observed that sample cross sectional distribution of price changes is generally positively skewed and highly kurtotic (Roger 1998, Bryan and Cecchetti, 1993). In that case, the sample mean (weighted) i.e. $\sum w_i \phi_i$ (w_i =weight, ϕ_i =price index) is inferior to some other statistics like median[5], and trimmed mean[6] for measuring the underlying inflation.

The trimmed mean involves taking a weighted average of a subset of the CPI by trimming the most extreme movement in inflation. In this case, a prior judgement for the choice of exclusion of items is not necessary, but a decision is to be made about the level of trim to cut the tails of the cross-sectional price distribution. As the sample distribution of price change may undergo a change over time, the associated optimal level of trimming may not be robust and the need for new calculation of this optimal level at every time makes the measure lose its credibility (see Samanta 1999). For trimming process, highly disaggregated level of price index data should be available so that trimming can be applied at a higher precision.

In practice, many central banks use some sorts of exclusion-based measures of core inflation based on systematically excluding prices of some items. This type of measure is timely, simple to understand, easy to verify and comparatively robust. In this method, core inflation is measured by modifying the normal expenditure based weighting system in the CPI. In this case, the existing index is reweighed by placing zero weights on some components which are excluded, and the remaining weights are rescaled.

General CPI is computed as:

$$CPIn = \sum_{i=1}^{n} w_{i0} P_{it}/P_{i0} * 100$$

Then, the exclusion based core inflation is computed as:

$$CORE_{it} = \frac{\sum_{i41}^{m} w_{i0} \frac{P_{it}}{P_{i0}} \Delta 100}{\sum_{i|1}^{m} w_{i0}} \quad \text{Where } m <= n$$

Generally, many central banks exclude food and energy[7] prices from the CPI basket. Some also exclude indirect taxes[8], administered prices[9] and interest charges[10].However, temporary disturbances are not necessarily limited to specific sub-components. A prior judgement needs to be made regarding the exclusion of certain components of CPI. It

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[5] Median item in the cross sectional distribution of price change.

[6] The ζ % trimmed mean inflation rate is defined as

$$IT(\zeta 0\# \# \frac{1 O W_i \phi_1}{14 2\zeta / 100}$$ where, W_i = weight, ϕ_i = price index

[7] Generally influenced by supply shocks, impacted by weather conditions.

[8] Infrequent, once-and-for-all canges have no long run effects on inflation.

[9] Possible conflicts between monetary and fiscal policy.

[10] Perverse response- prices of these items rise when monetary policy tightened.

may be that price changes in certain items could be more volatile but completely removing these items from the price distribution over medium to long term horizon has the potential risk of permanent loss of significant signals. These sort of problems are likely to arise when the economy is undergoing significant structural changes (Roger, 1998). In contrast, the trimmed mean estimates do not exclude any component a priori, instead they systematically determine those components to exclude at each point of time based on information of relative price variability . In addition, as mentioned in Mahanty, D et.al (2000) exclusion principle for core inflation would be inadequate for developing countries because of (a) a large array of commodities show relative price volatility over time and hence it would not be appropriate to move them all from the core measure; (b) due to structural transformation, the basket of volatile commodities keeps shifting over time; the exclusion of certain items on a permanent basis may render the inflation measure less efficient; and (c) primary commodities have a strong influence on the underlying inflation as they form sizeable part of household consumption basket and therefore are crucial in the formation of price expectation.

Each method has own merits and demerits. As a result, many central banks and other researchers have computed core inflations by applying more than one methods, in addition to the exclusion based method.

IV. INTERNATIONAL EXPERIENCES AND EMPIRICAL EVIDENCE

This section reviews the existing practice of computing core inflation in a number of countries. In Australia, the Federal Treasury constructed a measure of core inflation by excluding components of inflation based on a wider set of criteria; the excluded components represents more than 40 percent of the consumption basket (Cockerel, 1999). In addition, the Reserve Bank of Australia computed other alternative core inflations for monetary policy purposes such as weighted median and trimmed core inflation.

In Canada, the Bank of Canada, a pioneer bank in computing core inflation, officially corresponds to the 12-month change in the CPI excluding food and energy, and the effects of indirect taxes, denoted by CPI*FET. It has also been taken as the operational target for policy purpose (Johnson, 1999). In addition, other alternative measures such trimming, weighted median, are also used to calculate alternative core inflations to supplement the official measure.

Appendix 1 shows a further cursory look in the international practices of measuring core inflation. A majority of countries have been adopting some sorts of exclusion, but no uniqueness in the methods adopted for exclusion. Very few countries officially use the other alternative methods of measuring core inflation. Hence, it can be argued that method of measuring core inflation is country specified, influenced by the nature of goods in consumer baskets, features of price distribution, stage of development and structure of the economy.

Regarding the empirical evidence, there are no unique way of measuring core inflation. Hence, different authors have tried to compute a set of core inflation measures and identified the best measures among them, which varies from the country to country. Some empirical researches are reviewed here.

Bryan and Cecchetti (1993) investigated the use of exclusion based and the limited-influence estimators like the 15-percent trimmed mean, and the median in the USA's CPI

data. They found that the median of the cross-sectional distribution of inflation which has the strongest relationship with past money growth and provides the most accurate forecast of future inflation, can be as a superior measure of core inflation. However, Tahir (2003), in Pakistan, found that trim-based measure compares favourably with those based on methods of excluding fixed items from the basket of CPI.

Marcos and Figueiredo (2001) also evaluated the performance of five alternative measures of core inflation such as exclusion, symmetric trimmed mean, symmetric trimmed mean with smoothed series, weighted median and double weighted indicator in Brazilian data and found that the double weighted measures and the 20% trimmed with smoothed series performed better. Moreover, in Turkey, Berkmen (2002) found that the trimmed means provide statistically more efficient estimators of inflation and the optimal trim is found to be 19 percent from each tail of the cross sectional distribution of price.

Similarly, Bryan and Cecchetti (1999), in Japan's data found that trimming the tails of the price-change distribution substantially improves high-frequency estimates of Japanese core inflation. They found that trimming approximately 35% from each tail of the price change distribution produces the most efficient monthly estimator over the full 27-year period. It seems to be a very high trimming ratio. Further, a range of trimmed-mean estimators (between 21% and the median price change) also provide nearly the same signal. These estimators were found superior to the standard monthly core inflation estimator in Japan, i.e. the CPI less fresh food.

However, in India, Samanta (1999) computed four different types of exclusion based core inflation and found that some of the exclusion-based core inflation measures are superior to the measured inflation for the purpose of monetary policy. He did not compute and compare the other measures of core inflation in Indian context. Uzagalieva (2005) also investigates core inflation in the Krygyz Republic on the basis of exclusion, trimmed mean and percentile, and found that trimmed means and exclusion based core measures are preferable, particularly in the period of decline in inflation.

Interestingly, Rich and Steindel (2005), in the US data, recently found no single individual measure of core inflation that can be considered superior to other measures. They measured various core inflations by applying exclusion methods, median and exponentially smoothing methods. In similar line, Landau (2000), in Germany data, have found very poor outcome from core inflation. Hence, he advises that it would be better not to use core inflation rate as the sole monetary policy indicators , but he agrees that core inflations are useful supplement to measured inflation.

Hence, the choice or identification of the preferred measures of core inflation appear to be an open empirical question which need to be tested on country specific data. It can be affected by the pattern of expenditure weight, goods in CPI basket and the factors that affect the price movement.

V. Data Coverage and Methodology Applied

For the computation of core inflation in Nepal, monthly indexes between 1996/97 and 2004/05 were used because it is the index series which is based on the recent base year and revised weight (Appendix 2), and comparatively more disaggregation figures are available on these data. Data on 33 components of National Urban Consumer Price Index

from mid-August 1996 to mid-July 2005 are used to calculate the various measures of core inflation.

Moreover, inflation is measured or defined as the change in the natural log of the price level for analysis. As there are no seasonally adjusted price series published in Nepal, the results cannot be filtered out from the seasonal effects. Hence, year-on-year monthly change in price has been calculated in this paper.

Y-o-Y price change or inflation has been calculated as

$\phi_t = 100*\ln(CPI_t/CPI_{t-k})$,

k=12 months

As discussed earlier, there is no unique and consensus method to measure the core inflation. However, based on the above discussion of the different methodologies , the following methods are applied to measure core inflation in the Nepalese context, considering the nature of data availability.

(a) exclusion method- three different core inflation series have been computed by excluding different commodities from the CPI basket.
(b) stochastic method –weighted median, and trimmed mean (5 different trimmed core inflation series have been computed)

These methods tend to be robust, credible and verifiable. However, these methods will be tested later on by applying various criteria to select the best one, among others. To select the best core that fits with the Nepalese price data, some criteria have been used, such as observing statistical properties, tracking the trend line, examining the relationship with money and evaluating the forecasting ability.

VI. DISTRIBUTION OF PRICE CHANGES IN NEPAL

The shape of distribution of price changes is reflected in the moments of the cross-sectotional distribution of price changes. For a symmetric distribution, the coefficient of skewness should be zero and the coefficient of kurtosis should be three. At that time, the mean can be an unbiased estimators of the distribution. But, the actual distribution of price changes, on an average, during the sample period, has positive skewness and high kurtosis (Table 1). The positive skewness shows that the distribution is skewed to the right, which means exceptional price rises are more common or more extreme than the exceptional price declines (Tahir, 2003). A skewed distribution implies the existence of predominance of outliers in price changes, resulting in a distortion in the general trend of inflation. Moreover, the high kurtosis (i.e. leptokurtic) indicates that exceptionally large price changes are much common than in a normal distribution. In this way, CPI inflation calculated on the basis of weighted mean in case of high skewness and kurtosis, cannot be 'robust' indicator of the general trend of inflation, it is just a biased estimator of the central tendency.

TABLE 1: Moment of Price Changes#*

	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	Average
Arithmetic mean	7.8	8.1	10.3	3.5	2.4	3.0	4.6	3.6	4.1	5.24
Variance	27.2	61.0	133.3	150.3	121.8	34.3	51.1	36.0	28.5	71.50

SD	5.0	7.5	11.4	11.8	10.9	5.8	7.0	6.0	5.2	7.84
Skewness	0.4	1.0	1.3	-1.3	-0.4	-0.6	0.3	-0.2	1.7	0.25
Kurtosis	7.1	7.2	7.0	6.5	4.0	9.3	9.7	8.2	9.7	7.65
Jarque-Bera Statistic	22.6	35.4	27.8	18.7	3.0	66.5	53.0	46.9	77.6	39.07
Normality test	reject	reject	reject	reject		reject	reject	reject	reject	reject

 # Calculations are based on year-on-year monthly inflation

** Using the adjusted formulae (Roger, 2000a), moments of the distribution of CPI component were calculated.*

Table 1 shows that the distribution of the prices is not normal, typically having excess kurtosis and positively skewed on an average. The Jarque-Bera tests for normality, a joint test of deviations of the observed skewness and kurtosis from the normal distribution with values of zero and 3 respectively, reflect that the hypothesis of normality is rejected except in that of one year 2000/01. As such, the mean does not adequately represent the price movement with the median or trimmed mean measures-are likely to give much more reliable indication of the general trend of inflation than the CPI mean.

There are different reasons for asymmetric distribution of price change. Bryan and Ceccheti (1993) argue that price setters face a one-time cross-sectional shock and can pay a menu cost to adjust their price to it immediately. Only those price setters whose shocks were large enough will choose to change. As a result, the distribution of shocks is skewed, concentrating in certain sectors of the economy (Bryan and Cecchetti, 1993). Moreover, the practice of collecting prices of different goods in different frequency, such as weekly, fortnightly, monthly, half yearly and annually, also results in asymmetric distribution of price change. Infrequent price adjustment by the government on the administered items also caused the unequal relative shocks on the distribution of price changes.

Over the entire sample period, the annual average skewness was 0.25 which is similar to other findings like the skewness of 0.2 found by Bryan et al (1997) for US price changes, and the skewness of 0.6 found by Roger (1997) for New Zealand.

Further, Appendix 3 shows descriptive statistics of the price change of different components in CPI basket during the review period. Highly volatile items fall under the food and beverage group. It is interesting to note that many items in the CPI basket witnessed, not only rise in price,but also fall in price in certain times during the review period.

VII. MEASURES OF CORE INFLATION

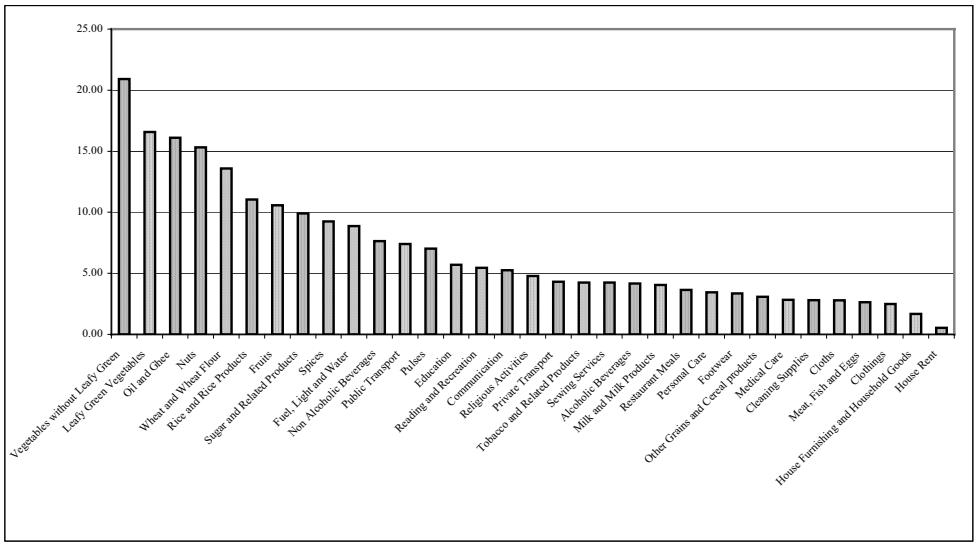
This section measures the core inflation in Nepal for the period of 1996/97:1 to 2004/05:12. Based on nature of data availability, stochastic measures and exclusion principle have been applied to derive core inflation. Empirical outputs of core inflation are subsequently explained below.

7.1 Exclusion Based Core Measures

The core inflation measure using exclusion principle possesses some merits such as they are readily understandable, easy to compute, transparent and easily variable, but it has some demerits such as involving subjectivity in deciding items to be excluded from the basket and also suffers from a potential risk of information loss (Tahir, 2003). In this section, an attempt has been made to provide a measure of core inflation for the Nepalese economy considering the peculiarities of price behaviour in Nepal based on the exclusion principle. The first crucial task necessary in using the exclusion-based measure of core inflation, is to identify the commodities/components which can be permanently excluded from the basket. A general rule is to exclude commodities whose prices are presumed to be prone to supply shocks and/or are under administrative control. Prices of these commodities for the most part are beyond the control of central bank or the preview of monetary policy. In this context, many central banks exclude 'food and energy' and/or 'government controlled/administered' prices and calculate price indices by readjusting weights of the rest of the commodities.

In the Nepalese context, the prices of food, pulses, vegetable, fruits and nuts, oil and ghee as well as sugar and related products are expected to be prone to supply shocks and vary from season to season, depending upon the production and availability/scarcity of these commodities in the market. Moreover, there are a number of items (see Appendix 3) whose prices are still administered by the government. Experience shows that government infrequently changes the prices of these goods.

FIGURE 1 : Standard Deviation of CPI Component, 1996/97:1 – 2004/05: 12



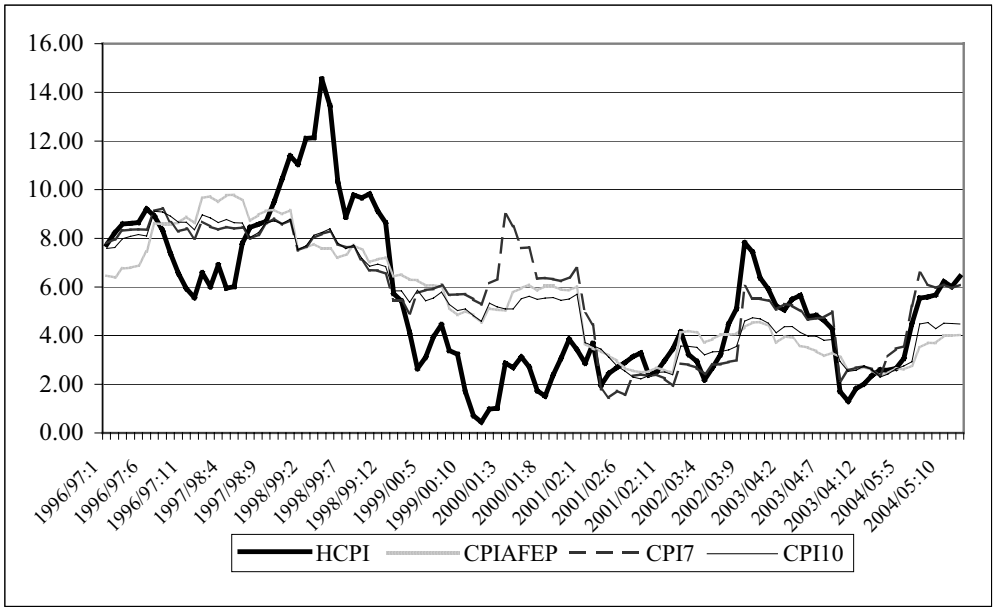
In applying the exclusion principle, it is important to remember that more exclusion of items of CPI basket results in less reliability of the data, due to a lower coverage. Hence, step by step, different core inflation by applying exclusion principle have been computed and tested for their superiority. First, CPI excluding food and energy (CPI*FE) has been computed in which grain and grain product, and fuel, light and water are excluded. In addition, the prices of a number of commodities in Nepal are also administered (Appendix 3) accounted for a 16.15 percent weight. As most of the administered items are grouped together under different headings, it is difficult to distinguish them and remove them from the subgroup level. However, fuel, light and water as well as communication can be removed from the CPI basket in the subgroup level as administered items. Hence, the second core inflation, CPI excluding food, energy and other administered items such as public transports and communication (CPI*FEP) has been computed. However, depending on the movement of price changes, these two exclusion based core inflations could not capture the core part of the price movement because the exclusion is not sufficient to exclude the supply shocked items. Hence, CPI*FE and CPI*FEP have been dropped out from further analysis. In addition, by excluding all items in food and beverage group except beverage and restaurant meal, and fuel, light and water, public transport and communication, the third core inflation, CPIAFEP, has been computed.

In the above methods, the selection of items for exclusion is guided by the general practice found in the other countries. To select the specific components for exclusion, one can identify the nature of the volatility in past by observing the historical performance of price series. Figure 1 shows the degree of volatility observed during the period under consideration of different components of CPI basket. Consequently, the fourth core inflation observed during the review period, have been calculated, named as CPI7. This CPI excludes the top seven highly volatile items, that have double digit standard

deviation,. These seven highly volatile items include (a) vegetables without leafy green, (b) leafy green vegetables, (c) oil and ghee, (d) nuts, (e) wheat and wheat flour, (f) rice and rice products, and (g) fruits (see Appendix 4 and Figure 1). In addition, since these seven items do not include the administered items like fuel, light and water, and public transport, another exclusion based core inflation, by excluding top 10 volatile items, has also been calculated, as indicated by CPI10. All of these core inflation have been reported in Appendix 5. Figure 2 shows the movement of these core measures.

However, it should be remembered that expenditures on food terms constitute a large share of the total expenditure in Nepal, as in many developing countries, but different from the developed ones. Together with energy prices, food items constitute approximately a third of weight in the CPI basket. Hence, excluding food and energy prices from the CPI may not be a good indicator of long-term inflationary trend since it constantly ignores a large portion that the consumers spend from their budgets. Moreover, this type of exclusion from CPI basket has a weak economic justification, as it is not necessary that noise only comes from the items excluded or the leftover items do not have shocks. Moreover, this method is based on the implicit assumption that the components of inflation exhibit similar behaviour in the future as in the past. Hence, the stochastic measures are also applied to compute the core inflation.

FIGURE 2 : Exclusion based Core Inflations



Note: NCPI – Headline inflation

7.2 Core Inflations from Stochastic Approaches

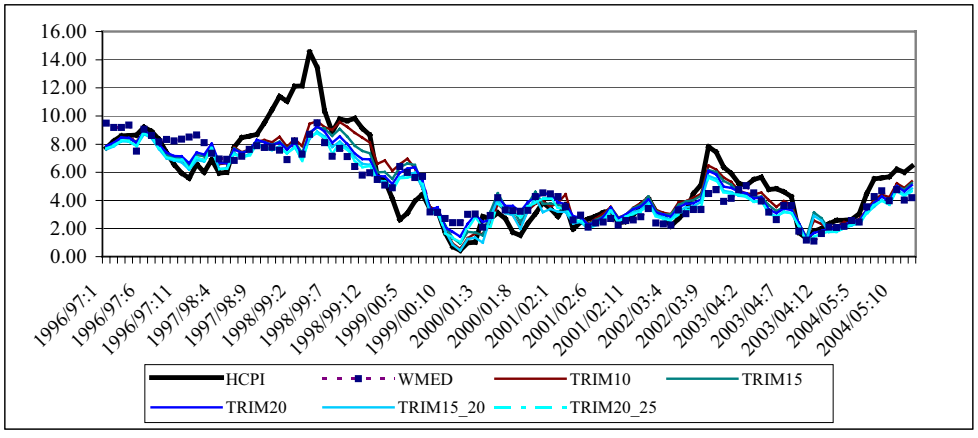
Excluding items from CPI basket in exclusion principle, a priori, may sometimes loose the information because the price of these items may not necessarily be volatile always. Hence, stochastic measures or limited influence estimators have been evolved. Instead of defining the more volatile components that are to be excluded a priori, for each observation, the stochastic measures look at the cross-sectional distribution of price changes to identify outliers.

On extreme stochastic measure of core inflation is weighted median, identifying the item on the median position as a representative for the distribution. Core inflation as measured by the weighted median is presented in Appendix 5 as indicated by WMED.

Regarding the trimming process, one needs to identify the optimal trim, which can be done by minimising Root Mean Square Error (RMSE) from the trend inflation. However, for the simplicity, three symmetric trimmed core inflations such as 10%, 15% and 20% have been computed in the line with the other studies. In this process, cross-sectional distribution of price change is sorted in ascending order. Then, this process excludes the items lie beyond the range set for the trimming. After that, it calculates the mean by re-weighting the remaining items. Resulted core inflation (trimmed mean) is depicted in Appendix 5 as indicated by TRIM10, TRIM15 and TRIM20.

Moreover, the mean percentile has been found as 53.02 consistently being greater than 50 indicate a persistent tendency toward right skewness in the distribution of price change. As such, asymmetric trimming process, trimming more on right tail, 15 percent left, 20 percent right and 20 percent left, 25 percent right have also been computed. Results are reported in Appendix 5 denoted by TRIM15_20 and TRIM 20_25. Figure 3 shows the movement of trimmed core measures and weighted median.

FIGURE 3: Weighted Median and Trimmed Core Inflations



Note: NCPI – Headline inflation

VIII. EVALUATION OF CORE INFLATIONS: WHICH MEASURE?

Out of many measures, we should select the best measures. Of the more than a dozen measures of core inflation have been computed in Nepalese data, four of them, CPI*FE, CPI*FEP, TRIM6_10, TRIM10_20 have been dropped outrightly because they could not capture the persistent part of headline inflation based on the character of distribution of price movement and weight assigned to each components in sub-group level. Nine different core inflation measures have been taken for further analysis. There are several criteria for selecting the best measure. For example, core inflation should be less volatile, and correlated with headline inflation. Moreover, if should follow the long run trend, and have close relationship with money. It must capture the persistent part of the headline inflation and must have some sort of forecasting ability.

8.1 Statistical Properties

Table 2 lists some descriptive statistics of various measures of core inflation and headline inflation (HCPI). The mean over the full sample ranges from 4.68 for the TRIM15_20 to 5.78 for CPI7. Measures of variability, shown by standard deviation, range from a low of 2.18 for CPI10, the least variable measure, to 2.44 for TRIM10. Moreover, all core inflation measures have volatility lower than that of headline CPI i.e. 3.09. It shows that core inflations are less volatile than the headline inflation. Hence, the core measures would increase the credibility of the monetary authority on conducting monetary policy.

TABLE 2: Statistical Properties of Various Measures of Core Inflation 1996/97:1 to 2004/05:12

	HCPI	CPIAFEP	CPI7	CPI10	WMED	TRIM10	TRIM15	TRIM20	TRIM15_20	TRIM20_25
Mean	5.35	5.49	5.78	5.46	4.91	5.14	5.06	5.02	4.68	4.69
Maximum	14.55	9.79	9.22	9.11	9.51	9.63	9.17	9.28	8.90	8.84
Minimum	0.45	2.34	1.45	2.21	1.11	0.56	0.94	1.31	0.45	1.03
Std. Dev.	3.09	2.25	2.26	2.18	2.37	2.44	2.31	2.26	2.28	2.23
Skewness	0.70	0.35	-0.33	0.24	0.43	0.20	0.22	0.27	0.24	0.30
Kurtosis	2.82	1.90	1.90	1.72	1.84	1.77	1.71	1.69	1.77	1.73

Of course, core inflations are fund less volatile that headline inflation, but it should be correlated with the latter for public accountability. A higher departure from headline inflation cannot represent the public sentiment of cost of living index. Therefore, that core measure can be taken as the best which has a higher degree correlation with the headline inflation. For this perspective, Table 3 shows the correlation coefficients between the headline inflation and different measures of core inflation. Comparatively, the correlation coefficient between headline inflation and TRIM10 is higher (0.92) than that of others, followed by the correlation with TRIM15, and TRIM15_20. It means that trimmed measures of core inflation are more closely correlated with headline inflation than the exclusion based core inflations.

TABLE 3: Correlation Matrix of Various Measures of Inflation

	HCPI	CPIAFEP	CPI7	CPI10	WMED	TRIM10	TRIM15	TRIM20	TRIM15_20	TRIM20_25
HCPI	1.00									
CPIAFEP	0.65	1.00								
CPI7	0.66	0.87	1.00							
CPI10	0.74	0.97	0.92	1.00						
WMED	0.83	0.85	0.82	0.92	1.00					
TRIM10	0.92	0.77	0.69	0.82	0.92	1.00				
TRIM15	0.90	0.81	0.73	0.86	0.94	0.99	1.00			
TRIM20	0.89	0.84	0.78	0.89	0.97	0.98	0.99	1.00		
TRIM15_20	0.90	0.80	0.73	0.86	0.95	0.99	1.00	0.99	1.00	
TRIM20_25	0.89	0.83	0.78	0.89	0.97	0.98	0.99	1.00	0.99	1.00

8.2 Tracking Trend Inflation

The long-term trend in CPI reflects the perception of the inflation by public in real terms (Berkman, 2002). A good measure of inflation should track trend inflation in two ways: first, over a long period of time, the average rate of core inflation should match with the average rate of headline inflation; second, the core inflation should move closely with the trend rate of inflation. Most policymakers prefer a measure of core inflation that neither understates nor overstates the long-term trend rate of price change. Whether core inflations follow the trend inflation or not, has been identified by computing the RMSE between trend inflation and core infation based on the following formula:

$$\text{RMSE}^{\text{core}} = \sqrt{O_t(\phi_t^{\text{TREND}}\ 4\ \phi_t^{\text{CORE}})2/\text{T}},\ \ t = 1,\ldots..,\text{T} \qquad (1)$$

Here, following the Bryan and Cecchetti (1993), a centered moving average of 24-month of CPI based inflation has been taken as a trend inflation to compute the RMSE for core inflation measures. Table 4 reports the RMSE which compares the how close each core measure captures the benchmark trend. It appears that the TRIM15 more closely approximates the persistent movement, followed by the TRIM20 and TRIM10. The reported RMSE suggests that all core measures, except CPI7 capture inflation trend better than then HCPI. It means the core measure provide a clear indication of current and future trends.

TABLE 4: Root Mean Square Error

Inflations	RMSE	Inflations	RMSE
HCPI	1.78	TRIM10	1.16
CPIAFEP	1.47	TRIM15	1.11
CPI7	2.05	TRIM20	1.15
CPI10	1.35	TRIM15_20	1.24
WMED	1.28	TRIM20_25	1.28

Moreover, RMSE is also used to identify the optimum trim. As per the RMSE, optimal trimming ratio is found to be 15 percent in both side of price distribution, which is similar to the finding of Tahir (2003) in Pakistan and Bryan and Cecchetti (1993) in the USA.

8.3 Core Inflation and Money Growth

Bryan and Cecchetti (1993) argue that a primary motivation for study of core inflation is to find a measure that is highly correlated with money growth, hence useful to conduct monetary policy. Bryan and Cecchetti (1999) also mention that among the properties generally attributed to an inflation estimate, is its underlying association with the growth rate of the money stock. Subsequently, the contemporaneous correlation between the growth rate of money stock (M_1 and M_2) and the several core inflation measures have been examined. The correlations were computed for annual percentage change of both monetary aggregates and the different measures of core inflation. The results are reported in Table 5. Interestingly, all exclusion based core inflation yield larger contemporaneous correlation with money growth than the headine and trimmed based core inflations.

TABLE 5: Contemporaneous Money Growth Correlations

	HCPI	CPIAFEP	CPI7	CPI10	WMED	TRIM	TRIM 10	TRIM 15	TRIM 15_20	TRIM 20_25
M_1	0.11	0.16	0.18	0.14	0.06	0.08	0.07	0.08	0.04	0.07
M_2	0.40	0.52	0.53	0.52	0.39	0.40	0.40	0.41	0.37	0.39

To examine whether the change in money growth actually forecast changes in inflation, Granger-Causilty has been done as:

$$\phi_1 = \zeta + \sum_{i|1}^{n} \eta_i \phi_{t41} 2 \sum_{i|1}^{n} \varsigma_i m_{t41} 2 O_t \qquad (2)$$

where, ϕ = various measures of inflation
m = growth of money (narrow and broad money)
Results for n = 24 are presented here.

Table 6 shows the results of the Granger Causality Test considering the growth of narrow money. A lag of 24 months seems to be representative based on the the concept that monetary policy has impact on inflation on long lags. Results show that the null hypothesis of growth of M1 does not Granger cause CPIAFEP and CPI10 are rejected at 5 percent significant level. It means that narrow money growth significantly Granger cause core inflations such as CPIAFEP and CPI10. But, narrow money growth does not Granger cause other measures of core inflation including headline inflation.

TABLE 6: Pairwise Granger Causality Tests Between Narrow Money and Core Inflation Measures
Sample: 1996/97:01 2004/05:12

Lags: 24

Null Hypothesis	Obs	F-Statistic	Probability
HCPI does not Granger Cause M_1	84	1.35003	0.20517
M_1 does not Granger Cause HCPI		0.58876	0.91117
CPIAFEP does not Granger Cause M_1	84	1.29180	0.24035
M_1 does not Granger Cause CPIAFEP		1.93772	0.03643
CPI7 does not Granger Cause M_1	84	1.27178	0.25354
M1 does not Granger Cause CPI7		0.93174	0.56482
CI10 does not Granger Cause M_1	84	0.76483	0.75142
M_1 does not Granger Cause CPI10		2.30821	0.01185
WMED does not Granger Cause M_1	84	1.04618	0.44315
M_1 does not Granger Cause WMED		1.05124	0.43810
TRIM10 does not Granger Cause M_1	84	1.41951	0.16906
M_1 does not Granger Cause TRIM10		0.47570	0.96984
TRIM15 does not Granger Cause M_1	84	1.10112	0.39014
M_1 does not Granger Cause TRIM15		1.01535	0.47459
TRIM1520 does not Granger Cause M_1	84	1.03128	0.45820
M_1 does not Granger Cause TRIM1520		1.04728	0.44205
TRIM20 does not Granger Cause M_1	84	1.72453	0.06934
M_1 does not Granger Cause TRIM20		0.34706	0.99579
TRIM2025 does not Granger Cause M_1	84	1.49340	0.13696
M_1 does not Granger Cause TRIM2025		0.36046	0.99455

Table 7 further reports the Granger Causality tests between broad money growth and the different core measures including the headline inflation. Of the different core measures and headline inflation, M2 growth only Granger causes CPIAFEP and CPI7 for which null hypothesis is rejected at 5 percent level and 10 percent level respectively. However, TRIM 20 and TRIM20_25, instead of Granger caused by M_2 growth, they themselves Granger cause the M2 growth.

TABLE 7: Pairwise Granger Causality Tests Between Broad Money and Core Measures
Sample: 1996:08 2005:07
Lags: 24

NULL HYPOTHESIS	Obs	F-Statistic	Probability
HCPI does not Granger Cause M_2	84	1.17591	0.32492
M_2 does not Granger Cause HCPI		0.56545	0.92641
CPIAFEP does not Granger Cause M_2	84	1.51337	0.12929
M_2 does not Granger Cause CPIAFEP		2.01204	0.02907
CPI7 does not Granger Cause M_2	84	0.81556	0.69571
M_2 does not Granger Cause CPI7		1.69278	0.07625
CPI10 does not Granger Cause M_2	84	0.92507	0.57224
M_2 does not Granger Cause CPI10		1.52965	0.12333
WMED does not Granger Cause M_2	84	1.48570	0.14003
M_2 does not Granger Cause WMED		1.43389	0.16233
TRIM10 does not Granger Cause M_2	84	1.64670	0.08745
M_2 does not Granger Cause TRIM10		0.42761	0.98374
TRIM15 does not Granger Cause M_2	84	1.40344	0.17688
M_2 does not Granger Cause TRIM15		0.85951	0.64618
TRIM1520 does not Granger Cause M_2	84	1.29687	0.23710
M_2 does not Granger Cause TRIM1520		0.94223	0.55318
TRIM20 does not Granger Cause M_2	84	3.05495	0.00133
M_2 does not Granger Cause TRIM20		0.51021	0.95598
TRIM2025 does not Granger Cause M_2	84	2.83166	0.00252
M_2 does not Granger Cause TRIM2025		0.51840	0.95218

Relationship with money can also help determine the selection of core inflation. The best core inflation should be explained by the money stock so that monetary policy can influence significantly. The estimating equation is taken as

$$\div \ln P_t = \zeta + \eta \div \ln M_t + \kappa_t, \quad (3)$$

where,

$\div \ln P_t$ = first difference of natural logarithmic of price indexes, indicating inflation

$\div \ln M_t$ = first difference of natural logarithmic of money supply.

Expected signs of coefficient : $\zeta <> 0$, $\eta > 0$, η will show us the degree of influence of change in money stock on change in price.

Before running OLS on equation (3), it would better to test for unit root test, otherwise regression results would be spurious. Table 8 reports the Augmented Dickey Fulller (ADF) test for all measured of core inflations, headline inflation and money supply M1 and M_2. ADF has been calculated at first lag with intercept but no trend.

TABLE 8: Unit Root Test

Variables in Level	ADF Value	Variables in Difference	ADF Value
Ln (HCPI)	-1.13	Dln (HCPI)	-5.68*
Ln (CPIAEFP)	-2.82	Dln (CPIAEFP)	-8.51*
Ln (CPI7)	-2.13	Dln (CPI7)	-7.20*
Ln (CPI10)	-3.15	Dln (CPI10)	-8.28*
Ln (WMED)	-1.69	Dln (WMED)	-10.79*
Ln (TRIM10)	-1.52	Dln (TRIM10)	-8.97*
Ln (TRIM15)	-1.52	Dln (TRIM15)	-9.34*
Ln (TRIM20)	-1.55	Dln (TRIM20)	-9.01*
Ln (TRIM1520)	-1.62	Dln (TRIM1520)	-9.69*
Ln (TRIM2025)	-1.63	Dln (TRIM2025)	-9.08*
Ln (M_1)	-0.9	Dln (M_1)	-11.03*
Ln (M_2)	-2.39	Dln (M_2)	-8.98*

* MacKinnon critical values for rejection of hypothesis of a unit root are
1% Critical Value* -3.4870
5% Critical Value -2.8861
10% Critical Value -2.5797
Note: ln – natural log D – difference

ADF statistics in the above table shows that all variable under consideration are stationary in first difference. Hence, OLS estimation on equation (3) is proceeded. Empirical results at lag length of 7 months have been found representative in case of M1 and 10 months in case of M2 which seems to be reasonable because monetary policy has lags effect on inflation. Empirical results are presented in the following Table 9 and Table 10.

Function Relationship of Different Inflation Measures with M_1

Regression results of equation (3) taking narrow money as an independent variable are presented in Table 9. η coefficients are significant at least at 5 percent significant level for all types of core inflation measures while it is significant at 10 percent for headline inflation. Of the various core measures, η coefficient is the highest in case of WMED, followed by TRIM15_20 and TRIM15. It means that WMED responses highly to change in narrow money, subsequently by TRIM15_20 and TRIM15. It also implies that narrow money aggregate influences WMED, then TRIM15_20 and TRIM15 significantly.

Adj/R^2 shown in column 4 reflects the higher explanatory power for core measures compared to headline inflation. However, the value of Adj/R^2 in all cases are below 10 percent which is usual in case of regression run in first difference of log value, and inflation in Nepal is caused by the factors other than money. Of the Adj/R^2 for various core measures, explanatory power of narrow money is higher in case of CPI10, followed by WMED.

TABLE 9: Regression Results of Different Inflation measures with Narrow Money

Dependent Variable	ζ	η	Adj/R^2	DW	AIC	SC	F-stat
HCPI	0.004	0.064***	0.018	1.13	-6.02	-5.97	3.04***
	(0.00)	(0.08)					
CPIAFEP	0.004	0.060*	0.069	2.22	-7.25	-7.20	9.26*
	(0.00)	(0.003)					
CPI7	0.004	0.053**	0.049	2.04	-7.17	-7.13	6.71**
	(0.00)	(0.011)					
CPI10	0.004	0.063*	0.099	2.14	-7.52	-7.47	13.15*
	(0.00)	(0.00)					
WMED	0.00	0.29*	0.078	2.26	-4.22	-4.17	10.45*
	(0.75)	(0.002)					
TRIM10	0.00	0.17**	0.043	2.05	-4.69	-4.64	6.01**
	(0.33)	(0.016)					
TRIM15	0.00	0.20*	0.054	2.11	-4.60	-4.56	7.31*
	(0.41)	(0.008)					
TRIM20	0.00	0.17**	0.037	2.08	-4.58	-4.53	5.29**
	(0.37)	(0.023)					
TRIM15_20	0.00	0.21*	0.06	2.04	-4.60	-4.55	8.06*
	(0.53)	(0.005)					
TRIM20_25	0.00	0.16*	0.033	2.09	-4.59	-4.54	4.80**
	(0.42)	(0.03)					

* significant in 1 percent level
** significant in 5 percent level
*** significant in 10 percent level
p value in bracket
AIC = Akaike info criterion
SC = Schwarz criterion

DW statistics shows the existence of serial correlation in the dependent variable, value of which should remain around 2 for no serial correlation, both positive and negative. The value of DW statistics is very low in case of headline inflation (HCPI) reflecting the positive serial correlation. However, the other core measures have DW stat around 2.

Table 9 also shows the value of AIC and SC. Higher negative value of them is better for the model. As per this value, CPI10 seems to perform better followed by CPIAFEP. F-statistics also supports the CPI10 followed by WMED, values of which are significant at 1 percent level.

Functional Relationship of Different Inflation Measures with Broad Money

Broad money has been taken as monetary target in conducting monetary policy in Nepal. Hence, it is imperative to look the functional relationship between the different inflation measures with broad money as well. Here, broad money includes narrow money plus time deposits.

TABLE 10: Regression Results of Different Inflation Measures with Broad Money

Dependent Variable	ζ	η	Adj/R^2	DW	AIC	SC	F-stat
HCPI	0.004	0.017	-0.009	1.12	-5.98	-5.93	0.04
	(0.006)	*(0.84)*					
CPIAFEP	0.003	0.16*	0.095	2.16	-7.25	-7.20	12.34*
	(0.00)	*(0.00)*					
CPI7	0.004	0.10**	0.031	2.07	-7.13	-7.08	4.50**
	(0.00)	*(0.036)*					
CPI10	0.003	0.14*	0.095	2.10	-7.49	-7.44	12.28*
	(0.00)	*(0.00)*					
WMED	-0.004	0.70*	0.08	2.11	-4.20	-4.15	10.96*
	(0.28)	*(0.001)*					
TRIM10	0.000	0.43*	0.05	2.00	-4.67	-4.62	6.81**
	(0.77)	*(0.010)*					
TRIM15	-0.002	0.50*	0.064	2.06	-4.59	-4.54	8.34*
	(0.59)	*(0.004)*					
TRIM20	0.00	0.37**	0.03	2.04	-4.55	-4.50	4.40**
	(0.94)	*(0.038)*					
TRIM15_20	-0.002	0.53*	0.071	1.99	-4.58	-4.53	9.20*
	(0.45)	*(0.003)*					
TRIM20_25	0.00	0.35**	0.026	2.05	-4.55	-4.50	3.93**
	(0.92)	*(0.05)*					

* significant in 1 percent level
** significant in 5 percent level
*** significant in 10 percent level
p value in bracket
AIC = Akaike info criterion
SC = Schwarz criterion

Estimate of the equation (3) considering broad money as an explanatory variable reveals that results are representative when M2 growth is taken at 10 months lag. It means that M2 growth exerts influence on core measures after lag of 10 months. Table 10 shows the empirical results of estimate of equation (3) considering broad money in right hand side. As expected, there is no any significant relationship between headline inflation and M2 growth, but all measures of core inflation have the significant η coefficient. It shows

that core measures are better explained by the money growth compared to headline inflation.

Of the η coefficients, WMED has the highest value, followed by TRIM15_20 and TRIM15 which is similar to the findings above taking narrow money in right hand side. However, the explanatory power of M_2 is higher in case of CPI10 and CPIAFEP, followed by WMED than that of others. DW stat shows that existence of serial correlation in case of headline inflation when it is taken as a dependent variable.

AIC and SC values shows the models with CPI10 found better followed by CPIAFEP and CPI7. Moreover, F-statistics of the all models are significant, highest value for CPIAFEP, followed by CPI10 and WMED.

All of these discussions in this section can prove that the core measures are more correlated with or controllable through monetary aggregates.

8.4 Testing the Relative Shocks

Headline inflation is supposed to contain both common trend and a temporary component, called relative price shock. By this definition, we have

$$\phi_t = \phi_c + u_t \qquad (4)$$
$$\phi_t - \phi_c = u_t$$

where ϕ_t is headline inflation and ϕ_c is core inflation and u_t is relative price shocks

The temporary disturbances u_t are caused by development such as change in weather conditions, disturbance in supply side. By definition, u_t is expected to have zero mean and finite variance or in other words, it should be stationary. If not, that would mean that the core inflation measure, ϕ_c ,would not be capturing all the systematic component of ϕ_t and there is a non vanishing difference between headline and core inflation. In this case, the core measure does not capture the true level of the permanent component of inflation and may give false signals to monetary authorities if they do not take this into consideration (Marques et.al, 2000). Hence, $\phi_t - \phi_c = u_t$ should be stationary which can be tested by ADF statistics.

Table 11 presents the ADF test on u_t. All relative shocks, except in case of WMED and TRIM15_20 are stationary reflecting that the corresponding core measures are capturing the permanent component of headline inflation.

TABLE 11: ADF test on Relative Shocks

	CPIAFEP	CPI7	CPI10	WMED	TRIM 10	TRIM 15	TRIM 20	TRIM 15_20	TRIM 20_25
ADF test on $(\phi_t - \phi_c)$	5.91*	5.77*	6.99*	2.47	3.19**	3.0**	2.86***	2.46	2.76***

* *Significant at 1 percent level*
** *Significant at 5 percent level*
*** *Significant at 10 percent level*

8.5 Forecasting Ability

In order to assess whether the core measure has any indicator property for the future trend in inflation, the simple correlations between each core measures and CPI inflation at various future intervals: 6 months, 12 months, 18 months, and 24 months have been calculated. Table 12 reports these correlation coefficients. Based on the correlation coefficients, forecasting ability of the core measures have been found mixed. However, they do contain information about future movements of inflation. The highest correlation of CPI inflation at 6 months is with TRIM15_20 and TRIM20_25, reported at 0.63; at 12 months is with CPIAFEP, reported at 0.53; at 18 months and 24 months is with WMED, reported at 0.43 and 0.37 respectively.

TABLE 12: Correlation of core Measures with future CPI inflation 1996/97:1 to 2004/05:12

	t	t+6	t+12	t+18	t+24
CPIAFEP	0.65	0.62	0.53	0.33	0.13
CPI7	0.66	0.49	0.35	0.28	0.25
CPI10	0.74	0.61	0.48	0.38	0.27
WMED	0.83	0.62	0.45	0.43	0.37
TRIM10	0.92	0.59	0.30	0.22	0.19
TRIM15	0.90	0.61	0.35	0.27	0.23
TRIM20	0.89	0.62	0.38	0.30	0.26
TRIM15_20	0.90	0.63	0.39	0.31	0.26
TRIM20_25	0.89	0.63	0.39	0.33	0.28

IX. CONCLUSION

Price stability has been a major objective of monetary policy in the recent years for the monetary authority to be more accountable and credible. However, conventional measures of price by consumer price index cannot isolate the supply shock effect on the price movement with which monetary policy has no any relationship. For the accountability and credibility of the monetary policy, there should be a measurement of core inflation, eliminating distortionary effects of supply shocks.

Distribution of price changes in Nepal has indicated that existence of high kurtosis and positive skewness rejecting normality proposition, which is also pointed out by the Jarque-Bera normality test statistic because of presence of supply shock and administered items. As such, the conventional measures of CPI by arithmetic mean can be inferior to represent the price movement. Therefore, it is imperative to compute core inflation.

Of the different measures computed in this article, none of the measures satisfies all the desirable properties of robustness, unbiasedness, efficient, timelines and credibility simultaneously. However, core inflation measures are better performed to headline inflation on conducting monetary policy on various ground. It has been found that core measures have less volatility, i.e. less susceptible to supply shocks, follow trend inflation and more responsive to money growth i.e. monetary policy than headline inflation. Since

there can be different measures of core inflation, an important matter is to select the best one. Comparison of performance of different core measures from different perspectives shows the mixed results in Nepal, no any one core measure is superior in all aspects. For example, CPI10 has the lower standard deviation, but TRIM10 has the strongest correlation with headline inflation. Tracking the trend inflation identifies TRIM15 performs better having the lowest RMSE. Further, CPI7 has the strong contemporaneous correlation with money growth. Looking from Granger causality performance, M1 Granger causes CPIAFEP and CPI10 while M2, Granger causes CPIAFEP and CPI7. Functional relationship with money further found that WMED is superior. Moreover, in the longer horizon, WMED is found to have forecasting ability. In this way, based on the various performance criteria, representative core inflation can be CPI10, CPI7, CPIAFEP, WMED and TRIM15.

However, most of the measures of core inflation seems to capture the permanent components because the relative shocks has been transitory in each core measure. As a result, instead of focusing on any single measure, it would be better to focus on various measures namely exclusion based like CPI10, trimmed based like TRIM15 and weighted median on conducting the monetary policy in Nepal.

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APPENDIX 1: International Practices of Measuring Core Inflation

Country	Measures of Core Inflation	
	Headline inflation adjusted for	Alternative Measures
Australia	Energy, mortgage interest, fruit, vegetables	Weighted median 30 percent trimmed mean
Belgium	*CPI less potatoes, fruit and vegetables*	

Canada	*CPIxFET*: food, energy, indirect taxes CPIX: fruits, vegetables, gasoline, fuel oil, natural gas, mortgage interest costs, inter-city transportation, tobacco products ⊄# CPIW: multiply the initial CPI basket weights by the reciprocal of the historical standard deviation of the relative price change (to give non-zero but lesser weights to items with volatile price movements) ⊄# Wmedian and trimmed mean
Chile	CPI excluding perishable goods and energy
Colombia	An average of four measures (CPI excluding food and three limited influence estimators)
Czech Republic	Food, energy, indirect taxes
Finland	*IUI*: Capital costs in owner-occupied housing, indirect taxes, subsidies
France	CPI less change in taxes, energy prices, food prices and regulated prices
Greece	CPI less food and fuel
Israel	CPI less government goods, housing, fruit and vegetables
Japan	CPI less fresh foods
Netherlands	CPI less vegetables, fruit and energy
New Zealand	- Interest services * - With an escape clause for "unusual events" concerning commodity, indirect taxes, controlled items
Norway	CPI less electricity prices and indirect taxes
Philippines	Rice, corn, fruits & vegetable, LPG, Kerosene, Oil, Gasoline and Diesel
Poland	A set of three measures (CPI less officially controlled prices, CPI less prices with higest volatilities and a 15% trimmed mean)
Portugal	10% trimmed mean of the CPI
Singapore	CPI less cost of private road transportation and accommodation
Spain	- IPSEBENE: energy, unprocessed food - Case-by-case: indirect taxes, exogenous prices
Sweden	- UND1: interest costs for owner-occupied housing, indirect taxes, subsidies, depreciation after float - UND2: UND1 plus heating oil and propellants
United Kingdom	⊄# *RPIX*: mortgage interest payments ⊄# RPIY: mortgage interest payments, indirect ⊄# and local taxes ⊄# RPIXFE: RPIX plus food, fuel, light ⊄# TPI: direct taxes, THARP: indirect and local taxes
Thailand	Rice and cereal products, meats, fruits & vegetables, electricity and gasoline

Source: Bryan and Cecchetti (1999) and several central bank publications.

APPENDIX 2 : Weight in Consumer Price Index

		Weight 1983/84 base year	Weight 1995/96 base year
A)	FOOD AND BEVERAGES	62.63	53.20
1	Restaurant Meals	4.88	6.91
2	Grains and Cereal Products	29.43	18.00
3	Pulses	3.27	2.73
4	Vegetables and fruits	8.47	7.89
5	Spices	2.23	1.85
6	Meat, fish and eggs	4.07	5.21
7	Milk and milk products	3.76	4.05
8	Oil and ghee	3.36	3.07
9	Sugar and related products	1.68	1.21
10	Beverages	1.48	2.28
B)	NON-FOOD AND SERVICES	37.37	46.80
11	Cloths, Clothings and Sew. Services	10.09	8.92
12	Footwear	1.72	2.20
13	House Fur.& H.H.Goods	2.56	3.50
14	House Rent	1.33	4.19
15	Cleaning Supplies	1.89	1.26
16	Fuel, light and water	6.88	5.92
17	Transport and Communication	2.13	4.03
18	Medical and Personal Care	4.59	8.03
19	Education, Read., and Recreation	4.14	7.09
20	Tobacco & Related Products	2.04	1.66

APPENDIX 3 : Administered Items with Their Weightages (Kathmandu Valley)

	1983/84 Base Year		1995/96 Base Year	
S.N	Commodities	% wght	Commodities	Wght
1	Salt	0.17	Dairy Ghee	0.15
2	Curd	0.11	Salt	0.12
3	Bottle milk	3.14	Dairy Milk	3.08
4	Sugar	1.80	Dairy curd	0.08
5	Poplin (a kind of Cloth)	0.05	Sugar	1.26
6	Chhit cotton (akind of cloth)	0.07	Chhit cotton	0.03
7	Jin for Dress (a kind of cloth)	0.13	Kerosene	1.73
8	Kerosene	3.33	Petrol	0.53
9	Electricity Charge	1.39	Cetamol drug	0.71
10	Water Charge	0.32	Jeevan Jal drug	0.10
11	Bus fare long route	0.54	Cigarettes (Yak)	0.81
12	Bus fare Short route	0.28	Cigarettes (Gaida)	0.09
13	Trolley bus fare	0.31	Bus fare long route	0.45
14	Petrol	0.52	Bus fare Short route	1.05
15	Mobile loose	0.07	Hospital per bed charge	0.15
16	Telephone charge	0.18	National Magazine (Gorkhapatra)	0.16
17	Aerogram inland	0.04	School fee (IX, X)	2.49
18	Cetamol drug	0.20	College Fee (Undergraduate)	0.24
19	Piracite drug	0.03	Text book (IX,X)	0.22
20	Jeevan Jal drug	0.04	Telephone charge	0.48
21	School fee (IX, X)	1.56	Postal stamp	0.04
22	College Fee (Undergraduate)	0.34	Electricity Charge	1.83
23	Text book (IX,X)	0.43	Water Charge	0.36
24	National Magazine (Gorkhapatra)	0.11		
25	Cigarettes (Yak)	0.89		
26	Cigarettes (Gaida)	0.72		
27	Cigarettes (Deurali)	0.59		
	Total	17.35	Total	16.15

APPENDIX 4 : Volatility of Components in CPI Basket, 1996/97:1 – 2004/05:12

	Items	Weight	Mean	Max	Min	Std
1.	Vegetables without Leafy Green	5.15	3.95	66.88	-48.55	20.92
2.	Leafy Green Vegetables	1.10	4.52	49.20	-35.13	16.58
3.	Oil and Ghee	3.07	4.56	46.41	-37.23	16.09
4.	Nuts	0.05	7.78	29.15	-24.35	15.31
5.	Wheat and Wheat Flour	1.79	5.87	31.38	-28.75	13.60
6.	Rice and Rice Products	14.16	3.94	31.29	-19.33	11.04
7.	Fruits	1.59	5.66	28.93	-19.04	10.58
8.	Sugar and Related Products	1.21	4.83	32.97	-12.33	9.91
9.	Spices	1.85	4.24	24.51	-15.20	9.25
10.	Fuel, Light and Water	5.92	9.24	44.76	-14.97	8.89
11.	Non Alcoholic Beverages	0.75	3.45	24.27	-5.11	7.63
12.	Public Transport	2.54	8.76	20.97	-2.45	7.40
13.	Pulses	2.73	3.05	29.50	-13.58	7.04
14.	Education	4.78	8.26	18.33	-3.35	5.70
15.	Reading and Recreation	1.63	3.83	18.42	-2.96	5.45
16.	Communication	0.42	2.41	17.62	-17.70	5.24
17.	Religious Activities	0.68	6.03	15.88	-6.22	4.77
18.	Private Transport	1.07	5.91	14.17	-4.94	4.32
19.	Tobacco and Related Products	1.66	4.96	17.65	-0.07	4.24
20.	Sewing Services	0.89	6.55	25.83	-4.62	4.24
21.	Alcoholic Beverages	1.53	6.31	14.43	-1.65	4.17
22.	Milk and Milk Products	4.05	4.59	15.07	-0.89	4.03
23.	Restaurant Meals	6.91	7.28	12.89	0.77	3.66
24.	Personal Care	1.82	4.84	11.54	-0.26	3.45
25.	Footwear	2.20	3.24	11.60	-0.75	3.34
26.	Other Grains and Cereal products	2.05	3.94	13.13	0.07	3.08
27.	Medical Care	6.21	6.35	11.98	0.74	2.82
28.	Cleaning Supplies	1.26	3.88	11.54	-0.82	2.81
29.	Cloths	2.28	2.98	11.66	-5.20	2.79
30.	Meat, Fish and Eggs	5.21	5.80	11.68	1.18	2.64
31.	Clothings	5.75	3.78	9.11	0.36	2.49
32.	House Furnishing and Household Goods	3.50	3.41	6.35	-1.00	1.68
33.	House Rent	4.19	4.55	5.46	2.50	0.55

APPENDIX 5 : Headline Inflation and Different Core Inflations Monthly (y-o-y)

	HCPI	CPIAFEP	CPI7	CPI 10	WMED	TRIM 10	TRIM 15	TRI M 20	TRIM 15_20	TRIM 20_25
1996/97:1	7.73	6.47	7.80	7.58	9.48	7.81	7.81	7.87	7.62	7.67
1996/97:2	8.23	6.39	7.97	7.62	9.18	8.06	8.04	8.09	7.83	7.90
1996/97:3	8.59	6.75	8.32	7.98	9.20	8.45	8.45	8.47	8.21	8.27
1996/97:4	8.62	6.80	8.35	8.09	9.36	8.39	8.39	8.44	8.18	8.24
1996/97:5	8.65	6.88	8.37	8.15	7.51	8.17	8.14	8.09	7.88	7.84
1996/97:6	9.20	7.44	8.35	8.10	9.06	8.85	8.88	8.93	8.71	8.79
1996/97:7	8.91	8.62	9.13	9.11	8.61	8.50	8.59	8.68	8.41	8.50
1996/97:8	8.32	8.59	9.22	9.09	8.16	7.96	7.93	7.98	7.66	7.70
1996/97:9	7.39	8.59	8.65	8.91	8.32	7.18	7.27	7.39	6.99	7.10
1996/97:10	6.56	8.64	8.30	8.66	8.23	6.99	7.06	7.16	6.83	6.92
1996/97:11	5.94	8.90	8.39	8.66	8.35	6.88	6.99	7.14	6.71	6.89
1996/97:12	5.57	8.62	7.99	8.35	8.50	6.37	6.51	6.65	6.19	6.35
1997/98:1	6.59	9.65	8.69	8.96	8.65	7.00	7.21	7.42	6.86	7.05
1997/98:2	6.01	9.73	8.48	8.84	8.09	6.86	7.13	7.26	6.76	6.86
1997/98:3	6.90	9.49	8.36	8.65	7.35	7.62	7.89	8.02	7.59	7.72
1997/98:4	5.95	9.78	8.46	8.77	6.94	6.58	6.63	6.66	6.23	6.22
1997/98:5	6.01	9.79	8.41	8.63	6.93	6.65	6.68	6.65	6.28	6.25
1997/98:6	7.79	9.57	8.44	8.63	6.84	7.77	7.70	7.64	7.37	7.30
1997/98:7	8.45	8.73	8.00	8.04	7.13	7.44	7.37	7.37	7.07	7.02
1997/98:8	8.57	8.96	8.15	8.23	7.64	7.63	7.58	7.53	7.30	7.22
1997/98:9	8.70	9.13	8.59	8.64	7.88	8.16	8.18	8.30	7.88	8.00
1997/98:10	9.51	9.18	8.83	8.71	7.75	8.29	8.17	8.14	7.81	7.77
1997/98:11	10.44	8.99	8.56	8.60	7.77	8.14	7.97	7.93	7.58	7.57
1997/98:12	11.39	9.16	8.74	8.78	7.57	8.53	8.19	8.11	7.83	7.78
1998/99:1	11.04	7.56	7.49	7.54	6.90	7.82	7.66	7.62	7.36	7.31
1998/99:2	12.11	7.61	7.68	7.70	8.22	8.37	8.18	8.09	7.80	7.80
1998/99:3	12.13	7.77	8.02	8.13	7.29	7.86	7.38	7.18	6.91	6.78
1998/99:4	14.55	7.57	8.18	8.24	8.70	9.44	8.84	8.76	8.40	8.44
1998/99:5	13.46	7.57	8.29	8.39	9.51	9.63	9.17	9.28	8.90	8.84
1998/99:6	10.34	7.20	7.76	7.81	8.09	9.22	9.10	8.88	8.54	8.38
1998/99:7	8.87	7.34	7.63	7.58	7.14	9.01	8.58	8.11	7.80	7.39
1998/99:8	9.78	7.71	7.66	7.72	7.70	9.57	9.08	8.54	8.18	8.02
1998/99:9	9.66	7.54	7.07	7.18	7.11	9.23	8.54	8.01	7.72	7.54
1998/99:10	9.83	7.03	6.69	6.85	6.41	8.80	7.89	7.33	7.08	6.86
1998/99:11	9.12	7.14	6.68	6.94	5.78	8.46	7.51	6.95	6.60	6.35
1998/99:12	8.64	7.21	6.54	6.84	5.95	8.13	7.35	6.92	6.55	6.46
1999/00:1	5.72	6.44	5.42	5.83	5.48	6.60	6.01	5.75	5.39	5.34
1999/00:2	5.42	6.51	5.43	5.84	5.08	6.83	6.03	5.71	5.35	5.30
1999/00:3	4.12	6.29	4.91	5.36	4.89	6.10	5.53	5.17	4.84	4.77
1999/00:4	2.64	6.28	5.75	5.87	6.42	6.58	6.36	5.96	5.62	5.57
1999/00:5	3.11	6.06	5.87	5.43	5.97	6.95	6.62	6.25	5.86	5.62
1999/00:6	3.95	6.07	5.91	5.54	5.61	6.27	6.52	6.36	5.95	5.75
1999/00:7	4.45	6.01	6.07	5.79	5.70	4.83	5.08	5.37	4.87	5.17
1999/00:8	3.38	5.15	5.68	5.28	3.18	3.53	3.40	3.36	3.12	3.08
1999/00:9	3.24	4.84	5.69	5.03	3.14	3.28	3.31	3.50	3.05	3.25
1999/00:10	1.70	5.01	5.71	5.09	2.71	1.86	2.23	2.10	1.84	1.70
1999/00:11	0.71	4.84	5.48	4.83	2.41	0.95	1.32	1.77	0.85	1.37
1999/00:12	0.45	4.54	5.28	4.59	2.41	0.56	0.94	1.43	0.45	1.03
2000/01:1	0.98	5.11	6.14	5.33	3.02	1.33	1.78	2.35	1.26	2.07
2000/01:2	1.02	5.05	6.33	5.18	3.04	1.65	1.71	2.96	1.35	2.69
2000/01:3	2.87	5.04	8.97	5.09	2.09	1.62	1.52	2.49	1.01	2.16

	HCPI	CPIAFEP	CPI7	CPI 10	WMED	TRIM10	TRIM 15	TRIM20	TRIM 15_20	TRIM 20_25
2000/01:4	2.69	5.77	8.51	5.09	2.93	2.26	3.18	2.60	2.76	2.14
2000/01:5	3.12	5.95	7.60	5.51	4.20	3.77	4.52	4.23	4.09	3.83
2000/01:6	2.71	6.09	7.63	5.61	3.31	3.22	3.57	3.62	3.10	3.33
2000/01:7	1.74	5.85	6.34	5.49	3.27	2.95	3.37	3.60	2.96	3.20
2000/01:8	1.51	6.03	6.37	5.54	3.24	2.16	2.44	3.20	1.98	2.83
2000/01:9	2.37	6.03	6.32	5.57	3.30	3.28	3.76	3.89	3.28	3.55
2000/01:10	3.06	5.88	6.24	5.45	4.27	3.76	4.61	4.18	4.20	3.85
2000/01:11	3.85	5.86	6.40	5.50	4.53	3.95	3.76	4.46	3.15	4.15
2000/01:12	3.42	6.01	6.75	5.70	4.46	3.57	3.78	4.49	3.39	4.14
2001/02:1	2.87	3.66	4.89	3.71	4.28	3.83	3.67	3.86	3.21	3.47
2001/02:2	3.69	3.47	4.46	3.58	3.55	4.44	3.56	3.74	3.18	3.38
2001/02:3	1.96	3.34	1.79	3.44	2.60	2.65	2.72	2.88	2.38	2.60
2001/02:4	2.45	3.19	1.45	3.11	2.95	2.85	2.80	2.78	2.45	2.53
2001/02:5	2.69	2.96	1.74	2.75	2.09	2.36	2.28	2.27	1.98	1.99
2001/02:6	2.88	2.65	1.56	2.54	2.39	2.71	2.61	2.44	2.34	2.24
2001/02:7	3.13	2.55	2.34	2.29	2.47	3.06	2.87	2.79	2.61	2.56
2001/02:8	3.28	2.50	2.40	2.21	2.72	3.55	3.48	3.48	3.22	3.25
2001/02:9	2.38	2.52	2.35	2.35	2.25	2.77	2.73	2.71	2.51	2.45
2001/02:10	2.51	2.69	2.39	2.49	2.56	2.96	2.99	3.02	2.82	2.83
2001/02:11	2.99	2.57	2.23	2.50	2.60	3.49	3.44	3.36	3.16	3.03
2001/02:12	3.45	2.48	1.93	2.39	2.84	3.81	3.69	3.56	3.33	3.17
2002/03:1	4.15	4.12	2.85	3.57	3.41	4.26	4.27	4.07	3.82	3.70
2002/03:2	3.22	4.19	2.81	3.55	2.39	3.32	3.24	3.14	2.97	2.88
2002/03:3	2.93	4.12	2.67	3.51	2.32	3.13	3.01	3.00	2.80	2.68
2002/03:4	2.19	3.72	2.43	3.20	2.25	3.03	2.98	2.84	2.65	2.56
2002/03:5	2.69	3.85	2.80	3.33	3.30	3.85	3.68	3.50	3.26	3.03
2002/03:6	3.22	4.04	2.83	3.35	3.05	3.96	3.92	3.77	3.51	3.30
2002/03:7	4.49	4.04	2.91	3.41	3.36	4.19	4.01	3.81	3.60	3.38
2002/03:8	5.10	4.07	2.98	3.56	3.35	4.47	4.33	4.09	3.88	3.60
2002/03:9	7.82	4.36	6.03	4.60	4.50	6.48	6.16	6.08	5.74	5.65
2002/03:10	7.44	4.53	5.51	4.74	4.76	6.21	6.02	5.86	5.54	5.34
2002/03:11	6.38	4.57	5.52	4.68	3.94	5.61	5.38	4.98	4.68	4.59
2002/03:12	5.91	4.40	5.43	4.51	4.15	5.32	5.11	4.89	4.60	4.47
2003/04:1	5.22	3.70	5.08	4.11	4.77	4.70	4.56	4.62	4.35	4.41
2003/04:2	5.06	3.97	5.31	4.36	5.04	4.51	4.46	4.51	4.27	4.28
2003/04:3	5.50	3.91	5.25	4.37	4.53	4.44	4.23	4.15	3.92	3.90
2003/04:4	5.65	3.58	5.01	4.13	3.96	4.54	4.28	4.21	3.96	3.96
2003/04:5	4.78	3.51	4.66	3.98	3.15	4.02	3.65	3.35	3.15	3.05
2003/04:6	4.84	3.36	4.71	3.98	2.63	3.55	3.25	3.10	2.85	2.85
2003/04:7	4.62	3.16	4.74	3.81	3.64	3.94	3.53	3.43	3.21	3.19
2003/04:8	4.27	3.30	4.99	3.84	3.63	3.72	3.44	3.31	3.10	3.07
2003/04:9	1.70	3.11	2.15	2.93	1.81	2.34	2.40	2.37	2.17	2.15
2003/04:10	1.31	2.61	2.57	2.53	1.17	1.32	1.37	1.31	1.13	1.07
2003/04:11	1.82	2.59	2.68	2.58	1.11	2.57	3.15	1.69	2.91	1.43
2003/04:12	2.00	2.70	2.74	2.75	1.64	2.33	2.74	1.83	2.56	1.60
2004/05:1	2.35	2.58	2.63	2.60	2.09	2.05	1.97	2.01	1.74	1.81
2004/05:2	2.59	2.34	2.34	2.30	2.06	2.12	1.97	1.98	1.76	1.76
2004/05:3	2.58	2.45	3.13	2.41	2.15	2.45	2.26	2.27	2.03	2.06
2004/05:4	2.65	2.66	3.46	2.63	2.57	2.35	2.41	2.50	2.21	2.30
2004/05:5	3.07	2.60	3.56	2.75	2.46	2.69	2.58	2.52	2.38	2.34
2004/05:6	4.49	2.76	5.21	2.93	3.54	3.32	3.27	3.36	3.09	3.10
2004/05:7	5.54	3.50	6.57	4.48	4.27	4.05	3.85	3.83	3.57	3.63
2004/05:8	5.59	3.71	6.09	4.54	4.67	4.41	4.28	4.29	4.01	4.01
2004/05:9	5.68	3.70	5.96	4.29	3.97	4.22	3.97	3.90	3.72	3.67
2004/05:10	6.23	4.01	6.09	4.51	4.76	5.20	5.03	5.02	4.76	4.75
2004/05:11	6.01	4.00	5.95	4.50	4.03	4.90	4.76	4.64	4.41	4.26
2004/05:12	6.44	4.03	6.08	4.48	4.18	5.36	5.24	5.08	4.86	4.69

Hydropower Development in Nepal

Deepak Adhikari*

Hydropower has been recognised as a sustainable source of energy with almost zero input cost. Its benefits are that it is non-polluting in the sense that it releases no heat or noxious gases, it has low operating and maintenance cost, its technology offers reliable and flexible operation, and hydropower stations have increased efficiencies along with long life. Nepal's huge potential in hydropower is still untapped. Though Nepal has not yet been able to tap even one percent of its potential electricity capacity and 60 percent of Nepal's population is still deprived of electricity, it is fascinating to note that Nepal's start in 1911 in the hydropower generation almost dates back to a century. As a cheap, renewable source of energy with negligible environmental impacts, small hydropower has an important role to play in Nepal's future energy supply. Accordingly, micro-hydro system is becoming increasingly popular as an energy source in rural Nepal. Use of environmentally-friendly technologies and implementation of sound legal and institutional issues are critical to improve the reach of the population to hydropower. To make the Plan targets in the power sector a reality, directing more resources to the power projects focusing on rural population remains the pre-requisite. The major strategies of the power sector have been appropriately identified as promoting private sector participation in power generation and distribution, integrating rural electrification with rural economic development programs, and strengthening power infrastructure. The immense role of the power sector in contributing to the generation of broad-based, sustainable and high level of economic growth as well as improving the relative competitiveness of the economy both on a regional and global basis makes it imperative that the programs and activities on power sector development as visualized in the plans and policies be given the utmost urgency, priority and focus.

I. INTRODUCTION

It is now not a new knowledge that flowing water creates energy that can be captured and turned into electricity called hydropower. Hydro comes from the Greek word 'hydra', meaning water. It is the electricity produced by the movement of fresh water from rivers and lakes. Also called hydropower, it is a renewable energy source dependent upon the hydrologic cycle of water, which involves evaporation, precipitation and the flow of

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water due to gravity. Gravity causes water to flow downwards and this downward motion of water contains kinetic energy that can be converted into mechanical energy, and then from mechanical energy into electrical energy. At a good site, hydropower can generate very cost effective electricity. The history of conversion of kinetic energy into mechanical energy dates back to two thousand years ago in ancient Greece when wooden waterwheels were used. Hydropower represents an important source of energy, accounting for one-fifth of the world's electricity supply. Most of the technically and economically feasible hydropower potential has been exploited in the developed countries and the developing countries, too, realizing the significance of this source of power for the higher sustained economic growth and development of their respective economies, have been embarking on the various phases of the hydropower development process.

Hydropower projects have a number of benefits. The prominent among them are that these projects have low energy production cost considering the long effective lifetime of the plants along with the low operation and maintenance cost, greater efficiency than of all the major types of plants using non-renewable and renewable energy resources, almost complete absence of greenhouse gas emission, possibility of multi-purpose water use and water management such as irrigation and regulation of river flows both during flood season and low flow periods, independence of fluctuating fuel prices and supply disruptions, efficient output regulation, rapid response capacity to variable energy demand, reliable, proven mature technology with known positive and negative influences, a renewable energy source, save consumption of fossil, fuel, or firewood which constitute classic energy sources that contribute to the greenhouse effects or atmospheric pollution as the hydropower plants make use of artificial fall of the river, the hydraulic conveyance circuit that can be integrated in other components for multiple purposes such as irrigation, water supply systems, fisheries, water-tourism, etc. The most important benefit is that hydropower plants produce electricity without consuming power.

Hydropower provides a reliable, efficient, safe and economic source of power for increasing effectiveness of the decentralized industries system. The use of water to produce hydropower has the advantage of absent of carbon-dioxide, sulphur-dioxide, nitrous-oxide and solid or liquid waste production. Thus, the water sources should contribute to a substantial reduction in emission of carbon-dioxide and other harmful gases responsible for greenhouse effects. The water will continue to fall downhill and will continue to be a resource for men and environment needs as a part of the natural hydrologic cycle. However, it has some disadvantages like high investment along with long lead-time for project realization, long gestation period, and environmental and social problems, mainly due to inundation of affected areas by large water reservoirs causing possible destruction of unique biotypes and endemic species. Some other disadvantages include, possible destruction of human habitat, high cost for the necessary resettlements and fallouts related to social and political implications.

Regarding the presentation of the analysis, this first section outlines the Introduction. The second section covers the History of the electricity development with reference to Nepal. The third section on Operations of Hydropower Stations and the fourth section on the Small Scale Hydropower describe, in short, the operational technicalities of the station operations. The fifth section on Development of Hydropower in Nepal describes the decadewise growth of hydropower and the sixth section on Small Hydroplants in Nepal analyses the distribution of smaller hydroplants. While the seventh section covers

the Hydropower Policy, the eighth section deals with the Challenges before arriving at the Conclusion which is given in the last or the ninth section.

II. HISTORY

In the modern days, it was only in 1882 that the first hydropower plant was built in Wisconsin, USA. This plant made use of a fast flowing river as its source. Some years later, dams were constructed to create artificial water storage area at the most convenient locations. These dams also controlled the water flow rate to the power station turbines. In Nepal, the first hydropower plant was established at Pharping (500-KW) in 1911, 29 years after the world's first plant was established, during Prime Minister Chandra Shamsher Rana's time to meet the energy requirements of the members of the ruling class. Though some 60 percent of Nepal's population remains deprived of electricity while the capital city continues to thirst for drinking water and suffers from regular load-shedding even at the present, it is fascinating to note that Nepal had such an early start in the hydropower generation. The first hydropower plant in India was established in 1898 in Darjeeling and the first hydropower plant in China was established in 1912. Originally, hydropower stations were of a small size set up at waterfalls in the vicinity of towns because it was not possible at that time to transmit electrical energy over long distance. The main reason why there has been large-scale use of hydropower is because it can now be transmitted inexpensively over hundreds of kms. where it is required, making hydropower economically viable. Transmission over long distances is carried out by means of high voltage, overhead power lines called transmission lines. The electricity can be transmitted as either alternating current (AC) or direct current (DC). Unlike conventional power stations, which take hours to start up, hydropower stations can begin generating electricity very quickly. This makes them particularly useful for responding to sudden increases in demand for electricity by customers, i.e., peak demand. Hydro-stations need only a small staff to operate and maintain them. No fuel is needed to operate, as such; fuel prices do not become a problem. Also, a hydropower scheme uses a renewable source of energy that does not pollute the environment. However, the construction of dams to enable hydropower generation may cause significant environmental damage. In the world today, the highest producers of hydropower are Canada, United States, Brazil, China, Russia, and Norway. Among the various countries, Canada ranks first in the production of hydropower as it has abundant water resources and a geography that provides many opportunities to produce low-cost energy. In fact, accessing the energy from flowing water has played an important role in the economic and social development of Canada for the past three centuries.

BOX 1: Pharping Hydropower: Nepal's First Hydroplant

Pharping Hydropower Plant is one of the oldest hydropower plants of Asia and the first hydropower plant of Nepal. The construction of the plant commenced in 1907 and was commissioned in 1911. The plant was inaugurated by His Late Majesty King Prithvi Bir Bikram Shah on May 1911(Jestha 9, 1968 BS, Monday, at 6:30 PM). In total, 900,050 thousand man-days were required to complete the construction of the plant. The plant was equipped with two turbines each of 250 KW. The water for the generation was tapped from Satmule and Shesh Narayan laying steel pipeline with diameter of 44 inch from Satmule and diameters of 10 inch and 9 inch from Shesh Narayan. A reservoir with 200 ft. diametre and 18 ft. depth with the capacity of 528,733 cu. ft. was built. From the reservoir, riveted steel pipes of 20 inch diameter were used as penstock up to the bifurcation point. An overhead transmission line of 6 miles from the plant to the distribution sub-station at Tundikhel was constructed using steel and wooden poles. In the transmission line, there are two major crossings of 600 ft. and 900 ft. on Bagmati river. The equipment of this plant was a grant from the British Government and other expenditures were borne by Nepal Government. The total cost borne by Nepal Government was CRs. 713,273.82, out of which CRs. 367,984.00 was spent locally inside Nepal. The breakdown of the total cost (CRs. 713,273.82) was: Pipeline/Headwork/Reservoir CRs.196,324.84, Powerhouse/Colony/Tailrace and Widening of Bagmati River CRs. 156,778.31, Substation/Office/Store CRs. 36,175.80, Transmission Line/Street Light/Distribution Line and Telephone Line CRs.111,049.50, London to Kolkata Transportation/Packing/Commission to Agent CRs. 28,699.26, Kolkata to Bhimphedi Transportation CRs. 40,311.79, Bhimphedi to Site Transportation CRs. 40,372.32, and Salary/ Wages CRs. 103,565.00. The plant was constructed under the overall supervision and monitoring of General Padma Sumsher JBR. Executive Engineer Colonel Kishor Narsingh Rana was responsible for planning of the powerplant.

Salient Features of the Plant

1. Turbine	*: Pelton Turbine, 2 Nos.*
2. Governor	*: Milton Oil Governor*
3. Penstock	*: Riveted Steel pipes of 20" dia. (length 2,538 ft.)*
4. Reservoir	*: 200' dia. and 18' deep (capacity 528,733 cu. ft.)*
5. Conveyance System	*: Pipeline:- 44" dia. from Satmule*
	10" and 9" dia. from Shesh Narayan
6. Water Pressure at Turbine	*: 288 lb/sq. inch*
7. Transmission Line	*: Length 6 miles, Support - Steel and Wooden Poles.*

Source: Nepal Electricity Authority, Aug.2005, Generation, Third Issue, Kathmandu, Nepal.

III. OPERATIONS OF HYDROPOWER STATIONS

The most common type of hydropower plant uses a dam on a river to store water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which, in turn, activates a generator to produce electricity. But hydropower doesn't necessarily require a large dam. Some hydropower plants just use a small canal to channel the river water through a turbine. Another type of hydropower plant—called a pumped storage plant—can even store power. The power is sent from a power grid into the electric generators. The generators then spin the turbines backward, which causes the turbines to pump water from a river or lower reservoir to an upper reservoir, where the power is stored. To use the power, the water is released from the upper reservoir back down into

the river or lower reservoir. This spins the turbines forward, activating the generators to produce electricity.

Thus, the main components of a hydropower facility are the dam, the powerhouse that contains the mechanical and electrical equipment, and the waterways. Water is released from the dam to turn turbines. The turbines drive generators that produce electricity. The purpose of the dam is to create height for the water to fall and to provide storage. However, the dam must also be provided with a spillway that can accommodate and pass high flows or flood waters without overtopping the dam or reducing its safety. The flood water come from heavy rain or rapid snowmelt on the upstream part of the basin. If it is proposed to utilize not only the head at the dam but also the fall in the river downstream, a canal, penstock or tunnel are needed to carry the water to the powerhouse. A canal may also be needed to carry water from the powerhouse back to the river.

The amount of electrical energy that can be generated from a water source depends primarily on two things: the distance the water has to fall and the quantity of water flowing. Hydropower stations are, therefore, situated where they can take advantage of the greatest fall of a large quantity of water: at the bottom of a deep and steep-sided valley or gorge, or near the base of a dam. Water is collected and stored in the dam above the station for use when it is required. Some dams create big reservoirs to store water by raising the levels of rivers to increase their capacity. Other dams simply arrest the flow of rivers and divert the water down to the power station through pipelines. The amount of energy available from water depends on both the quantity of water available and its pressure at the turbine. The pressure is referred to the head, and is measured as the height that the surface of the water is above the turbine. The greater the height (or head) of the water above the turbine, the more energy each cubic metre of water can impart to spin a turbine which, in turn, drives a generator. The greater the quantity of water, the greater the number and size of turbines that may be spun, and the greater the power output of the generators. It may be relevant to mention that current hydropower technology, while essentially emission-free, can have undesirable environmental effects, such as fish injury and mortality from passage through turbines, as well as detrimental effects on the quality of downstream water. A variety of mitigation techniques are in use now, and environmentally friendly turbines are under development.

IV. SMALL SCALE HYDROPOWER

Hydropower is available in a range of sizes from a few hundred watts to over 10 GW. Facilities range in size from large power plants that supply many consumers with electricity to small and micro plants that local community operates for its own energy needs or power producers operate to sell power to the central grid authority. Small-scale hydropower plants (up to 1000 KW) play an immense role in meeting the energy needs and do not require huge investment and market requirements. Micro-hydro systems (up to 100 KW) operate by diverting part of the river flow through a penstock (or pipe) and a turbine, which drives a generator to produce electricity. The water then flows back into the river. Micro-hydro systems are mostly run-of-the-river systems, which allow the river flow to continue. This is preferable from an environmental point of view as seasonal river flow patterns downstream are not affected and there is no flooding of valleys upstream of the system. A further implication is that the power output of the system is not determined

by controlling the flow of the river, but instead the turbine operates when there is water flow and at an output governed by the flow. This means that a complex mechanical governing system is not required, which reduces costs and maintenance requirements. The systems can be built locally at low cost, and the simplicity gives rise to better long-term reliability. However, the disadvantage is that water is not carried over from rainy to dry season. In addition, the excess power generated is wasted unless an electrical storage system is installed, or a suitable 'off-peak' use is found. There are two main types of turbines used in micro-hydro systems, depending on the flow and the head, namely, impulse turbines and reaction turbines. Typical impulse turbines are generally used for medium to high-head applications. Reaction turbines are generally used at low propeller turbine or medium head turbine. Electrical energy can be obtained from a micro-hydro system either instantaneously or through a storage system. In an instantaneous power demand system, the system provides 240V AC power to the load via-a turbine which must be sufficiently large to meet the peak power demand. These systems require a large head and/or flow. In a storage system, the micro-hydro generator provides a constant DC charge to a battery system, which then supplies power to the load via an inverter. The battery system must be sized to the daily electrical demand. However, the turbine is significantly smaller than for an instantaneous demand system, and it operates at a constant power output.

V. Development of Hydropower In Nepal

Nepal is rich in hydro-resources, with one of the highest per capita hydropower potentials in the world. The estimated theoretical power potential is approximately 83,000 MW. However, the economically feasible potential has been evaluated at approximately 43,000 MW. After the establishment of the first hydropower plant (500 MW) in 1911, the second hydropower plant (640 KW) was established at Sundarijal in 1936. Similarly the Morang Hydropower Company, established in 1939, built 677 KW Sikarbas Hydroplant at Chisang Khola in 1942 though this Plant was destroyed by landslide in the 1960s. The development of hydropower was institutionalized after the initiation of the development planning process. The First Five-year Plan (1956-61) targeted to add 20 MW of hydropower. However, the target was unmet. During the Second Three-year Plan (1962-65), some progress was achieved. Till 1962, the Electricity Department of HMG was responsible for the generation, transmission and distribution of electricity. In 1962, Nepal Electricity Corporation (NEC) was established and was given the responsibility of transmission and distribution of the electricity. The Electricity Department was responsible for the task of electricity generation. After a long gap since the establishment of the Chisang Hydroplant, the hydropower generation capacity of the country expanded with the construction of the Panauti Hydroplant (2400 KW) in 1965 and the Trishuli Hydroplant (21000 KW) in 1967. A series of hydropower projects then followed. The Eastern Electricity Corporation was established in 1974. In 1977, Small Hydropower Development Board was established. Institutional restructuring took place again in 1985, when the merging of the Electricity Department, Nepal Electricity Corporation and all the development boards (except the Marshyangdi Hydropower Development Board) resulted in the creation of Nepal Electricity Authority (NEA). Since this arrangement, the NEA has been responsible for the generation, transmission and distribution of electricity. Other

public sector institutions involved in the hydropower sector include Water and Energy Commission and its Secretariat constituted in 1976, the policymaking body established in 1981, and the Department of Electricity Development. Of late, the private sector is also emerging as an important player in the hydropower development. Independent Power Producers (IPPs) have been the ongoing institutional innovations in the power sector of Nepal, with the IPPs signing power purchase agreements (PPA) with the NEA to sell electricity. At present, the total hydropower generation has reached 556.8 MW or just 0.7 percent of the potential. Of the total energy consumption in Nepal, traditional energy like fuel-wood, agriculture residues and animal dung comprises 88 percent and commercial energy like petroleum, hydropower and solar energy constitutes 12 percent. Hydropower accounts for 75 percent of the commercial energy supply in Nepal. The hydropower plants have mainly catered to the electricity needs in the urban and semi-urban areas. The highest growth of hydropower took place during 2001-2005 wherein 195.3 MW (35.1 percent of the total) was produced followed by the decades of 1981-90 and 1991-2000 decades which saw the production of 180.3 MW (32.4 percent of the total) and 125.9 MW (22.6 percent of the total) respectively. The period since 1981 produced 501.5 MW (90.1 percent of the total), implying that only 55.3 MW (9.9 percent of the total) was produced during the entire period of 1911-1980 (Table 1 and Figures 1-4).

TABLE 1. Decadewise Development of Hydropower

	Generation		Cumulative	
Decade	Mega Watts	% of Total	Mega Watts	% of Total
1911-1920	0.5	0.1	0.5	0.1
1921-1930	0.0	0.0	0.5	0.1
1931-1940	0.6	0.1	1.1	0.2
1941-1950	0.0	0.0	1.1	0.2
1951-1960	0.0	0.0	1.1	0.2
1961-1970	27.5	4.9	28.6	5.1
1971-1980	26.7	4.8	55.3	9.9
1981-1990	180.3	32.4	235.7	42.3
1991-2000	125.9	22.6	361.5	64.9
2001-2005	195.3	35.1	556.8	100.0
Total	556.8	100.0		

Source: Compilations from NEA Publications.

FIGURE 1: Decadewise Development of Hydropower Generation (MW)

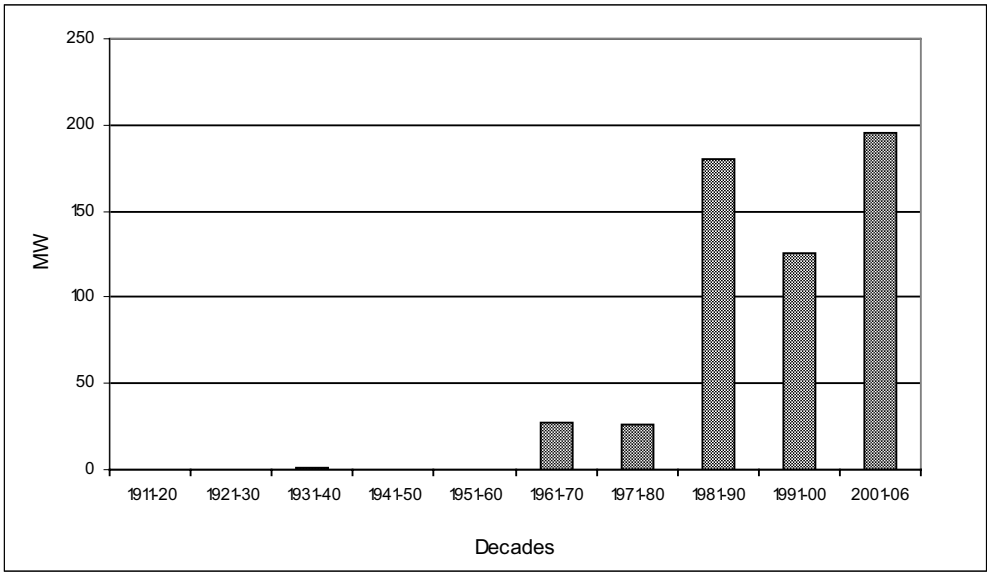


FIGURE 2 : Decadewise Development of Hydropower Generation (% of Total MW)

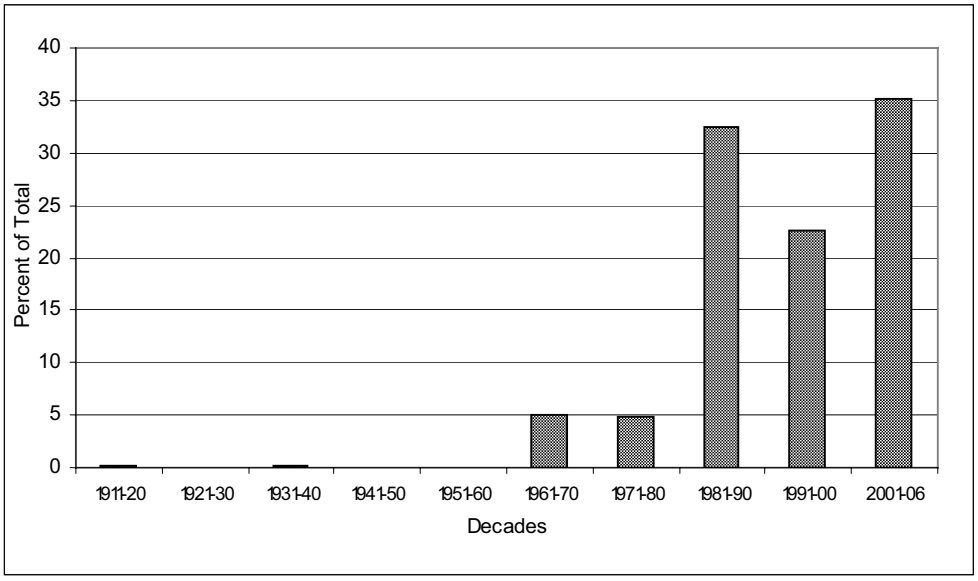


FIGURE 3 : Decadewise Cumulative Hydropower Development (MW)

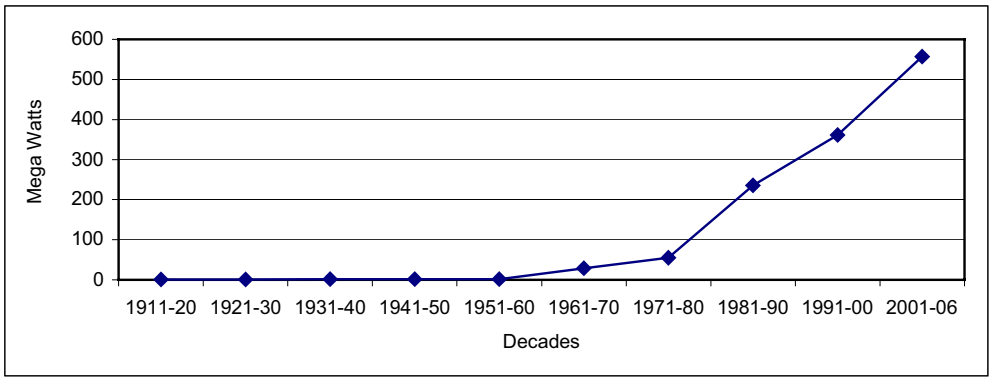
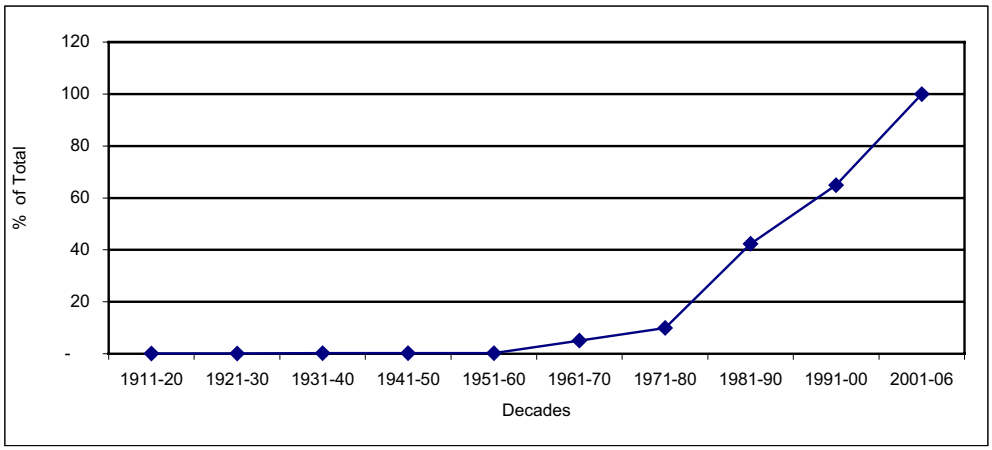


FIGURE 4 : Decadewise Cumulative Hydropower Development (% of Total)



VI. SMALL HYDROPLANTS IN NEPAL

Environmental problems with the dams such as inundation, siltation, negative impacts to river water quality, harm to riparian ecosystems, controversies over monopsony buyer, and the fact that the large projects rely on expensive foreign contracting firms have raised opposition against large-scale hydropower projects in Nepal. Although medium to large-scale hydropower (above 1000 KW) remains the likely choice for meeting Nepal's urban electricity demand, which is growing at an average annual rate of 15 percent, small hydropower is an attractive alternative to conventional power systems in rural and remote areas as a means of achieving rural electrification. As only 33 percent of the population has access to electricity from the national grid, there are many important micro-hydro schemes designed to meet the rural demands. Hence, as a cheap, renewable source of energy with negligible environmental impacts, small

hydropower has an important role to play in Nepal's future energy supply. Accordingly, micro-hydro system is becoming increasingly popular as an energy source in rural areas, which are excluded from the energy grid that transmits power from the large hydropower stations to the major urban areas. In fact, micro-hydro power generation is only one component out of the four that include bio-gas generation, solar energy schemes and improved stoves to meet the local need for fuel. As an example of the micro-hydro project, the village of Ghandruk that lies in the Annapurna region is one of many villages in the region that is generating electricity from the Modi Khola river. The stream is no more than a metre wide in the dry season, but generates 50 KW of power: enough for electric lighting for every house in the village and for 20 percent of the village to cook with electricity. The thrust of the micro hydro projects of this nature is to develop hydropower potential in a sustainable and environmentally-friendly way, with a maximum use of the domestic resources and expertise. Of the total electricity generation, the small hydroplants (up to 1000 KW) generate 8.4 MW and medium-sized hydroplants (above 1000 KW) generate 548.4 MW, with the respective shares of 1.5 percent and 98.5 percent (Annexes I, II and III , with Annex IV giving the details of the hydropower projects under construction). The following tables (Table 2 &3) and figures 5,6,7 and 8 provide the distribution of small and medium-sized hydropower plants.

TABLE 2. Distribution of Small Hydroplants (up to 1000 KW)

Kilowatts	No. of Plants	% of Total
1 – 100	8	22.2
101 – 200	14	38.9
201 – 300	6	16.7
301 – 400	3	8.3
401 – 500	3	8.3
501 – 600	1	2.8
601 – 700	1	2.8
Total	36	100.0

Source: Compilation from NEA Publications

TABLE 3. Distribution of Medium-sized Hydroplants (more than 1 MW)

Megawatts	No. of Plants	% of Total
1 – 20	18	72.0
21 – 40	3	12.0
41 – 60	2	8.0
61 – 80	1	4.0
81 – 100	0	0.0
101 – 120	0	0.0
121 – 140	0	0.0
141 – 160	1	4.0
Total	25	100.0

Source: Compilation from NEA Publications

FIGURE 5 : Distribution of Small Hydroplants (Number)

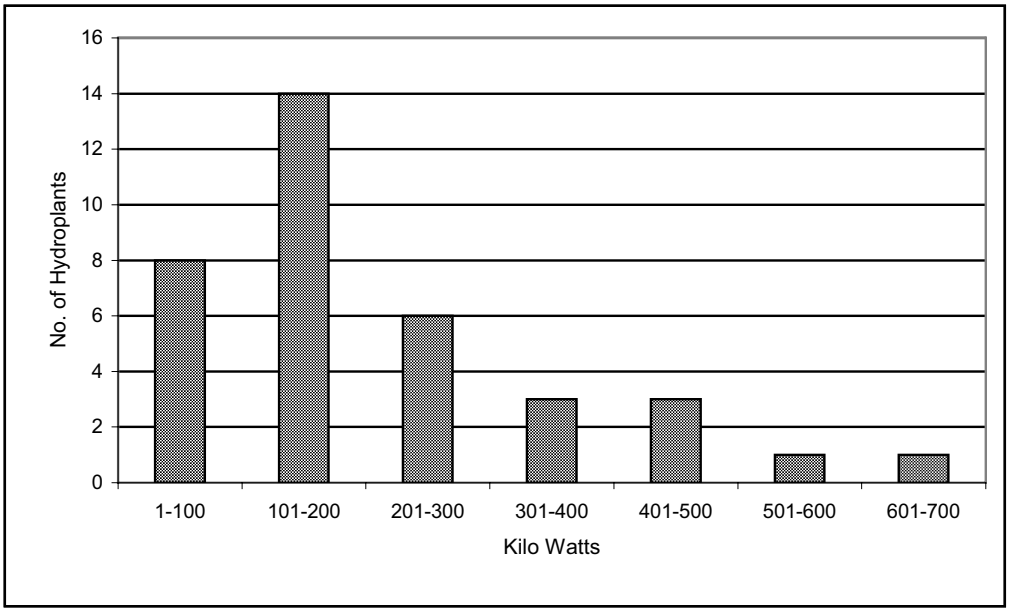


FIGURE 6 : Distribution of Medium-sized Hydroplants (Number)

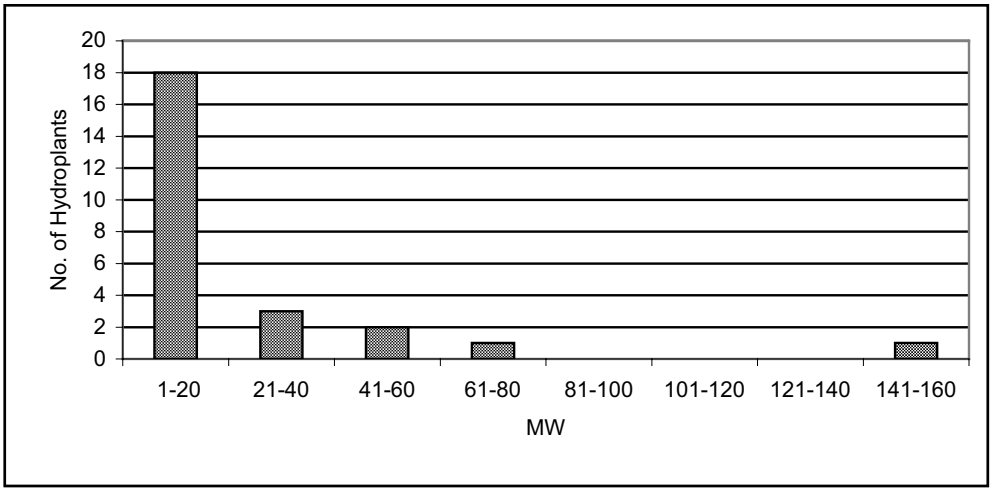


FIGURE 7: Contribution of Small and Medium-Sized

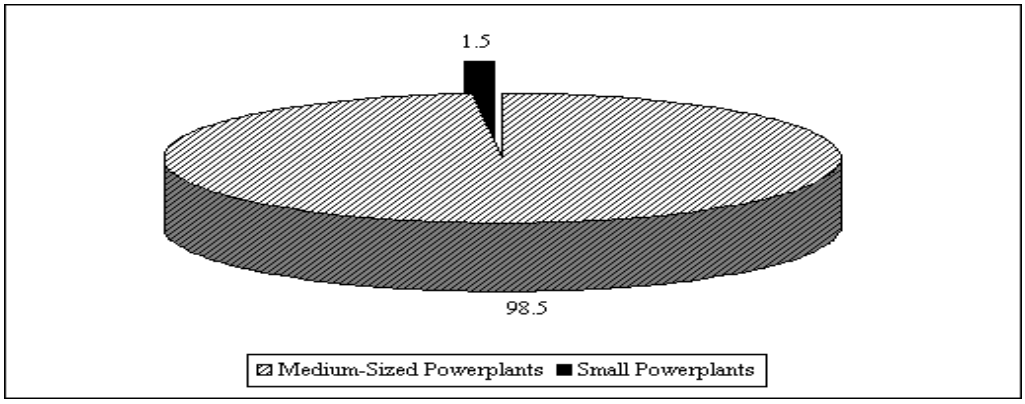
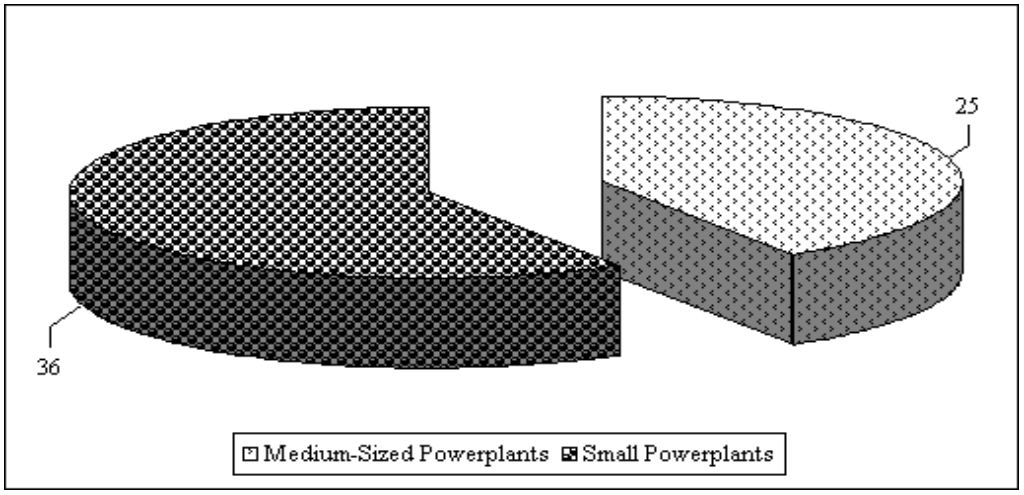


FIGURE 8 : Contribution of Small and Medium-Sized Powerplants (Number)



VII. HYDROPOWER POLICY

The Tenth Plan's (2002-07) key objectives in the power sector include expanding, in a sustainable and environmental-friendly manner, electricity coverage by generating low-cost power; accelerating rural electrification to promote economic growth and improve living standards, and to develop hydropower as an important export item. Rural electrification is particularly important in a rural-based economy of Nepal. It plays an important role in accelerating both agricultural and rural development. It could have a catalytic effect on agricultural growth, especially by accelerating shallow tubewell irrigation. In addition to supporting the development of agro-business, the extension of rural electrification would also help modernize cottage industries and improve the living standards of rural households. Accordingly, key programs are aimed at expanding grid-

based rural electrification, promoting small projects where grid-based expansion is not possible, and enhancing the capacity of cooperatives for management at local levels. To achieve the objective of increasing rural coverage of electricity over the Plan period, the government's strategy envisages initiating an explicit subsidy policy for grid-based rural electrification.

Water Resources Strategy 2002 has formulated 10 different strategies, out of which the strategy for the hydropower development aims to achieve "cost-effective hydropower development in a sustainable manner". The strategy has prescribed short-term (5 years), medium-term (15 years) and long-term (25 years) strategic plan of hydropower development. The target of the strategy is: (a) by 2007, to develop hydropower capacity to meet projected demand of 700 MW, (b) by 2007, laws making national contractors/consultants' participation mandatory in all types of projects promulgated, (c) by 2017, 25 percent of households supplied with electricity, (d) by 2017, 2230 MW hydropower developed to meet projected demand including 400 MW for export, (e) by 2017, 38 percent of households supplied with electricity, (g) by 2027, 60 percent of households accessing the grid-supplied electricity, and (h) by 2027, Nepal exporting substantial amount of electricity.

The major strategies of the power sector include promoting private sector participation in power generation and distribution, unbundling the activities of the NEA as well as improving its financial viability, integrating rural electrification with rural economic development programs, and strengthening power infrastructure. The major initiatives/activities to be undertaken to improve power sector development include the establishment of a Power Development Fund (PDF); creation of an independent regulatory authority; initiation of an explicit subsidy policy for grid-based rural electrification; and promotion of small, medium and storage hydropower projects. Hydropower policy has been accordingly revised to allow the private sector entry into a full range of power sector activities, i.e., generation, transmission and distribution. Considerable private investments have already taken place in a number of power generation projects. But progress has been constrained by the insecurity caused by the civil disorder. The major outcomes expected are that the proportion of population having access to electricity will increase from 40 percent to 55 percent by the end of the Tenth Plan period, as stated above, and adequate power will be supplied as needed to support economic growth. To make this outcome a reality, directing more resources to the power projects focusing on rural population remains the pre-requisite.

In accordance with the priority accorded to this sector, HMG has spent substantial sums of money for the electricity development in Nepal. The actual capital outlays on electricity during FY 1998/99 through FY 2003/04 are: Rs. 2.3 billion in FY 1998/99, Rs. 2.5 billion in FY 1999/00, Rs. 2.8 billion in FY 2000/01, Rs. 2.5 billion in FY 2001/02, Rs. 2.2 billion in FY 2002/03 and Rs. 2.3 billion in FY 2003/04, representing 20.9 percent, 21.6 percent, 23.7 percent, 17.6 percent, 17.4 percent and 20.6 percent of the total capital outlay of HMG during these six years respectively. The average of these components works out at 20.4 percent. The Public Statement on Income and Expenditure of HMG for FY 2005/06 has termed roads, electricity and communications as the pre-requisite for economic growth. Accordingly, important programs have been outlined for the electricity development. To expedite the construction of the Middle Marshyangdi Hydro Project, Rs. 2.8 billion has been allocated. Rs. 1.5 billion has been allocated for the

rural electrification program which includes handing over the electricity distribution responsibility to the consumer groups in 100 places. There is also a program to generate 2,075 KW electricity in different districts not accessed by the national grid. Necessary preparations will be made to initiate the construction of the 302-MW Upper Tamakoshi and 42-MW Upper Modi "A" under the joint investment of the NEA and the private sector. In order to address the rising demand for electricity by taking advantage of the lower interest rate prevailing in the financial system, the NEA will issue Power Bonds with maturity period of 20 to 30 years and invest them for the construction of new projects.

The immense role of the power sector in contributing to the generation of broad-based, sustainable and high level of economic growth makes it imperative that the programs and activities on power sector development as visualized in the plans, policies and the Annual Public Statement on Income and Expenditure of HMG be given the utmost urgency, priority and focus. The programs of the NEA also need to be completed timely and efficiently. It is very important to realize that, in the present global scenario where the oil prices are remaining higher and future provides an uncertain outlook with respect to oil, optimal utilization of the abundant natural endowment, viz., hydropower, would reduce Nepal's import cost substantially and contribute to improve the relative competitiveness of the economy both on a regional and global basis.

VIII. CHALLENGES

Conventional energy plays an important role in the energy sector of Nepal. The role of conventional energy is more significant in the rural areas where around 85 percent of the population resides. The fuel-wood supply is constrained because of environmental considerations and depleting forest resources. In contrast, the country's enormous hydropower potential is virtually untapped to meet its energy needs, creating a unique situation of a chronic imbalance between energy consumption and energy resource endowment. Large increase in population resulting in the big loss of per-capita land and the poor state of the development of other types of renewable energy have left Nepal no space except to rely on hydropower.

The consumption pattern of hydropower supply in Nepal displays a prominent share of industrial and domestic demand which together accounts for about 80 percent of the total use. Nepal's power supply and demand patterns have a noticeable seasonality characteristic of imbalance in the form of power shortages during dry-months (mid-December through mid-April) and surpluses during wet-months. Despite the introduction of some demand management measures to even them out, these imbalances are still very evident. According to demand supply projections concluded under Water Resources Strategy 2002, such imbalances are expected to persist in the years ahead and this presents an unique opportunity as well as challenge for evening-out the power imbalances on a long-term basis.

Hydropower projects are more capital intensive and most of the existing hydropower plants owned and operated by NEA have mainly come up through bilateral donor financing in combination with soft loan financing from multilateral development financing institutions. The low per-capita consumption of energy in Nepal is not attributed to lack of demand but to the supply bottleneck resulting from financial

constraints and inherent delay in hydropower project development. The existing hydropower projects are expensive due to heavy reliance on bilateral and multilateral financing agencies, costly foreign consultants and contractors, limited manufacturing capability of power generation, transmission, and distribution-related equipment, inefficient management and high cost of preparatory works as well as unfavorable geological condition. High cost of project development together with initially expensive power purchase agreement with IPPs, transmission and distribution losses, non-payments or payments in arrears from the public sector consumers and wastage of surplus power contribute to high electricity tariffs, thereby making adverse impact on industrial use and export purposes.

For the implementation of plan and achieving the targets relating to the hydropower, development of cost effective small and medium-sized projects to meet domestic demand at affordable price, encouragement of private sectors investment in hydropower development and power distribution on competitive basis, acceleration of rural electrification attracting investment from community and private entrepreneurs, improvement in the integration of social and environment mechanism into power development process, encouragement of the power-based industries and transportation systems to create market for existing surplus energy and future energy growth are extremely important. Besides, facilitating the flow of funds from domestic financial sector to the hydropower sector and the institutional set-up for the power export, promoting hydropower research and development (R&D) center to assist in preparation of national power system and improve NEA as a commercially viable entity remain the other challenges.

Financing and cost considerations provide major challenges in the process of materializing the hydropower potential of Nepal. It is estimated that the government developed medium-sized hydropower cost an average of US$ 2,800/KW while private generators have been able to produce at US $ 1,000/KW. In this context, making the government-developed hydropower at a cheaper rate comparable to that of the private sector becomes an important challenge. To meet the existing gap in the supply of hydropower, new and cheap hydropower generation must come on national grid very fast. Producing hydropower in sufficient quantity and quality constitutes another challenge. Regional balance in production and distribution capacity needs to be maintained for both socio-political and techno-economic reasons. The people of Nepal from east to west must feel that they are part of the overall national development process, and this will occur if important symbols of development such as hydropower is available to them. Large-scale export potential should not be entertained without first achieving a strong domestic base because once Nepal's needs are adequately met from hydropower development efforts within Nepal, it will be in a more comfortable bargaining position then if it is in a situation where her internal demands have to be met, especially in border towns, with the generosity of the Bihar and the Uttar Pradesh Electricity Boards. So, there is a need for seriously pushing forward a strong hydropower development program that matches Nepal's own power demand growth. State monopoly with no contractual accountability to supply the consumers power of reliable quantity and quality needs to be discouraged at all costs. Hence, the challenge facing Nepal is to generate sufficient financial resources to develop its hydropower in an environmentally sustainable and socially acceptable manner to meet the needs of its people. This calls for least cost approach that makes power

affordable to domestic consumers and competitiveness in the export markets of the neighbouring countries in the medium-term. In this context, it is interesting to observe that the hydropower development policy 2001 and the Tenth Plan has attempted to address these issues by way of power sector reform focusing on promotion of private investment, creation of competition through institutional restructuring and establishment of an independent regulatory authority though the reform is progressing very slowly.

IX. CONCLUSION

The hydropower potential of Nepal is huge and the sustainable hydropower development becomes the key to make Nepal's economic growth scenario brighter, gaining deep inroads into the national goal and priority of poverty reduction. Hydropower has a number of benefits: (a) it is a continuously renewable electrical energy source; (b) it is non-polluting, i.e., no heat or noxious gases are released; (c) it has no fuel cost and, with low operating and maintenance cost, is essentially inflation-proof; (d) hydropower technology is a proven technology that offers reliable and flexible operation, (e) hydropower stations have a long life and many existing stations have been in operation for more than half a century and are still operating efficiently; (f) hydropower station efficiencies of over 90 percent have been achieved making it the most efficient of the energy conversion technologies.

Hydropower offers a means of responding within seconds to changes in load demand. Fortunately, Nepal is rich in hydro-resources, with one of the highest per capita hydropower potentials in the world. However, at present, the total hydropower generation has been 556.8 MW, merely 0.7 percent of the potential, with connection to 40 percent of the people. It is notable to mention that, by the end of the Tenth Plan (2002-07), 55 percent of the population will have connection to the electricity. Use of environment-friendly technologies and implementation of sound legal and institutional issues are critical to improve the reach of the population to the hydropower. Putting into place a favorable environment for increasing investments in cost-effective projects would definitely contribute to make this target a reality. As a cheap, renewable source of energy with negligible environmental impacts, small hydropower has an important role to play in Nepal's future energy supply. Micro-hydro systems are particularly suitable for power supplies in rural and isolated communities, as an economic alternative to extending the electricity grid. These systems provide a source of cheap, independent and continuous power, without degrading the environment, so essential for a mountainous and environmentally fragile country like Nepal. To make this outcome a reality, directing more resources to the power projects focusing on rural population remains the pre-requisite. The Acts and regulations should be made to support the environment as well as the hydropower development efforts so that the environment and development go together, especially when it comes to the most important natural resource development endeavors of the nation. The major strategies of the power sector have been appropriately identified as promoting private sector participation in power generation and distribution, unbundling the activities of the NEA as well as improving its financial viability, integrating rural electrification with rural economic development programs, and strengthening power infrastructure. In the present global scenario where the oil prices are remaining higher and future provides an uncertain outlook with respect to oil, optimal

utilization of the abundant natural endowment, viz., hydropower, would reduce Nepal's import cost substantially, contribute in improving the relative competitiveness of the economy both on a regional and global basis, and fulfill the desire of double-digit sustainable growth in the coming decades.

ANNEX 1: Development of Hydropower Projects in Nepal (1911-2005)*

S. No.	Hydropower Projects	Commissioned Year	Capacity (KW)	Cumulative Generation (KW)	Type	Located District	Grid Status	Ownership
1	Pharping **	1911	500	500	RoR	Kathmandu	Grid Connected	NEA
2	Sundarijal	1936	640	1,140	RoR	Kathmandu	Grid Connected	NEA
3	Panauti	1965	2,400	3,540	RoR	Kavre	Grid Connected	NEA
4	Phewa	1967	1,088	4,628	RoR	Kaski	Grid Connected	NEA
5	Trisuli	1967	24,000	28,628	RoR	Nuwakot	Grid Connected	NEA
6	Dhankuta	1971	240	28,868	RoR	Dhankuta	Isolated	NEA
7	Sunkosi	1972	10,050	38,918	RoR	Sindupalchowk	Grid Connected	NEA
8	Jhupra	1977	345	39,263	RoR	Surkhet	Isolated	NEA
9	Dhading	1978	32	39,295	RoR	Dhading	Isolated	NEA
10	Tinau	1978	1,024	40,319	RoR	Rupendehi	Grid Connected	NEA
11	Gandak	1979	15,000	55,319	RoR	Nawalparasi	Grid Connected	NEA
12	Baglung	1981	200	55,519	RoR	Baglung	Grid Connected	NEA
13	Doti	1981	200	55,719	RoR	Doti	Isolated	NEA
14	Phidim SHP	1981	240	55,959	RoR	Panchthar	Isolated	Leased
15	Gorkhe	1982	64	56,023	RoR	Ilam	Isolated	NEA
16	Jumla	1982	200	56,223	RoR	Jumla	Isolated	Leased
17	Jomsom	1982	240	56,463	RoR	Mustang	Grid Connected	Leased
18	Kulekhani 1	1982	60,000	116,463	Storage	Makwanpur	Grid Connected	NEA
19	Devighat	1983	14,100	130,563	RoR	Nuwakot	Grid Connected	NEA
20	Syangja	1984	80	130,643	RoR	Syangja	Isolated	NEA
21	Helambu	1985	50	130,693	RoR	Sindupalchowk	Isolated	NEA
22	Seti (Pokhara)	1985	1,500	132,193	RoR	Kaski	Grid Connected	NEA
23	Salleri	1986	400	132,593	RoR	Solukhumbu	Isolated	NEA
24	Kulekhani 2	1986	32,000	164,593	Storage	Makwanpur	Grid Connected	NEA
25	Chame	1987	45	164,638	RoR	Manang	Isolated	Leased
26	Manang	1988	80	164,718	RoR	Manang	Isolated	NEA
27	Tehrathum	1988	100	164,818	RoR	Tehrathum	Isolated	Leased
28	Taplejung	1988	125	164,943	RoR	Taplejung	Isolated	Leased
29	Chaurjhari	1989	150	165,093	RoR	Rukum	Isolated	Leased
30	Ramechhap	1989	150	165,243	RoR	Ramachhap	Isolated	NEA

S. No.	Hydropower Projects	Commissioned Year	Capacity (KW)	Cumulative Generation (KW)	Type	Located District	Grid Status	Ownership
31	Serpodaha	1989	200	165,443	RoR	Rukum	Isolated	Leased
32	Bajhang	1989	200	165,643	RoR	Bajhang	Isolated	Leased
33	Dolpa	1989	200	165,843	RoR	Dolpa	Isolated	NEA
34	Khandbari	1989	250	166,093	RoR	Sankhuwasabha	Isolated	Leased
35	Bhojpur	1989	250	166,343	RoR	Bhojpur	Isolated	Leased
36	Marsyangdi	1989	69,000	235,343	RoR	Lamjung	Grid Connected	NEA
37	Okhaldhunga	1990	125	235,468	RoR	Okhaldhunga	Isolated	NEA
38	Bajura	1990	200	235,668	RoR	Bajura	Isolated	NEA
39	Rupalgad	1991	100	235,768	RoR	Dadeldhura	Isolated	NEA
40	Arughat	1991	150	235,918	RoR	Gorkha	Isolated	NEA
41	Surnaiyagad	1991	200	236,118	RoR	Baitadi	Isolated	NEA
42	Tatopani 1 and 2	1991	2,000	238,118	RoR	Myagdi	Grid Connected	NEA
43	Andhi Khola (BPC)	1991	5,100	243,218	RoR	Sangja	Grid Connected	Pvt. Sector
44	Darchula	1992	300	243,518	RoR	Darchula	Isolated	NEA
45	Namche	1993	600	244,118	RoR	Solukhumbu	Isolated	NEA
46	Jhimruk (BPC)	1994	12,300	256,418	RoR	Pyuthan	Grid Connected	Pvt. Sector
47	Achham	1995	400	256,818	RoR	Achham	Isolated	NEA
48	Chatara	1996	3,200	260,018	RoR	Sindupalchowk	Grid Connected	NEA
49	Kalikot**	1999	500	260,518	RoR	Kalikot	Isolated	NEA
50	Puwa Khola	1999	6,200	266,718	RoR	Ilam	Grid Connected	NEA
51	Modi Khola	2000	14,800	281,518	RoR	Parbat	Grid Connected	NEA
52	Chilime (CPC)	2000	20,000	301,518	RoR	Rasuwa	Grid Connected	Pvt. Sector
53	Khimti Khola (HPL)	2000	60,000	361,518	RoR	Dolakha	Grid Connected	Pvt. Sector
54	Sange Khola (SHP)	2001	183	361,701	RoR	Lamjung	Grid Connected	Pvt. Sector
55	Bhotekosi (BKPC)	2001	36,000	397,701	RoR	Sindhupalchowk	Grid Connected	Pvt. Sector
56	Chaku Khola (APCO)	2002	1,500	399,201	RoR	Sindhupalchowk	Grid Connected	Pvt. Sector
57	Indrawati (NHPC)	2002	7,500	406,701	RoR	Sindhupalchowk	Grid Connected	Pvt. Sector
58	Kali Gandaki A	2002	144,000	550,701	RoR	Sangja	Grid Connected	NEA
59	Piluwa Khola (AVHP)	2003	3,000	553,701	RoR	Sankhuwasabha	Grid Connected	Pvt. Sector
60	Rairang (RHPD)	2004	500	554,201	RoR	Dhading	Grid Connected	Pvt. Sector
61	Sunkosi- Small (SHP)	2005	2,600	556,801	RoR	Sindhupalchowk	Grid Connected	Pvt. Sector
	Total		556,801					

* Hydropower Stations Producung Less than 100KW are excluded.

** Not in normal operation.

Source: NEA

ANNEX II: Small Hydropower Projects (up to 1000 KW)

S. No.	Hydropower Projects	Capacity (KW)	Type	Commissioned Year	Located District	Grid Status	Ownership
1	Dhading	32	RoR	1978	Dhading	Isolated	NEA
2	Chame	45	RoR	1987	Manang	Isolated	Leased
3	Helambu	50	RoR	1985	Sindupalchowk	Isolated	NEA
4	Gorkhe	64	RoR	1982	Ilam	Isolated	NEA
5	Sangja	80	RoR	1984	Sangja	Isolated	NEA
6	Manang	80	RoR	1988	Manang	Isolated	NEA
7	Tehrathum	100	RoR	1988	Tehrathum	Isolated	Leased
8	Rupalgad	100	RoR	1991	Dadeldhura	Isolated	NEA
9	Taplejung	125	RoR	1988	Taplejung	Isolated	Leased
10	Okhaldhunga	125	RoR	1990	Okhaldhunga	Isolated	NEA
11	Chaurjhari	150	RoR	1989	Rukum	Isolated	Leased
12	Ramechhap	150	RoR	1989	Ramachhap	Isolated	NEA
13	Arughat	150	RoR	1991	Gorkha	Isolated	NEA
14	Sange Khola	183	RoR	2001	Lamjung	Grid Connected	Private Sector
15	Baglung	200	RoR	1981	Baglung	Grid Connected	NEA
16	Doti	200	RoR	1981	Doti	Isolated	NEA
17	Jumla	200	RoR	1982	Jumla	Isolated	Leased
18	Serpodaha	200	RoR	1989	Rukum	Isolated	Leased
19	Bajhang	200	RoR	1989	Bajhang	Isolated	Leased
20	Dolpa	200	RoR	1989	Dolpa	Isolated	NEA
21	Bajura	200	RoR	1990	Bajura	Isolated	NEA
22	Surnaiyagad	200	RoR	1991	Baitadi	Isolated	NEA
23	Dhankuta	240	RoR	1971	Dhankuta	Isolated	NEA
24	Phidim SHP	240	RoR	1981	Panchthar	Isolated	Leased

S. No.	Hydropower Projects	Capacity (KW)	Type	Commissioned Year	Located District	Grid Status	Ownership
25	Jomsom	240	RoR	1982	Mustang	Grid Connected	Leased
26	Khandbari	250	RoR	1989	Sankhuwasabha	Isolated	Leased
27	Bhojpur	250	RoR	1989	Bhojpur	Isolated	Leased
28	Darchula	300	RoR	1992	Darchula	Isolated	NEA
29	Jhupra	345	RoR	1977	Surkhet	Isolated	NEA
30	Salleri	400	RoR	1986	Solukhumbu	Isolated	NEA
31	Achham	400	RoR	1995	Achham	Isolated	NEA
32	Pharping **	500	RoR	1911	Kathmandu	Grid Connected	NEA
33	Kalikot**	500	RoR	1999	Kalikot	Isolated	NEA
34	Rairang	500	RoR	2004	Dhading	Grid Connected	Private Sector
35	Namche	600	RoR	1993	Solukhumbu	Isolated	NEA
36	Sundarijal	640	RoR	1936	Kathamndu	Grid Connected	NEA
	TOTAL	8,439					

Source: NEA.

ANNEX III: Medium-Sized Hydropower Projects (more than 1000 KW)

S. No.	Hydropower Projects	Capaciy (KW)	Type	Commissioned Year	Located District	Grid Status	Ownership
1	Tinau	1,024	RoR	1978	Rupendehi	Grid Connected	NEA
2	Phewa	1,088	RoR	1967	Kaski	Grid Connected	NEA
3	Seti (Pokhara)	1,500	RoR	1985	Kaski	Grid Connected	NEA
4	Chaku Khola (APCO)	1,500	RoR	2002	Sindhupalchowk	Grid Connected	Private Sector
5	Tatopani 1 and 2	2,000	RoR	1991	Myagdi	Grid Connected	NEA
6	Panauti	2,400	RoR	1965	Kavre	Grid Connected	NEA
7	Sunkosi- Small (SHP)	2,600	RoR	2005	Sindhupalchowk	Grid Connected	Private Sector
8	Piluwa Khola (AVHP)	3,000	RoR	2003	Sankhuwasabha	Grid Connected	Private Sector
9	Chatara	3,200	RoR	1996	Sindupalchowk	Grid Connected	NEA
10	Andhi Khola (BPC)	5,100	RoR	1991	Sangja	Grid Connected	Private Sector
11	Puwa Khola	6,200	RoR	1999	Ilam	Grid Connected	NEA
12	Indrawati (NHPC)	7,500	RoR	2002	Sindhupalchowk	Grid Connected	Private Sector
13	Sunkosi	10,050	RoR	1972	Sindupalchowk	Grid Connected	NEA
14	Jhimruk (BPC)	12,300	RoR	1994	Pyuthan	Grid Connected	Private Sector
15	Devighat	14,100	RoR	1983	Nuwakot	Grid Connected	NEA
16	Modi Khola	14,800	RoR	2000	Parbat	Grid Connected	NEA
17	Gandak	15,000	RoR	1979	Nawalparasi	Grid Connected	NEA
18	Chilime (CPC)	20,000	RoR	2000	Rasuwa	Grid Connected	NEA & Private Sector
19	Trisuli	24,000	RoR	1967	Nuwakot	Grid Connected	NEA
20	Kulekhani 2	32,000	Storage	1986	Makwanpur	Grid Connected	NEA
21	Bhotekosi (BKPC)	36,000	RoR	2001	Sindhupalchowk	Grid Connected	Private Sector
22	Kulekhani 1	60,000	Storage	1982	Makwanpur	Grid Connected	NEA
23	Khimti Khola (HPL)	60,000	RoR	2000	Dolakha	Grid Connected	Private Sector
24	Marsyangdi	69,000	RoR	1989	Lamjung	Grid Connected	NEA
25	Kali Gandaki A	144,000	RoR	2002	Sangja	Grid Connected	NEA
	Total	548,362					

Source: Compilation of different publications of NEA.

ANNEX IV: Up-coming Hydropower Projects (Under-Construction)

S. No.	Hydropower Company	Name of River	Capacity (KW)	Located District
1	Gautam Buddha Hydro Power Company	Sisne Khola	750	Palpa
2	Unique Hydro Power Company	Baramchi Khola	999	Sindhupalchowk
3	Khudi Hydro Power	Khudi Khola	3,450	Lamjung
4	Lower Nyadi Hydroelectric Project	Lower Nyadi	4,500	Lamjung
5	Molnia Power Pvt. Ltd.	Mailung Khola	5,000	Rasuwa
6	Gitec. Nepal Pvt. Ltd.	Upper Modi Khola	14,000	Kaski
7	Kathmandu Small Hydro Power System	Sali Nadi	232	Kathmandu
8	NEA	Middle Marsyangdi	70,000	Lamjung
9	NEA	Chamelia	30,000	Darchula
10	NEA and Private Sector	Chilime	11,000	Rasuwa
11	NEA	Kulekhani III	14,000	Makawanpur
12	NEA	Gomgad	400	Mugu
13	NEA	Heldung	500	Humla
	Total		154,831	

ACRONYMS USED

AC	Alternating Current
CBIP	Central Board of Irrigation and Power, India
CBS	Central Bureau of Statistics
CRs.	Company Rupees.
DC	Direct Current
dia	Diameter
ft.	Feet
GW	Giga Watts
HMG	His Majesty's Government, Nepal
IPPs	Independent Power Producers
KW	Kilo Watts
lb.	Pounds
MW	Mega Watts
NEA	Nepal Electricity Authority
NEC	Nepal Electricity Corporation
PDF	Power Development Fund
PPA	Power Purchase Agreement
R&D	Research and Development
RoR	Run-of-River
sq.	Square
US$	United States Dollar
V	Volts

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