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From The Editor's Desk

In an environment of fast changing technology and innovative thinking, diagnosing cause of any development in an economy, be it at macro or micro level, has become complex. Without a proper diagnosis it is futile to make an attempt to suggest corrective measures. Moreover, set of parameters contributing to a development at one particular point of time may not lead to the same result in another context. Otherwise, policy makers would not have been seen helpless when they were caught by unanticipated developments such as sub-prime crisis in mid-2008. Even in the case of recent financial crisis in Greece or for that matter, China's totally unexpected response to domestic economic crisis forced policy strategists all over the world to re-design their thinking.

The Editorial Board felt that it would be a worthy attempt to examine certain developments in the above mentioned context and examine cause and effects relationship. That is why we thought of bringing out a special issue focusing exclusively on Input-Output research on different issues. For instance, Michiya Nozaki made an attempt to describe production processes in the economy of Tohoku region by using an inter-regional input-output framework. Inter-dependence in the production structure of the region is relevant in the current context of globalization and localization. He used the concept of average propagation length [APL].

Authors Deepa Saran, K.V. Bhanu Murthy and Meghna Malhotra examined application of Input-Output model to study spillover effects foreign direct investment in Indian manufacturing industries. The study has measured FDI spillovers through vertical linkages [including backward and forward linkages] for 13 manufacturing industries for the period 2001-01 to 2009-10 with standard techniques. The results showed spillover effects foreign direct investment due to inter industry linkages are more in case of foreign firms as compared the domestic firms.

With increasing regional cooperation among the South-Asian economies, there has been tremendous rise in intermediate input flows across boundaries. In this context, import intensities, domestic production structure and export competition, no doubt, play important roles in determining the extent and pattern of international trade. An attempt has been made to investigate the factors that contribute to the difference in inter-country trade pattern during the year 2006-07. The countries under consideration are Bangladesh, Srilanka and China. Authors Arun Sengupta and Tushar Das have used the "domestic input-output matrices" made available by Asian Development Bank for getting more correct projection of domestic output requirement and consequently, the import requirements.

In India, the fundamental problems associated with stock markets are linked with changes in macroeconomic variables. Researchers A.Giri and Pooja Joshi examined the dynamic long-run and the short-run relationship between stock price and a set of macroeconomic variables for Indian economy using monthly data from April 2004 to January 2015. The long-run relationship is examined by implementing the ARDL bounds testing approach to co-integration. VECM method is used to test the short-run and long-run causality and variance decomposition. Empirical evidence suggested that index of industrial production, inflation and real effective exchange rate influence stock prices positively, whereas, gold price influences stock price negatively.

Performance of Indian public sector banks has been examined by P. Sivakumar and Kanika Sachdeva in terms of total factor productivity growth [TFPG], technological change and technical efficiency performances. Data envelopment analysis [DEA] based Malmquist productivity index approach has been used to measure the productivity indices for 25 public sector banks during 1992-93 to 2012-13. Empirical results indicated that 96 percent of public sector banks have reported improvement in TFPG change, mainly due of increase in technological change. On the other hand, 52% of banks experienced decline in technical efficiency change due to decay in scale efficiency and pure technical efficiency change.

A paradoxical situation of the National Food Security Act facilitating subsidized food grains and at the same time, constant rise in farmers committing suicide due to loss in crops in an abnormal weather condition has been examined by A.M. Swaminathan and Medha Tapiwala. The authors examined the extent to which weather influenced buffer stock in agricultural products. The results obtained through use of an integrated optimization and dynamic input-output model showed that weather or rainfall to a great extent did not influence buffer stock or agricultural output. Analysis further reflected drawbacks in the system of agricultural productivity.

Water crisis has become a serious challenge for water management officials and policy makers in Iran. With size of population getting quadrupled during 1956-2011, per capita water availability decreased from 7200m3 to 1830m3. Researchers A.A.Banouei, J.Banouei and Z. Momeni proposed measurement of National Water Footprint [NWF], Virtual Water [VW] trade and the net Virtual Water of Imports [NVWI] in input-output framework for a scarce water resource country like Iran. That could provide a holistic view for a view for the consumption aspects of water.

National Rural Employment Guarantee programme in India has been analyzed by Joydeep Ghosh using CGE model. The program has the potential to enhance economic growth, reduce inefficiency and generate employment in India. The program has significant spillover effects on both the rural and urban population although most of the benefits accrue to rural population. MGNREGA has the potential to transform rural India provided the country is able to generate enough resources to finance the program.

The editorial board sincerely hopes that the special issue on application of input-output model would generate adequate intellectual debate. We are sincerely looking for your valuable comments.

Jagdish Shettigar
Editor-in Chief

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RESEARCH PAPERS

Identifying an Interregional Input-Output Framework by Means of Average Propagation Lengths: A Case Study of Tohoku Region

Michiya Nozaki*

Abstract

This paper describes the production process(es) used in the economy of Tohoku region by using an interregional input-output framework. Interdependencies in the production structure of different prefectures in Tohoku region are relevant in understanding the simultaneous growth of globalization and localization, where disturbances quickly travel from one prefecture to another through industries and markets.

In this paper, we use the concept of average propagation length (APL), which was presented by Dietzenbacher, Romero, and Bosma (2005), and Dietzenbacher and Romero(2007), to empirically study Tohoku region.

In this paper in the second section, we have reviewed APL proposed by Dietzenbacher, Romero, and Bosma (2005), and Dietzenbacher and Romero (2007). In section three, we have used the APL concept to empirically study the Tohoku region in Japan and in the last section, we have presented our concluding remarks. Needless to say the analysis has implications for the global economy.

JEL Classification: *R15, R58*

Keywords: *Interregional Input-Output Table, Production Chains, Average Propagation Length, Tohoku region*

Introduction

This paper describes the production processes in the economy of the Tohoku region (i.e. the northern-east part of Japan) by using an interregional I-O framework. Interdependencies of the production structures of different prefectures in the Tohoku region are relevant because of the simultaneous progress of globalization and localization, where disturbances quickly propagate from one

Author is grateful to the anonymous referees for comments and suggestions for improving the text and contents of the paper. Author alone is responsible for any errors/mistakes still remaining in the paper.
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prefecture to another through industries and markets.

A substantial body of literature is devoted to measuring the strength of the links between industries. Many studies address the question of how such interdependencies or linkages can be accurately measured (e.g. Chenery and Watanabe, 1958; Rasmussen, 1956; Miller and Lahr, 2001; Sonis et al., 1995). These studies have proposed various alternative measures for such inter-industry linkages.

In this paper, we use the concept of average propagation length (APL), which was presented by Dietzenbacher, Romero and Bosma (2005) and Dietzenbacher and Romero (2007), to study empirically the Tohoku region. We have attempted to determine the chains in interregional production structures within the Tohoku region. These chains differ from product chains, which focus on a single product, and hence; we term them production chains. We adopt the underlying concept of sequencing in supply chains by viewing production as a stepwise procedure. In the analysis of production processes, some industries are placed in the early stage, and others, in a later stage.

Oosterhaven and Bouwmeester (2013) discuss that 'the average propagation length (APL) has been proposed as a measure of a fragmentation and sophistication of an economy, and for an one-sector economy, they show that the APL is strictly proportional to the macro multiplier of that economy' (Oosterhaven and Bouwmeester, 2013, 481). Chen (2014) also extends the definition of APL to the grouping-APL from the double-counting of APL.

Antr`as, et al. (2012) discuss that the fragmentation of production across national boundaries has been a discriminative feature of the world economy by the concept of forward linkages in Input-Output analysis on the empirical sides.

With Asian International Input-Output Tables, Inomata (2008) investigates the possibility of constructing a new measurement for analyzing international fragmentation of the production process, and the new measurement is formulated by the Input-Output model of Average Propagation Lengths.

On the other hand, we have another application of Average Propagation Length about indirect foreign trade related R&D spillovers (Franco et al., 2011) and ownership relations in the presence of cross shareholdings (Dietzenbacher & Temurshoev, 2008).

This paper is organized as follows. In section 2, we have reviewed the APL proposed by Dietzenbacher, Romero, and Bosma (2005), and Dietzenbacher and Romero (2007). In section 4, we use the APL concept to empirically study the Tohoku region in Japan. In the last section, we present our concluding remarks.

A Review of Average Propagation Lengths (APLs)

When we define average propagation, we analyse how a cost-push or a demand-pull propagates throughout the industries in the economy.

According to Dietzenbacher, Romero, and Bosma, (2005, 411-412), an initial demand-pull in industry i increases the output value in industry j by l_{ij}-d_{ij} (neglecting the initial effects). d_{ij} is the Kronecker delta; i.e. d_{ij}= 1 if i = j and 0 otherwise. The share $a_{ij}/(l_{ij}-d_{ij})$ of this output increase requires only one round, but the share $[A^2]_{ij}/(l_{ij}-d_{ij})$ requires two rounds to get from i to j. $[A^2]_{ij}$ denotes the element (i,j) of matrix A^k, which differs from $(a_{ij})^k$ (Dietzenbacher, Romero, and Bosma, 2005, 411-412).

The average number of rounds required to pass over a demand-pull in industry, i to industry j yields

$$v_{ij}=\{1a_{ij}+2[A^2]_{ij}+3[A^3]_{ij}+...\}/(l_{ij}-d_{ij}) \qquad (2.1)$$

Let the numerator of the right-hand side of (2-1) be denoted by h_{ij}, with $H = \sum_k K A^k$.

Then the terms h_{ij} can easily be calculated by using

$H=\sum_k K A^k = L(L-I)$.

We can reduced equation (2-1) to (2-2) as the matrix V of APL as follows:

$$v_{ij} = \begin{cases} \{1a_{ij} + 2[A^2]_{ij} + 3[A^3]_{ij} + \cdots\}/l_{ij} & \text{if } l_{ij} - \delta_{ij} > 0, \text{when } i \neq j \\ \{1a_{ij} + 2[A^2]_{ij} + 3[A^3]_{ij} + \cdots\}/(l_{ij} - 1) & \text{if } l_{ij} - \delta_{ij} = 0, \text{when } i = j \end{cases} \quad (2\text{-}2)$$

Alternatively, in the same way, we can define the APL for a cost-push. Analysing how a one-yen cost-push increase in industry *j* affects the total output of industry *i*, we find $b_{ij}+[B^2]_{ij}+[B^3]_{ij}+\ldots= g_{ij} - d_{ij}$. The APL for a cost-push yields

$$\{1b_{ij}+2[B^2]_{ij}+3[B^3]_{ij}+\ldots\}/(g_{ij}-\delta_{ij}) \quad (2.3)$$

Note that input matrix A and output matrix B are related to each other.

Inter-regional, Inter-industrial Characteristics for APL of Tohoku IRIO

The outline of the study region consists of the prefectures of Aomori, Iwate, Miyagi, Akita, Yamagata, Fukushima, and Niigata. The aim of compiling the table (for the year 2005) is mainly to use it as a database for statistically exploring economic experiences in the Tohoku region.

Tohoku Regional Advancement Center (2011) further proceeded to complete the prototype of an interregional I-O table 1 for the Tohoku region tentatively. We then also examined this prototype table so as to satisfy the double constraints (relating to the row sum and column sum) in an I-O framework. Judging from the present circumstances of data availability with respect to the seven prefectures for the year 2005, Tohoku Regional Advancement Center (2011) determined the total number of industrial sectors as 28 sectors and 43 sectors.

For our empirical studies, we measured the APLs for inter-regional I-O table for the Tohoku region.

In this paper, we have tested the methodology of APLs for an inter-regional I-O table for the Tohoku region (28 sectors) in 2005. Figure 1 shows the regional definition and characteristics of Tohoku region. Besides, Table 2 is the classification of the 28 industrial sectors, and Table 3 is the name of the prefecture of the Tohoku region.

Figure 1: Regional Map of Tohoku region

(Source: http://www.bing.com/images/search)

Let us examine the inter-regional APL matrix of Tohoku region for an inter-regional I-O table for Tohoku region (see Table 2 & Table 3).

According to Dietzenbacher, Romero, and Bosma (2005, 415), in line with the development of the propagation length, the choice for the type of linkage is based on the total size of the cost-push and demand-pull effects. Ignoring the initial effects, these effects can be given by G-I and L-I, respectively.

Along with the way of analysing of Dietzenbacher, Romero, and Bosma (2005), instead of using the Leontief inverse for the backward linkages and the Ghosh inverse for the forward effects, we take the average. So, the linkages are given by the elements of the matrix F, which is defined as follows (Dietzenbacher, Romero, and Bosma, 2005, 415):

$$F = \frac{1}{2}[(L - I) + (G - I)] \quad (3.1)$$

"The element f_{ij} gives the size of the linkage, and equals the average of the forward effect of a cost-push in sector, *i* on the output in the sector *j* and the backward effect of a demand-pull in sector *j* on the output in sector, I"(Dietzenbacher, Romero, and Bosma, 2005, 416). The results of the linkages Fare given in Table 5.

A relationship between the figures in matrix V of an interregional APL (Table 4) and the linkages F (Table 5) suggests that there could be an inverse relationship between APLs and elements' f_{ij} of the linkages' F.

The computing procedure of the economic distances from industry, i to industry, j is to take APLs into account only if the linkage is sufficiently large, using a threshold value a. Further; the APLs are rounded off to the closest integer. From the matrix V with APLs and matrix F with linkages, we can calculate a new matrix S as follows:

$$s_{ij} = \begin{cases} int(v_{ij}) & if \ \ f_{ij} \geq a \\ 0 & if \ \ f_{ij} < a \end{cases} \quad (3.2)$$

where int (v_{ij}) indicates the closest integer to which (v_{ij}) has been rounded off.

There seems to be an inverse relationship between APLs and elements f_{ij}.

The Pearson correlation coefficient between APL (Table 4) and the matrix F (Table 5) of the Tohoku region equals 0.0593.

[R,P]=corr coef(x,y)
$x = v_{ij}$, $y = f_{ij}$,
R = -0.0593, P-value=0.000

Then, we can similarly construct a new matrix S of the Tohoku region as (3-2) where int(v_{ij}) is used to indicate the nearest integer to which v_{ij} has been rounded. For the calculations with the 34 sector Classification, we have used a threshold value *a*=0.01247 (See, Dietzenbacher, Romero, and Bosma, 2005, 416).

The production chain with respect to the Beverages and Foods industry in Aomori Prefecture shows as follows: About the backward linkage, the solid line indicates the linkage from other industries' to Aomori's Beverages and Foods with int(vij) = 1 (i.e. Agriculture, Fishery, Beverages and Foods in Tohoku region, etc.), and the dotted line indicates the linkage from other industries to Aomori's Beverages and Foods with int(vij) = 2 (i.e. Textile, Pulp, Papers and Wooden Products in Aomori , etc.), and the dashed lines is the linkages from other industries to Aomori's Beverages and Foods with int(vij) = 3 (i.e. Chemical Products in Miyagi, Mining, Petroleum and Coal Products in Fukushima, etc.). On the other hand, about the forward linkage, the solid line from Aomori's Beverages and Foods to other industries shows linkage with int(vij) = 1 (i.e. Aomori's Agriculture, Fishery, and Iwate's Agriculture, Fishery), and the dotted line shows the linkage from Aomori's Beverages and Foods to other industries with int(vij) = 2 (i.e. Aomori's services).

The production chain with respect to the Motor and Vehicles and other cars industry in Iwate Prefecture are as follows: About the backward linkage, the dotted line indicates the linkage from other industries to motor vehicles and other cars with int(vij) = 2 (i.e. Metal Products, General Machinery, and Miyagi's motor vehicles and other cars, etc.), and the dashed lines are the linkages from other industries to motor vehicles and other cars with int(vij) = 3 (i.e. Mining, Petroleum and Coal Products, Public Utilities in Iwate, Ceramic and Cray Products in Akita, etc.), and int(vij) =4 (i.e. Plastics and rubber products in Akita, Petroleum and Coal Products in Fukushima, Mining in Niigata, etc.).

At the same time, for the forward linkages, the dotted lines from motor vehicles and other cars to other industries show the linkage with int(vij) = 2 (i.e. Iwate's services, and Miyagi's motor vehicles and other cars).

The production chains with respect to the Electric Machinery industry in Miyagi Prefecture are as follows: For the backward linkages, the solid line is the linkage from other industries in Tohoku region to Miyagi's Electric Machinery industry with int(vij)=1 (i.e. Plastics and rubber Products, Ceramic, Stone and Cray Products, etc. in Miyagi, Electric Machinery in Fukushima, etc.). The dotted lines show the linkages from other industries in Tohoku region to Miyagi's Electric Machinery industry with int(vij) = 2 (i.e. Textile, Commerce, Transport, etc. in Miyagi, Metal Products in Yamagata and Niigata, etc.), besides; the dashed lines are int(vij) = 3 (i.e. Forestry, Mining, etc. in Miyagi, Iron and Steel in Yamagata, etc.), and int(vij)) =4 (i.e. Petroleum and Coal Products in Yamagata and Akita, etc.)

On the other hand; about the forward linkages, the solid line is the linkage from Miyagi's Electric Machinery to other industries with int(vij)=1(i.e. Electric Machinery in Fukushima, and General Machinery and Construction in Miyagi).

The production chains with respect to Electric Machinery industry in Akita Prefecture are as follows: For the backward linkages, the solid line is the linkage from other industries to Akita's Electrical Machinery industry with int(vij)=1 (i.e. Electric Machinery, Ceramic, Stone and Cray in Yamagata, etc.). The dotted lines show the linkages from other industries to Akita's Electrical Machinery industry with int(vij) = 2 (i.e. Textile, Petroleum and Coal Products, Construction, etc. in Akita, etc.), besides; the dashed lines are int(vij) = 3 (i.e. Iron and Steel, Metal Products, etc. in Yamagata, etc.) and int(vij) =4 (i.e. Mining, and Miscellaneous Manufacturing Products in Yamagata, etc.).

On the other hand, about the forward linkages; the solid line is the linkage from Akita's Electrical Machinery to other industries with int(vij)=1 (i.e. General Machinery, Miscellaneous Transportation Equipment in Akita, etc.).

The production chain with Electric Machinery industry in Yamagata Prefecture shows the backward linkages; the dotted line shows the linkages from Yamagata's Electric Machinery Industry to other industries with int(vij) = 2 (i.e. Textile Products, Pulp, Paper and Wooden Products in Yamagata, Metal Products in Miyagi, etc.), besides, the dashed lines are int(vij) = 3 (i.e. Motor Vehicles and other cars in Yamagata, Iron and Steel in Miyagi, Fukushima, etc.), and int(vij) =4 (i.e. Motor Vehicles and other cars in Aomori, Petroleum and Coal Products in Iwate, and Mining in Niigata).

On the other hand, about the forward linkages, the solid line is the linkage from Yamagata's Electric Machinery to other industries with int(vij)=1(i.e. Miscellaneous Manufacturing Products in Akita.). The dotted lines show the linkages from Yamagata's Electric Machinery to other industries with int(vij) = 2 (i.e. Motor Vehicles and other cars, Services industry in Yamagata, and etc. Mining in Yamagata, General Machinery, Electric Machinery, Miscellaneous Transportation Equipment, etc. in Akita etc).

The production chain with Beverages and Foods industry in Fukushima Prefecture shows the backward linkages; the solid line is the linkage from other industries to Fukushima's Beverages and Foods industry with int(vij)=1 (i.e. Agriculture, Fishery in Fukushima Miyagi, Commerce in Fukushima, etc.). The dotted line shows the linkages from other industries to Fukushima's Beverages and Foods industry with int(vij) = 2 (i.e. Chemical Products, Petroleum and Coal Products in Fukushima, Plastics and Rubber Products in Akita, etc.), besides; the dashed line is int(vij) = 3 (i.e. Iron and Steel in Fukushima, Petroleum and Coal Products in Akita, Yamagata and Aomori, etc.).

On the other hand, about the forward linkages, the solid line is the linkage from Fukushima's Beverages and Foods to other industries with int(vij)=1

(i.e. Agriculture and Fishery in Fukushima, and Beverages and Foods in Miyagi and Yamagata).

The production chain with respect to Electric Machinery industry in Niigata Prefecture shows the backward linkages; the solid line is the linkage from other industries to Niigata's Electric

Machinery industry with int(vij)=1 (i.e. Ceramic, Stone and Cray Products, General Machinery, Metal Products, and Services industry, etc. in Niigata, Electric Machinery in Miyagi). The dotted line shows the linkages from other industries to Niigata's Electric Machinery industry with int(vij) = 2 (i.e. Textile products, Commerce, Transport industries in Niigata, Public Utilities in Fukushima, etc.), besides; the dashed lines are int(vij) = 3 (i.e. Mining, Iron and Steel, Miscellaneous Manufacturing Products, etc. in Niigata, Mining in Fukushima, etc.) and int(vij) = 4 (i.e. Mining in Miyagi, Petroleum and Coal Products in Aomori, Akita, Yamagata, etc.).

On the other hand, as for the forward linkages, the solid line is the linkage from Niigata's Electric Machinery to other industries with int(vij)=1 (i.e. General Machinery, Metal Products, Precision Instruments, and Services and construction industries, etc. in Niigata, and Electric Machinery in Miyagi). The dotted line shows the linkage from Niigata's Electric Machinery to other industries with int(vij) = 2 (i.e. Motor Vehicles and other cars industry in Niigata, and Electric Machinery industry in Yamagata.).

Summarizing above all, by analysing interregional trade with regard to the structure of seven prefectures in the Tohoku region, we found three types of strong economic relations between Tohoku prefectures in 2005. That is to say, (1) Iwate, Miyagi and Yamagata prefectures in Motor vehicle and other cars industry; (2) Iwate, Miyagi, Fukushima, Yamagata and Akita prefectures in Electric Machinery industry; (3) Aomori, Iwate, Miyagi, Yamagata and Fukushima prefectures in Beverages and Foods industry.

Besides, Mining, Petroleum and Coal industries in Miyagi and Fukushima prefectures connect with other related industries in Aomori, Iwate, Akita, Yamagata, and Niigata prefectures, for instance, Beverages, Foods, Electrical Machinery, and Motor vehicle and other cars industries.

We must maintain the limitation of calculating an inter-industry, interregional APL for utilising an interregional Input-Output Table for the Tohoku Region for the Year 2005. The inter-industry, interregional economic structure which we can consider in this table is that of the year 2005.

Concluding Remarks

Our objective was to determine the chains of interregional production structures within the Tohoku region. These chains differ from product chains, which focus on a single product, and hence; we term them production chains. We adopt the underlying concept of sequencing in supply chains by viewing production as a stepwise procedure. In the analysis of production processes, some industries are placed in the early stage, and others, in a later stage. In this paper, we use the concept of APL, which was presented by Dietzenbacher, Romero, and Bosma (2005), to empirically study the Tohoku region.

Firstly, we use the concept of APL, which was presented by Dietzenbacher, Romero, and Bosma (2005), to empirically study the Tohoku region.

$$v_{ij} = \begin{cases} \left\{1a_{ij} + 2\left[\mathbf{A}^2\right]_{ij} + 3\left[A^3\right]_{ij} + \cdots\right\}/l_{ij} & if\ l_{ij} - \delta_{ij} > 0, when\ i \neq j \\ \left\{1a_{ij} + 2\left[\mathbf{A}^2\right]_{ij} + 3\left[A^3\right]_{ij} + \cdots\right\}/(l_{ij} - 1) & if\ l_{ij} - \delta_{ij} = 0, when\ i = j \end{cases}$$

Secondly, by analysing interregional trade with regard to the structure of seven prefectures in the Tohoku region, we found three types of the strong economic relations between Tohoku prefectures in 2005. That is to say, (1) Iwate, Miyagi and Yamagata prefecture's in Motorvehicle and other cars industry; (2) Iwate, Miyagi, Fukushima, Yamagata and Akita prefectures in Electric Machinery industry; (3) Aomori, Iwate, Miyagi, Yamagata and Fukushima prefectures in Beverages and Foods industry.

Thirdly, the Mining, and Petroleum and Coal industries in Miyagi and Fukushima prefectures connect with other related industries in Aomori, Iwate, Akita, Yamagata, and Niigata prefectures, for instance, Beverages and Foods, Electrical Machinery, and Motor vehicle and other cars industries.

And last, but not the least, the economic implications for calculating an inter-industry, interregional APL is to construct the reference criteria in forecasting the inter-industry, interregional economic structures for the national or regional government's policy makers in the future.

We must maintain the limitation of calculating an inter-industry, interregional APL for utilising an interregional Input-Output Table for the Tohoku Region for the Year 2005. The inter-industry, interregional economic structure which we can consider in this table is that of the year 2005. Therefore, to estimate an updated APL nowadays, we have to compile an updated inter-regional Input-Output Table for Tohoku Region for the Year 2011, then it may be possible to look at the post-disaster economic structure in the Tohoku region.

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Table 1: Definition of Interregional Input-Output Table for Tohoku region for the year 2005

	Total of intermediate sectors							Regional Final demand							Total of Regional Final Demand	Total of Regional Demand	Internal Export to Rest of Japan	Export to Rest of World	Internal Import from Rest of Japan	Import from Rest of World	Regional Products
	Aomori	Iwate	Miyagi	Akita	Yamagata	Fukushima	Niigata	Aomori	Iwate	Miyagi	Akita	Yamagata	Fukushima	Niigata							
Aomori																					
Iwate																					
Miyagi																					
Akita																					
Yamagata																					
Fukushima																					
Niigata																					
Total of Intermediate inputs																					
Total of Gross value added sectors																					
Regional Production (Total Inputs)																					

Source: Author

Table 2: The classification of the 28 industrial sectors

1	Agriculture
2	Forestry
3	Fishery
4	Mining
	Beverages and Foods
6	Textile products
7	Pulp, paper and wooden products
8	Chemical products
9	Petroleum and coal products
10	Plastics and rubber products
11	Ceramic, stone and clay products
12	Iron and steel
13	Metal products
14	General machinery
15	Electrical machinery
16	Motorvehicle and other Automobiles
17	Miscellaneous transportation equipment
18	Precision instruments
19	Miscellaneous manufacturing products
20	Construction
21	Public construction
22	Miscellaneous civil engineering and construction
23	Public utilities
24	Commerce
25	Finance, insurance and real estate
26	Transport
27	Services
28	Others

Source: Author

Table 3: Name of Prefectures at Tohoku region

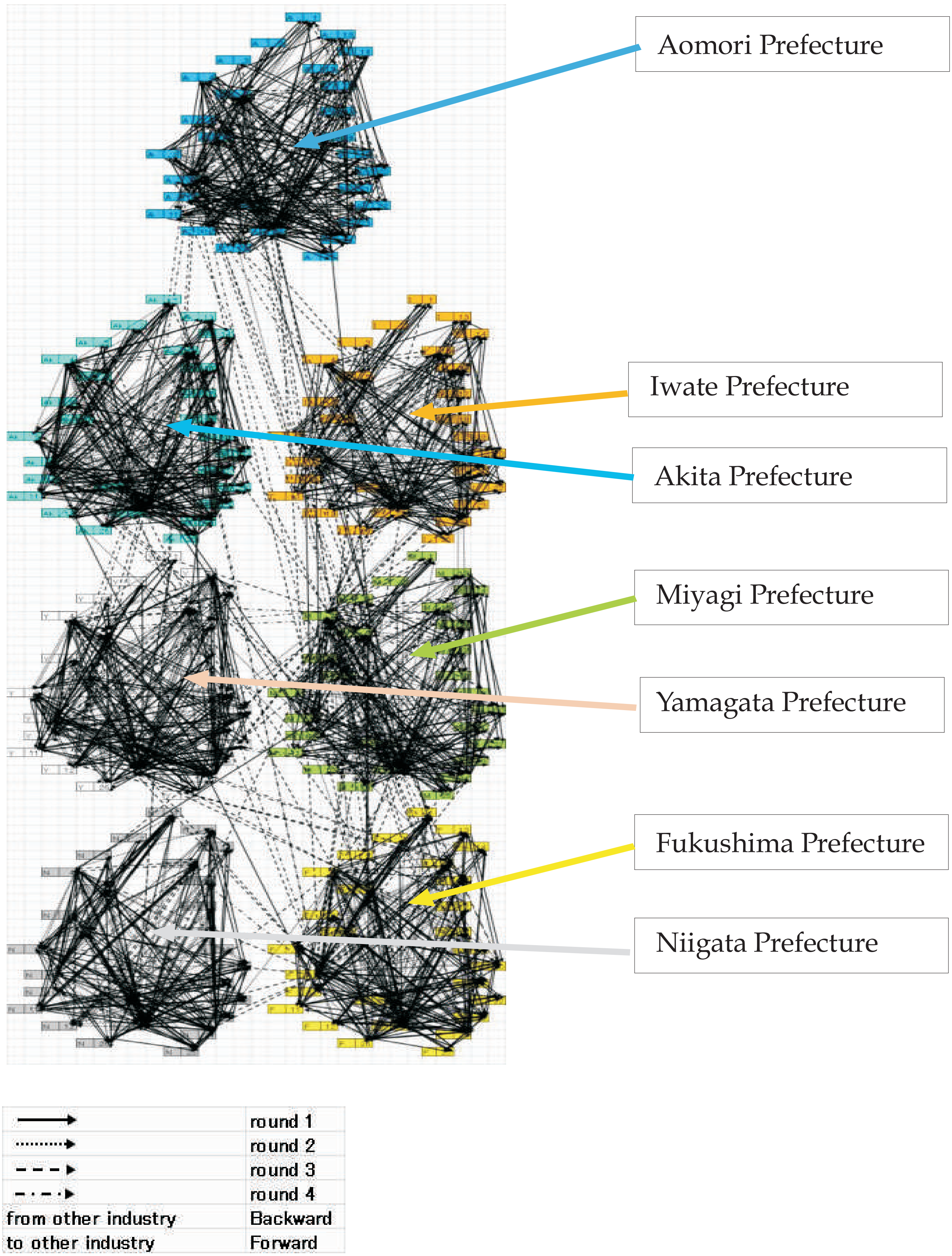
Symbol	**Name of Prefecture**
A	Aomori
I	Iwate
M	Miyagi
Ak	Akita
Y	Yamagata
F	Fukushima
N	Niigata

Source: Author

Table 4: Inter-regional APL matrix of Tohoku region (excerpted matrix)

[illegible]

Table 5: Inter-regional Linkages between Sectors (An excerpted F matrix)


Aomori Prefecture
Iwate Prefecture
Akita Prefecture
Miyagi Prefecture
Yamagata Prefecture
Fukushima Prefecture
Niigata Prefecture
round 1
round 2
round 3
round 4
from other industry
Backward
to other industry
Forward

Applying Input-Output Models to Study the Spillover Effects of Foreign Direct Investment in Indian Manufacturing Industries

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Abstract

As a part of a larger framework of spillover effects of foreign direct investment developed by Murthy and Malhotra (2014) which enables the measurement of primary indirect spillover effects through horizontal and vertical linkages, the present paper deploys this framework and methodology for measurement of such spillover effects in India. Using the Input-Output tables 2006-07 by MOSPI the study has measured FDI spillovers through vertical linkages (including backward and forward linkages) for 13 manufacturing industries during the period 2000-01 to 2009-10 with standard techniques. The results show spillover effects of foreign direct investment due to inter industry linkages are more in case of foreign firms as compared to the domestic firms. The spillovers through backward linkages are found to be robust in chemicals, rubber and plastic, basic metal, metal products and the machinery and equipment industry. The spillovers through forward linkages are found to be strong in the textiles, chemicals, rubber and plastic products, electrical equipment, machinery and equipment and automobile industry. Overall, six out of thirteen manufacturing industries under study show robust spillovers due to vertical linkages.

Keywords: *Input-Output Models, FDI, Spillover Effects*

JEL Classification: *C67, F2, L1, L2, L6, O1, O3.*

Introduction

Spillovers from FDI occur when the entry or presence of Multinational Corporation increases the productivity of domestic firms in a host country, and the multinationals do not fully internalize the value of these benefits (Gachino, 2007-16). This happens because the multinational corporations have new advanced technology and their entry in the host country affects the existing equilibrium and forces local domestic firms belonging to the same industry to use their

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existing resources more efficiently or to search for new technologies to maintain their market shares and profits (Blomstrom & Sjoholm, 1998). In addition to this the domestic firms which are in backward or forward linkages to foreign firms need to update their technology and skills to meet the quality requirements demanded by their downstream foreign customers or to absorb advanced intermediate products supplied by their upstream foreign firms as suppliers. These two factors may affect the productivity and growth of local firms by changing their financing methods, their marketing and production techniques, and their managerial skills. It is believed that spillovers are more likely in the case of inter-industry than within the same industry. The reason behind such a belief is that, MNCs can prevent the leakage of technology to its competitors, while it has no incentive to prevent the technology diffusion to its suppliers and clients (Blalock and Gertler, 2005, 2008).

This paper shows the application of input-output models to spillover effects of foreign direct investment in Indian manufacturing industries as these models capture the inter industry linkages. In particular, it measures FDI spillovers through vertical linkages (including backward and forward linkages) for 13 manufacturing industries at the two-digit level during the period 2000-01 to 2009-10 with standard techniques using the Input-Output tables 2006-07 by MOSPI. The period of our study is a very important period in India's economic growth as during this phase India's per capita income gain is the largest income gain in growth episodes witnessed in developing world in the post-world war period. However, India's growth acceleration ended in 2010 probably due to impact of global crisis, which started in 2007-08 and started showing its impact on Indian economy from the year 2010-11. (Sen & Kar, 2014). Therefore, this is the best phase to study whether our manufacturing firms benefited from FDI due to spillover effects.

The paper is organized as follows. Section 2 gives a brief literature review. Section 3 presents the basic concepts and algebra relating to input-output transaction tables. Section 4 presents the research methodology, including data, estimation techniques and construction of variables. In Section 5, we look at the results and analysis and finally, Section 6 presents the conclusion and policy implications.

Literature Review

The studies on spillovers from foreign direct investment in host countries suggest that such effects exist, they may be substantial both within and between industries, and they vary systematically between countries and industries but there is no comprehensive evidence on their exact nature and magnitude (Blomstrom & Kokko, 1998). The main focus of this paper was on productivity and market access spillovers from MNCs to local firms in host countries, and it also discussed the spillover effects on the home countries of MNCs. The significance and character of the home-country spillovers may therefore vary depending on what activities the MNCs retain in their home country and how internationalized the firms are.

Harris & Robinson (2004) state that there are three levels at which spillovers may have an impact on indigenous firms. The first category of spillovers is defined as intra-industry, which may occur through demonstration effects, competition effects or the labor market. The second classification of spillovers occurs at the inter-industry level, through backward and forward (i.e. intermediate buyer-seller) linkages. Finally, there are agglomeration spillovers that occur as a result of geographic proximity to foreign firms. They measured the indirect impact of FDI on the total factor productivity of domestic plants in 20 UK manufacturing industries for the period 1974-95 through augmented Cobb Douglas production function approach.

According to a survey of domestic suppliers, competitors and customers to foreign investors conducted by Potter, Moore & Spires (2002) it was concluded that the impact of foreign investment on host economies can be broken into direct effects, indirect effects and wider effects. "Direct effects" relate to activities taking place within the local facilities of the foreign investors, including their direct output and employment. "Indirect effects" relate to activities created by local presence of foreign facilities but taking place elsewhere. This refers to activities supported in other enterprises by the purchasing and sales linkages of foreign subsidiaries and local spending of the wages and salaries by their employees. "Wider effects" relate to further impacts that come about through changes in the strategy, practices and competitive advantage of domestic firms "as a result of the local presence of foreign investors". The sample of this paper covered foreign subsidiaries with at least 250 employees in 1994 that located in the UK between 1970 and 1992, covering all manufacturing sectors, all modes of entry and all nationalities. Thus, the very presence of foreign firms in host economy reduces x-inefficiency in domestic firms leading to improvement in their sales, investments, productivity, employment and profitability.

In light of this theoretical background and the review of the literature *(for details refer to Malhotra (2013)* it can be inferred that the foreign firms can have two types of spillover effects on the domestic firms namely primary and secondary spillover effects (Murthy & Malhotra, 2014). The primary spillover effects include direct and indirect spillover effects. The direct primary spillover effects refer to the increase in the output and productivity of the local facilities of foreign firms, that is spillover effects directly in the subsidiaries or joint ventures of the firms in which MNCs have equity participation more than 10 percent. The indirect primary spillover effects occur in the domestic firms due to their horizontal, backward and forward linkages with the foreign firms, that is these spillover effects in the form of transfer of knowledge and technology flows from foreign firms to domestic firms which belong to the same industry as that of foreign firms or to those which are in customer supplier relation to foreign firms.

The secondary spillover effects from the presence of local foreign firms to the domestic firms can be seen in the form of general improvement in productivity, embodied technology and disembodied technological progress in the domestic firms. That is these benefits accrue to even those domestic firms which are not in linkages with the foreign firms.

Out of these spillovers discussed above primary indirect vertical spillovers can be approximated with the help of the linkages which the industries may have with one another. For calculating the variables depicting spillovers through vertical linkages for this study input-output tables are required because they capture the linkages between different industries of the economy. A few papers which have used this methodology include Javorick (2004), Sasidharan (2006), Joseph (2007), Marcin (2008) and Malik (2010). Like Javorick (2004) has estimated spillovers by using following equation.

$$\ln Y_{ijrt} = a + \beta_1 \ln K_{ijrt} + \beta_2 \ln L_{ijrt} + \beta_3 \ln M_{ijrt} + \beta_4 \text{Foreign Share}_{ijrt} + \beta_5 \text{Horizontal}_{jt} + \beta_6 \text{ Backward}_{jt} + \beta_7 \text{ Forward}_{jt} + a_t + a_r + a_j + e_{ijrt}.$$

Other research papers mentioned above used almost similar variables to measure spillover effects of FDI.

The objectives of this paper are firstly to estimate backward linkages in domestic and foreign firms; secondly to estimate forward linkages in domestic and foreign firms; thirdly to estimate vertical linkages (including both backward and forward linkages) in domestic and foreign firms; fourthly to compare inter-industry spillover effects between domestic and foreign firms and lastly to derive policy implications of spillover effects between domestic and foreign firms. As the linkages between different industries of an economy are the basis of vertical spillovers from foreign firms to domestic firms our hypothesis is that the spillovers through linkages of foreign firms are greater than the spillovers through linkages of domestic firms. This is because the efficient productive capabilities of foreign firms should be manifested by the inter industry linkages also.

Concepts and Algebra relating to Input output Transaction Tables

For calculating the variables for this study input output tables are required because they capture the linkages between different industries of the economy. In India, the input-output transaction tables are provided by the Central Statistical

Organization(CSO), Ministry of Statistics and Programme Implementation. The latest Input-Output transaction tables (IOTT) available for India pertains to the year 2006-07 *(Ideally, different input-output tables should be used for each year, since the inter-industry relationships they capture may change over time (altough sizable changes are rather unlikely). However, input-output tables are available only at five-year intervals. Therefore the latest input-output transaction tables 2006-07 are used for this study)*. The input-output table consists of two matrices: absorption matrix (commodity x industry) and make-matrix (industry x commodity). For the purpose of this study, an industry x industry matrix is made *(For details refer to Appendix-II)*.

According to National Accounts Division (CSO), the input output tables consist of 130 industries. An IOTT also called transactions table or inter-industry table or flow matrix-gives the flows of goods and services from each branch or industry of the economy to different branches of the economy over a specified period of time, usually a year. For producing the output in any branch of the economy, different types of raw material inputs and capital equipment, along with labor, are required. The outputs produced may be distributed either for intermediate use (that is, as input for further production of goods and services by other branches) or for private or public consumption, private or public investment, or exports. An IOTT provides a systematic description of this interdependence or linkages among different branches in the economy. The table may also be regarded as a disaggregation of the production accounts in a national accounting system.

The first 37 industries in the industry classification in IOTT represent primary production, the next 68 industries relate to manufacturing industries and remaining 25 industries deal with the construction, electricity, water supply, different modes of transport and other services industries. The final uses have been distinguished under 6 categories (i) private final consumption expenditure (ii) government final consumption expenditure (iii) gross fixed capital formation (iv) change in stocks (v) exports and (vi) imports. All the entries in the IOTT are at factor cost. First the table is prepared at purchaser's prices i.e. at the prices in which the actual transactions take place. The entries at factor cost are arrived at by removing the components of trade and transport margins and net indirect taxes. These are shown in separate rows in the table. The row of indirect taxes depicts the taxes paid by the industries on intermediate inputs used in the process of production of industry's output.

To construct an IOTT, the economy is divided into a number of homogeneous industries, each of which is represented in the table by a row and a column. The row corresponding to the industry gives the use pattern of the total supply of the industry, while the column gives the details of the inputs absorbed by the industry. The entry into the cell of the ith row and jth column is the quantity of output of industry i consumed as input by industry j, and its generally denoted by Xij. The output of industry j is denoted as Xj.

The input-output table consists of four quadrants. The first quadrant gives the distribution of that part of the output, which is absorbed by the producing industries of the economy. This quadrant is the most important and largest part of the table. The second quadrant gives the consumption by the final consumers. Its components are the private consumption expenditure, government current expenditure, gross fixed capital formation, changes in inventories, imports with negative sign and exports. If the imports are shown as a column with negative entries, then the imports by final consumers will be shown along with other domestically produced goods. Quadrants I and II together allocate the total output of each industry in the economy. The third quadrant consists of the primary inputs utilized by the different producing industries. The primary inputs consist of the factor payments to labor and capital, indirect taxes, depreciation, etc. Quadrant I and III together show the total inputs used in production by each industry of the economy. The fourth quadrant records the primary inputs into final demand industries; some typical entries such as income of government employees, domestic services and aggregate of final demand vectors, can be shown in this quadrant, but it must be observed that this fourth quadrant is generally omitted from the IOTT. A schematic arrangement of the input-output table is given in Figure 4.1 below:

Figure 4.1: Schematic Arrangement of the Input-Output Transaction Table

Consuming Sectors					
	1	**2**	**n**	**Final demand**	**Output**
Producing Sector					
1	X_{11}	X_{12}	....X_{1n}	F_1	X_1
2	X_{21}	I X_{22}	....X_{2n}	F_2	II X_2
:				:	
N	X_{n1}	X_{n2}	....X_{nn}	F_n	X_n
Primary input					
	V_{11}	V_{12}	....V_{1n}	$V_{1,n+1}$	
	V_{21}	III V_{22}	....V_{2n}	$V_{2,n+1}$	IV
	V_{k1}	V_{k2}	....V_{kn}	$V_{k,n+1}$	
Output					
	X_1	X_2	....X_n		

X_{ij} is the amount of the output of ith industry utilized as input for the production of *j*th industry.

F_i is the amount of the final demand of the output of the ith industry and is equal to $C_i + G_i + I_i + E_i - M_i + S_i$.

Where, the components of final demand are private consumption, government consumption, gross fixed investment, exports, imports and changes in inventories, respectively.

V_{ij} $i = 1, 2, \ldots\ldots\ldots, k$, $j = 1, 2, \ldots\ldots\ldots n$, are the different primary input rows.

V_i, $n + 1$ $i = 1, 2, \ldots, k$ are the primary inputs into the final demands.

The IOTT can be derived from the absorption (use) and make matrix (supply). This is essential because classification of commodities into various commodity groups or industries is affected by the problem of secondary production. For example the data on industrial products is generally based on the industrial censuses of different establishments. There are very few establishments, which are producing a single commodity. The establishments are classified into different industries on the basis of their primary products. It may so happen that an establishment produces commodities, which do not belong to the industries (commodity groups) to which it is assigned. Any such production is termed as secondary. The data are then aggregated for different establishments coming under each industry and are published for the industry as a whole. The output of the industry consists of one or more primary products (commodities) and several secondary products (commodities). The data on inputs relates to the inputs into industries and not the particular commodities produced in those industries. The inputs are given in terms of the commodities. The tables compiled on the basis of these data on inputs and outputs are called commodity x industry tables (Absorption matrix). In this table the column total of an industry is not necessarily the same as its row total. In most of the cases where secondary production is there or where a part of the production comes from other industries, the row total is not equal to the corresponding column total. For getting a symmetrical IOTT, which is to be used for the input output model, an additional table called the make matrix is required. Each row of the make matrix gives the distribution of the output of different commodities produced by an industry. Each column of this matrix represents the value of the output of a commodity produced by different industries. The method of combining these two matrixes and deriving the industry x industry matrix has been discussed in Appendix-II.

Data and Estimation Techniques

Data

The basic database for the study is the firm level panel data *(The firm level data has been aggregated in two categories namely "foreign" (with foreign equity participation of at least 10 percent) and "domestic" (with foreign equity participation of less than 10 percent) to study spillover effects and compare their performances)* of 13 manufacturing industries in National Industrial Classification, 2008 (NIC-2008) at two digit level for the period 2000-01 to 2009-10, obtained from the Centre for Monitoring Indian Economy's (CMIE) electronic database "Prowess". In addition to Prowess database, wholesale price indices are taken from the "Handbook of Statistics on Indian Economy 2010-2011" of Reserve Bank of India. Latest input-output tables 2006-07, obtained from National Accounts Division of CSO are used for this study. In order to aggregate the input-output table for the manufacturing industry to two-digit level a concordance table had to be constructed between NIC-2008 and input-output tables 2006-07 as given in Appendix-I.

The sample set comprises of 1846 firms including 1559 domestic firms and 287 foreign firms. *Firms with foreign capital participation are defined as firms in which the share of capital owned by foreign investor is equal to at least 10 percent (According to OECD Benchmark definition of Foreign Direct Investment (OECD, 2008). Since this definition is followed by most of the countries internationally, RBI also follows this 10% rule).*

Estimation Techniques

For the purpose of calculating spillovers due to backward and forward linkages for domestic firms and foreign firms standard techniques as defined by Javorick (2004) are used.

Backward (Bw_{jt}): The backward variable is a proxy for the foreign presence in the industry *k* that is being supplied by industry *j*. This variable captures the extent of potential contacts between domestic suppliers in industry j and multinational buyers in industry k.

$$Bw_{jt} = \sum_{k \, if \, k \neq j} \alpha_{jk} \, Hz_{kt}$$

a_{jk} is a coefficient which measures the proportion of industry *j*'s output supplied to industry *k* taken from the latest available input output matrix 2006-07 at two digit level. The proportion of industry *j*'s output supplied to industry *k* is calculated excluding products supplied for final consumption. The formula indicates that inputs supplied within the industry are not included, since this effect is captured by the horizontal variable. The greater the foreign presence in industry *k* and larger the share of intermediates supplied from industry *j* to such industry, higher will be the value of the backward variable.

Forward (Fw_{jt}): The Forward variable is a proxy for the foreign presence in industries *m* (multinational suppliers) which are supplying to industry *j* (domestic customers). The forward variable is defined as the weighted share of output in upstream or supplying industry *m*, produced by its firms with foreign capital participation. As only intermediates sold in the domestic market are relevant to this study, goods produced by foreign affiliates for exports (X_{it}) are excluded.

$$Fw_{jt} = \sum_{m \, if \, m \neq j} \sigma_{jm} [[\sum_{i \, for \, all \, i \in m} FS_{it} * (Y_{it} - X_{it})] \, / \, [\sum_{i \text{ for all } i \in m} (Y_{it} - X_{it})]]$$

s_{jm} is the share of inputs purchased by industry *j* from industry *m* in total inputs sourced by industry *j*. FS_{it} is foreign equity participation and Y_{it} is the output of firm *i* at time *t*.

For the same reason as before, inputs purchased within the industry are excluded. The value of the variable increases with the increase in the share of foreign affiliates in the (domestically sold) output of upstream industries.

The backward and forward linkages are calculated for each of the 13 industries under study both for domestic firms and foreign firms. These spillovers through linkages are compared between foreign and domestic firms and also over the industries under study. Spillover through vertical linkages are studied by combining backward and forward linkages of all the industries under study.

Variables and their measurement

Estimating spillovers through backward and forward linkages require three variables: horizontal variable, output and exports. Since input output tables are in 2006-07 prices therefore data on all these variables should also be in 2006-07 prices. The value of these variables are reported in current prices by prowess database therefore they are deflated using appropriate price indices from RBI's "Handbook of Statistics on Indian Economy 2010-2011" and the base of Wholesale Price Index is changed to 2006-07 prices. All variables used in this research work are in 2006-07 prices. The specific details on the construction of variables are as follows.

Horizontal (HZ_{jt}): This variable captures the extent of foreign presence in industry *j* at the time *t* and is defined as foreign equity participation averaged over all firms in industry, weighted by each firm's share in industry's total output (deflated). Symbolically it can be expressed as:

$$Hz_{jt} = [\sum_{i \text{ for all } i \in j} FS_{it} * Y_{it}] \ / [\sum_{i \text{ for all } i \in j} Y_{it}$$

where, $i = 1, 2, \ldots\ldots n.$

FS_{it} is foreign equity participation and Y_{it} is the output of firm *i* at time *t*. The value of this variable depicting spillovers through horizontal linkages increases with the increase in the output (deflated) of the foreign investment enterprises Y_{it} and the share of the foreign equity in such firms FS_{it}.

Output (Y): Output is the real output of a firm operating in an industry at time *t*. It is calculated by adjusting the reported sales for changes in inventories of finished goods (Output = Sales - Opening stock of finished goods + Closing stock of finished goods) and the resulting value is deflated by the wholesale price index for the "manufactured products" as reported by RBI.

Exports (X): Exports of goods are values of exports (fob) as obtained from the Prowess database deflated by the WPI of the "manufactured products" obtained from from the website of RBI (rbi.org.in).

Results and Analysis

On the basis of methodology discussed above the results are shown by Table-1. As expected the spillovers through inter industry linkages are found to be more in case of the foreign firms as compared to the domestic firms. This is because the average of values of all the industries under study depicting spillovers through backward and forward linkages are higher in case of foreign firms as compared to the domestic firms. The value of variables depicting spillovers through backward and forward linkages for the foreign firms are 0.0274 and 0.0214 respectively whereas for the domestic firms these values are 0.0045 and 0.0053 which are lower than foreign firms.

The spillovers through backward linkages are found to be strong in chemicals, rubber and plastic products, basic metal, metal products and the machinery and equipment industry because the value of variable depicting the backward spillovers is robust in these industries than the average of value of backward linkage of all the industries under study for instance, in the case of chemicals industry foreign firms having robust backward linkages who are manufacturing paints, varnishes and similar coatings are benefitting domestic suppliers in upstream firms by giving them market and thus providing impetus to increase their production which itself will lead to increase in their internal economies.

The spillovers through forward linkages are found to be strong in the textiles, chemicals, rubber and plastic products, electrical equipment, machinery and equipment and automobile industry because these industries have robust value of variables depicting forward spillovers than the average of all the industries under study 0.0214. Like for textiles industry the value of this variable is 0.0265, for chemicals industry it is 0.0283 which are higher than the average of the values of all the industries under study. Thus, in all these industries easy supply of products from upstream foreign firms to downstream domestic customers is making domestic firms more efficient.

Combining the spillovers through backward and forward linkages we find six out of thirteen manufacturing industries under study show robust spillovers due to vertical linkages. These industries include chemicals, rubber and plastic products basic metal, metal products, electrical equipment, machinery and equipment industry. The comparison of spillovers through total vertical linkages of foreign firms with domestic firms further confirms that foreign firms manifest higher inter-industry spillovers as compared to domestic firms.

Conclusion and Policy Implications

As a part of the larger framework of spillover effects of foreign direct investment developed by Murthy and Malhotra (2014) which enables the measurement of primary indirect spillover effects through horizontal and vertical linkages, the present paper deploys this framework and methodology for measurement of such spillover effects in India. Using the Input-Output tables 2006-07 by MOSPI the study has measured FDI spillovers through vertical linkages (including backward and forward linkages) for 13 manufacturing industries a two-digit-level during the period 2000-01 to 2009-10 with standard techniques.

The results show spillover effects of foreign direct investment due to inter industry linkages are more in case of foreign firms as compared to the domestic firms. The spillovers through backward linkages are found to be strong in chemicals, rubber and plastic, basic metal, metal products and the machinery and equipment industry. The spillovers through forward linkages are found to be strong in the textiles, chemicals, rubber and plastic products, electrical equipment, machinery and equipment and automobile industry. Overall, six out of thirteen manufacturing industries under study show robust spillovers due to vertical linkages.

Not only high technology industries like electrical equipment and machinery and equipment but low technology industries like basic metals and metal products industries are also experiencing these vertical spillover effects. With foreign presence, domestic firms are able to reap benefits of spillovers because foreign owners provide guidance and training to domestic partners to be able to absorb advanced technology and skills. Domestic firms on themselves may not be to absorb it at all or may take a lot of time to do the same. However, not all industries are found to have these spillover effects due to foreign presence. The notion about FDI is that they may not be advantageous for the host economy is found not to be true according to our study as the spillovers through backward and forward linkages are invariably higher in case of foreign firms.

The policy implications are that given the current international scenario and macro-economic conditions of India, the fact that there is a large domestic sector in our economy; there are spillover effects through backward and forward linkages due to foreign presence. Our results show that India's foreign direct investment policies have been successful in extracting benefits from flow of FDI as our input-output analysis shows that the economy is benefiting from their presence by virtue of spillover effects. However, since there is heterogeneity in terms of the strength of the linkages among different industries there is a need to review our sectoral foreign direct investment policy. It may be necessary to ensure that FDI is diverted towards those industries, where spillovers through vertical linkages are stronger.

Certainly, there is more scope of research to fully understand the effects of foreign direct investments on the domestic firms of Indian manufacturing industries. In particular, input-output transaction tables at a firm level will give better insight into the spillovers through customer supplier linkages than the input-output transactions' table at the industry level which is currently available to researchers. Moreover, it would be interesting to learn about the characteristics of individual investor companies that determine the extent of spillovers operating through different channels. Thus improved data availability will allow researchers to examine these questions more in depth.

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Appendix-I
Concordance between Classification of Manufacturing Industries as per NIC-2008 and Input Output Transaction Tables 2006-07

NIC code	Industry	Input output table 2006-07 - industry codes
10	Food products	38-43
11	Beverages	44
12	Tobacco products	45
13	Textiles	46-52, 54
14	Wearing apparel	53
15	Leather and related products	59,60
16	Wood and products of wood and cork except furniture; manufacture of articles of straw and plaiting materials	56
17	Paper and paper products	57
18	Printing and reproduction of recorded media	58

19	Coke and refined petroleum products	63,64
20	Chemicals and chemical products	65-69 ,71-73
21	Pharmaceuticals, medicinal chemical and botanical products	70
22	Rubber and plastics products	61,62
23	Other non-metallic mineral products	74-76
24	Basic metals	77-80
25	Fabricated metal products, except machinery and equipment	81,82
26	Computer, electronic and optical products	92,94,101,102
27	Electrical equipment	88-91, 93
28	Machinery and equipment n.e.c.	83-87
29	Motor vehicles, trailers and semi-trailers	97
30	Other transport equipment	95,96,98-100,104
31	Manufacture of furniture	55
32	Other manufacturing	103,105

**Constructed by authors*

Appendix - II

The IOTT can be derived from the absorption matrix (use) and make matrix (supply). This methodology is also employed by Sasidharan (2006). The absorption matrix consists of values of commodities supplied to different industries for final use as well as intermediate inputs. The make matrix represent the values of output produced by different industries. As mentioned before, an industry x industry matrix is constructed from these two matrices. Therefore as a first step, the input output table for the manufacturing industry is aggregated to two-digit level. Secondly, a matrix of coefficient (matrix X) is created by dividing each row of the absorption matrix by the total output of the commodity. Another matrix Y, using the make matrix is created by dividing each row by the total output produced by the respective industry. As a final step, a new matrix Z=YX is created. This new matrix Z is nothing but an industry x industry matrix. Each row of the matrix Z represents the total industry output delivered to different industries in the economy.

Table 1: Spillovers through Inter Industry Linkages

Industry	Backward				Forward				Vertical*			
	Domestic		Foreign		Domestic		Foreign		Domestic		Foreign	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Food	0.0010	0.0003	0.0092	0.0039	0.0054	0.0036	0.0128	0.0052	0.0064	0.0037	0.0220	0.0065
Textiles	0.0012	0.0005	0.0102	0.0031	0.0038	0.0015	0.0265	0.0081	0.0051	0.0017	0.0367	0.0083
Petroleum	0.0029	0.0007	0.0220	0.0043	0.0006	0.0002	0.0036	0.0004	0.0035	0.0008	0.0255	0.0045
Chemicals	0.0072	0.0016	0.0348	0.0088	0.0105	0.0045	0.0283	0.0073	0.0177	0.0054	0.0631	0.0127
Drugs and Pharmaceuticals	0.0009	0.0002	0.0058	0.0009	0.0021	0.0009	0.0100	0.0011	0.0030	0.0010	0.0158	0.0019
Rubber and Plastic Products	0.0073	0.0020	0.0432	0.0113	0.0030	0.0010	0.0250	0.0047	0.0103	0.0028	0.0682	0.0115
Non-Metallic Mineral Products	0.0024	0.0009	0.0107	0.0023	0.0036	0.0016	0.0075	0.0021	0.0060	0.0020	0.0182	0.0031
Basic Metals	0.0121	0.0067	0.0789	0.0178	0.0060	0.0024	0.0178	0.0041	0.0181	0.0087	0.0967	0.0218
Metals Products	0.0102	0.0038	0.0672	0.0176	0.0035	0.0013	0.0171	0.0040	0.0136	0.0046	0.0843	0.0214
Electrical Equipment	0.0055	0.0023	0.0196	0.0067	0.0144	0.0072	0.0565	0.0122	0.0199	0.0086	0.0761	0.0176
Machinery and Equipment	0.0056	0.0021	0.0342	0.0106	0.0094	0.0045	0.0303	0.0084	0.0150	0.0060	0.0644	0.0188
Automobile	0.0009	0.0003	0.0048	0.0010	0.0054	0.0024	0.0323	0.0061	0.0062	0.0026	0.0371	0.0064
Transport Equipment	0.0022	0.0008	0.0164	0.0054	0.0024	0.0011	0.0105	0.0025	0.0046	0.0016	0.0269	0.0077
(Grand Mean)	0.0046		0.0275		0.0054		0.0214		0.0100		0.0489	

Source: Computed by the authors.
**Total vertical linkages including both backward and forward linkages.*

Trade and Import Intensity Pattern of Select Asian Countries: A Comparative Study

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Abstract

With increasing regional cooperation among the south Asian economies, there has been a tremendous rise in intermediate input flows across boundaries. In this context, import intensities, domestic production structure and export composition, no doubt, play important roles in determining the extent and pattern of international trade. This paper investigates the factors that contribute to the difference in inter country trade pattern in the year 2006-07. The countries under consideration are Bangladesh, Srilanka and China. As we have utilised the 'domestic input output matrices' made available by Asian Development Bank (ADB) for getting a more correct projection of domestic output requirement and hence the import requirement consequent to a certain export vector, possibly our results appear to be robust enough. We observe that the import intensity of export (Direct and Induced) of goods and services is 7.18 percent for Bangladesh, 22.74 percent for Srilanka and 6.24 percent for China. As far as import intensity (Direct and Induced) of 'Goods' is concerned, it is 8.07 percent for Bangladesh, 27.98 percent for Srilanka and 6.51 for China. For the import intensity (Direct and Induced) of 'services', we find that it is 0.17 percent for Bangladesh, 2.32 percent for Srilanka and 0.03 percent for China.

Our decomposition result reveals that though the difference in 'direct import requirements' contribute significantly to the difference in import intensity of exports of Bangladesh and Srilanka, the difference in 'domestic production structure' becomes a major contributor to the growth of difference in import intensity of export between Srilanka and China. The difference in 'export composition' significantly contributes to the change in import intensity of exports between China and Bangladesh.

Keywords: *Import Intensities, International Trade, Input-Output, Export Vector, Export Composition*

Introduction

With increasing regional cooperation among the south Asian economies, there has been a tremendous rise in intermediate input flows across boundaries and import intensities of

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countries. In this context, domestic production structure and export composition, no doubt, play important roles in determining the extent and pattern of international factor flows. The basis of this increasing regional cooperation seems to have been closer political and economic contacts and growing trade relations among the countries.

This paper investigates the factors that contribute to the differences in inter country import intensity of exports in the year 2006-07. The countries under consideration are Bangladesh, Srilanka and China. As we have utilised the 'domestic input output matrices' made available by Asian Development Bank for getting a more correct projection of domestic output requirement and hence the import requirement consequent to a certain export vector, possibly our results appear to be robust enough.

In Section-1.1 after highlighting the purpose of the paper, section -1.2 discusses about the methodological framework for our study. Section-1.3 deals with the sources of the data base utilized in this exercise In section-1.4, the results of the study have been interpreted. Finally in section-1.5 some concluding observations are made for the purpose of drawing a few inferences for policy purposes.

The Methodological Framework

Leontief open input-output model obviously is a useful analytical tool for analyzing the import intensity of export. Total output from each industry equals total inter-industrial demand plus the final demand. So, we have the balance relations as follows:

$$Xi = \sum_{j=i}^{m} Xij + Fi \ldots\ldots\ldots(1)$$ where Xi = Output in the ith sector (in value terms),

Fi = Final Demand in the ith sector (in value terms) and Xij = input flow from ith sector to jth sector

Assuming a production function with fixed coefficients,

Xij = aij.Xj …………..(2) where aij = Xij/Xj

By substituting (2) in (1), gross output or sales of sector i can be expressed as:

$$Xi = \sum_{j=i}^{m} aij.Xj + Fi \ldots\ldots(3)$$

Therefore $X = AX + F$ where $X = (Xi)$, $A = (aij)$ and $F = (Fi)$

Or $F = X - AX = IX - AX = (I - A)X$

Or $X = (I - A)^{-1} F \cdots\cdots\cdots (4)$

In the equation (4) if F is prescribed from outside, the required gross output levels X's get determined. For our present purpose it is not the entire Final Demand but the export part of the final demand is relevant.

If Xij(m) = Imported input of ith sector to jth sector and if Xij(t) = total supply of input of ith sector to jth sector and Xij(d) = domestically produced input of ith sector to jth sector, we may write Xij(d) = Xij(t) - Xij(m)

Now we may define mj = ∑aij - ∑aij(d) where (aij) = (Xij/Xj) and (aijd) = (Xijd/Xj) as the direct total import requirement for the jth sector per unit of output . For each country for the year 2006-07, we get mj for j = 1,…………, 15. Then, we may obtain total (direct plus induced) import intensity of output as $m.(I\text{-}Ad)^{-1}$

Now, to obtain import intensity of exports we proceed as follows:
$m.(I\text{-}Ad)^{-1}.\,E$ where E is a vector of sectoral share of export.

We have computed import intensity of export based on data of these economies for the year 2006-07. We have shown the results in the table-8. In the results section, we have given the interpretation of the above result. Further, we also discuss here a framework for the decomposition of the inter country differences in the import intensity of export.

Let, C_1 and C_2 be two countries. So, $m(C_1)$ and $m(C_2)$ be the direct import requirement vector for the country, C_1 and C_2 respectively.

Let, A_d (C_1), A_d (C_2), $e(C_1)$, $e(C_2)$ be the corresponding domestic I-O matrices and export share vector respectively. Then, we may write

$m(C_2).(I-A_d)^{-1}{}_{C2}.e(C_2) - m(C_1).(I-A_d)^{-1}{}_{C1}.e(C_1)$ = Total difference in Import Intensity of Export between the countries C_1 and C_2.

Now we like to separate out the contribution of difference in direct import intensity in the total inter country difference in import intensity between the countries C_1 and C_2 assuming unchanged domestic I-O matrix and export vector.

So, for the above, we may compute as follows allowing import intensity vector to change from $m(C_1)$ to $m(C_2)$.

$m(C_2).(I-A_d)^{-1}{}_{C1}.e(C_1) - m(C_1).(I-A_d)^{-1}{}_{C1}.e(C_1)$.........(1)

Next, we may like to separate out the contribution of difference in domestic production structure reflected in Ad matrix assuming unchanged direct import intensity and export vector. Obviously, the computation will be in the following way allowing only $A_d(C_1)$ to be changed to $A_d(C_2)$.

$m(C_1).(I-A_d)^{-1}{}_{C2}.e(C^1) - m(C_1).(I-A_d)^{-1}{}_{C1}.e(C_1)$ ....(2)

In an analogous way, we separate out the contribution of inter country difference in sectoral export share, the computation for which will be as follows allowing only $e(C_1)$ to changed to $e(C_2)$.

$m(C_1).(I-A_d)^{-1}{}_{C1}.e(C_2) - m(C_1).(I-A_d)^{-1}{}_{C1}.e(C_1)$ ....(3)

Now, the total decomposition exercise can be expressed in the following way

$m(C_2).(I-A_d)^{-1}{}_{C2}.e(C_2) - m(C_1).(I-A_d)^{-1}{}_{C1}.e(C_1)=$ $\{m(C_2).(I-A_d)^{-1}{}_{C1}.e(C_1)- m(C_1).(I-A_d)^{-1}{}_{C1}.e(C_1)\}$ +(contribution of direct import intensity difference) $\{m(C_1).(I-A_d)^{-1}{}_{C2}.e(C_1)-m(C_1).(I-A_d)^{-1}{}_{C1}.e(C_1)\}$ $+\{m(C_1).(I-A_d)^{-1}{}_{C1}.e(C_2)-m(C_1).(I-A_d)^{-1}{}_{C1}.e(C_1)\}$. (contribution of domestic production structure difference) (contribution of difference in the export composition) We have decomposed the total import intensity difference in the above way for three cases (three comparisons) as stated below.

Comparison-I: Bangladesh--Srilanka
(C_1) (C_2)

Comparison-II: Srilanka--------China
(C_1) (C_2)

Comparison-III: China-----Bangladesh
(C_1) (C_2)

The Data Base of the Study

For our empirical study of import intensity of exports, I-O tables (Total inter-industry Transaction matrix) prepared and circulated by Asian Development Bank (ADB) for the year 2006-07 provide major part of the information required for our purpose. The import matrices for the said year are also prepared by ADB and available for use. The matrices (Transaction and import) as obtained from ADB for the year 2006-07 are of order 15*15 and our study is based on the 15 sectors classification.

Results of the Study

This section of the paper is concerned with a discussion of the results contained in Tables from 1to 8.

Table-1 presents the direct import requirement per unit of goods, services and output of various sectors of Bangladesh for the year 2006-07. We observe that 'Clothing and Wearing Apparel, and Leather and Leather Products' is the sector for which the direct import content per unit of good is found to be significantly high. 'Basic Metals, Fabricated Metals, Machinery, Equipment and Apparatus' ranks second. As far as direct import requirement per unit of services are concerned, 'Transportation, Communication, and Supporting Services' ranks first. We observe that

'Clothing and Wearing Apparel, and Leather and Leather Products' ranks top in terms of direct import requirement per unit of output.

Table-2 displays total (direct and induced) import intensities per unit of goods, services and output of Bangladesh for the year 2006-07. It is observed that total (direct and induced) import intensities per unit of goods is found to be highest in 'Clothing and Wearing Apparel, and Leather and Leather Products' and it ranks first. 'Basic Metals, Fabricated Metals, Machinery, Equipment and Apparatus' ranks second. As far as direct import requirement per unit of services are concerned, 'Transportation, Communication, and Supporting Services' ranks first and 'Financial Intermediation, Insurance and Auxiliary Services' comes second. We observe that 'Clothing and Wearing Apparel, and Leather and Leather Products' ranks first and 'Basic Metals, Fabricated Metals, Machinery, Equipment and Apparatus' ranks second in terms of direct import requirement per unit of output.

Table-3 presents the direct import requirement per unit of goods, services and output of various sectors of Srilanka for the year 2006-07. We observe that 'Products of Wood, Paper and Paper Products' is the sector for which the direct import content per unit of good is found to be significantly high. 'Clothing and Wearing Apparel, and Leather and Leather Products' ranks second. As far as direct import requirement per unit of services are concerned, 'Transportation, Communication, and Supporting Services' ranks first. We observe that 'Products of Wood, Paper and Paper Products' ranks at the top in terms of direct import requirement per unit of output.

Table-4 displays total (direct and induced) import intensities per unit of goods, services and output of Srilanka for the year 2006-07. It is observed that total (direct and induced) import intensities per unit of goods is found to be highest in 'Products of Wood, Paper and Paper Products' and it ranks first. 'Clothing and Wearing Apparel, and Leather and Leather Products' ranks second. As far as direct import requirement per unit of services are concerned, 'Transportation, Communication, and Supporting Services' ranks first and 'Real Estate, Leasing or Rental, and Other Business Services' comes second. We observe that 'Products of Wood, Paper and Paper Products' ranks at the top and 'Clothing and Wearing Apparel, and Leather and Leather Products' ranks second in terms of direct import requirement per unit of output.

Table-5 presents the direct import requirement per unit of goods, services and output of various sectors of China for the year 2006-07. We observe that 'Basic Metals, Fabricated Metals, Machinery, Equipment and Apparatus' is the sector for which the direct import content per unit of good is found to be significantly high. 'Clothing and Wearing Apparel, and Leather and Leather Products' ranks second. As far as direct import requirement per unit of services are concerned, 'Transportation, Communication, and Supporting Services.' ranks second. We observe that 'Basic Metals, Fabricated Metals, Machinery, Equipment and Apparatus ' ranks first in terms of direct import requirement per unit of output.

Table-6 displays total (direct and induced) import intensities per unit of goods, services and output of China for the year 2006-07. It is observed that total (direct and induced) import intensities per unit of goods is found to be highest in 'Basic Metals, Fabricated Metals, Machinery, Equipment and Apparatus' and it ranks at the top. 'Clothing and Wearing Apparel, and Leather and Leather Products' ranks second. As far as direct import requirement per unit of services are concerned, 'Transportation, Communication, and Supporting Services' ranks second and 'Other Services' comes first. We observe that 'Basic Metals, Fabricated Metals, Machinery, Equipment and Apparatus' ranks first and 'Clothing and Wearing Apparel, and Leather and Leather Products' ranks second in terms of direct import requirement per unit of output.

Table -7 presents the estimates of total(direct and induced) import intensity of export of Bangladesh, Srilanka and China for the year 2006-07.

As indicated in the table-7, the total (direct and indirect) import intensity of export of goods is highest for Srilanka (27.98 percent) followed by Bangladesh (8.07 percent) and China (6.51 percent). As expected, the import intensity of services is insignificant for the countries. The total (direct and indirect) import intensity of export of output is highest for Srilanka (22.74 percent) followed by Bangladesh (7.18 percent) and China (6.24 percent). The import intensity of exports are depicted in Bar Diagram. (Figure 7F)

The (Figure 7F) observed increase may be explained in terms of the change in the composition of exports in favour of goods with high import intensity or increase in the import intensities of the industries or in terms of the change in the production structure. We have estimated the relative contribution of each separately and have discussed the same in the interpretation of decomposition results.

Decomposition Results

Table-8 reflects the import intensity of export growth decomposition between the countries namely Bangladesh and Srilanka, Srilanka and China and China and Bangladesh. Diagramed Charts for the same are presented in the Figures also.

A look into the table-8 and the figures $8F_1$, $8F_2$ and $8F_3$ reveal the following:

In case of comparison-I (Bangladesh-Srilanka), the magnitude of total import intensity difference was of the order 15 percent. Out of this, as table-8 shows, direct import intensity difference accounts for 72.0 percent. However, an insignificant part of the increased total import intensity contributed exclusively by direct import intensity was cancelled out by the opposite impact of difference in production structure (1 percent) but a significant part of the increased total import intensity contributed exclusively by direct import intensity was cancelled out by the opposite impact of difference in export composition(55 percent).

For comparison-II(Srilanka-China), we find that the magnitude of total import intensity difference was of the order (-) 16 percent. Out of this difference, direct import intensity difference accounts for (-)21 percent . But a significant part of the increased total import intensity is contributed exclusively by domestic production structure (27 perecnt). Export composition difference contributes (-)22 percent .

We find a different picture regarding the role of contributing factors towards total difference in import intensity in comparison-III(China-Bangladesh) The magnitude of total import intensity difference, in comparison-III, was of the order 0.94 percent. Out of this, direct import intensity difference accounts for (-)0.27 percent). A small part of the total difference in import intensity is accounted for the difference in domestic production structure (2 percent). The increased total import intensity contributed exclusively by export composition was 3 percent.

Conclusion

In this paper, we have examined the direct import intensity as well as the direct and induced import intensity of the industries, growth of import intensity of exports and its decomposition for three countries namely Bangladesh, Srilanka and China. The broad implications of this study can be summarized as follows-

1. We have used in our study the, I-O tables prepared by Asian Development Bank for the year 2006-07. We have collected the import matrices for the said year from ADB. So, we are in a position to use domestic I-O tables to find out domestic input requirements and in that sense, we hope that our result seems to be robust, enough and dependable.
2. The direct import requirement per unit of output as well as the direct and induced import requirement per unit of sales is found to be highest for 'Clothing and Wearing Apparel, and Leather and Leather Products' in Bangladesh, for 'Products of Wood, Paper and Paper Products' in Srilanka and for 'Basic Metals, Fabricated Metals, Machinery, Equipment and Apparatus' in China.
3. The total (direct and indirect) import intensity of exports of output is highest for Srilanka (22.74 percent) followed by Bangladesh (7.18 percent) and China (6.24 percent).

4. We have decomposed the difference in import intensity of export between Bangladesh and Srilanka (Comparison-I), Srilanka and China (Comparison-II) and China and Bangladesh (Comparison-III). We note that while the difference in production structure contributes significantly to the difference in import intensity of export between Bangladesh and Srilanka, it is domestic production structure for Srilanka and China and exports composition for China and Bangladesh.

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Table 1: Direct Import Requirement per Unit of Output of various Sectors of Bangladesh, 2006-07 (Ranks are in Descending Order)

Sl. No	Sectors	Goods	Rank	Services	Rank	Goods+ Services	Rank
1	Agriculture, Forestry and Fishery Products	0.0038	5	0.0000	15	0.0038	5
2	Products of Mining and Quarrying	0.0003	8	0.0000	14	0.0003	11
3	Food, Beverages and Tobacco Products	0.0014	7	0.0000	10	0.0014	9
4	Clothing and Wearing Apparel, and Leather and Leather Products	0.0680	**1**	0.0000	5	0.0680	**1**
5	Products of Wood, Paper and Paper Products	0.0015	6	0.0000	6	0.0015	7
6	Basic Metals, Fabricated Metals, Machinery, Equipment and Apparatus	0.0318	2	0.0000	7	0.0318	2
7	Other Manufacturing	0.0229	3	0.0000	9	0.0229	3
8	Electricity, Town Gas, Steam and Hot Water	0.0000	9	0.0000	12	0.0000	12
9	Water	0.0000	10	0.0000	11	0.0000	13
10	Construction Services	0.0000	11	0.0000	8	0.0000	14
11	Wholesale and Retail Trade Services	0.0000	12	0.0000	13	0.0000	15
12	Transportation, Communication, and Supporting Services	0.0039	4	0.0040	**1**	0.0079	4
13	Financial Intermediation, Insurance and Auxiliary Services	0.0000	13	0.0024	2	0.0024	6
14	Real Estate, Leasing or Rental, and Other Business Services	0.0000	14	0.0014	3	0.0014	8
15	Other Services, n.e.c.	0.0000	15	0.0008	4	0.0008	10

Source: Author's Own Calculations

Table 2: Direct and Induced Import Requirement per Unit of Output of various Sectors of Bangladesh, 2006-07 (Ranks are in Descending Order)

Sl. No	Sectors	Goods	Rank	Services	Rank	Total Output	Rank
1	Agriculture, Forestry and Fishery Products	0.0056	6	0.0001	15	0.0056	6
2	Products of Mining and Quarrying	0.0014	13	0.0001	14	0.0015	14
3	Food, Beverages and Tobacco Products	0.0044	7	0.0003	10	0.0047	7
4	Clothing and Wearing Apparel, and Leather and Leather Products	0.0992	**1**	0.0007	5	0.0998	**1**
5	Products of Wood, Paper and Paper Products	0.0082	4	0.0005	6	0.0086	5
6	Basic Metals, Fabricated Metals, Machinery, Equipment and Apparatus	0.0383	2	0.0004	7	0.0387	2
7	Other Manufacturing		3	0.0004	9	0.0284	3
8	Electricity, Town Gas, Steam and Hot Water	0.0017	11	0.0001	12	0.0018	12
9	Water	0.0015	12	0.0002	11	0.0017	13
10	Construction Services	0.0041	8	0.0004	8	0.0046	8
11	Wholesale and Retail Trade Services	0.0009	14	0.0001	13	0.0010	15
12	Transportation, Communication, and Supporting Services	0.0068	5	0.0044	**1**	0.0112	4
13	Financial Intermediation, Insurance and Auxiliary Services	0.0017	10	0.0027	2	0.0044	9
14	Real Estate, Leasing or Rental, and Other Business Services	0.0005	15	0.0015	3	0.0020	11
15	Other Services, n.e.c.	0.0018	9	0.0010	4	0.0028	10

Source: Author's calculation.

Table 3: Direct Import Requirement per Unit of Output of various Sectors of Srilanka, 2006-07 (Ranks are in Descending Order)

Sl. No	Sectors	Goods	Rank	Services	Rank	Total Output	Rank
1	Agriculture, Forestry and Fishery Products	0.0104	7	0.0000	5	0.0104	7
2	Products of Mining and Quarrying	0.4465	4	0.0000	6	0.4465	4
3	Food, Beverages and Tobacco Products	0.0031	8	0.0000	7	0.0031	9
4	Clothing and Wearing Apparel, and Leather and Leather Products	0.7528	2	0.0000	8	0.7528	2
5	Products of Wood, Paper and Paper Products	0.9363	1	0.0000	9	0.9363	1
6	Basic Metals, Fabricated Metals, Machinery, Equipment and Apparatus	0.5960	3	0.0000	10	0.5960	3
7	Other Manufacturing	0.0490	5	0.0000	11	0.0490	5
8	Electricity, Town Gas, Steam and Hot Water	0.0000	10	0.0000	12	0.0000	14
9	Water	0.0000	9	0.0000	13	0.0000	12
10	Construction Services	0.0000	11	0.0000	14	0.0000	13
11	Wholesale and Retail Trade Services	0.0000	12	0.0000	15	0.0000	15
12	Transportation, Communication, and Supporting Services	0.0134	6	0.0250	1	0.0385	6
13	Financial Intermediation, Insurance and Auxiliary Services	0.0000	13	0.0002	3	0.0002	10
14	Real Estate, Leasing or Rental, and Other Business Services	0.0000	14	0.0089	2	0.0089	8
15	Other Services, n.e.c.	0.0000	15	0.0000	4	0.0000	11

Source: Author's calculation.

Table 4: Direct and Induced Import Requirement per Unit of Output of various Sectors of Srilanka, 2006-07 (Ranks are in Descending Order)

Sl. No	Sectors	Goods	Rank	Services	Rank	Total Output	Rank
1	Agriculture, Forestry and Fishery Products	0.0227	8	0.0008	14	0.0235	8
2	Products of Mining and Quarrying	0.4539	4	0.0007	15	0.4547	4
3	Food, Beverages and Tobacco Products	0.0150	11	0.0024	4	0.0174	12
4	Clothing and Wearing Apparel, and Leather and Leather Products	0.8306	2	0.0016	7	0.8322	2
5	Products of Wood, Paper and Paper Products	0.9898	1	0.0016	8	0.9914	1
6	Basic Metals, Fabricated Metals, Machinery, Equipment and Apparatus	0.6293	3	0.0016	9	0.6309	3
7	Other Manufacturing	0.1004	5	0.0020	5	0.1024	5
8	Electricity, Town Gas, Steam and Hot Water	0.0195	9	0.0012	12	0.0207	11
9	Water	0.0098	14	0.0012	13	0.0109	14
10	Construction Services	0.0368	7	0.0014	11	0.0382	7
11	Wholesale and Retail Trade Services	0.0061	15	0.0016	10	0.0077	15
12	Transportation, Communication, and Supporting Services	0.0391	6	0.0268	1	0.0659	6
13	Financial Intermediation, Insurance and Auxiliary Services	0.0100	13	0.0017	6	0.0117	13
14	Real Estate, Leasing or Rental, and Other Business Services	0.0126	12	0.0107	2	0.0234	9
15	Other Services, n.e.c.	0.0190	10	0.0031	3	0.0221	10

Source: Author's calculation.

Table 5: Direct Import Requirement per Unit of Output of various Sectors of China, 2006-07 (Ranks are in Descending Order)

Sl. No	Sectors	Goods	Rank	Services	Rank	Total Output	Rank
1	Agriculture, Forestry and Fishery Products	0.0007	8	0.0000	5	0.0007	9
2	Products of Mining and Quarrying	0.0094	5	0.0000	6	0.0094	5
3	Food, Beverages and Tobacco Products	0.0021	6	0.0000	7	0.0021	6
4	Clothing and Wearing Apparel, and Leather and Leather Products	0.0247	2	0.0000	8	0.0247	2
5	Products of Wood, Paper and Paper Products	0.0094	4	0.0000	9	0.0094	4
6	Basic Metals, Fabricated Metals, Machinery, Equipment and Apparatus	0.0507	1	0.0000	10	0.0507	1
7	Other Manufacturing	0.0147	3	0.0000	11	0.0147	3
8	Electricity, Town Gas, Steam and Hot Water	0.0000	9	0.0000	12	0.0000	12
9	Water	0.0000	10	0.0000	13	0.0000	13
10	Construction Services	0.0000	11	0.0000	4	0.0000	11
11	Wholesale and Retail Trade Services	0.0000	12	0.0000	14	0.0000	14
12	Transportation, Communication, and Supporting Services	0.0014	7	0.0005	2	0.0018	7
13	Financial Intermediation, Insurance and Auxiliary Services	0.0000	13	0.0002	3	0.0002	10
14	Real Estate, Leasing or Rental, and Other Business Services	0.0000	14	0.0000	15	0.0000	15
15	Other Services, n.e.c.	0.0000	15	0.0016	1	0.0016	8

Source: Author's calculation.

Table 6: Direct and Induced Import Requirement per Unit of Output of various Sectors of China 2006-07 (Ranks are in Descending Order)

Sl. No	Sectors	Goods	Rank	Services	Rank	Total Output	Rank
1	Agriculture, Forestry and Fishery Products	0.0083	14	0.0001	15	0.0084	14
2	Products of Mining and Quarrying	0.0287	5	0.0002	11	0.0289	5
3	Food, Beverages and Tobacco Products	0.0126	12	0.0002	13	0.0128	12
4	Clothing and Wearing Apparel, and Leather and Leather Products	0.0520	2	0.0003	6	0.0523	2
5	Products of Wood, Paper and Paper Products	0.0310	4	0.0003	8	0.0312	4
6	Basic Metals, Fabricated Metals, Machinery, Equipment and Apparatus	0.0927	1	0.0003	7	0.0929	1
7	Other Manufacturing	0.0375	3	0.0002	10	0.0378	3
8	Electricity, Town Gas, Steam and Hot Water	0.0220	7	0.0002	12	0.0222	7
9	Water	0.0177	10	0.0002	9	0.0179	10
10	Construction Services	0.0282	6	0.0003	5	0.0285	6
11	Wholesale and Retail Trade Services	0.0135	11	0.0004	4	0.0139	11
12	Transportation, Communication, and Supporting Services	0.0195	8	0.0007	2	0.0202	8
13	Financial Intermediation, Insurance and Auxiliary Services	0.0088	13	0.0005	3	0.0093	13
14	Real Estate, Leasing or Rental, and Other Business Services	0.0049	15	0.0002	14	0.0051	15
15	Other Services, n.e.c.	0.0182	9	0.0019	1	0.0201	9

Source: Author's calculation.

Table 7: Total (Direct and Induced) Import Intensity of Export of Bangladesh, Srilanka & China

	Bangladesh	Srilanka	China
Import Intensity of Exports of Goods	0.0807	0.2798	0.0651
	(8.07)	(27.98)	(6.51)
Import Intensity of Exports of Services	0.0017	0.0232	0.0003
	(0.17)	(2.32)	(0.03)
Import Intensity of Exports of Output	0.0718	0.2274	0.0624
	(7.18)	(22.74)	(6.24)

Source: Author's calculation.

Table 8: The Decomposition of the change in Import Intensity of Exports

	Comparison-I	Comparison-II	Comparison-III
	Bangladesh-Srilanka	Srilanka--China	China -Bangladesh
A) Total Import Intensity Change	(+)0.1556	(-)0.1650	(+)0.0094
a) Contribution of Direct Import	(+)0.7275	(-)0.2164	(-)0.0027
Intensity change assuming export			
composition and Domestic Production			
Structure unchanged			
b) Contribution of change in Domestic	(-)0.0163	(+)0.2737	(-)0.0246
Production Structure assuming			
Sectoral export share and Direct Import			
Intensity unchanged			
c) Contribution of change in Sectoral Share	(-)0.5557	(-)0.2223	(+)0.0368
of Export assuming Direct Import			
Intensity and Production Structure			
Unchanged			
B) Sum of (a + b + c)	(+)0.1556	(-)0.1650	0.0094

Source: Author's calculation.

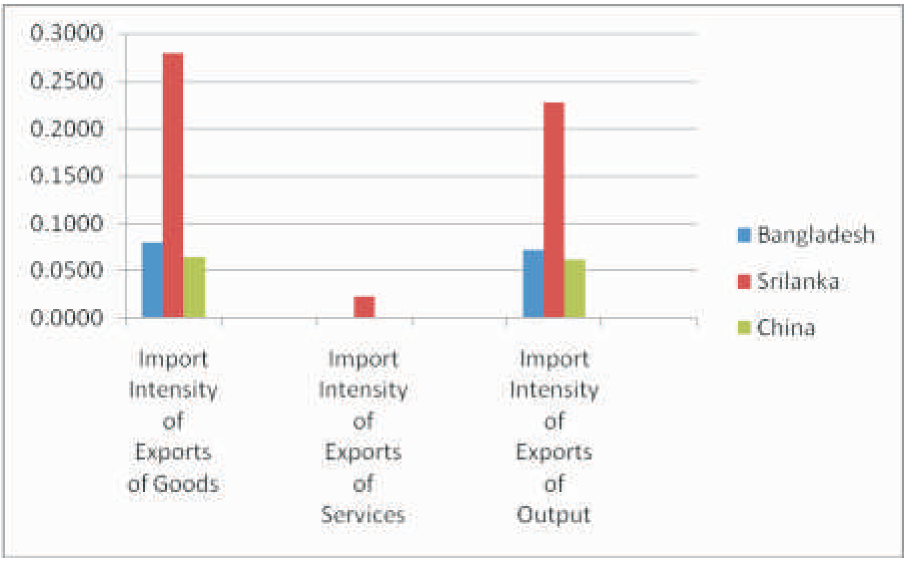

Fig.- 7 F: Bar Diagram Showing Import Intensity of Exports

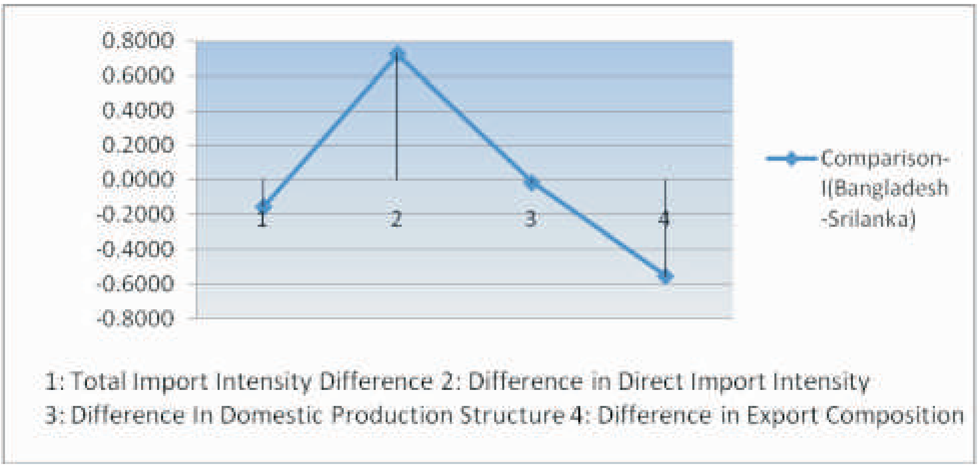

Fig.-8F1: Decomposition of the Difference of Import Intensity of Exports Comparison-I (Bangladesh-Srilanka)

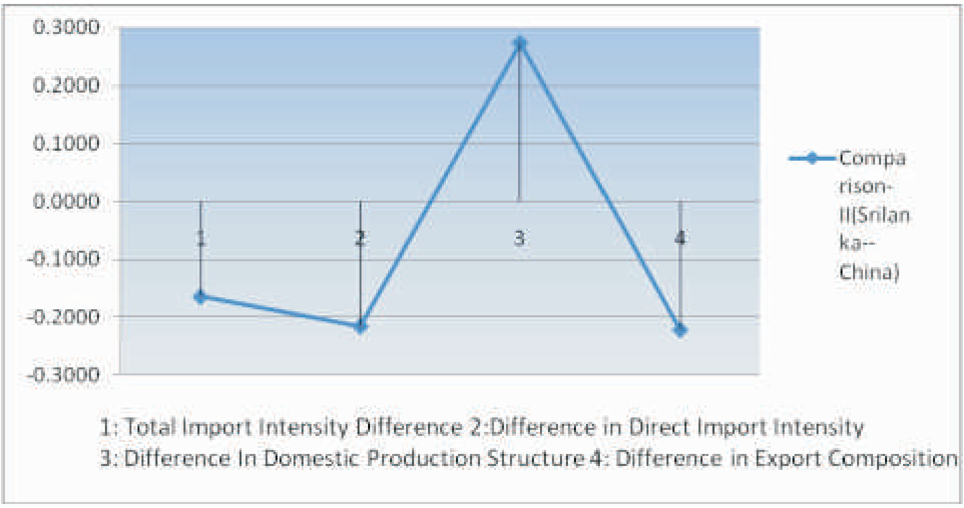

Fig-8F2: Decomposition of the Difference of Import Intensity of Exports Comparison-II (Srilanka-China)

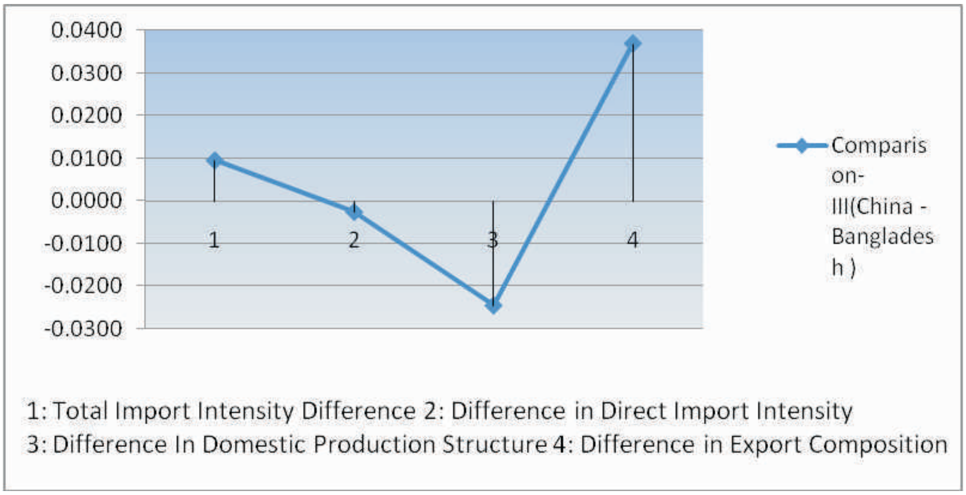

Fig-8F3: Decomposition of the Difference of Import Intensity of Exports Comparison-III (China-Bangladesh)

Macroeconomic Determinants of Stock Market Development: Empirical Evidence from India

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Abstract

In India, the fundamental problems associated with the stock markets are linked to changes in macroeconomic variables. Thus, the purpose of the present study is to examine the dynamic long run and the short run relationship between stock price and a set of macroeconomic variables for Indian economy using monthly data from April 2004 to January 2015. For this purpose, the Ng-Perron unit root test is utilized to check the order of integration of the variables. The long run relationship is examined by implementing the ARDL bounds testing approach to co-integration. VECM method is used to test the short and long run causality and variance decomposition. The results confirm a long run co-integrating relationship between the variables. Evidence suggests that the Index of Industrial Production, inflation and real effective exchange rate influence stock prices positively, whereas, gold price influences the stock price negatively. The VECM result indicates that only long-run causality running from all the variables used in the study to stock prices in India. The result of the variance decomposition shows that stock market development in India is mostly explained by its own shocks.

Keywords: *BSE Sensex, Index of Industrial Production, ARDL, VECM.*

JEL Classification: *G10, N25, C58*

Introduction

A stock market is the central place where the buyers and sellers meet at a specified price for transactions of securities. Stock market plays a key role in the mobilization of capital in emerging and developed countries, leading to the growth of industry and commerce of the country. There exist many factors in the economy that works as a sign for stock market participants to anticipate the higher or lower return when investing in the stock market and one of these factors are macroeconomic variables. The change in macroeconomic variables can significantly impact stock price return. In the literature, it is well

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established that macroeconomic fundamentals play determining role in the performance of the stock market. Specifically, numbers of studies offer the evidence that macroeconomic indicator affects stock prices to a large extent. After the findings of the Fama (1981) between macroeconomic indicators and stock prices, several studies have been conducted to investigate the interrelationship between macroeconomic indicators and stock prices (Hamao, 1988; Fama, 1990; Chen, 1991; Poon and Taylor, 1992; Canova and de-Nicolo, 1995; Dickson, 2000 and Nasseh and Strauss, 2000). But most of these studies are conducted on developed market where all aspects are more efficient and well connected with the overall economy. There are very few studies analyzing the relationship in the developing and emerging markets. More recently, some amount of empirical studies has been focusing attention to relate the stock prices and macroeconomic factors for both developed and emerging economies (Mukherjee and Naka, 1995; Maysami et al., 2004; Ratanapakorn and Sharma, 2007; Rahman et al., 2009). These studies conclude that stock prices do respond to the changes in macroeconomic fundamentals, but the sign and causal relationship might not hold equal for all the studies. However, the role of macroeconomic variables in stock markets is relatively less studied in developing country like India. Further, these studies have been carried out either in a bivariate setting or have mostly used orthodox econometric technique. Hence, to investigate the effect of macroeconomic variables on stock prices, the present study includes variables such as index of industrial production (IIP), interest rate, inflation (CPI), exchange rate and gold price.

Indian stock market has undergone tremendous changes since 1991, when the government has adopted liberalization and globalization policies. As a result, there is a growing importance of the stock market from the aggregate economic point of view. Now a days, the stock market has become a key driver of the modern market based economy and is one of the major sources of raising resources for Indian corporate, there by enabling financial development and economic growth. In fact, Indian stock market is one of the emerging markets in the world. The smoothing development process in Indian stock markets continues to be breathtaking. From 3,739.69 points on March 31st, 1999, within nine years; Bombay Stock Exchange (BSE) Sensitivity Index (SENSEX) had reached to 21,000 level points in January, 2008. But this impact doesn’t last long as it was affected by the recent global financial crisis of 2007-08 and emerging euro-crisis. Now SENSEX is around 26,000 plus points (bseindia.com). The 2007-08 crises have resulted in structural changes in the way people think and behave with respect to the risk borne by them, particularly the systematic risk. Due to the global crisis the economy experienced extreme volatility in terms of fluctuations in stock market prices, exchange rates and inflation levels during a short duration. Economic growth decelerated in 2008-09 to 6.7 percent. This represented a decline of 2.1 percent from the average growth rate of 8.8 percent in the previous five years. From all accounts, except for the agricultural sector, initially as noted above, economic recovery seems to be well underway. Economic growth stood at 8.6 percent during fiscal year 2010-11. When compared to countries across the world, India stands out as one of the best performing economies. Although there was a clear moderation in growth from 9 percent levels to 7 plus percent soon after the crisis hit, in 2010-11, at 8.6 percent, GDP growth in nearing the pre-crisis levels and this pace makes India the fastest growing major economy after China.

Studies on Indian stock market behavior have also been conducted in recent years. Agarwalla and Tuteja (2008) stated that rising indices in the stock markets cannot be taken to be a leading indicator of the revival of the economy in India and vice-versa. However, Shah and Thomas (1997) supported the idea that stock prices are a minor which reflect the real economy. Similar results were found in Kanakaraj et al. (2008). There are several other studies regarding the interaction of share market returns and the macroeconomic variables and all studies provide a different conclusion related to their test and methodology. Hence, this study helps in exploring whether the movement of stock market indices is the result of some related macroeconomic variables or it is one of the causes of variation in those macroeconomic variables of the Indian economy. However, unlike the conventional studies, in this paper, we employ the Auto Regressive Distributed Lag (ARDL) approach to co-integrate to examine the long-run stability between the macroeconomic variables and Indian stock prices. The study also uses VECM based granger causality to check the direction of causal relationships between variables. Variance Decomposition (VDC) is also used to explore the degree of exogeneity of the variables involved in this study. For the purpose of analysis monthly data starting from the April 2004 to January 2015 is used.

The rest of the paper is organized as follows: Section 2 presents the theoretical perspectives of the stock price and macroeconomic variables, Section 3 presents the review of empirical literature on the relationship between selected macroeconomic variables and stock market development. Section 4 outlines the data issues and econometric methodology used in the study; section 5 analyses the empirical results of the study, and section 6 presents the concluding remarks.

Theoretical underpinnings

Stock market development is usually measured by stock market size, liquidity, volatility and prices. The stock market index is Sensex (or BSE 30) an index of 30 well established and financially sound companies listed on the BSE. The Sensex is intended to represent an entire stock market and thus track the market changes over time. Therefore, in this study, we have taken the Sensitivity index of BSE (Sensex) to track the changes in the market over time (with respect to other macroeconomic variables) (Naik and Padhi (2012); Saleem and Yasir et al. (2012); Singh (2010); Tripathi and Seth (2014) used different methodologies with different data periods).

The idea that financial markets may be related to economic activities is not new, but the interpretation of this relationship has changed over time, with changing international and domestic economic environment and growing econometric techniques. Explaining such a relationship involves assessing the direction of causality and the type of influence (positive and negative). The relationship between stock price and economic growth has been studied by Fama (1990, 1991), Levine (1991), Levin and Zervos (1996). The study expects a strong positive correlation between stock prices and real activity. The present study has taken Index of Industrial Production (LIIP) as the proxy for economic growth (Agarwalla and Tuteja, 2008; Shabri and Rosylin, 2009).

Fluctuations in exchange rates can sometimes have a significant effect on firm value, as they influence the terms of competition, the input and output prices, and the value of firm's assets and liabilities denominated in foreign currencies. According to Fama (1981), the exchange rate is a double edge weapon. A devaluation of domestic currency increase export, hence improve the cash flow and divide payoffs for firms that rely on exports. On the other hand, depreciation of home currency makes imports costlier and decreases the cash flow and hence affects the industries which depend on imports. The relationship between exchange rate and stock prices is positive (Gay, 2008; Lijuan and Ye, 2010) whereas others found it negative (Abugri, 2008). Hence the relationship between stock prices and exchange rate is an empirical one.

Inflation represents one of the major threats to stock investors. When the inflation rates start to rise, investors get very nervous anticipating the potentially negative consequences and therefore because of lack of confidence among investors, they resist to invest in the stock market which leads to a decline in stock prices. Therefore, researcher found a negative relationship between inflation and stock prices (Fama, 1981). On the other hand, Fisher (1911) hypothesized that shares, are hedged against inflation in the sense that an increase in expected inflation leads to a proportional change in nominal share returns, some studies propounded that positive relationship is also possible between inflation and stock prices as unexpected inflation raises the firms' equity value if they are net debtors (Ioannidis et al., 2004).

Call money rate is considered as a proxy of interest rate (Mukherjee and Naka, 1995; Sarbapriya Ray, 2012). The logic behind the negative relationship between interest rates and stock prices suggest that an upward trend in interest rates, enhances the opportunity cost of holding money and thus substitution between stocks and interest bearing securities resulting declining stock prices. Thus, a change in nominal interest rates should move asset prices in the opposite direction.

Gold is a substitute investment avenue for Indian investors. It is often stated that gold is the best preserving purchasing power in the long run. Gold also provides high liquidity; it can be exchanged for money anytime the holders want. Gold investment can also be used as a hedge against inflation and currency depreciation. As the gold price rises, Indian investors tend to invest less in stocks, causing stock prices to fall. Therefore, a negative relationship is expected between gold price and stock price. (Sarbapriya Ray, 2012; Gupta and Reid, 2013)

Literature Review

The relationship between macroeconomic variables and the stock market is an important area of research addressed by many researchers nationally and internationally. Gjrde and Saettem (1999) examined the causal relation between stock returns and macroeconomic variables in Norway. Results showed that a positive link exists between oil price, real activity and stock returns. A study by Flannery and Protopapadakis (2002) concluded that two popular measures of aggregate economic activity (real gross national product and industrial production) were not related to stock returns. Mookerjee and Qiao (1997) investigated that stock prices co-integrated with both measures of the money supply (M1 and M2) and aggregate foreign exchange reserves. Ibrahim and Aziz (2003) investigated the relationship between stock prices and IPI, money supply, CPI and exchange rate in Malaysia. Stock prices were found to share a positive long-run relationship with IPI and CPI.

Geske and Roll (1983); Chen et al. (1986); Mukherjee and Naka (1995); Wongbangpo and Sharma (2002); Maysami et al. (2004); Nishat and Shaheen (2004); Erdogan and Ozlale (2005); Ratanapakorn and Sharma (2007); Sohail and Hussain (2009); Rahman et al. (2009); found a positive relationship between IIP and stock prices. Samadi, Bayani & Ghalandari (2012), Sharman and Mahendru (2010),Sarbapriya Ray (2012) and Gupta and Reid (2013) found significant negative relation of gold price with stock prices.

Cheng and Ng (1998) investigated long-run co-movement between the selected macroeconomic variables and real stock market prices. Sharma (2002) investigated the relationship between stock prices and some macroeconomic factors in five Asian countries and the results suggest that in the long run, stock prices will be positively related to growth and output. Uddin and Alam (2007, 2009) found that Interest Rate has a significant negative relationship with Share Price. Mukherjee and Naka (1995) and Sarbapriya Ray (2012) found a relationship of the call money rate with stock prices. Coleman and Tettey (2008) studied the impact of macroeconomic indicators on the Ghana Stock Exchange (GSE) and concluded that lending rates from deposit money banks and inflation have an adverse impact on stock market performance contradict to the findings of Adam and Tweneboah (2008). Rahman et Al. (2009) showed that monetary policy variables have considerable long-term effects on the Malaysian stock exchange. Pal and Mittal (2011) found that changes in Indian stock markets are affected by change in few selected macroeconomic variables.

Studies on Indian stock market have also been conducted in recent years. Bhattacharya and Mukherjee (2002), Dharmendra Singh (2010), Naik and Padhi (2012), Dasgupta (2012) and Rafique et al. (2013) by using different methodologies, studied the impact of macroeconomic variables like the Index of Industrial Production, Money Supply, national income, Gross Domestic Product, interest rate, inflation, FDI, FII, trade openness, exchange rate and Whole Sale Price Index on stock market and found a significant impact of selected macroeconomic variables on the stock market. Naik and Padhi (2012) and Hussin et. al. (2012) used the VECM to model the relationship between the stock prices and macroeconomic variables and, hence, a long-run equilibrium relationship exists between them. Hsing and Budden (2012) applied the exponential GARCH model and found that the Argentine stock market index is positively associated with real GDP, the ratio of M2 money supply to GDP, the peso/USD exchange rate and the U.S. stock market index. Bekhet and Matar (2013) found the existence of a long-term equilibrium relationship between the Stock Price Index and the macroeconomic variables. Mazuruse (2014) used canonical Correlation Analysis (CCA) found that maximization of stock returns at the ZSE is mostly influenced by the changes in CPI, money supply, exchange rate and treasury bills. Rafay et. al. (2014) found a unidirectional relationship between exchange rate and KSE 100 index. Bhargava (2014) found that interest rates are significant predictors of stock price movements. Pradhan (2014) used panel VAR and found the presence of both unidirectional and bidirectional causality links between macroeconomic variables and stock market.

Methodology and Data Description

Model Specification and Data:
The following general specification has been used in this study to empirically examine the effect of economic growth and other fundamental macroeconomic factors on the stock market.

$$LBSE_t = a_0 + a_1\, LIIP + a_2\, LCPI + a_3\, LREER + a_4\, LCMR + a_5\, LGOR + e_t \quad ......(1)$$

Where LBSE= Sensitivity index of Bombay Stock Exchange (Sensex), LIIP= Index of Industrial Production, LCPI= Consumer Price Index, LREER= Real Effective Exchange Rate, LCMR= Call Money Rate, and LGOR = Gold Prices variable in the general model specification above. All the variables[1] are taken in their natural logarithm.

The Study empirically estimated the effect of fundamental macroeconomic variables on stock prices with the help of above described methodology for India. The study uses monthly data covering the period from April 2004 to January 2015[2]. The data has been taken and compiled from Handbook of Statistics on Indian economy, RBI; Economic Survey, Govt. of India; World Bank database; Official website of SEBI and RBI.

Co-integration with ARDL
To empirically analyze the long run relationship and dynamic interaction of Stock Market Index with macroeconomic variables, the above model has been estimated by the Auto Regressive Distributed Lag (ARDL) co-integration procedure developed by Pesaran et al. (2001). The procedure is adopted for four reasons. Firstly, the bounds testing is simple as opposed to other multivariate co-integration technique such as Johansen & Juselius (1990), it allows co-integrating relationship to be estimated by OLS once the lag order is selected. Secondly, the bound test procedure does not require the pre testing of the variables included in the model for unit root unlike other techniques such as Engel and Granger (1987) and Johansen & Juselius (1992). These approaches require that all the variables to be integrated of the same order I(1). Otherwise the predictive power will be lost (Kim et al., 2004; Perron, 1989, 1997). However ARDL technique is applicable irrespective of whether regressor in the model is I(0) or I (1). The procedure will, however crash in the presence of I(2) series. Thirdly, the test is relatively more efficient in small sample data sizes as is the case of this study. Fourth the error correction method integrates the short run dynamics with long run equilibrium without losing long run information. The unrestricted error correction model (UECM) of ARDL model is used to examine the long run & the short run relationship takes the following form.

$$\Delta LBSE_t = \delta_0 + \delta_1 T + \delta_2 LIIP_{t-1} + \delta_3 LCPI_{t-1} + \delta_4 LREER_{t-1} + \delta_5 LCMR_{t-1} + \delta_6 LGOR_{t-1} + \sum_{i=1}^{q} \alpha_i \Delta LBSE_{t-i} + \sum_{i=1}^{q} \beta_i \Delta LIIP_{t-i} + \sum_{i=1}^{q} \mu_i \Delta LCPI_{t-i} + \sum_{i=1}^{q} \sigma_i \Delta LREER_{t-i} + \sum_{i=1}^{q} \omega_i \Delta LCMR_{t-i} + \sum_{i=1}^{q} \partial i\, \Delta LGOR_{t-i} + \varepsilon_t \quad .....(2)$$

Where the series is as defined earlier and T is time trend and L implies that the variables have been transformed in natural logs. The first part of the equation (2) with δ_2, δ_3, δ_4, δ_5 and δ_6 refer to the long run coefficients and the second part with $\alpha, \beta, \mu, \sigma, \omega$ and ∂ refers to the short run coefficients. The null hypothesis of no co-integration $H_0: \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$ and the alternative hypothesis $H_1: \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq 0$ implies co-integration among the series (equation 2).

ARDL Bounds Testing Approach

The first step in the ARDL test is to estimate the equation (2) by OLS in order to test for the existence of a long run relationship among variables by conducting an F-test for the joint significance of the coefficients of the lagged levels of variables i.e. H_0 (Null hypothesis) as against H_1 (Alternative hypothesis) as stated earlier.

In the second step, once the co-integration is established the conditional ARDL long run model [4] for $LBSE_t$ can be estimated as:

$$\Delta LBSE_t = \alpha_0 + \sum_{i=1}^{q} \delta_1 LBSE_{t-i} + \sum_{i=1}^{q} \delta_2 LIIP_{t-i} + \sum_{i=1}^{q} \delta_3 LCPI_{t-i} + \sum_{i=1}^{q} \delta_4 LREER_{t-i} + \sum_{i=1}^{q} \delta_5 LCMR_{t-i} + \sum_{i=1}^{q} \delta_6 LGOR_{t-i} + \varepsilon_t \quad \text{.........(3)}$$

All the variables used are defined in section 4.1

The third and final step, we obtain the short run dynamic parameters by estimating an error correction model with the long run estimates. This is specified as below:

$$\Delta LBSE_t = \mu + \sum_{i=1}^{q} \alpha_i \Delta LBSE_{t-i} + \sum_{i=1}^{q_1} \beta_i \Delta LIIP_{t-i} + \sum_{i=1}^{q_2} \mu_i \Delta LCPI_{t-i} + \sum_{i=1}^{q_3} \sigma_i \Delta LREER_{t-i} + \sum_{i=1}^{q_4} \omega_i \Delta LCMR_{t-i} + \sum_{i=1}^{q_5} \partial \Delta LGOR_{t-i} + \phi ECM_{t-1} + \varepsilon_t$$

......(4)

Where $\alpha, \beta, \mu, \sigma, \omega$ and ∂ are short run dynamic coefficient to equilibrium and ϕ is the speed adjustment coefficient.

VECM based Granger Causality Test:

The direction of causality between stock prices and macroeconomic indicators is investigated by applying Vector Error Correction Model (VECM) granger causality approach after confirming the presence of co-integrating relationship among the above mentioned variables. Granger (1969) argued that VECM is more appropriate to examine the causality between the series at I(1). VECM is restricted form of unrestricted VAR and restriction is levied on the presence of the long-run relationship between the series. The system of error correction model (ECM) uses all the series endogenously. This system allows the predicted values to explain itself both by its own lags and lags of forcing variables as well as the lags of the error correction term and by residual term. The VECM equation is modeled as follows:

$$\begin{pmatrix} \Delta LBSE_t \\ \Delta LIIP_t \\ \Delta LCPI_t \\ \Delta LREER_t \\ \Delta LCMR_t \\ \Delta LGOR_t \end{pmatrix} = \begin{pmatrix} C1 \\ C2 \\ C3 \\ C4 \\ C5 \\ C6 \end{pmatrix} + \sum_{i=1}^{p} \begin{bmatrix} \beta_{11i} & \beta_{12i} & \beta_{13i} & \beta_{14i} & \beta_{15i} & \beta_{16i} \\ \beta_{21i} & \beta_{22i} & \beta_{23i} & \beta_{24i} & \beta_{25i} & \beta_{26i} \\ \beta_{31i} & \beta_{32i} & \beta_{33i} & \beta_{34i} & \beta_{35i} & \beta_{36i} \\ \beta_{41i} & \beta_{42i} & \beta_{43i} & \beta_{44i} & \beta_{45i} & \beta_{46i} \\ \beta_{51i} & \beta_{52i} & \beta_{53i} & \beta_{54i} & \beta_{55i} & \beta_{56i} \\ \beta_{61i} & \beta_{62i} & \beta_{63i} & \beta_{64i} & \beta_{65i} & \beta_{66i} \end{bmatrix} \begin{pmatrix} \Delta LBDE_{t-i} \\ \Delta LIIP_{t-i} \\ \Delta LCPI_{t-i} \\ \Delta LREER_{t-i} \\ \Delta LCMR_{t-i} \\ \Delta LGOR_{t-i} \end{pmatrix} + \begin{pmatrix} \gamma_1 \\ \gamma_2 \\ \gamma_3 \\ \gamma_4 \\ \gamma_5 \\ \gamma_6 \end{pmatrix} ECM_{t-1} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \end{pmatrix} \ldots (5)$$

The C's, β's and γ's are the parameters to be estimated. ECM_{t-1} represents the one period lagged error-term derived from the co-integration vector and the e's are serially independent with mean zero and finite covariance matrix. From the Equation (5) given the use of a VAR structure, all variables are treated as endogenous variables. The F test is applied here to examine the direction of any causal relationship between the variables. The LIIP variable does not Granger cause LBSE in the short run, if and only if all the coefficients of β12i's are not significantly different from zero in Equation (5). There are referred to as the short-run Granger causality test. The coefficients on the ECM represent how fast deviations from the long-run equilibrium are eliminated. Another channel of causality can be studied by testing the significance of ECM's. This test is referred to as the long run causality test.

Estimation results

Stationarity test and Lag length selection before co-integration

Before we conduct tests for co-integration, we have to make sure that the variables under consideration are not integrated at an order higher than one. Thus, to test the integration properties of the series, we have used Ng-Perron unit root test. The results of the stationarity tests are presented in Table 1. The results show that all the variables are non-stationary at levels. The next step is to difference the variables once in order to perform stationary tests on differenced variables. The results show that after differencing the variables once, all the other variables were confirmed to be stationary. It is, therefore, worth concluding that all the variables used in this study are integrated of order one i.e. difference stationary I(1). Therefore the study uses auto regressive distributed lag (ARDL) approach to co-integration. In addition, it is also important to ascertain that the optimal lag order of the model is chosen appropriately so that the error terms of the equations are not serially correlated. Consequently, the lag order should be high enough so that the conditional ECM is not subject to over parameterization problems (Narayan, 2005; Pesaran 2001). The results of these tests are presented in Table 2. The results of Table 2 suggest that the optimal lag length is one based on both LR, FPE, SIC and HQ.

ARDL Estimations:

After determining the order of integration of all the variables in table 1, the next step is to employ an ARDL approach to co-integration in order to determine the long run relationship among the variables. By applying, the procedure in OLS regression for the first difference part of the equation (1) and then test for the joint significance of the parameters of the lagged level variables when added to the first regression.

The F-Statistics tests the joint Null hypothesis that the coefficients of lagged level variables in the equation (1) are zero. Table 3, reports the result of the calculated F-Statistics & diagnostic tests of the estimated model. The result shows the calculated F-statistics were 5.2890. Thus the calculated F-statistics turns out to be higher than the upper-bound critical value at the 5 percent level. This suggests that there is a co-integrating relationship among the variables included in the model, i.e. Sensex (LBSE), the Index of Industrial Production (LIIP), Inflation (LCPI), Real Effective Exchange Rate (LREER), Call Money Rate (LCMR) and Gold Prices (LGOR)

The second step is to estimate the long- and short-run estimates of ARDL test. The long run results are illustrated in Table 4. The results show that the rise in IIP, Inflation and Exchange Rate have a positive effect on stock prices. The coefficient of Index of Industrial Production(LIIP), Inflation (LCPI) and Real Effective Exchange Rate (LREER) is statistically significant and positive at 1%, 1% and 5% respectively. It is evident from the table that 1% increase in IIP, a 1% increase in Inflation, and 5% increase in Exchange Rate leads to 1.201%, 1.821%, and 1.221%, respectively, increase in Stock Prices (Sensex). The findings are consistent with Chen et al. (1986), Maysami et al. (2004), Rahman et al. (2009), and Ratanapakorn and Sharma, (2007) for IIP, Ioannidis et al. (2004) for Inflation and Mukherjee and Naka (1995) for Exchange Rate.

Whereas, the coefficient of Gold Price is negative and significant at the 1% level. Therefore, Gold Prices have a significant negative relationship adversely affecting stock prices and the findings are consistent with Ray S. (2012); Gupta and Reid (2013).

The short-run relationship of the macroeconomic variables on stock market index is presented in Table 5. As can be seen from the table, IIP and Inflation has a significant and positive impact on stock market index in the short run also at 10% and 1% level, respectively. Similar to long-run, gold prices and real effective interest rate are significantly negative at 1% and 10%, respectively, in the short-run.The short run adjustment process is examined from the ECM coefficient. The coefficient of the error correction term is an adjustment coefficient capturing the proportion of the disequilibrium in economic growth in one period which is corrected in the next period. The coefficient generally represents the speed of adjustment towards equilibrium, that means how quickly the equilibrium is established if the path is in disequilibrium. The larger the error term, the earlier the economy's return to the equilibrium rate of growth; following a shock. The coefficient lies between 0 and -1, the equilibrium is converging to the long run equilibrium path, is responsive to any external shocks. However, if the value is positive, the equilibrium will be divergent from the reported values of ECM test. The coefficient of the lagged error-correction term (-0.221) is significant at the 1% level of significance. The coefficient implies that a deviation from the equilibrium level of stock market index in the current period will be corrected by 21 percent in the next period to resort the equilibrium.

The short run and long run granger causality test findings are reported in Table 6. In the above table the values mentioned under the heading $ECM_{(t-1)}$ are indicating long run granger causality, whereas, the rest of the values are the values of F-test. The results of table 6 indicate that there is no causality running from any of the variable to LBSE in India. It is also observed that error correction term is statistically significant for specification with LBSE as the dependent variable which indicate that there exist a long run causal relationship among the variable with LBSE as the dependent variable. This result is also confirmed by the ARDL test statistics.

The robustness of the short run result are investigated with the help of diagnostic and stability tests. The ARDL-VECM model passes the diagnostic against serial correlation, functional misspecification and non-normal error. The cumulative sum (CUSUM) and the cumulative sum of square (CUSUMSQ) tests have been employed in the present study to investigate the stability of a long run and short run parameters. The cumulative sum (CUSUM) and the cumulative sum of square (CUSUMSQ) plots are between critical boundaries at 5% level of significance. This confirms the stability property of the long run and short run parameters which have an impact on the market index in case of India. This confirms that models seem to be steady and specified appropriate.

Variance Decomposition (VDC) Analysis:
It is pointed out by Pesaran and Shin (2001) that the variable decomposition method shows the contribution in one variable due to innovation shocks stemming in the forcing variables. The main advantage of this approach as it is insensitive to the ordering of the variables. The results of the VDC are presented in table 7.The column SE is the forecast error of the variable to be forecast at different lengths into the future. The empirical evidence indicates that 71.93% of stock price change is contributed by its own innovative shocks. Further shock in Gold price explains the stock price by 13.19%. IIP contributes to stock prices by 9.67% and inflation and exchange rate contributes 2.14% and 2.77% respectively. The share of call money rate is very minimal.

Conclusions and Policy Implications

An effort has been made in this paper to examine the impact of fundamental macroeconomic variables on the stock prices in India by using monthly data from April 2004 to January 2015 for the variables included in the estimation. The ARDL approach has been applied as it is a more powerful technique to explore the long run and short run dynamics of relationship and yields consistent estimates of the long-run coefficients that are asymptotically normal, irrespective of whether the underlying regressors are I(0) or I(1). The study makes use of Ng-Perron unit root tests to check the non-stationarity property of the series. The test statistics of the unit root suggest that none of the variables included in the study are I(2). The bounds test confirms that the estimated equation, and the series are co-integrated. The ARDL suggests a long run positive and significant relationship exists between economic growth (IIP) and stock prices. It also confirms a significant and positive influence of Exchange Rate and Inflation on stock price movements in India in the long run. Further, the study confirms long run negative and significant relationship between gold prices and stock prices. Similar results were found for short run variables, except for the real effective exchange rate, which is negatively significant in short-run. The error correction model of ARDL approach reveals that the adjustment process from the short-run deviation is slow. More precisely, it is found that the ECM_{t-1} term is -0.211. This term is significant at 1%, again confirming the existence of co-integration that the derivation from the long run equilibrium path is corrected 21% per annum.

To determine the direction of causality VECM is used in the study, and the result found no short run causality running from any of the variables to BSE in India. Further, the result indicates the presence of long run causality for the equation for the stock price as the dependent variable. The CUSUM and CUSUMSQ test results suggest the policy changes considering the explanatory variables of the stock price equation will not cause major distortions in India. To predict the long-run and short-run shocks' variance decomposition is used for the study, the results of the VDC analysis show that a major percentage of stock price change is its own innovative shocks.

The finding implies that, in a country when economic growth picks up, it helps stock prices to increase and boost up the investor's confidence. Higher economic activity implies higher expected profitability, which causes stock prices to rise. The findings also suggest that stock market returns may provide an effective hedge against inflation in India. This also implies that investors in making better portfolio decisions should perhaps view, shares as long-term holdings against inflation's loss of purchasing power. The relationship between real exchange rates and stock prices may be useful because devaluation of domestic currency increase export, hence improve the cash flow and divide payoffs for firms that rely on exports in India. The finding also implies that, the increase in gold prices, gives an alternative and uncontroversial safe investment during the time of financial crisis as it allows its holder to resell it without loss at any time especially in the financial markets' collapse. finally, Policy makers should be informed of these macroeconomic effects on stock market and help them to take efficient and effective policy decisions.

Foot Notes

1. The study excludes the variable Money Supply (M3) because of the high correlation of M3 with inflation and exchange rate.

2. The study limits to the starting period as April 2004 to January 2015 due to the non-availability of data with a common base year on IIP and CPI prior to this period.

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Table 1: Unit root test: Ng-Perron Test

Variables	With trend and intercept				Stationarity Status
	Mza	MZt	MSB	MPT	
LBSE	-89.750	-6.762	0.064	1.018	I (1)
ΔLBSE	-20.262	-3.159	0.148	4.522	
LCMR	-21.286	-3.392	0.153	3.478	I (1)
ΔLCMR	-42.613	-4.419	0.110	2.936	
LCPI	-21.071	-3.324	0.129	4.212	I (1)
ΔLCPI	-9.894	-2.113	0.222	9.232	
LGOR	-2.684	-0.912	0.318	25.938	I (1)
ΔLGOR	-38.29	-4.532	0.191	2.129	
LIIP	-25.410	-3.779	0.129	3.190	I (1)
ΔLIIP	-7.441	-1.850	0.233	11.125	
LREER	-6.323	-1.933	0.219	12.552	I (1)
ΔLREER	-39.759	-3.501	0.115	2.655	

Source: Author's own Calculation by using E-views 8.0
Δ denotes the first difference of the series. L implies that the variables have been transformed in natural logs.

Table 2: Lag Order Selection Criterion

Lag	*LogL*	*LR*	*FPE*	*AIC*	*SIC*	*HQ*
0	356.298	NA	1.58e-12	-10.127	-9.964	-10.074
1	899.597	1032.363	1.38e-18	-24.193	-23.815*	-23.682
2	696.843	44.291	1.76e-18	-23.876	-22.491	-22.816
3	1206.728	44.021	2.16e-18	-23.717	-21.237	-22.419
4	1771.441	73.943*	1.12e-18	-24.615	-18.843	-22.310
5	1233.304	61.391	1.89e-18	-23.943	-19.167	-22.207
6	1163.409	31.477	1.61e-18	-24.462	-17.684	-21.799
7	1211.650	42.181	1.68e-18	-24.737	-16.913	-21.515
8	1272.928	43.784	1.46e-18	-25.421	-16.462	-21.842
9	1350.687	38.897	1.40e-18	-26.211	-16.106	-22.333
10	1426.592	46.008	7.97e-19	-29.066	-16.936	-23.620
11	1625.994	41.428	2.74e-19*	-31.472*	-18.026	-26.478*

** indicates lag order selected by the criterion*
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 3: ARDL Bounds test

Panel 1: Bound testing to co-integration:

Estimated Equation:
LBSE = F (LIIP LCPI LREER LCMR LGOR)

Indicators	
Optimal lag	04
F – Statistics	5.289021

Panel 2: Diagnostic Tests:

Diagnostic Tests Indicators	
Normality J-B value	0.8911
Serial Correlation LM Test	1.5114
Heteroscedasticity Test (ARCH)	1.0155
Ramsey Reset Test	0.0725

Table 4: Estimated Long Run Coefficients using ARDL Approach (Dependent variable: LBSE)

Regressors	*ARDL(1,0,0,0)*		
	Coefficient	*t- values*	*Prob. Values*
LIIP	1.2013***	2.290	[0.006]
LCPI	1.8215***	3.343	[0.000]
LREER	1.2219**	1.658	[0.043]
LCMR	-0.092	-0.755	[0.352]
LGOR	-0.796***	-2.943	[0.003]
CONS	-2.271	-1.238	[0.320]
Robustness Indicators			
R^2	0.947		
Adjusted R^2	0.948		
F Statistics	127.768[0.000]		
D.W. Stat	1.999		
Serial Correlation, F	9.532 [0.548]		
Heteroskedasticity, F	7.767 [0.004]		
Ramsey reset test, F	2.811 [0.079]		

Note: (1) The lag order of the model is based on Schwarz Bayesian Criterion (SBC).
*(2) *, ** and *** indicate significant at 10, 5 and 1 percent level of significance, respectively. Values in [#] are probability values.*

Table 5: Estimated Short Run Coefficients using ARDL Approach (Dependent variable: LBSE)

Regressors	*ARDL(1,0,0,0)*		
	Coefficient	*T – Ratio*	*Prob. Values*
ΔLIIP	0.275*	1.676	[0.070]
ΔLCPI	0.678***	2.624	[0.005]
ΔLREER	-0.250*	1.554	[0.098]
ΔLCMR	-0.059	-0.566	[0.383]
ΔLGOR	-0.446***	-3.974	[0.000]
ΔCONS	-0.779	-1.272	[0.212]
ECM_{t-1}	-0.211	-3.438	[0.001]
Robustness Indicators			
R^2	0.416		
Adjusted R2	0.348		
D.W. Stat	1.889		
SE Regression	0.043		
RSS	0.302		
F Statistics	6.044 [0.000]		

Note: (1) The lag order of the model is based on Schwarz Bayesian Criterion (SBC).
*(2) *, ** and *** indicate significant at 10, 5 and 1 percent level of significance, respectively. Values in [#] are probability values.*

Table 6: Results of Vector Error Correction Model

Dependent variable	*Sources of Causation*						
	Short run independent variables						*Long run*
	LBSE	**LIIP**	**LCPI**	**LREER**	**LCMR**	**LGOR**	*ECM*$_{(t-1)}$
LBSE	-	0.525	0.567	0.890	0.639	0.823	-2.714***
LIIP	5.489***	-	1.613	0.799	0.502	5.832***	-2.523***
LCPI	2.321*	3.244**	-	1.415	0.853	1.629	2.282
LREER	0.629	0.240	1.347	-	0.201	0.321	0.445
LCMR	1.563	4.667***	1.373	0.211	-	0.524	4.548
LGOR	1.156	0.712	1.221	1.024	0.323	-	0.785

, ** and * indicate significant at 10, 5 and 1 percent level of significance, respectively.*

Table 7: Variance Decomposition (VDC) Analysis

Period	*S.E.*	*LBSE*	*LIIP*	*LCPI*	*LREER*	*LCMR*	*LGOR*
1	0.069	100.00	0.000	0.000	0.000	0.000	0.000
2	0.100	97.745	1.417	0.195	0.058	0.010	0.122
3	0.135	95.608	2.676	0.526	0.275	0.195	0.133
4	0.156	94.859	3.746	0.525	0.718	0.304	0.299
5	0.169	94.049	3.539	0.701	0.923	0.343	0.376
6	0.190	92.452	4.451	0.825	0.724	0.377	0.304
7	0.211	91.650	6.132	0.744	0.704	0.406	0.326
8	0.221	91.351	6.330	0.659	0.832	0.425	0.321
9	0.233	89.664	7.522	0.665	1.141	0.414	0.543
10	0.241	87.444	8.329	0.649	1.669	0.344	1.361
11	0.254	85.135	9.261	0.883	2.105	0.365	2.440
12	0.263	82.622	9.662	1.239	2.439	0.357	3.815
13	0.276	79.924	9.726	1.543	2.684	0.395	5.596
14	0.283	77.624	9.968	1.851	2.832	0.362	7.378
15	0.289	75.653	10.031	2.021	2.906	0.350	9.046
16	0.297	74.145	9.977	2.157	2.916	0.357	10.434
17	0.306	73.062	9.894	2.221	2.883	0.344	11.561
18	0.311	72.374	9.823	2.179	2.861	0.374	12.337
19	0.319	72.021	9.737	2.174	2.823	0.332	12.933
20	0.324	71.930	9.676	2.149	2.776	0.320	13.190

Cholesky Ordering: LBSE LIIPLCPI LREERLCMR LGOR

Performance of Indian Public Sector Banks: A Non-Parametric DEA Approach

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Abstract

The objective of this paper is to analyze the performance of Indian Public Sector Banks in terms of Total Factor Productivity Growth (TFPG), Technological Change and technical efficiency performances. Data Envelopment Analysis (DEA) based Malmquist productivity index approach is used to measure the productivity indices for 25 public sector banks during 1992-93 to 2012-13. Empirical results indicate that 96 percent of public sector banks have reported improvement in TFPG change, mainly due to the increase in technological change. On the other hand, 52% of banks experienced decline in Technical efficiency change due to decay in scale efficiency and pure technical efficiency change. Also, first phase of the reform period has played a significant role in increasing performance of Public Sector Banks in India, since there is a less competition from foreign and private banks. Reform measures have brought significant improvements in technological changes rather than technical efficiency change in Indian public sector banks, which resulted in increasing total factor productivity growth changes. The study concludes that there is enough scope for improvement in the performance of public sector banks in India in terms of technical efficiency, technological change, and total factor productivity changes.

Keywords: *Data Envelopment Analysis, Indian Banks, Productivity Index, Technical Efficiency, Scale Efficiency, TFPG, Panel Data*

Introduction

The rapid growth of the banking system in India in terms of presence as well as penetration over past four decades after nationalization of banks in 1969 was extremely impressive. While the first phase of banking reforms focused mainly on increasing the role of private banks, opening market for foreign banks, enhancing competitiveness, capital adequacy, etc, the second phase announced in 1998 laced greater emphasis on structural measures, improvement in standards of

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disclosure and levels of transparency. Reforms have brought about considerable improvements, in capital adequacy, asset quality, profitability and operational efficiency.

The profitability of the Indian banking sector has been maintained at about 1.0 per cent in terms of Return on Assets (RoA), even in the post-crisis period. The banks have also shown significant improvement in other efficiency indicators such as cost to income ratio (18.5% in 2012), business per employee (Rs. 8.3 Lakhs in 2012) and business per branch (Rs. 99.3 Lakhs in 2012). Post financial crisis, in 2009 the deposits of Indian banking sector were $ 763 bn and rose to $ 1170 bn in 2012 and further rose to $ 1274 bn in 2013. The total assets were $ 1271bn in 2010, rose to $ 1736 bn in 2012 and further to $ 1763 bn in 2013. Table-1 shows the structure of commercial banks in India in terms of investment, deposits, borrowing, fixed assets and total assets. It is clear from the table that, public sector banks played a key role in the Indian banking industry.

One of the important objectives of financial sector reforms announced in India was to improve the efficiency of the banking system. Banking sector reforms provided the platform to grow on the basis of operational flexibility, competition, functional autonomy and thereby enhancing productivity, efficiency and profitability. The existing studies on the productivity and efficiency of Indian banks have focused pre and post reform period across Public, Private and Foreign Banks. Public sector banks play a very important role in the Indian commercial banking sector. Public sector banks constitute more than 80% of branches and employees 72% of total commercial banking operations. Moreover, share of Public sector banks in terms of investment is 68.48 %, Deposits to the tune of 77.22% and total assets is 72.68%, as on March 31st, 2014.

This paper makes an attempt to evaluate the total factor productivity growth in the Indian Public Sector, over the period 1992-2013. Non-parametric DEA based Malmquist Index Method is used for the purpose. The measures of productivity growth are computed across the various bank. Decomposition of total factor productivity growth into technical efficiency change and technological change will help to determine what kinds of policies are better suited to improve the growth prospects of the banking sector. The bank-wise results reported in the present study avoids the problem of dominance of one bank over others within the same group, and would be more useful in designing micro-level policies in the public sector banks.

The remainder of this paper is organized as follows. Section II presents the reviews of selected literature, and section III describes the methodology and data for measuring efficiency and its components. Section IV presents the empirical findings and section V summary and policy suggestions

Literature Review

There is very rich literature, mostly with regard to developed countries, on assessing bank performances using measures of productivity and efficiency. Studies by Nag & Shiva Swamy (1990) on the performance of banks in India found that foreign banks operating in India in comparison their competitor domestic banks have performed well in terms of various indicators of performance, particularly profitability. Another study by Ibrahim (2011) found that Scheduled Commercial Banks in India have significantly improved their operational performance. A study by Nandi (2013) found that the overall technical efficiency in the selected banks is 89 percent. Bhawan Jagwani (2011) in his study found that public sector banks, under the present competitive and deregulated environment, dominate the formation of the efficient frontier of the Indian banking industry which supports that public sector banks are relatively more efficient than private-domestic and foreign banks. The study also finds that the overall technical inefficiency in banks is primarily due to the under performance of management rather than scale inefficiency. Mariappan and G. Sreeaarthi in their study suggested that by improved handling of operating expenses, advances, capital and by boosting banking investment operations, the less efficient banks can successfully endorse resource utilization efficiency.

Bhuia, Baten, Kamil and Deb (2012) and Mohammad, Azizul, Anaton and Nandini (2012) in their study evaluated the relative efficiency of Bangladesh online banks during 2001 - 2007 by utilizing Data Envelopment Analysis (DEA). Results suggest that Bangladesh Islamic Commercial Banks are more efficient than that of the State-Owned commercial Banks and the Private commercial banks. A study by Wu (2008) analyses productivity and efficiency of banks operating in Australia by applying DEA and the result indicates that there is a decline in productivity of the Australian banking sector over the sample period. Bruce Q Budd and D. B. Budd (2008) examined the comparative efficiency performances of the top Middle East Arab Banks using DEA and Principal Components Factor Analysis (PCFA) using the data collected from 62 banks for the year 2008. The empirical results depicted that the higher technically efficient scoring banks were not necessarily the larger banks and bank that were efficient were not necessarily profitable. No significant relationship was detected between larger banks that are efficient at generating website visits and those that are efficient at generating revenues. Smaller banks revealed more evidence of comparative efficiency performance towards generating website traffic output.

Piyu Yue (2009) in his study evaluated the economic performance of 60 largest Missouri commercial banks for the period from 1984 to 1990 by using DEA. The results of DEA efficiency scores suggest that the scale inefficiency is not a major source of overall inefficiency for these banks. Suraya Ahmad and Abdul Rahim Abdul Rahman (2008) in their study examine the relative efficiency of the Islamic commercial banks (ICBs) and conventional commercial banks (CCBs) in Malaysia using data envelopment analysis (DEA).The results indicate that the technical inefficiencies of banks are largely contributed by the scale inefficiency rather than pure technical inefficiency.

Application of DEA and Malmquist Index in analyzing the performance of efficiency and productivity measures found to be most valuable and significant in the literature. The present study uses the DEA and Malmquist Index approach to analyze the efficiency and productivity performance of Indian Public sector banks for the period of 1992 to 2013.

Methodology

Data Envelopment Analysis (DEA) and Malmquist Productivity Index

In economic theory, productivity can be used as an alternative measure of firm's performance, which is the relation between inputs and the resulting outputs. In the case of multiple inputs and outputs, Total Factor Productivity (TFP) is used as measure for productivity, which is defined as the ratio of aggregated output to aggregated input at a given point of time.

Though the researchers have propounded several theories and methods for total factor productivity measurement over the last four decades, the empirical literature spells out two basic approaches to measure TFP growth, parametric and non-parametric techniques. One of the extensively used non-parametric approaches is Date Envelopment Analysis (DEA) which employs mathematical linear programming model to measure efficiency of Decision Making Units (DMUs) and it has the capacity to consider multiple inputs and output calculating relative efficiency scores of DMUs. DEA also identifies, for inefficient DMUs, the sources and level of inefficiencies for each of the inputs and output. In DEA, the performance of a firm is evaluated in terms of its ability to either shrink usage of an input or expand the output level subject to the restrictions imposed by the best observed practices. Efficiency of each DMU is evaluated against the most efficient DMU, and it is measured by the ratio of actual output to maximum potential output.

Charnes, Cooper, and Rhodes first developed DEA in the literature in1978 and since then this model is known as CCR model. Later, Bankar, Charnes, and Cooper (1984) extended CCR model to allow variable return to scale. The CRS assumption of DEA is suitable only when all DMUs are operating at an optimal scale. There are basically two types of DEA model: those that maximize output, leaving the input vector fixed (output-oriented), and those that minimize inputs, keeping the output vector constant (input-oriented). Input oriented technical efficiency addresses the issue related to how much can input quantities be proportionally reduced without changing the output quantities produces on the other hand, output oriented technical efficiency addresses the issues related to by how much can output quantities be proportionally expanded without altering the input quantities used. The output and input oriented measures will only provide equivalent measures of technical efficiency when CRS exists, but will be unequal when IRS or DRS are present (Fare & Lovell, 1978). Original DEA specification has been extended in several ways and multistage models were developed to identify the nearest efficient points and to make the model invariant to units of measurement. Coelli (1996) developed such a multi stage methodology and a computer program which implements a robust multi-stage model among other options.

When one has a panel data, one may use DEA-like linear program and Malmquist Index to measure productivity change and to decompose productivity change into technological change and technical efficiency change as discussed in Fare, Grosskopf, Norris & Zhang (1994).

Fare et al (1994) specifies an output-based Malmquist productivity changes index as:

$$m_0(y_{t+1}, x_{t+1}, y_t, x_t) = \left[\frac{d_o^t(x_{t+1}, y_{t+1})}{d_o^t(x_t, y_t)} \times \frac{d_o^{t+1}(x_{t+1}, y_{t+1})}{d_o^{t+1}(x_t, y_t)}\right]^{1/2} \quad \text{.... (1)}$$

Equation (1) represents the productivity of production point (x_{t+1}, y_{t+1}) relative to the production point (x_t, y_t). A value greater than one will indicate positive TFP growth from period 't' to period 't+1'. This index is the geometric mean of two output based Malmquist TFP indices, one uses period 't' technology and the other period 't+1' technology.

Equation (1) can be decomposed as follows:

$$m_0(y_{t+1}, x_{t+1}, y_t, x_t) = \frac{d_o^t(x_{t+1}, y_{t+1})}{d_o^t(x_t, y_t)} \times \left[\frac{d_o^t(x_{t+1}, y_{t+1})}{d_o^{t+1}(x_{t+1}, y_{t+1})} \times \frac{d_o^t(x_t, y_t)}{d_o^{t+1}(x_t, y_t)}\right]^{1/2} \quad \text{.... (2)}$$

Ratios outside the brackets in equation (2) implies the measurement change in relative efficiency in the output based technical efficiency between periods 't' and 't+1'. On the other hand, the terms inside the brackets indicates the geometry of two ratios in the equations, which indicate the shift in technology of two banks. Efficiency change is obtained by calculating the ratio of efficiency in 't+1' period in proportion to efficiency in 't' period.

Malmquist total productivity index may be divided into two as technical efficiency change and technological change.

Technical efficiency change between the period's 't+1' and 't' can be defined as follows,

$$TE\Delta = \frac{d_0^{t+1}(y_{t+1,} x_{t+1})}{d_0^t(y_{t,} x_t)} \quad \text{....(4)}$$

Technological change is defined as,

$$T\Delta = \left[\frac{d_0^t(y_{t+1,} x_{t+1})}{d_0^{t+1}(y_{t+1t,} x_{t+1})} \times \frac{d_0^t(y_{t,} x_t)}{d_0^{t+1}(y_{t,} x_t)}\right]^{1/2} \quad \text{....(5)}$$

TFP Growth =
Technical Efficiency Change × Technological Change
(Catching up Effect) (Frontier Effect)

Technical efficiency change is described as the efficiency in approximating to the production limit and the technological change is described as curve shift in production limit. Technical efficiency change more than 1 depicts the organization being able to satisfy its production limit. Technological change greater than 1 indicates a positive shift in the production function or technological progress, less than 1 indicates a negative shift or technological regress. That is to say, the frontier has moved onward, generating more output but with less input. The negative change value of the technological change index means that there has been a reduction on the output produced by similar amount of input.

On the other hand, technical efficiency change is divided into two in itself as pure technical efficiency change and scale efficiency change. The pure technical efficiency measure reflects the managerial performances to organize the inputs in the production process. Thus, it has been used as an index to capture managerial performances. The ratio to technical efficiency change to pure technical efficiency change provides scale efficiency change. The measure of scale efficiency provides the ability of management to choose the optimum size of resources, in other words to choose the scale of production that will attain the expected product level.

In order to build Malmquist total factor productivity change index, a range of Linear Programming Problem (LPP) should be measured. Given the CRS hypothesis and input-based approach, the following LPP is used to calculate Malmquist total factor productivity change index.

$$\left[d_o^t(x_t, y_t)\right]^{-1} = \max_{\phi,\lambda} \phi,$$

st

$$-\phi y_{it} + Y_t\lambda \geq 0,$$

$$x_{it} - X_t\lambda \geq 0,\ \lambda \geq 0 \qquad ....(5)$$

$$\left[d_o^{t+1}(x_{t+1}, y_{t+1})\right]^{-1} = \max_{\phi,\lambda} \phi,$$

st

$$-\phi y_{i,t+1} + Y_{t+1}\lambda \geq 0,$$

$$x_{i,t+1} - X_{t+1}\lambda \geq 0,\ \lambda \geq 0 \qquad ....(6)$$

$$\left[d_o^t(x_{t+1}, y_{t+1})\right]^{-1} = \max_{\phi,\lambda} \phi,$$

st

$$-\phi y_{i,t+1} + Y_t\lambda \geq 0,$$

$$x_{i,t+1} - X_t\lambda \geq 0,\ \lambda \geq 0 \qquad ....(7)$$

$$\left[d_o^{t+1}(x_t, y_t)\right]^{-1} = \max_{\phi,\lambda} \phi,$$

st

$$-\phi y_{it} + Y_{t+1}\lambda \geq 0,$$

$$x_{it} - X_{t+1}\lambda \geq 0,\ \lambda \geq 0 \qquad ....(8)$$

Equation (5) and (6) are evaluated by using the efficient limit of the given period as a base. Equation (7) compares the data of period (t) with the efficient limit period (t+1) while model (8) compares the datum of period (t+1) with period (t)'s efficient limit. Each of the four linear programming models should be solved for each period and observation in the examples so as to quantify the Malmquist total productivity.

Data

Various studies including P.S. Joan Kingsly & M. Selvam (2012), P. Mariappan & G. Sreeaarthi (2013), Bhagwan Jagwani (2012) estimated efficiency of Indian banks using DEA and yield different results in terms of performance. It is commonly agreed that the results are significantly affected by the choice of the variables. This problem is further compounded by the fact that selection of variables is often constrained by lack of data on relevant variables. Two approaches are commonly used in literature for modeling a bank's efficiency and choosing related input and output variables, are 'production approach & intermediate approach'. The production approach deals with the production of a company but in banking literature this approach is viewed as provider of the services to the customers. On the other hand, the intermediate approach is complimentary to production approach and it differs in the way of specifications of a bank's activity. Financial institutions are regarded as intermediates that transforms and transfer financial assets from depositors to borrowers. This approach views that banks produce intermediate services through collection of deposits and other liabilities and they utilize them in interest earning assets, such as loans, securities and other type of investments.

Berger & Humphrey (1997), in their study recommends that the intermediate approach is best suited for analyzing bank level efficiency, whereas the production approach is best suited for measuring branch level efficiency.

Accordingly the following variables have been used as inputs and output in this present study. Number of employees, loanable funds and fixed assets are used as input variable, and investment and advances are used as output variable. Number of employee in banks includes the sum of officers, clerical staff and sub staff. Loanable fund consists of deposits and borrowings and fixed assets are defined as premises, furniture and fixtures, leased assets and other assets under construction possessed by the bank. Total Investment of a bank includes the investment made by the bank with in India and outside India.

Empirical Findings

The measurement of total factor productivity and its corresponding changes in its components from 1991-92 to 2012-13 using DEAP 2.1 programme developed by Coelli (1996) are discussed in this section. The estimates of Malmquist Productivity index components which are used in performance measurement; Changes in technical efficiency, technological change, change in pure technical efficiency, change in scale efficiency, and change in total factor productivity growth are discussed in the section. Table-2 presents the summery of variables used in the empirical analysis.

Annual average of TFP growth and its Indices are reported in table-3 for the whole study period as well as for three sub-periods. Results show that change in total factor productivity growth is recorded highest during 1993-94 to the extent of 14.4% and technological change to the tune of 36.3%. TFPG change in the year 2005-06 is lowest to the extent of 13.5% which is due to deterioration of technological change to the tune of 12.4% and technical efficiency change of 1.2%. During the first phase of post reform period TFP Growth change recorded highest improvement to the extent of 4.2% mainly due to high technological change to the tune of 6.1%. 0.7% of TFPG change recorded during second phase of reform period, mainly due to increased technical efficiency change by 1.2%. It is evident from the results that during first phase post reform period and post financial crisis period increase in the TFP Growth change is mainly due to increase in the technological change, whereas during the second phase of post reform period it is due to technical efficiency change. Also, the TFPG change during the whole study period is improved by 1.8% and it is mainly due to 2% improvement in technological change and 0.4% increase in technical efficiency change.

Averages of TFPG change and its indices for each banks during first phase of post reform period is reported in the table-4. During this period 96 per cent of banks have reported improvement in TFPG change mainly because of increase in technological change. It is evident from the findings that 96% banks have reported increased technological change during this period. State Bank of Patiala, the only bank during this study period is found in deterioration of TFPG change by 5%. During the same period 52% of banks experienced decline in Technical efficiency change due to decay in its both scale efficiency and pure technical efficiency change. Highest TFPG change is observed with corporation bank by 13.9% followed by 8.5% in Andhra Bank. Best performance in terms of highest technological change is observed in Bank of Baroda by 14.4% and Indian Bank by 13.4%, followed by Allahabad Bank to the tune of 10%. Reform measures announced in the first phase have brought significant improvement in the all the Public Sector Banks except Bank of Patiala, in their performances in terms of TFPG and Technological change.

Performances of PSBs in terms of TFPG and its indices during second phase of post reform period (1998-99 to 2007-08) are reported in Table-5 for all banks. 64% of banks reported increased TFPG change during this period as against 94% reported in the first phase of post reform period. Union bank of India exhibits the highest TFPG change to the tune of 3.9%, followed by 3.7% in Bank of Baroda and 3.6% in Corporation Bank during this period. Central Bank of India recorded highest deterioration of TFPG to the extent of 3.2% followed by 2.6% in UCO Bank during this period. 60% banks found to have decreased technological change as against 4% reported in the first phase of post reform period. On the other hand, 80% of the banks increased their technical efficiency change during this period as against 44% reported during the first phase reform period. Increase in the TFPG in PSBs during second phase of post reform period is mainly accounted by increase in the technical efficiency change rather then technological changes. Increased technical efficiency change found in most of the sample banks is mainly due to increase in the scale efficiency observed in 72% of the banks during this period.

To observe the responses of Indian Pubic Sector Banks during the post Global Financial crisis, their performances in terms of TFPG Indices during 2008-09 to 2012-13 are reported in table-6. Corporation Bank exhibits highest TFPG change during this period to the extent of 10.4% followed by Oriental Bank of Commerce to the tune of 6.5%. Indian Bank have reported decline in TFPG to the extent of 3.4% followed by State Bank of Mysore by 3.3% during this period. During the same period 80% of the banks have reported increase in their technological change and 60% Banks have reported deterioration in technical efficiency change.

All the 25 PSBs have been grouped into three categories as small, medium and large banks according to the Total Assets size. Total assets size less than Rs. 200 Billion is considered as small Banks, Rs. 200-500 Billions category is considered as medium size and Assets worth more than Rs.500 Billion is considered as large banks. Accordingly, 12 banks are found to be in small category, 8 banks are medium and 5 banks are found to be in large category. Group-wise TFPG and its components are reported in the table-7.

Highest TFPG during first phase of post reform period is reported among the medium size banks as compared with small and large banks to the extent of 6.2%. On the other hand large banks have reported increased technological change to the extent of 8.3% during this period. Decline in technical efficiency change is observed in large banks to the extent of 2% mainly due to decline in scale efficiency change by 2.5%. Similarly, second phase of post reform period recorded 1.2% increase in TFPG for both medium and large banks. Increase in technical efficiency change by 1.7% and decline in Technological change by 0.03% recorded in large banks during this period. On the other hand, medium size banks reported 0.9% increase in technical efficiency change and 0.5% increase in technological change during the second phase of post reform period.

Post global financial crisis period recorded highest TFPG in medium size banks to the extent of 2.4% due to increased technological change by 2.7%. Deterioration of technical efficiency change by 0.4% in the large banks observed due to decline of scale efficiency change to the tune of 0.9% during the post financial crisis period.

Summary and Policy Suggestions

Though there are numerous studies exists in the literature in the analysis of productivity and efficiency performance of Indian banks, not many studies found to be focusing on analyzing the performance of public sector banks, which contribute more than 70% in commercial banking operations in India. The present study focuses in analyzing the performance of 25 Indian Public Sector banks in India for the duration of 1992 to 2013. The whole study period is divided into three sub-periods to capture the impact of deregulation policies announced during 1992 and 1998, as well as to assess the impact of global financial crisis on Indian PSBs during 2008-09 to 2012-13. Performance measurement in terms of Total Factor Productivity Growth and its components such as technical efficiency changes, technological changes, pure technical efficiency changes, and scale efficiency changes are estimated using DEA Malmquist Indices using panel data of 550 observations using DEAP 2.1 program developed by Coelli (1995).

Results show that the average total factor productivity growth change is recorded highest during 1993-94 by 14.4% and technological change to the tune of 36.3%. The impact of banking reform policy announced during 1992 has brought remarkable change in the Indian public sector banking sector in terms of increasing technological change during 1993-94. TFPG change during the whole study period is improved by 1.8% and it is mainly due to 2% improvement in technological change and 0.4%

increase in technical efficiency change among the public sector banks in India.

Results of annual averages of TFPG change and its indices for each bank during first phase of post reform period indicated that 96 per cent of banks have reported improvement in TFPG change, mainly because of the increase in technological change. During the same period 52% of banks experienced decline in Technical efficiency change due to decay in its both scale efficiency and pure technical efficiency change.

On the other hand, 80% of the banks increased their technical efficiency change during the second phase post reform period as against 44% reported during the first phase reform period. Increase in the TFPG in PSBs during second phase of post reform period is mainly accounted by an increase in the technical efficiency change rather than technological changes. Decline in TFPG change is observed in 36% of banks during this period.

During the post, global financial crisis period 80% of the banks have reported an increase in their technological change, and 60% Banks have reported deterioration in technical efficiency change. It is worth mentioning that, first phase of the reforms period from 1992-93 to 1997-98, played a significant role in increasing performance of Public Sector Banks in India, since there is no high competition from foreign banks and Indian private banks. Reform measures have brought significant improvements in technological changes rather than technical efficiency change in Indian public sector banks resulted in increased total factor productivity growth rates.

Corporation Bank and Oriental Bank of Commerce found to be high performers in terms of high total factor productivity growth changes during all three study periods. Also, Bank of Baroda found to be the member of high performers' bank group during first and second phase post reforms period. On the other hand, State Bank of Patiala, Central Bank of India, Indian Bank, and State Bank of Mysore are found to be low performing banks with declined TFPG during the study period.

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Table 1: Structure of Commercial Banking in India (as on March 31st 2014)

Bank Group	No. of Banks	No. of Branches	No. of Staff	Investments (in Rs. millions)	Deposits (in Rs. millions)	Borrowing (in Rs. millions)	Fixed Assets (in Rs. millions)	Total Assets (in Rs. millions)
Public Sector Banks	27	70421	830250	19736985	65890205	6334615	539756	79679110
% Share	**30**	**82.52**	**72.12**	**68.46**	**77.22**	**57.54**	**71.39**	**72.68**
Indian Private Sector Banks	20	14584	296115	6486985	15916937	3261912	162007	22588102
% share	**22.22**	**17.00**	**25.72**	**22.50**	**18.65**	**29.63**	**21.43**	**20.60**
Foreign Banks in India	43	331	24834	2604563	3524239	1411658	54338	7367533
% share	**47.78**	**0.39**	**2.16**	**9.03**	**4.13**	**12.82**	**7.19**	**6.72**
Total Commercial Banks	90	85336	1151199	28828533	85331381	11008185	756101	109634745
% share	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: Various reports from RBI

Table 2: Descriptive Statistics

Variable	No. of Observations	Mean	Standard Deviation	Minimum	Maximum
Investment	550	2166681	3092368	157887	23661449
Employees	550	31641	40642	8041	239649
Fixed Assets	550	58332	67232	2337	454308
Loanable Funds	550	6266494	9533510	407161	88975457

Source: Authors Calculations

Table 3: Averages of TFP Growth and its Components among Public Sector Banks in India

Year	Technical Efficiency change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity Growth Change
1992-93	1.040	0.964	1.038	1.002	1.002
1993-94	0.842	1.363	0.900	0.938	1.144
1994-95	1.168	0.846	1.096	1.070	0.987
1995-96	0.992	0.959	1.012	0.980	0.952
1996-97	0.925	1.189	0.981	0.943	1.098
1997-98	1.025	1.045	1.010	1.015	1.072
1998-99	0.978	1.091	0.984	0.994	1.068
1999-00	0.993	1.063	0.973	1.022	1.053
2000-01	0.981	1.035	0.963	1.018	1.015
2001-02	1.056	0.983	1.025	1.030	1.038
2002-03	1.015	1.078	1.012	1.002	1.094
2003-04	0.994	1.020	1.010	0.983	1.013
2004-05	1.056	0.904	1.025	1.030	0.955

2005-06	0.986	0.876	1.031	0.959	0.865
2006-07	1.027	0.932	1.022	1.005	0.957
2007-08	1.034	0.981	0.998	1.036	1.013
2008-09	0.968	1.058	0.969	0.998	1.022
2009-10	0.961	1.089	0.997	0.965	1.046
2010-11	0.962	0.993	1.012	0.951	0.956
2011-12	1.064	0.939	1.010	1.058	0.999
2012-13	1.012	1.010	1.001	1.010	1.023
1992-93 to 1997-98	**0.999**	**1.061**	**1.006**	**0.991**	**1.042**
1998-99 to 2007-08	**1.012**	**0.996**	**1.004**	**1.008**	**1.007**
2008-09 to 2012-13	**0.993**	**1.018**	**0.998**	**0.996**	**1.009**
1992-93 to 2012-13	1.004	1.020	1.004	1.001	1.018

Source: Authors calculation from the results estimated using DEAP 2.1 programme

Table 4: Averages of TFP Growth and its Indices during 1992-93 to 1997-98

	Technical Efficiency change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity Growth Change
Allahabad Bank	0.987	1.100	0.989	0.997	1.074
Andhra Bank	1.040	1.060	1.036	1.007	1.085
Bank of Baroda	0.969	1.144	1.001	0.969	1.075
Bank of India	0.983	1.072	0.991	0.983	1.012
Bank of Maharashtra	0.999	1.049	0.997	1.000	1.036
Canara Bank	1.004	1.076	1.028	0.977	1.064
Central Bank of India	1.001	1.059	1.026	0.975	1.053
Corporation Bank	1.036	1.096	1.000	1.036	1.139
Dena Bank	0.992	1.062	0.994	1.000	1.051
Indian Bank	0.995	1.134	0.978	1.002	1.070
Indian Overseas Bank	0.987	1.057	0.996	0.987	1.016
Oriental Bank of Comm	1.005	1.101	1.002	1.001	1.082
Punjab and Sind Bank	1.009	1.053	1.014	0.996	1.047
Punjab National Bank	0.959	1.074	0.995	0.964	1.017
State Bank of Bik & Jai	1.004	1.033	1.009	0.995	1.026
State Bank of Hyderabad	1.002	1.034	1.000	1.003	1.011
State Bank of India	0.983	1.048	1.000	0.983	1.009
State Bank of Mysore	0.986	1.038	1.000	0.986	1.017
State Bank of Patiala	0.989	0.994	0.997	0.992	0.950

State Bank of Travancore	1.029	1.028	1.040	0.992	1.044
Syndicate Bank	1.000	1.030	1.011	0.989	1.023
UCO Bank	1.034	1.045	1.043	0.992	1.069
Union Bank of India	0.988	1.051	1.009	0.981	1.040
United Bank of India	1.005	1.028	1.002	1.001	1.028
Vijaya Bank	0.994	1.067	1.006	0.989	1.038
>1	**11 (44%)**	**24 (96%)**	**13(52%)**	**6(24%)**	**24(96%)**
<1	**13 (52%)**	**1(4%)**	**8 (32%)**	**17(68%)**	**1(4%)**
=1	**1 (4%)**	**0**	**4(16%)**	**2(8%)**	**0**

Source: Authors calculation from the results estimated using DEAP 2.1 programme
Note: Figures in parenthesis indicates per cent

Table 5: Averages of TFP Growth and its Indices during 1998-99 to 2007-08

	Technical Efficiency change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity Growth Change
Allahabad Bank	1.009	0.999	1.010	0.999	1.006
Andhra Bank	1.005	1.013	1.004	1.000	1.015
Bank of Baroda	1.016	1.021	1.002	1.018	1.037
Bank of India	1.018	1.001	1.003	1.018	1.014
Bank of Maharashtra	0.994	0.988	0.994	1.000	0.980
Canara Bank	1.009	1.007	0.998	1.014	1.012
Central Bank of India	0.991	0.975	0.978	1.014	0.968
Corporation Bank	1.006	1.035	1.003	1.005	1.036
Dena Bank	0.997	1.011	1.008	0.989	1.006
Indian Bank	1.024	0.979	1.019	1.005	1.001
Indian Overseas Bank	1.033	0.995	1.022	1.010	1.025
Oriental Bank of Comm	1.000	1.058	1.000	1.000	1.058
Punjab and Sind Bank	0.997	0.992	1.001	0.997	0.989
Punjab National Bank	1.013	0.974	0.995	1.017	0.985
State Bank of Bik & Jai	1.016	0.972	1.008	1.014	0.985
State Bank of Hyderabad	1.020	1.003	1.018	1.002	1.026
State Bank of India	1.031	0.982	1.000	1.031	1.013
State Bank of Mysore	1.030	0.975	1.000	1.030	1.004
State Bank of Patiala	1.031	1.006	1.023	1.008	1.035
State Bank of Travancore	1.013	0.981	1.003	1.010	0.995
Syndicate Bank	1.016	0.981	1.008	1.007	0.993

UCO Bank	1.001	0.976	0.994	1.006	0.974
Union Bank of India	1.018	1.023	1.013	1.009	1.039
United Bank of India	1.001	0.976	1.001	1.000	0.978
Vijaya Bank	1.025	0.999	1.014	1.011	1.021
>1	**20 (80%)**	**10(40%)**	**17(68%)**	**18(72%)**	**16(64%)**
<1	**4(16%)**	**15(60%)**	**5(20%)**	**3(12%)**	**9(36%)**
=1	**1(4%)**	**0**	**3(12%)**	**4(16%)**	**0**

Source: Authors calculation from the results estimated using DEAP 2.1 programme
Note: Figures in parenthesis indicates per cent

Table 6: Averages of TFP Growth and its Indices during 2008-09 to 2012-13

	Technical Efficiency change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity Growth Change
Allahabad Bank	1.010	1.002	1.004	1.006	1.010
Andhra Bank	1.000	1.023	1.010	0.990	1.015
Bank of Baroda	0.982	1.029	1.014	0.965	1.009
Bank of India	0.983	1.010	0.991	0.999	0.992
Bank of Maharashtra	1.015	1.007	1.015	1.002	1.021
Canara Bank	1.026	1.003	1.013	1.014	1.026
Central Bank of India	1.052	0.993	1.040	1.010	1.042
Corporation Bank	1.000	1.104	1.000	1.000	1.104
Dena Bank	1.045	1.004	1.015	1.034	1.047
Indian Bank	0.971	0.995	0.970	1.002	0.966
Indian Overseas Bank	0.976	1.002	0.979	0.998	0.978
Oriental Bank of Comm	0.991	1.079	0.991	0.999	1.065
Punjab and Sind Bank	1.013	0.999	1.000	1.013	1.010
Punjab National Bank	1.028	0.990	1.023	1.010	1.017
State Bank of Bik & Jai	0.970	1.031	1.008	0.964	0.995
State Bank of Hyderabad	0.970	1.036	0.976	0.994	1.004
State Bank of India	0.965	1.010	1.000	0.965	0.974
State Bank of Mysore	0.968	1.001	1.000	0.968	0.967
State Bank of Patiala	0.955	1.065	0.967	0.987	1.008
State Bank of Travancore	0.985	1.043	1.000	0.985	1.022
Syndicate Bank	0.962	1.013	0.960	1.003	0.972
UCO Bank	1.008	1.011	1.008	0.999	1.020
Union Bank of India	0.992	1.011	0.984	1.009	1.003
United Bank of India	0.992	0.988	0.994	0.997	0.983

Vijaya Bank	0.985	1.009	0.995	0.991	0.993
>1	**8(32%)**	**20(80%)**	**10(40%)**	**10(40%)**	**16(64%)**
<1	**15(60%)**	**5(20%)**	**10(40%)**	**14(56%)**	**9(36%)**
=1	**2(8%)**	**0**	**5(20%)**	**1(4%)**	**0**

Source: Authors calculation from the results estimated using DEAP 2.1 programme
Note: Figures in parenthesis indicates per cent

Table 7: Averages of TFP Growth and its Indices with Respect to Assets Size

Group	Technical Efficiency change	Technological Change	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity Growth Change
1992-93 to 1997-98					
Small	1.004	1.048	1.006	**0.997**	1.033
Medium	1.005	1.067	1.010	0.995	1.062
Large	0.980	1.083	1.003	0.975	1.035
1998-99 to 2007-08					
Small	1.013	0.991	1.008	**1.005**	1.003
Medium	1.009	1.005	1.004	1.006	1.012
Large	1.017	0.997	1.000	1.020	1.012
2008-09 to 2012-13					
Small	0.989	1.017	0.996	**0.994**	1.003
Medium	0.999	1.027	0.996	1.003	1.024
Large	0.996	1.009	1.008	0.991	1.003

Source: Authors calculation from the results estimated using DEAP 2.1 programme

Table 8: Performances Comparison of PSBs in India

Group	Technical Efficiency change	Technological Change	Total Factor Productivity Growth Change
1992-93 to 1997-98			
High Performance	Andhra Bank (4%) Corporation Bank (3.6 %)	Bank of Baroda (14.4%) Indian Bank (13.4) Oriental bank (10.1%)	Corporation Bank (13.9) Oriental Bank (8.2%) Bank of Baroda (7.5 %)
Low Performance	PNB (-4.9 %) Bank of Baroda (-3.1%)	State Bank of Patiala (-0.6)	State Bank of Patiala (-5.0%)
1998-99 to 2007-08			
	IOB (3.3%) SBI (3.1%)	Oriental Bank (5.8%) Corporation Bank (3.5%)	Oriental Bank (5.8%) Union Bank of India (3.9%) Bank of Baroda (3.7%) Corporation Bank (3.6%)

Low Performance	Central Bank of India (-0.9%)	State Bank of Bik & Jaipur (-2.8%) PNB (-2.6%) Bank of Mysore (-2.5%) Central Bank of India (-2.5%)	Central Bank of India (-3.2%) UCO Bank (-2.6%) United Bank of India (-2.2%)
2008-09 to 2012-13			
High Performance	Central Bank of India (5.2%)	Corporation Bank (10.4%) Oriental Bank (7.9%) State Bank of Patiala (6.5%)	Corporation Bank (10.4%) Oriental bank (6.5%) Central Bank of India (4.2%)
Low Performance	State Bank of Patiala (-4.5%) Syndicate Bank (-3.8%) SBI (-3.5%) Indian Bank (-2.9%)	United Bank of India (-1.2%) Central Bank of India (-0.7%)	Indian Bank (-3.4%) State Bank of Mysore (-3.3%) Syndicate Bank (-2.8%)

Source: Authors calculation from the results estimated using DEAP 2.1 programme

Food Security Policy and Weather Induced Agricultural Production a Paradoxical Status: An Integrated Optimization and Dynamic Input-output Model

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Abstract

On one side the National food Security Act aims at providing subsidised food grains and on the other side the constant rise in suicides by farmers due to loss of crops in an abnormal weather condition showing insufficient agricultural production is almost a common feature off late. Aiming at seeing the extent to which weather influences the buffer stock in agricultural production the results by use of an integrated optimization and dynamic input output model shows that weather/rainfall do not influence the buffer stock or agriculture output to a great extent. The analysis further reflected the drawbacks in the system of agricultural productivity.

Keywords: *Food security, dynamic input-output, weather, agriculture-productivity.*

Introduction

Although, the National Food Security Act aims at providing subsidised food grains, the food security system has a backward linkage towards buffer stock which in turn depends on the vagaries of nature. Changes in weather/rainfall and its negative effect on agricultural production had seen suicides by farmers in many parts of the country, especially Maharashtra. The greater dependence of agricultural production on nature along with the poor irrigation facilities in this country is a well-known fact and this, has been regularly emphasised by pointing out the lack of public investment in agriculture. Another study (2011) trying to find the inter-sectoral linkages highlighted the steep decline in the share of capital stock in agriculture since the late 1990s. Besides, food security system and price policy are related to other instruments such as the minimum support price and public distribution system. It is believed that agricultural price policy plays an important role Dev et al. (2010) in achieving food security by improving production, employment and income of farmers. At the same time

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recommendation of a higher support price in the recent past is also being criticised for the supposed distortions of markets, which is said to have led to food deprivation. Role of non-price factors is invariably debated by researchers (Dev and Ranade (1998); Chand R (2010)) to play a role in increasing production in this sector. Apart from these Dev (2012), is of the view that subsidies in agriculture are fiscally unsustainable, and this encourages misuse of resources which he felt were leading to environmentally malignant developments. Suggesting goals, Dev (2012) also talks of diversification to high value agriculture. Here it is felt that a study on buffer stocks and agricultural production, and its sensitivity of rainfall could possibly help in analysing the influence of rainfall or otherwise on its productivity. Besides, the use of an integrated dynamic input output model could further help in analysing the deficiencies in the system as well as interdependencies between sectors. Thus, the study uses the latest input output table, i.e. 2007-08 along with a capital coefficient table formulated and converts it into a linear programming problem to get solutions to sensitivity of rainfall, productivity of the agricultural sector, and deficiencies if any. The results have shown the need to improve the share of value addition in the agriculture and interrelated sectors. It is also clear that the share or cost in the intermediate consumption of agriculture, needs to be reduced. The results also show that weather/rainfall to a greater extent do not influence the buffer stock and agricultural output.

Accordingly, the next section deals with the approach to the study, followed by the mathematical model in section 3. Section 4 deals with data base and section 5 we have analysed the results of empirical testing. In section 6 is dealt the policy implications followed by the conclusion in section 7.

Approach to the study

Although there are a number of studies related to pricing policy of food grains (Sutopo W et al., (2010); Dev et al. (2010)), policy for raising agricultural productivity (Dev, (2012), food grain and management of food policy (Munish and Alagh (2013); Ganesh Kumar et al., (2007)), food security (Reutlinger, (1978)) a simulation model for evaluating world wide buffer stocks of wheat (Reutlinger, (1976)), most of them relate to time series analysis or partial equilibrium analysis in econometrics. The study by Prasad et al. (1992) analyses the buffer stock in Indian agriculture in pre-reform era using 1979-80 Input Output table in a general equilibrium frame work by using an integrated linear programming and dynamic input output techniques. Adopting the same methodology, this paper analyses the buffer stock in Indian agriculture in post reform era using the latest Input Output Table 2007-08. Since the methodology is Input Output and that too dynamic, in this study inter sectoral interdependence is considered in terms of flow and capital coefficients. Optimal amount of buffer stocks/trade variables are derived in these models by considering the given resource constraints together with land and rainfall. Vagaries of nature have been accounted for by incorporating rainfall as a constraint constant in the second model and looking for the sensitivity of rainfall1on the results for three different years. The details of the model are given in the Model section.

In this integrated linear programming and dynamic input output models, the objective function relates to maximization of value added. The input output coefficients in the constraints relate to both flow and capital coefficients. Using the latest input output table 2007-08, model I does not consider weather restrictions. Apart from the balance equations of input output the constraints also pertain to labour and land. In model II rainfall for years 2005-06, 2006-07 and 2007-08 are considered to find out the exclusive effects of fluctuating rainfall and constancy of our composite input-output capital coefficients.

Model

The mathematical model used in this study is as presented below:-

Model I

Max: $\sum_{j}^{14} vjXj + vkXk$

Subject to $\sum_j^{14}(I - aij + bij) - ci1 \le Fi.$

$$\sum_j^{14} ljXj + lkXk \le L$$

$n_jX_j + n_kX_k \le N$

$X_j \ge 0,\ X_k$ *unrestricted*

Model II

Max: $\sum_j^{14} vjXj + vkXk$

Subject to

$$\sum_j^{14}(I - aij + bij) - ci1 \le Fi.$$

$$\sum_j^{14} ljXj + lkXk \le L$$

$n_jX_j + n_kX_k \le N$

$r_jX_j + r_kX_k \le R$

$X_j \ge 0,\ X_k$ unrestricted

As the input output table considered relates to a 14 sector table the model indicates i,j = 1…….14 and k =15. While 'v_j' represents value added coefficients, 'a_{ij}' represents technical coefficients and b_{ij} represents capital coefficients. Similarly, 'c_{ij}' represents the composite column coefficients for sector 1 i.e. agriculture which has been used for trade/buffer stocks concerning agriculture. Further, while 'F', represents non-investment final demand, 'L' represents labour, 'N' represents total cropped area and 'R' represents rainfall.While, 'l_j', 'l_k', represent labour output ratios, 'n_1', 'n_k'represents land output ratios and 'r_1' & 'r_k' represent rainfall output ratios. Similarly, X_j represents output of the 14 different sectors in the input output table and X_k represents the buffer stocks/trade components of the agricultural produce that are to be determined in the respective models for the corresponding variables. Thus, models derive specific values of sectoral output with respect to the X_j instrumental variables. The instrumental variable X_k is considered as unrestricted so as to represent buffer stocks / trade of agricultural produces. If X_k is positive, it indicates optimal value of buffer stocks or exports of agricultural produce, where as if X_k is negative it indicates the possibility of either depletion of existing buffer stocks or imports. The constraint constants are in terms of non-investment final demand, labour and land (total cropped area in hectares) in model I and rainfall (in millimetres) which is additional in Model II. The first constraint constant shows the availability of sectoral outputs after meeting intermediate demand[2]. In the same way labour and land in model I & II and total use of rainfall in model II represent the other constraint constants. Sensitivity analysis is carried out by changing constraint constants in model II.

Data Base

The study uses the latest 130 sector commodity by commodity table 2007-08 brought out by the Central Statistical Organization, India. The said table is carefully aggregated to form a 14 x 14 sector[3] table. The 130 sectors table is aggregated to the above 14 sectors table because employment figures which form one of our constraint is not available for all the disaggregated 130 sectors. The all India Economic Survey gives sector wise employment data for only 10 sectors, however, adjustment to data on different proportions is considered to increase the sectors to 14. The gross output also available in the 130 sector table is duly aggregated to match the 14 sector table. The gross fixed capital formation and changes in inventory available in the final demand are duly aggregated to the 14 sectors and is used to calculate the capital coefficient matrix[4]. Besides, the study also uses the industry wise gross domestic product published by the Reserve Bank of India while calculating the capital coefficient matrix. Industry wise employment data is collected from the Economic Survey[5] and adjustments to that have been made to suit the 14 sectors aggregated from the input output table 2007-08. The 14 sector table is duly added to the capital coefficient table to finally form the linear programming problem.

Empirical Results and Analysis

The linear programming problem framed by using the 14 sector input output table is solved by using the package LINDO (Linear Interactive and Discrete Optimizer) to get the optimal figures of output. The optimal figure clearly indicated the availability of both the agriculture output as well as buffer stock apart from various other sectors. As the two models showed identical results, sensitivity analysis was done to use the right rainfall figure in the second model. The deviation in rainfall from the actual figures was maximum to the extent of 0.23%. Table 1 shows 10 sectors possible capability to produce output for the three years (2005-06, 2006-07 and 2007-08) under consideration under both the models. It also shows the availability of buffer stocks for all the considered years under both the models. Four sectors - i) Construction, ii) Transport, iii) Trade Hotels & Restaurants and iv) Banking Insurance &Business Services do not show any optimal output. As the study is concentrated on buffer stock and agricultural output, efforts have not been made to arrive at the optimal outputs of the above four sectors.

Observing Table 1 it is seen that the variations in results in the two models are reflected for all the three year after the sensitivity analysis for rainfall figures. Besides, these variations between the two models are quite marginal clearly indicating the lack of influence of the constraint on rainfall. Again, the output figures for sectors (2-agriculture allied activities, 3- Mining & Quarrying, 8-Storage and warehouse, 11-Education & Health, 12- Real Estate and Ownership dwelling, 13- Personal and legal Services and 14 Public Administration and other services) have remained constant for both the models and for all the three years under consideration. This could possibly be due to adjustments made in the objective function of the problem i.e. here the results relate to the linear programming problem where the objective function (value added coefficients) values are changed as compared to the original value added coefficients.

The value added coefficients were changed according to the indications of the solutions for the initial problem given in Table II. It is observed in Table II that the original results showed varied results for both the models for all the three years. Although, the solution had optimal buffer stocks it had a zero agricultural output. Besides, agriculture sector, other sectors like i) Manufacturing, ii) Construction, iii) Transport, and iv) Trade Hotels & Restaurants also showed zero optimal output. Analysing this further it was observed that these above sectors starting from agriculture and not having optimal output, had a reduced cost[6] of 1.275221, 2.118824, 10.18788, 0.585081 and 0.092130 respectively (presented in column 3 of Table III). This indicated that the objective function coefficient on the corresponding variable had to be improved by the amount of reduced cost so as to get positive optimal solution for the above sectors. In other words it indicated to what extent the cost of the activity had to be reduced so that the activity is carried out. Thus changing the objective function by adding these reduced cost to the corresponding variables, gave the solution as presented in Table I.

Although, these changes in the objective function gave optimal output for the agriculture sector the other three sectors i) Construction, ii) Transport and iii) Trade Hotels & Restaurants along with a new sector - Banking Insurance & Business Services continued to show zero output. Here again the above sectors showing zero output were shown to have reduced costs to the extent of 0.552251, 0.29583, 0.029316 and 0.020757 respectively (presented in column 4 of Table III). Correcting the objective function for these reduced cost were not initiated for the study is focused on agriculture and buffer stock[7].

Now observing Table III it seems that the value added coefficients of the agriculture, Manufacturing, Construction, Transport and Trade Hotels & Restaurants sectors had to be increased from their original levels to an amount above the additions of the originals plus reduced cost i.e. as shown in column 4 of the Table III. It is an increase of 1.360034 units for the agricultural sector which means that the share of the factors of production in the value of output is expected to be three times of the present data (see Table III). This amounts to the same where researchers have been asking for increasing the value addition in agriculture. As already pointed out, Dev (2012) also talks of diversification to high value agriculture. The implications of increasing the objective function (value added) coefficients also means that the cost on intermediate products has to be reduced to this extent such that, the share amount increases under factors of production. Research to this effect is also seen in Dev (2012), where he is of the view that subsidies in agriculture are fiscally unsustainable and this encourages misuse of resources which he felt was leading to environmentally malignant developments. Both together they imply that there is wastage of resources in the intermediate consumption and this wastage should be reduced to see that the share of factors of production increases. The slack variables presented in table I also support this wastage.

The reason could be the negative effect of high level of disguised unemployment in this sector. Possibly by removing the excess labour and using skilful labour due to greater level of mechanized cultivation in large firms, it could help in increasing the value addition to this sector. Besides, these could also be possibly because of the subsidized rate at which resources are available for cultivation, which are thereby used beyond the required level, resulting in increasing share of intermediate consumption. Added to that it has also led to an increased procurement prices which is said to have led to market distortions. Thus, there needs to be an effort to thoroughly check in the consumption of raw materials as well as use of labour for cultivation in the agricultural sector. The change in the objective function coefficients of the other sectors reflects the extent of interdependence between these sectors and the agriculture.

Policy Implications

The wastage of resources at the intermediate level calls for policy reforms on subsidies to be restricted to the agricultural sector. Such indications have been pointed out by several researchers, including the World Bank. The need for the increase in value addition in this sector directs the need for public investment leading to diversification towards value added products in agriculture. However, with public investment on the decline, there is a need for initiatives on the part of the government to increase public investment thereby bringing about crowding-in private investment. Besides, the assessment of NREGA program in effectively employing labour is also called for. This could possibly help in reducing the extent of disguised unemployment in the agriculture sector.

Conclusions

The results clearly indicated that the cost at the intermediate level of agricultural production has to be reduced considerably, which indicates the heavy expenditure by the agricultural sector at this level. The high slack shown in the results shows the wastage of resources thereby indicating heavy investment in inputs. This could be due to availability of raw materials at a subsidized rate. Thus, the analysis showed the major role played by the drawbacks in the system in influencing agricultural productivity, and an almost insignificant role played by the weather/rainfall in influencing the same. These drawbacks in the system are spelt out by the presence of wastage of resources in the intermediate stages and lack of profitable cultivation to farmers. The interdependence between agriculture and other sectors is also clearly reflected.

End Notes

1. It would always be advisable to consider weather, rainfall and land by looking into the spatial and geographical dimensions. This calls for dealing with regional input output tables. However, in India as regional input output tables are not readily available we have considered the latest National input output table 2007-08. The consideration of average rainfall is surely a limitation.

2. The intermediate demand gets increased under two situations i) if available buffer stock is used rather than produced and ii) if buffer stock is imported. The foreign exchange

implications of imports is beyond the purview of this paper.

3. The 14 sectors refer to 1) agriculture; 2) agriculture & allied activities, 3) Mining & Quarrying, 4) Manufacturing, 5) Construction, 6) Electricity & water supply, 7) transport, 8) storage warehouse & communication, 9) trade hotel's & restaurants, 10) banking insurance & business services, 11) education & health, 12) real estate and ownership dwelling, 13) personal & legal services and 14) public administration and other services.

4. The details of preparation of the capital coefficient matrix could be given to interested readers on request.

5. The economic survey under section employment provides industry wise employment figures both for public and private sector. The two have been added together to get the total employment figures for different sectors. The data is limited only to the organized sector.

6. Reduced cost value indicates how much the objective function coefficient on the corresponding variable must be improved before the value of the variable will be positive in the optimal solutions.

7. Surely the adjustments could have possibly given positive outputs to the above sectors, however, a separate study analysing all sectors would have to be undertaken in a separate paper.

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Table I: Final Results of Model I and II- Sectoral Outputs and Objective value

		Model I			Model II	
	2005-06	2006-07	2007-08	2005-06	2006-07	2007-08
Obj Value	179551500	184363400	190534000	179550700	184362700	190532900
Sectors						
1	360545.3	2132524	4404823	360267.3	2132245	4404424
2	19228740	19235450	19244050	19228740	19235450	19244050
3	40987500	40993280	41000690	40987500	40993280	41000690
4	555868.8	554235	552140	555869	554235.3	552140.4
5	0	0	0	0	0	0
6	7014771	7075428	7153212	7014762	7075419	7153198
7	0	0	0	0	0	0
8	4989815	4990605	4991619	4989815	4990605	4991619
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	29247410	29247540	29247690	29247410	29247540	29247690
12	26239770	26239810	26239860	26239770	26239810	26239860
13	1420745	1420793	1420854	1420745	1420793	1420854
14	33725630	33726150	33726820	33725630	33726150	33726820
15	78630030	80434420	82748300	78629740	80434140	82747900
Agri slack	114395700	114424500	114461400	114395700	114424500	114461400

NB:- Sectors refer to 1) agriculture, 2) agriculture & allied activities, 3) Mining& Quarrying, 4) Manufacturing, 5) Construction, 6) Electricity & water supply, 7) transport, 8) storage warehouse & communication, 9) trade hotels & restaurants, 10) banking insurance & business services, 11) education & health, 12) real estate and ownership dwelling, 13) personal & legal services and 14) public administration and other services. 15 - refers to buffer stock/trade

Table II: Initial Results of Model I and II- Sectoral Outputs and Objective value

		Model I			Model II	
	2005-06	2006-07	2007-08	2005-06	2006-07	2007-08
Obj Value	179448000	184109900	180948800	179447300	184109200	190087100
Sectors						
1	0	0	0	0	0	0
2	20379310	21009040	21235450	20379210	21008950	21816440
3	40915330	40927270	40658570	40915320	40927270	40942590
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	7045874	7164059	4454937	7045855	7164041	7315588
7	0	0	0	0	0	0
8	5020040	5070307	5088902	5020033	5070299	5134754
9	0	0	0	0	0	0
10	1626746	4092196	6984380	1626359	4091808	7253216
11	29277070	29323070	2937350	29277060	29323070	29382050
12	26246820	26257520	21837350	26246810	26257520	26271250
13	1426568	1436250	1424323	1426567	1436248	1448663
14	33727020	33736560	33719360	33727020	33736550	33748780
15	78990580	82566950	82581640	78990020	82566380	87152320
Agri slack	115268000	118412600	118477400	115267500	118412100	122444400

NB:- Sectors refer to 1) agriculture, 2) agriculture & allied activities, 3) Mining& Quarrying, 4) Manufacturing, 5) Construction, 6) Electricity & water supply, 7) transport, 8) storage warehouse & communication, 9) trade hotels & restaurants, 10) banking insurance & business services, 11) education & health, 12) real estate and ownership dwelling, 13) personal & legal services and 14) public administration and other services. 15 - refers to buffer stock/trade

Table III: Reduced costs before and after adjustments in Objective function

Variables	Original Value added coefficients	Reduced costs before adjustments	Changed Value added coefficients	Reduced costs after adjustments
X1	0.663366	1.275221	2.0234	0
X4	0.211746	2.118824	2.4617	0
X5	0.347702	10.187880	10.8477	0.552251
X7	0.395021	0.585081	0.995	0.29583
X9	0.700242	0.092130	0.8102	0.029316
X10	0.749459	0	-	0.020757

NB:-XVariables refer to sectors relating to 1) agriculture, 4) Manufacturing, 5) Construction, 7) transport, 9) trade hotels & restaurants and 10) banking insurance & business services.

Using Input-output Model To Measure National Water Footprint In Iran

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Abstract

In recent years water crisis has become a serious issue for water management officials and policy makers in Iran. On the one hand; the size of population during 1956-2011 has quadrupled while on the other hand, the water stress has decreased from 7200 m^3/per person in 1956 to 1830 m^3/per person in 2011. In 2014, the Iranian Minister of Power reported that the total amount of renewable water resources have decreased from 130 billion m^3 in 2006 to 120 billion m^3 in 2013 and has warned that the country is currently using about 80% (103.4 billion m^3) of total existing stock of renewable water resources. The available literature using the partial approach for agricultural crops in Iran suggests that not only per capita consumption of WF in Iran is relatively high but Iran also is a net importer of Virtual Water. The outcome of the net imports of VW implicitly confirms the tenet of the factor endowment theory and in addition the so called "Virtual Water Hypothesis of MENA Region". We claim that these findings are simply necessary conditions, and are not sufficient conditions, because the partial approach considers only agriculture sector and neglects the other sectors of the economy. In this article, we propose that measuring the National Water Footprint (NWF), Virtual Water (VW) of trade and the net Virtual Water of Imports (NVWI) in Input-output (IO) framework for a scarce water resource country like Iran could provide a holistic view for the consumption aspects of water. Our main purpose is to use a modified IO model with the following two questions: One: Does Iran have a relatively high per-capita consumption of WF? Second: being a scarce water resource country, is Iran really a net importer of VW and saving her domestic water resources? For this purpose, we use two types of data: One, the 2006 domestic monetary IOT (Valued in Iranian Currency) in which intermediate and final imports are separated, and the Second; the physical amount of sectoral water used for the same year. Our results are two folds. One: per-capita consumption of WF in Iran is relatively high, and the Second, Iran is the net exporter of VW. This does not vindicate the earlier findings from Iran.

Keywords: *Water footprint, Consumption, Virtual Water*

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Introduction

At present the Iranian economy is facing the problems of high stagflation, high unemployment, economic embargo and water crisis. The last mentioned problem has become a serious issue for water management officials and policy makers.

Geographically, Iran with an area of 165 million hectares is located in a semi-arid region of Middle East (Arabi et al., 2012). This region is characterized as the most water scarce region of the world (Roudi-Fahimi et al., 2002). There is a growing awareness of the scarcity of water resources among researchers, water management officials and policy makers in Iran. The report of the Power Minister to the Parliament in 2014, states that the total volume of renewable water resources has decreased from 130 billion cubic meters (bcm^3) in 2006 to 120 (bcm^3) in 2013 and warned that the country is currently depleting about 80 percent (approximately 103.4 (bcm^3) of the total existing stock of renewable water resources) (Arman, 2014).

In 2013, the UN Commission for Sustainable Development has estimated the percentage of volume of water used to the total volume of existing water resources for 16 selected countries, including Iran. The figures depict that Iran with 73 percent stands the third place after Saudi Arabia and Pakistan with 986% and 234% respectively and Brazil with 1.3% is the lowest and India with 53% of total volume of water resources ranks fourth among the 16 selected countries (World Bank, 2014). According to this estimation, the country which uses more than 40 percent of the total stock of water resources is categorized as having a serious water crisis. If we take the 40% as a cut-off point, 4 out of 16 countries (Saudi Arabia, Pakistan, Iran and India) are facing water crisis.

Iran's Agricultural sector uses more than 90 percent of the total renewable water. This issue provided an impetus for the Iranian analysts to analyze the water footprint and virtual water of agricultural crops. Their overall findings suggest that Iran's agricultural sector appears to be a net importer of virtual water. These findings implicitly confirm not only factor endowment trade theory but also the idea of Virtual Water Hypothesis of MENA Region.

In this article, our aim is to show that these findings portray only necessary conditions but not necessary and sufficient conditions on the following grounds: First, only agricultural crops are considered, and other sectors of the economy are neglected. Second, because of partial approach, the importance of sectoral interdependencies with respect to direct and indirect water flows are not taken into account. Third, direct water content for some sectors like agriculture are very high whereas the other sectors like food processing sectors and hotels and restaurants may have high indirect water content or requirement. We believe that quantifying these aspects with input-output framework will provide a more suitable holistic perspective for national water footprint and Virtual Water to water management officials and policy makers in Iran.

For this purpose, the contents of this article are organized as follows. The concepts and background of NWF and Virtual Water (VW) are given in the Second Section. We briefly present some aspects of water sources, and also a comparative view of sectoral water used in Iran, World average and MENA average.

A summary of literature review with emphasis on NWF and VW and the suitability of applying input-output approach are discussed in the third section. In the fourth section, we highlight the method of measuring NWF and VW in input. Output framework and data based adjustments of two types of data: monetary Input-Output Tables of 2006 and volume of sectoral water used are explained in the fifth section. The empirical analysis and concluding remarks are presented in the sixth and seventh sections respectively.

The Concepts of NWF and VW

To measure the broad concept of sustainability, Wackernagel and Rees introduced the concept of Ecological Footprint in the 90s (Wackernagel, 1994; Wackernagel and Rees, 1996; Rees, 2012).

Analogous to the concept of EF, later on many analysts introduced different components of EF, For instance Land Footprint (Giljum and Hubacek, 2003; Ferng, 2001; Banouei et al., 2014; McDonald and Peterson, 2004), Energy Footprint (Hong, et. al., 2007; Panela and Villasant, 2008), Carbon Footprint (Virtanen et. al., 2011; Kenny and Gray, 2009, Drukman and Jackson, 2009) and Water Footprint (Chapagain and Orr 2009, Zhao, Chen and Yang, 2009).

The pioneers of introducing the concept of the NWF are Hoekstra and Hung in 2002 (Zhao and Yang, 2009; Gawel and Kristina, 2011)

NWF is defined as the total volume of freshwater that is used to produce the goods and services and finally consumed by the population of the country (Hoekstra and Chapagain, 2007). This definition provides an impression that NWF reveals the consumption focus of the water footprint. To supplement this, the term virtual water (VW) which is concerned with production focus is used (Velazquez and Beltran, 2011). Initially VW was coined by Allan in 1988 (Dietzenbacher and Velazquez, 2007). It is defined as the amount of the water consumed in the production process of a product, i.e. the virtual water embodied in the product which means that the physical amount of water used to produce goods and services. Therefore, it differs with the amount of water physically contained within the product (Allan, 2001).

Aspects of Water Resource and Water Use in Iran

Iran like other Middle East countries is known as a water-scarce country. Table 1 reveals the water availability and use in Iran.

From Table 1, we observe that out of total precipitation water in Iran, about 33% constitutes renewable water. The main question is that how much of the total available renewable water is actually used? Table 2 not only illustrates the question but also provides a comparative view of used water in Iran, with world average and MENA average[1].

From Table 2, we can make the following observations: One: Iran is using about 77% of the total available renewable water (103430/13400 =0.77). The estimation is close to the report of Ministry of Power (80%) and near to the estimation of UN Commission for Sustainable Development for the 16 selected countries in Table 3.

Second, more than 90% of the total withdrawal water is used by the Iranian agricultural sector which is more than the world average (75%) and also MENA average (87%). Third, the share of domestic consumption is 5.9% which is above the world average and below the MENA average, whereas the share of other sectors of economy uses only 3.5% of the total used water, 5.6 times lower than world average and even below the MENA average. Whether or not low share of used water in other sectors of Iranian economy could be regarded as relatively low degree of industrialization in Iran, and/or poor quality of data are the issues which required further research.

A brief Summary of Literature with Emphasis on NWF and VW in Iran

In the previous section, we observe that the agricultural sector (Iran, world or MENA) has highest share of water. Since agricultural production in most countries accounts for the largest proportion of consumed water, investigating water footprint and virtual water trade of agricultural sector appears to be more attractive.

This attractiveness is paramount for water scarce countries of MENA (Allan, 1998; Hoekstra and Chapagain, 2007 and Hakimian, 2003). The available literature in Iran reveals no exception. For this purpose, Iranian analysts have used the methodology introduced by Chapagain and Hoekstra (Chapagain and Hoesktra, 2004) for measuring NWF and VW of agricultural products in Iran[2]. Their findings show that Iranian agriculture is a net importer of virtual water and therefore, saving domestic water resources. These findings, however, though not stated directly, confirm the conventional factor endowment theory of Hecksher-Ohlin, as wells as the idea of Virtual Water Hypothesis of MENA region (Hakimian, 2003).

The method used in the above studies has at least two limitations: One, it is suitable for quantification of water footprint and Virtual Water only in agricultural products, but not fit for measuring the water footprint of industry and service sectors. Second, the interdependence of economic sectors is neglected, and therefore, the importance of indirect effects of domestic, and water trade (export and imports) contents could not be taken into account.

Methods of Measuring NWF and VW in IO Framework

In the past, for different reasons water was not a central issue for input-output analysis. The lack of physical quantity of sectoral water in most countries, the relative abundance of water in advanced- industrialized countries, the idea that water was essentially an agricultural issue, are the, main factors for the neglect of water aspects from input-output applications. This lacuna has been filled in the twenty-first century (Duarte and Yang, 2011).

Iranian IO Model

Iranian IO Table describes the flow of goods and services among different sectors of Iran in monetary units over a year, which among IO practitioners is known as monetary IO Table (MIOT)[3]. Table 4 reveals the structure of the Iranian IOT which assumes competitive imports.

As it is assumed that imports are competitive with the domestic supply, the imports can then be incorporated with domestic supply for each supply sector in row of Table 4. All the distributed imports are summed as a single column in Iranian IOT shown in Table 4, as mi which shows imports of sector i. Applying this Table for analysis of factor endowment theory and specifically measuring NWF and VW for the following two reasons seems to be implausible: First, it is assumes that the intermediate transactions (xij) from supplying sector has global nature, which means that the intermediate inputs from the rest of world are produced by the Iranian industries. Second, it is assumed that the total imports are exogenous, that is they do not depend on the size of domestic and final demands which may lead to inconsistency with the endogenous intermediate imports (Pei, et. al., 2012).

Therefore, for our analytical purposes, we have modified Table 4 with separation of imports in terms of intermediate imports and final imports. Table 5 gives a snapshot of structure of the modified Table.

As compared to the conventional structure of Table 4, imports and domestic supply are separated. For separation we have used the method of a fixed ratio of imports to domestic supply in each row. In addition to that, a row of sectoral water consumption (wa_j) is added to the Table 4, the function of which will be explained in the next section.

In contrast to Table 4, Table 5 can provide two following separate equations. One for domestic equation.

$$x_i = \sum_{j=1}^{n} xd_{ij} + y_i \qquad (1)$$

$$y_i = fd_i + e_i$$

Where x_i is the gross sector i, y_i contains domestic consumption and exports of sector i, and xd_{ij} shows domestic input from sector i to sector j.

The second equation is for imports:

$$m_i = \sum_{j=1}^{n} m_{ij} + mf_i + me_i \qquad (2)$$

Where m_{ij} is the matrix of intermediate imports from the supply sector i abroad to domestic sector j, mf_i is the imports from sector i abroad to domestic consumption of final demand, and mei is the import from sector i abroad to home country for the use of exports.

On the basis of domestic technical coefficient matrix $ad_{ij} = xd_{ij}[\hat{x}_j]^{-1}$, the Equation (1) is solved as:

$$X = (I - Ad)^{-1}Y \quad (3)$$

Where $(I - Ad)^{-1} = \alpha_{ij}$ is Leontief inverse matrix which denotes the direct and indirect effect of additional increase monetary unit of domestic final demand to the additional increase of production (Miller and Blair, 2009).

Method of Measuring Virtual Water Content in IO Framework

In order to find the direct and indirect effects of water used, analogous to the labour, land, energy or Co_2 coefficients, the first step is to derive direct water input-output coefficient (DWIC).

$$DWIC = [wa_j], \qquad wa_j = Wa_j[\hat{x}_i]^{-1} \quad (4)$$

Where wa_j shows for each monetary unit of output of sector j how much fresh water (M^3) is directly required.

Direct and indirect fresh water used to satisfy the additional increase of monetary unit of domestic final demand can be written as follows:

$$WC = [wc_j], \qquad wc_j = \sum_i wa_i \times \alpha_{ij} \quad (5)$$

wc_j in the equation (5) known as virtual water content (VWC) denotes the volume (M^3) of water used in sector i for the requirement of one monetary unit of final demand in Sector j (Guan and Hubacek, 2007). In the next section we show that on the basis of eq (5), NWF and VW can be easily derived.

Methods of Measuring NWF and VW of Trade

Like ecological footprint and their sub-categories, like Energy Footprint, Land Footprint and Co_2 Footprint, methods of measuring NWF is divided into two parts (Wiedman, et al., 2006, Hoekstra and Chapagain, 2007; Bicknell, et al. and Ferng, 2001).

One is the internal use of water resources which is known as internal water footprint (IWF). It is defined as the use of domestic water resource and consumed by the inhabitants of host country to produce goods and services. The IWF can be written as:

$$IWF = [iwf_j], \qquad iwf_j = wc_j \times fd_j \quad (6)$$

Where iwf_j represents the water used for the domestic consumption of final demand, produced domestically in sector j and fd_j is the domestic consumption of final demand of sector j. The second is external WF (ENWF) which is specifically concerned with the virtual water of exports and imports of a country.

From an economic point of view and following comparative advantage of factor endowment theory, water-scarce countries should be importers and water-abundant countries should be exporters of virtual water (Dietzenbacher and Velazquez, 2007; Guan and Hubacek, 2007). Therefore, in order to take into account of NWF, and also to estimate the Net VW (NVW), it is required to derive the water contents of exports and imports. The virtual water of exports (VWE) can be derived as

$$VWE = [vwe_j], \qquad vwe_j = wc_j \times e_j \quad (7)$$

Where vwe_j is the virtual water exports (produced at home and consumed abroad) of sector j and e_j is the exports of sector j.

As compared to the treatment of exports in IOTs, the treatment and the nature of imports in IOTs are relatively vague, and therefore the calculation of external water footprint for two reasons is much more complex. One, since imports into countries come from a number of different countries and world regions with different production technologies, differences cannot easily be modeled with a single IOT due to the lack of data. Two- the prevalence of assumption of competitive imports in the Iranian IOT adds further to the complexity.

In order to ease these complexities we use the prevailing conventional and widely used assumption of taking the procedure and technology of the production of an imported product as the same with domestic product to solve the problem. Under this assumption the virtual water embodied in the imports is not the real and consumed at the production site, but the water that the country would have consumed, if it had to produce the product itself. Applying this assumption will approximately clarify how much water a country can save by importing a product instead of producing it domestically.

In Table 5, imports are two parts, intermediate imports are entered in the domestic production process and final imports directly used for domestic final demand. Therefore the external water footprint (ENWF) can be expressed as follows:

$$ENWF = IMF + IMin \quad (8)$$

From the above equation, we observed that ENWF constitutes two parts: Part one, the virtual water imported directly for domestic final demand (IMf) which can be estimated as

$$IMf = [Imf_j], Imf_j = wc_j \times mf_j \quad (9)$$

Imf_j shows the virtual water imported for final demand of sector j and mfj is the value of import for the domestic final demand of sector j; part two, only a fraction of virtual water embodied in the domestic intermediate input will be consumed by the domestic final demand. The remaining imported virtual water will support the exports which had already been taken in to account in equation (7). Therefore, virtual water imported as intermediate use and consumed by domestic final demand is derived as:

$$IMin = [IMin_j], IMin_j = \left(\sum_i wc_j \times m_{ij}\right) \times t_j \quad (10)$$

Where m_{ij} shows intermediate import matrix, t_j is an adjusted factor, derived as the proportion of domestic final demand minus exports over total final demand. $IMin_j$ is the virtual water imported as intermediate use of sector j.

From the above equation, the total NWF can be written as

$$NWF = IWF + IMf + IMin \quad (11)$$

We have not included the virtual water of exports (VWE) in NWF, and instead used it for measuring the net virtual water imports (NVWI) both at sectoral and national level as

$$NVWI = (IMf + IMin) - VWE \quad (12)$$

On the basis of eq. (12) and considering the factor endowment trade theory and also the idea of virtual water hypothesis, water-scarce countries like Iran should be net importer of virtual water with positive sign of NVWI and vice-versa.

Data Base

We have used two types of data. One is an updated activity × activity Table based on fixed activity sale structure for 2006 (Parliament Research Center, 2014). This table comprises 62 activities. The second is the amount of water used in different activities of Iran which has been collected from different sources. Due to the lack of sectoral water used data, the 62 activities culled into 8 activities: Mining, Agriculture-base industries, other industries, Electricity and Gas, Water, Construction and Services.

Empirical Results and Analysis

The results are organized in Tables 6 and 7 respectively. Table 6 shows the aggregate results of NWF, Per capita NWF for the three aggregated sectors (primary, secondary and tertiary), and % of Internal Water Footprint (IWF). External Water Footprint (ENWF), Virtual Water Exports (VWE) and the Net Virtual Water Imports (NVWI) to the total NWF.

From the results of the Table 6, we can make the following main observations:

First, our estimation reveals that per capita NWF in 2006 is 1433 m^3 for each person. This figure is lower than the estimated figure of 1624 m^3 for Iran by Hoekstra and Chapagain during 1997-2001[4]. Their estimation shows that, first of all, the per capita WF of world average is 1243 m^3. The USA with 2483 m^3 stands first and China has lowest per capita NWF of 700 m^3. Per capita NWF of India (980 m^3) is lower than world average, but higher than corresponding figure of China.

Second, both the estimations show that per capita consumption of WF in Iran is not only relatively high and above the world average, but also relatively close to the per capita consumption of WF of developed Countries like U.K. (1245 m^3), the Netherlands (1223 m^3), and France (1875 m^3). Having relatively high per capita consumption of WF in Iran, could be explained due to following factors: low yield of crop production, very low water productivity, low degree of industrialization[5], and very high evaporation of water[6].

Thirdly, the results of Table 6 show that the NWF of Iran is surprisingly more than the actual water used in different sectors of the country (100305 mm^3 versus 97259 mm^3). The following two possible explanations could illustrate this issue:

One, the volume of direct and indirect water used in the production process of the economy is more then the country's need for final consumption. The second, which appears to be more plausible is the exclusion of Virtual Water Exports (VWE) which is 12627 mm^3. Therefore, if we include the above mentioned figure, the revised figure will be 87627 mm^3 which is less than the actual amount of water used.

Fourthly, on the basis of the Factor endowment trade theory and also the empirical investigation of Virtual Water Hypothesis in MENA region, we intuit that water- scarce countries can save water by importing Virtual Water from water abundant countries, this prima-facie can be regarded as a promising direction for postponing the water crisis in Iran.

Our main findings do not vindicate them[7]. In contrast, the aggregate results of Table 6 and more detailed results of Table 7 depict that Iran with scarce water resources is a net exporter of Virtual Water. The Virtual Water export of country in 2006 is 12627 mm^3 (Table 7, Col.9) which is 13 percent of NWF (Table 6). The external Virtual Water of the country is estimated to be 7450 mm^3 (Table 7, total of Cols. 6 and 7), which constitutes 7 percent of NWF (Table 6).

These paradoxical findings are not specifically for Iran but rather in consonance with the observations made by Zhao, Chen and Yang for China (Zhao, Chen and Yang, 2009), Dietzenbacher and Velazquez (2007) for a scarce water region of Spain, namely Andalusia, and Guan and Hubacek (2007) for scarce water resource of the region of North China.

Concluding Remarks and Limitations

Currently, Iran is facing water crisis, which has become a serious issue for water management officials and policy makers in Iran. To analyze different aspects of water problems, Iranian analysts with diverse backgrounds (water engineers, environmentalists and geographers) have concentrated their attention to the product-focus and the consumption-focus of only agricultural crops in Iran, because this sector uses more than 90 percent of the total fresh water. The term's Water Footprints, Virtual Water, Net Virtual Water Import and Virtual Water Exports provide suitable ground for such analysis. Using partial water content approach introduced by Hoekstra and Chapagain for Iranian agricultural corps. They have reached two general conclusions: One, per capita NWF in Iran is relatively high and higher than the world average, and the Second; Iran is a net importer of Virtual Water which implicitly confirms factor endowment trade theory and also the so called Virtual Water Hypothesis of MENA region.

Our main objective is the claim that these outcomes are necessary but not sufficient. Then we propose that using the holistic approach like a modified input-output model which considers all sectors of the economy is more suitable to quantify the following two questions:

One, does Iran have a relatively high per capita consumption of NWF? And second, being a scarce-water resource country, is Iran really a net importer of Virtual Water and saving her domestic water resources?

For quantifying the above two questions, we have used two types of data: One is domestic monetary IOT of 2006, and the second is the physical amount of sectoral water used for the same year. With respect to the first question, we found that per capita consumption of NWF is 1433 mm^3 which appears to be relatively high and close to the corresponding figures of some of the water abundant industrialized countries.

Regarding the second question, our finding does not support the hypothesis that Iran is a net importer of Virtual Water. Therefore, this outcome does not vindicate the factor endowment trade theory and Virtual Water Hypothesis of the MENA region. Instead of being net importer of Virtual Water, Iran is exporting 5178 mm^3 of net Virtual Water.

This article has at least two limitations: First, the estimation of Virtual Water imports is based on the assumption that the importing country has the same productive technology as the other countries. The water productivity in Iran is five times less than the world average (2.8 versus 14, in Table 3), this may cause over estimation of Virtual Water of imports and hence under estimation of NVW of Iran.

Second, we assumed that productive sectors do not use drinking water in their process of production, and therefore, domestic consumption of drinking water has been excluded from the total used fresh water.

Foot Notes

1. Middle East and North Africa region includes 19 countries: Algeria, Bahrain, Iran, Israel, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Syria, Tunisia, Turkey, UAE and Yemen.

2. For instance: Arabiyazdi, et.al., (2006), Arabi, et.al, (2012) and Baghestary, et.al, (2011).

3. In Contrast to MIOT, in the last quarter century, Physical IOT (PIOT) was given due recognition by many analysts. However, which one of these should be used for measuring sustainability remains debatable. For more information on these aspects, refer to: Giljum, et.al., 2004; Giljum and Hubacek, 2004; Suh, 2004, and Dietzenbacher, 2005.

4. Using World data on agricultural crops during 1997-2001, Hoekstra and Chapagain have estimated Water Footprints and per capita Water Footprint of nations. For more information see Hoekstra and Chapagain (2007).

5. The observations made by Gawel and Kristian show that the share of the per capita water footprint consumption of industrial sectors in the water-rich industrialized country is around 20 percent where as corresponding share for Iran is around 3.6 percent. See Table 6 and Gawel and Kristina (2011).

6. The share of water evaporation in Iran is more than 67 percent. See Table 1.

7. Using partial approach of Hoekstra and Chapagain with only agricultural crops, the overall findings of the Iranian analysts supports their observations.

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Table 1: Water Availability and Use in Iran in 2006

Component	Volume (bcm³)	Percentage total
Precipitation	412	100
Evaporation	278	67.4
Surface water	79	19.2
Ground water	55	13.4
Renewable water (surface and ground)	134	32.6

Source: Report of Ministry of Power (2006).

Table 2: Used Water in Iran, World Average and MENA Average

Sectors	Iran				World Average %	MENA Average %
	Million m³	%	Domestic Excluded	%		
Agriculture	93700	90.6	93700	96.3	75	87
Other Sectors (Mining, Industry and services)	3630	3.5	3630	3.7	20	5
Domestic (Households)	6100	5.9	---	---	5	8
Total	103430	100.0	97330	100.0	100	100

Source: Ministry of Power, Management of Water resource in Iran.
Duarte and Yang (2011), Roudi-Fahimi, Greel and Desouza (2002)

Table 3: Percentage of Used to total Renewable Water for 16 Selected Countries in 2013 and Water Productivity for the Selected Countries in 2012

Selected countries	Ratio of used water to the total renewable water (%)	Water productivity constant 2005 $^{GDP}/_{M^3}$ ($)
Turkey	17.8	15.7
Pakistan	333.6	0.8
S. Korea	39.2	45.8
Japan	20.9	52.1
Iran	72.6	2.8
India	52.6	1.8
France	15.8	71.1
China	19.7	8.2
USA	16.9	24.7
Canada	1.4	28.1
Brazil	1.3	15.2
Austria	4.6	---
Algeria	50.8	---
Saudi Arabia	986	---
Spain	29.2	---
Morocco	12.6	---
World Average	---	14.0

Source: World Bank (2014)

Table 4: Structure of Iranian IOT

Input-Output	Intermediate Use	Final demand		Import	Gross Output
		Domestic consumption	Export		
Intermediate input	x_{ij}	f_i	e_i	m_i	x_i
Value added	v_j	-	-	-	-
Total inputs	x_j	-	-	-	-

Table 5: Modified structure of Iranian IOT

Input-Output		Intermediate Use	Final demand		Gross Output
			Domestic consumption	Export	
Intermediate input	Domestic input	Xd_{ij}	fd_i	e_i	x_i
	imports	m_{ij}	mf_i	me_i	m_i
Value added		v_j	-	-	-
Total inputs		x_j	-	-	-
Volume of water		wa_j	-	-	-

Source: Author

Table 6: Aggregate Results of NWF, per capita NWF, and % of WC, ENWF, VWE and NVWI to Total NWF

	Total NWF	Primary Sector	Secondary Sector	Tertiary Sector
NWF (mm^3)	100304	96026	2676	1602
per capita NWF	1433	1372	38	23
% Primary, Secondary and Tertiary Sectors to NWF	100	95.7	2.7	1.6
% IWF/NWF	92.6	-	-	-
% ENWF/NWF	7	-	-	-
% VWE/NWF	12.6	-	-	-
% NVWI/NWF	5.2	-	-	-

NWF= National Water Footprint, IWF= Internal Water Footprint, ENWF= External Water Footprint, VWE= Virtual Water Exports, NVWI= Net Virtual Water Imports

Table 7: Detailed Results of NWF, VW and NNWF

Sectors	Waj (mm^3)	% to total	xj (billion Rials)	% to total	waj	IWF (mm^3)	IMf (mm3)	IMin (mm3)	NWF (mm3)	VWE (mm3)	NVWI (mm3)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1. Agriculture	93700	96	342995	9.3	0.273	89211	6415	397	96022	11978	-5167
2. Mining	27	0.03	529060	14.3	0.000	3	1	0	4	24	-23
3. Agro-based industry	1136	1.2	243259	6.6	0.005	1129	236	21	1386	312	-55
4. Other industry	637	0.7	714459	19.3	0.001	751	227	21	999	171	77
5. Electricity and Gas	57	0.1	76137	2.1	0.001	35	7	1	44	33	-25
6. Water	0	0.0	10015	0.3	0.000	0	0	0	0	0.00	0
7. Construction	243	0.3	278076	7.5	0.001	243	3	0	246	3	-0.3
8. Services	1460	1.5	1505039	40.7	0.001	1482	110	10	1602	105	15
Total	97259	100	3699040	100	-	92854	6999	451	100304	12627	-5178

$Col.5 = \frac{Col.1}{Col.3}$, $Col.8 = Col.6 + Col.7 + Col.8$, $Col.10 = Col.4 + Col.7 + Col.9$

One \$= 330.000 Rials.

Analysis of India's National Rural Employment Guarantee Program using an Economy-wide Framework

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Abstract

A static multi sectoral CGE model was used to estimate the economy wide effects of MGNREGA. The program has the potential to enhance economic growth, reduce inequality, and generate employment in India. The program has significant spillover effects as both the rural and urban population are benefited by the program, although most of the benefits accrue to the rural population. MGNREGA has the potential to transform rural India provided the country can generate enough resources to finance the program and there is an increase in agricultural productivity to meet the higher demand for food.

Keywords: *MGNREGA, CGE model, employment guarantee program, efficiency, equity, India*

Introduction

Wage employment programs, an important component of anti-poverty policies of India, have sought to achieve multiple objectives. They not only provide employment opportunities during lean agricultural seasons but also in times of floods, droughts and other natural calamities. They create rural infrastructure, which supports further economic activity. These programs also put an upward pressure on market wage rates by attracting people to public works programs. While public works programs to provide employment in times of distress have a long history, major thrust to wage employment programs in India was provided only after the attainment of self-sufficiency in food grains in the 1970s. The National Rural Employment Program (NREP) and the Rural Landless Employment Guarantee Program (RLEGP) are examples of early wage employment programs in India.

The Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) is the world's largest rights based public works

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program. The program started in February 2006, after the National Rural Employment Guarantee Act was passed in 2005, in the 200 most backward districts of India. It was extended to an additional 130 districts in the first year of the Eleventh Plan (2007-08) and to the entire country in 2008-09. MGNREGA entitles each rural household to seek 100 days of employment every year. A brief overview of the performance of MGNREGA is given in Table 1. As Table 1 shows on average more than 3 crore rural households were provided employment per year under the scheme between 2006-07 and 2009-10. It is estimated that in 2009-10 nearly 5 crore families would be provided around 300 crore man-days of work under the program. This is more than three times the employment created by the rural employment program in 2006-07. From its inception in 2006 until September 2009, the program has provided nearly 600 crore man-days of work at a total expenditure of around Rs 70,000 crore. There has also been an increasing trend in the average program wage rate during this period. MGNREGA has a strong mandate that the shares of labour and other costs should not exceed 60 and 40 percent of total program costs, respectively. The program explicitly prohibits contractors to ensure high employment intensity. The works undertaken through MGNREGA like water harvesting, groundwater recharge, drought-proofing have the potential to increase land productivity and thus rural incomes.

A salient feature of the program is that it has benefited socially disadvantaged groups, rural women and differently-abled workers, although some states have performed than others in this respect. The share of Scheduled Caste (SC) and Scheduled Tribe (ST) families in the work provided under MGNREGA has ranged between 51-56 percent, while 41-50 percent of the workers were women. As many as 8.50 lakh differently-abled workers have so far registered for work. The program has led to financial inclusion in rural areas. Nearly 9 crore bank/post office accounts of the poorest people have been opened for MGNREGA payments and around 85 per cent of MGNREGA payments are made through this route. The program has, however, not been able to meet its objective of providing 100 days of employment. The number of days provided work under the program varies across states. The national average was 48 days in 2008-09 and as many as 15 states fall below the national average (see Table 1). Only 14 per cent of worker households completed 100 days of work.

Wage employment programs provide only short-term relief to the poor. Long term sustainable poverty reduction in underdeveloped regions can come about only if other sectors of the economy grow rapidly. It is imperative therefore to ensure that the growth process is inclusive and pro-poor. Agricultural growth still holds the key to poverty alleviation in India. The ultimate potential of MGNREGA lies in improving the productivity of agriculture. Millions of small and marginal farmers are forced to work under MGNREGA because the productivity of their own farms is no longer enough to make ends meet. MGNREGA can become a really powerful policy tool if it helps to rebuild the decimated productivity of small farms and allows small and marginal farmers to return to full-time farming, thereby also reducing the load on MGNREGA.

In brief the potential of MGNREGA to lower poverty is enormous despite daunting challenges, including the quality of the assets it creates. However, Dreze and Khera (2009) after acknowledging problems with the quality of the assets suggest that the return on MGNREGA investments might not be inferior to the return on many other investments elsewhere in the economy. Moreover, they argue that it is not necessary to change MGNREGA rules for asset creation and that the quality of assets can greatly be enhanced with affordable, well directed research and development. If the benefits of an employment guarantee scheme were short term poverty alleviation one could look for an alternative lower cost program such as conditional cash transfer. However, if the scheme can reduce long term poverty by creating productive assets then it is worthwhile to bear the higher costs.

The above discussion thus points to the different roles MGNREGA could play in the economy. Specifically, MGNREGA could reduce poverty and inequality, reduce the rural-urban divide in income/consumption, boost growth by creating productive assets in rural areas, and provide an alternate source of employment for the rural poor during the agricultural off season. At the same time investments in MGNREGA are associated with large opportunity costs for the economy. Keeping in view the above the main objective of this paper is to analyze the efficiency and equity implications of MGNREGA using an economy-wide framework. A static multi sectoral computable general equilibrium (CGE) model was for conducting the analysis. A CGE model is an ideal tool for estimating aggregate economic impacts of specific policies, and the intention of this study is to find answers to the following research questions -

- What are the efficiency and equity implications of MGNREGA? Can MGNREGA lower disparities between rural and urban income/consumption levels?
- How do alternate ways of funding MGNREGA affect the efficiency and equity implications?
- What are the efficiency and equity implications if MGNREGA is accompanied by the creation of productive assets in rural areas?
- What is the potential of MGNREGA as a hedging tool against adverse agricultural productivity shocks?
- How do investments in MGNREGA compare with investments in other sectors of the economy?

There are relatively few studies that have analyzed MGNREGA in an economy-wide framework, and it is hoped that the answers to the above research questions will give us an indication of the true potential of MGNREGA as a tool to promote rural development.

The paper is divided into five sections. In the next section (Section 2) a review of the literature on employment guarantee programs is provided, followed by a discussion of the model and data (Section 3). In Section 4 results are discussed and finally in Section 5 the conclusions and policy implications are presented.

Literature review

Employment guarantee programs (public works or workfare programs) have been frequently implemented by countries to assist the poor during periods of crises. Dreze and Sen (1989) argue that workfare programs are perhaps the only politically acceptable scheme to operate large scale transfer of resources to the poor. A public works program can impact the economy in several ways (O'Keefe, 2005). The different types of impacts are:

A. The transfer impact (i.e. direct transfer benefits in cash or kind to participating households)

B. Impact on overall wage levels, which will be felt both by participating households and non-participating households whose incomes are below the post-program area wage. This positive impact may be offset by negative impacts on labour demand due to higher mean wages in the program area.

C. Indirect impacts from the economic benefits of assets created under the scheme. These benefits would typically be spread among a wider population.

D. Consumption smoothing that public works may perform by lowering income variability.

And,

E. Impacts on gender and other social and economic relations due to features of programs such as equal pay for equal work.

It is clear both in theory and from available evidence internationally that studies which focus only on the direct transfer benefits of work fare programs are likely to underestimate aggregate economic impacts of public works programs. The aggregate economic impacts of public works programs are likely to be substantial.

There are a number of studies that look at the theory and practice of public works programs. Early reviews include Dreze and Sen (1989) of famines and public works programs in Africa and India, and the comprehensive review of Subbarao et al. (1997) that looked at safety nets and public works programs in Africa, Asia, Latin America, and the Middle East. More recent reviews include, among others, Devereux and Solomon (2006); Lal, Miller, Lieuw-Kie-Song and Kostzer (2010), and McCord (2009). In general, reviews converge in pointing out that public works programs, if well designed and implemented, can constitute a powerful policy to reach the poor and transfer resources to them. The work requirement combined with a low wage makes the program only attractive to the poor, who thereby self-select themselves to the program. Self-selection is an attractive feature as it reduces administrative costs of the program. Nevertheless, geographical and ethnic targeting is sometimes recommended as a complementary tool to better reach the poor. Wages, which should not be too low to render the program incapable of meaningfully supporting households, neither too high to avoid attracting better off households, which can lead to crowding out of the poor, inflate the program budget and substitute productive jobs in labour markets.

Devereux and Solomon (2006), drawing mainly from 4 national employment programs, stress two points relevant to our discussion of the link with poverty reduction. First, the authors argue that although public works programs were generally adopted for their self-targeting capabilities, it is increasingly recognized that the assets produced by programs are also important. Public works programs have created assets with long lasting benefits for individuals, communities and society in general. Second, public works programs provide workers with life skills that can help them to escape poverty and build institutions that entail the creation of individual and community capacities for employability and development.

The capacity of public works programs to reduce poverty necessitates, among other things, a sizeable, timely and continuous transfer of resources to the poor. However, most public works programs are temporary and small. In a study of more than hundred work programs, McCord (2009) finds that almost half of them were conceived as one-time interventions, 11 percent had a life time of 6 or more years, only 6 percent were open ended, and their average life length was only 3 years.

The Maharashtra employment guarantee scheme (EGS) is one of the foremost examples of employment guarantee schemes in the world. The scheme provides unskilled manual labour on small-scale rural public works projects, such as roads, irrigation facilities, and reforestation. The EGS was introduced during the severe drought of 1970-73 and expanded rapidly to reach average monthly participation of about 500,000 persons over the period 1975-89. In a typical year the scheme provides about 100 million person-days of employment in a state with a rural work force (including cultivators) of about 20 million persons, though we do not know the figure net of displaced employment. There has been much debate about how effectively Maharashtra's EGS has reached the rural landless. Dandekar and Sathe (1980) estimated that the scheme eliminated three-quarters of unemployment among landless or near landless households in 1977-78. Under more conservative assumptions Osmani (1988) argued that the scheme could not have eliminated more than one-third of this group's unemployment. Acharya and Panwalkar (1988) reported that the mean income of participating households was found to be about 20 percent below the poverty line. From this evidence, the EGS would appear to have performed well in reaching the poorest. Bhende, Walker, Lieberman and Venkataram (1990) have studied the targeting performance of the EGS using household-level data over five years (1979-83) for two Maharashtra villages. Their results suggest that the scheme is well targeted, days of participation on EGS decrease rapidly with increases in wealth, and participation is higher in the poorer of the two villages. The program effectively screens the poor, particularly in the richer village, where the potential losses from leakage are larger.

An ex ante analysis by Murgai and Ravallion (2005) for a lean season scheme providing 100 days of work for rural households indicates that such a program would be progressive and that income gains to the poor would be significant (see Table 2). The authors find that a lean season employment guarantee has a significant poverty reduction impact, with whole year poverty rates reduced from 37 to 27 percent at a wage rate sufficient for a typical family to reach the poverty line. The impact is also seen in reductions in the poverty and squared poverty gap indices. The scheme would also reduce inequality, though the impacts are diluted once the wage rate is raised above Rs. 40-45 (in 1999-00 prices). The simulated distribution of gainers by quintile is quite progressive, with around 55 percent of gainers in the bottom two quintiles of the consumption distribution. Just as importantly, the transfer gains as share of pre-EGS consumption are even more pro-poor with the proportional gain for households in the poorest quintile around 9 times those of the richest quintile at the mid-range wage rate and approaching twice the proportional gain of even the second poorest quintile.

Cash transfers have a much greater impact because even though they are less well targeted to the poor, they do not result in any foregone income. The cash transfers also benefit those households which are poor but are unlikely to enter the labour market (like senior citizens). With even highly imperfect targeting, cash transfers would have far greater short-term impact on poverty. The study suggests that unless the program's design assures that the indirect benefits to the poor through the assets created and the extra insurance provided are sufficiently high, policy-makers would be better advised to consider other options to reach the poor. This could include expansion of existing schemes such as social pensions for destitute elderly, widows and disabled, or social security for unorganized workers. It might also include conditional transfer schemes, i.e., family allowances targeted to poor areas and conditional on children attending school and receiving adequate health care (such as Bangladesh's Cash-for-Education, Mexico's Progresa and Brazil's Bolsa Escola).

Creation of quality assets under workfare schemes clearly has a significant impact on the cost effectiveness of the intervention. The aggregate economic impacts of assets created are generally held to be positive. Like all public programs, employment guarantee schemes work within fiscal constraints. Murgai and Ravallion (2005) have estimated the potential costs of a rural employment guarantee at different wage rates. The results are presented in Table 3 under different assumed wage rates (in 1999-00 rupees) for both a full year (300 day) employment guarantee and a lean season (100 day) guarantee. The fiscal costs of even a lean season guarantee remain substantial. At the wage rate of Rs. 50, the cost of a lean season employment guarantee scheme is estimated to be 1.7 percent of GDP for full country coverage. Thus, the costs of employment guarantee schemes are huge, and given India's constrained fiscal position issues related to financing of such schemes have often been raised.

Imai (2007) has analyzed the direct and indirect effects of Maharastra's EGS in the village of Kanzara. He looks at direct and indirect effects, and compares the EGS with an equivalently budgeted uniform transfer. Imai's results suggest that the impact of the full wage bill of Maharastra's EGS increases village household income by 2.6 percent. Multiplier effects result in an increase of 1.3 percent in total output and 0.9 percent in savings. The distribution effects of the EGS are reasonably good. Households classified as landless unsalaried and small farmers benefit the most, while medium farmers make moderate gains as well. If the effect of the assets created by the EGS is considered, there are further increases in household income (0.5 percent), village output (0.7 percent), and savings (0.7 percent). Taking into account foregone income reduces gains from the EGS, so household income only increases by 1.6 percent. Imai concludes that EGS can be an effective way to reduce poverty if assets are adequately created and maintained and if the EGS self-targeting mechanism is supplemented with other targeting instruments. Otherwise, a uniform transfer is a more efficient policy tool to transfer resources to the poor.

Narayana, Parikh and Srinivasan (1988) use a computable general equilibrium model to assess the impact of a rural public works program on growth, welfare and income of poor households. The simulated program provides 200 person days per year to every household in the bottom 40 percent of the rural income distribution. The program is assumed to operate only in the lean season and to have no effect on agriculture wages. The conclusions of are - first, the program is an effective policy tool to eliminate hunger at a modest cost to growth. If no investment or leakage failures are incurred and the program is financed with a tax increase, which means other public investments are not reduced, the model suggests that the economy gains 0.13 percent points in the average growth rate between 1980 and 2000. If tax rates remain constant, the program has a cost to the economy equivalent to a reduction of 0.25 percent points in the average growth rate, for public investment is reduced, but no damage is done to the re-distributive effects of the program. Second, the impact on welfare of poor households compare favorably with those of a transfer of a similar total budget to everyone. Third, if well planned and executed, the program also compares well with a uniform transfer. Always assuming fixed taxes, the reduction in GDP that follows from a uniform transfer is significantly smaller compared to a badly run public works program, but the public works program has a more positive impact on the welfare of poor households. Comparing the uniform transfer with the best public works scenario results in similar costs, but the public works program clearly has superior re-distributive effects. The comparison thus makes it evident that rural public works programs are potentially excellent tools to reduce poverty but they need to be well planned and executed to obtain the maximum benefits. Finally, the authors acknowledge that past rural work programs suffered from implementation problems, but argue that these are not arguments against public works programs per se.

Investment in basic rural infrastructure is widely thought to have a high economic rate of return in developing economies, through increased agricultural output (Antle, 1983). The key issues are, jointly, the extent to which that return is realized by the infrastructure actually created by rural public works schemes whose prime objective is to alleviate poverty and the extent to which the poor have shared those benefits. A common criticism of the rural public works schemes in India is that the assets created have often been "privatized," with benefits going to the rural non poor (Dandekar & Sathe, 1980).

The effect of rural public works schemes on agricultural labour markets and tenancy contracts is an important but relatively unexplored issue. The transfer benefits from a rural public works project include effects on wages and other earnings from alternative activities. Time series evidence for India suggests that increases in the real agricultural wage rate generally reduce poverty (van de Walle, 1985). There is evidence that employment guarantee schemes have pushed up agricultural wages. It is widely believed that the EGS wage rate has influenced the agricultural wage rate in Maharashtra.

Like many social programs in developing countries, workfare programs involve a transfer to the rural poor funded by mostly urban tax payer money. Through their effect on labour markets, workfare programs also trigger a redistributive effect within rural areas, from households which are net labour buyers to households which are net labour sellers. Farmers have opposed the implementation of the scheme during the peak season of agriculture precisely because of its effect on wages. These political economy considerations could explain why the implementation of MGNREGA has been poor in some states (like Bihar, Jharkhand, West Bengal) despite the large potential demand for public employment.

It is sometimes argued that employment guarantee schemes should not be allowed to compete with existing employment opportunities, because they distort market allocations. The economics of this argument needs to be looked at carefully. Avoiding new distortions to existing labour markets is imperative only if those markets were functioning efficiently before the policy intervention and if better policy instruments were available for achieving distributional objectives. A well-functioning public works scheme can make a positive contribution to both efficiency and equity by reducing existing noncompetitive features in rural labour markets.

The stabilization benefits of public employment schemes can be very important in risky agricultural settings. Rural public works have had a long and generally successful history as an instrument of seasonal stabilization and famine relief in India (Dreze & Sen, 1989).

If the EGS provides an effective employment guarantee it will tend to increase the prevailing level of agricultural wages. This might be due to (i) gains in agricultural productivity through the assets created and, associated with such gains, a shift in the demand for agricultural labour, and (ii) a higher reservation wage as a consequence of a "guaranteed" employment option in slack periods. Analysis of ICRISAT data has confirmed the existence of such an effect (Gaiha, 1997). Specifically, if EGS wages rise by a rupee, agricultural wages are estimated to rise by about 17 paise in the short-run, and by about 28 paise in the long-run.

There is a growing literature on MGNREGA, and a few papers relevant from the point of view of this study are discussed next. Berg, Bhattacharyya, Durgam and Ramachandra (2012) have studied the effects of MGNREGA on agricultural wages at the district level in India. They analyzed the impact of MGNREGA on agricultural wages using monthly data from 249 districts spread over 19 Indian states over the period May 2000 to June 2011. After controlling for average rainfall, district and time fixed effects and phase-wise linear, quadratic and cubic time trends, they find that MGNREGA intensity treatment in an average district boosts real daily agricultural wage rates by 1.6 per cent. This translates into an average annual effect of MGNREGA on real daily agricultural wages of 5.3 per cent. The study finds no statistically significant difference in the impact of MGNREGA on male and female wages. Further, the scheme only affects unskilled wages and not skilled wages. Public works programs provide governments with an additional mechanism with which to influence wage rates in the rural unskilled labour market. Since the link between agricultural wages and poverty rates are well established, if public works can influence agricultural wages then they constitute an attractive policy instrument to reduce poverty. Kloner and Oldiges (2012) have analyzed the welfare impacts of the MGNREGA arguing that a pure labour market perspective is certainly important in its own right but not a sufficient basis to judge the MGNREGA's effects on the quality of life of rural households. Considering that higher wages are only a means to an end the authors explored whether the MGNREGA does translate into higher levels of living. The authors find that several measures of welfare do improve with the MGNREGA in place and that the scheme especially impacts extreme poverty. Further, the authors argue that money metric welfare measures may not be sufficient in capturing the entire effect of a program like MGNREGA. Being employed under the MGNREGA may not only increase wages or consumption but may also improve the status of women and marginalized groups. The entitlements under the Act have the potential to empower marginalised groups in many ways, which a multi-dimensional welfare analysis might capture much better.

Dutta, Murgai, Ravallion and van de Walle (2012) use India's National Sample Survey of 2009-10 to test some of the claims that have often been made in debates regarding MGNREGA using data for all the major states of India. The paper has focused on a distinctive and important feature of MGNREGA: the guarantee of employment at the stipulated wage rate. The paper confirms expectations that the demand for work under MGNREGA tends to be higher in poorer states. This appears to reflect the scheme's built-in self-targeting mechanism, whereby non-poor people find work on the scheme less attractive than do poor people. However, actual participation rates in the scheme are not any higher in poorer states. The reason for this paradox lies in the differences in the extent to which the employment guarantee is honored. Rationing is common, but far more so in some of the poorest states. The paper does not find that the local-level processes determining who gets work amongst those who want it are generally skewed against the poor. There are places where the poor are left out, but it does not appear to standup as a generalization. The study finds evidence that the poor fare somewhat less well off when it comes to the total number of days of work they manage to get on the scheme.

However, despite the pervasive rationing, the scheme is still reaching poor people as well as the scheduled tribes and backward castes. Participation rates on the scheme are higher for poor people than others. This holds at the official poverty line, but the scheme is also reaching many families just above the official line. It is only at relatively high consumption levels that participation drops off sharply. This should not be interpreted as indicating that well-off families in rural India are turning to MGNREGA as there may be individual needs for help that are not evident in household consumption aggregates. The study finds that targeting performance varies across states. Some of those living above the official poverty line in better-off states will no doubt be relatively poor, and need help from the scheme. The overall participation rate seems to be an important factor in accounting for these inter-state differences in targeting performance, with the scheme being more pro-poor and reaching scheduled tribes and backward castes more effectively in states with higher overall participation rates. While the allocation of work through the local-level rationing process is not working against the poor, there are clearly many poor people who are not getting help. While the scheme is clearly popular with women who have a participation rate that is double their participation rate in the casual labour market, the rationing process does not appear to be favoring them. The authors also find evidence of a strong effect of relative wages on women's participation - both wages on the scheme relative to the market wage and the male-female differential in market wages. As one would expect, poor families often choose whether it is the man or the woman who goes to the scheme according to relative wages. It has been claimed by some observers that the scheme is driving up wages for other work, such as in agriculture; some observers see this as a good thing, others not. For India as a whole, the study finds that the scheme's average wage rate is roughly in line with the casual labour market wage rate in 2009-10. Further, there is a significant negative correlation between the extent of rationing and the wage rate in the casual labour market relative to the wage rate on the scheme. The authors suggest that other economic factors might be at work for this observation. The correlation largely vanishes when there is control for the level of poverty. Poorer states tend to see both more rationing of work on the scheme and lower casual wages, possibly due to a greater supply of labour given the extent of rural landlessness.

Thus, the main conclusion from the literature survey is that employment guarantee programs if well designed and properly implemented constitute a powerful policy tool to reach the poor and transfer resources to them. Further, such schemes lead to reduction of inequality and enhance the welfare of disadvantaged groups. On the flip side, such schemes are prone to leakages of resources and administrative bottlenecks. Despite these shortcomings the returns to investments on such schemes are likely to outweigh the costs.

This study differs from previous studies in this area mainly on three counts. First, there is explicit modeling of the Indian rural and urban labour markets. The labour market is disaggregated into rural and urban, and unemployment is taken into account in both the markets, as discussed in greater detail in the next section. This disaggregation of the labour market helps to disaggregate the effects of MGNREGA on the two labour markets, and thus facilitates comparison of the effects of the program between the two segments (rural and urban) of the population. Second, this study also analyzes the effects of the creation of productive assets in rural areas, due to the program, on the economy. Finally, investments in MGNREGA are compared to investments (subsidies) in other sectors (agriculture and manufacturing) of the economy.

Model and data

The model used in this study is a multi-sectoral static CGE model, based on Lofgren, Harris and Robinson (2002). The model consists of 10 sectors - Agriculture, Mining, Manufacturing I (food and beverages, textiles, wood, minerals), Manufacturing II (plant and machinery), Electricity, Construction, Transport, Trade, Financial Services and Commercial Services. There are two factors of production, capital and labour. Further, labour is disaggregated into rural and urban labour. The disaggregation of labour into rural and urban is necessary to distinguish the effects of MGNREGA on the rural and urban labour markets.

Producers are assumed to maximize profits and to operate in perfectly competitive markets. Households maximize utility subject to income and prices, and the household demand for commodities is modelled through the linear expenditure system (LES). Household income comprises of income derived from labour and capital and transfers from the government and the rest of the world. Households also save part of their income and pay taxes to the government. Further, households are classified into nine categories: five are rural (Self Employed in Non Agriculture, Agricultural Labour, Other Labour, Self Employed in Agriculture and Other Households) and four are urban (Self Employed, Regular Salaried, Casual Labour, and Other Households).

Government expenditure is on the consumption of goods and services, transfers to households and enterprises, and subsidies. Government income is from taxes (direct and indirect), capital, public and private enterprises, and rest of the world. Indirect taxes include excise duty (production tax), import and export tariffs, sales, stamp, service, and other indirect taxes. Government savings which is the difference between government expenditure and income is determined residually.

Imperfect substitution between domestic goods and foreign goods is allowed for in CGE models. In other words, producers/consumers are free to sell or consume goods from the domestic or foreign market based on relative prices. The Armington function is used to capture the substitution possibilities between domestic and imported goods. The import demand function, derived from the Armington function, specifies the value of imports based on the ratio of domestic and import prices. The CET function is used to capture substitution possibilities between domestic and foreign sales. The export supply function, derived from the CET function, specifies the value of exports based on the ratio of domestic prices to export prices. The elasticity of substitution determines the relative ease of substitution between domestic and foreign goods in response to changes in relative prices.

The model is Walrasian in character. Markets for all commodities clear through adjustment in prices. The consumer price index (CPI) is chosen as the numeraire and is therefore fixed. Macro closures play an important role in determining the results of CGE models. The model follows an investment-driven closure, that is, aggregate investment is fixed. The saving-investment balance is maintained through adjustment in aggregate savings (sum of household, government, corporate and foreign savings). The model assumes foreign savings to be fixed and the real exchange rate to be flexible. Government consumption expenditure is fixed within a period, and government savings is residually determined. Both direct and indirect tax rates are fixed. The household savings rate is also fixed. Two types of closures are assumed in case of capital. In the short run version of the model sectoral capital as well as the economy wide rental rate is fixed, but a sectoral distortion factor is used to capture differences in returns to sectoral capital. In the long run version of the model inter-sectoral mobility is assumed in case of capital, and the economy wide rental rate adjusts to clear the capital market. In case of the rural labour market the wage rate is held fixed in order to capture the elastic nature of rural labour supply. However, in case of urban labour both the wage rate and supply endogenous variables. Thus, the model incorporates structuralist features like unemployment, which is an important characteristic of the Indian labour market. The model is solved using the GAMS software (PATH solver).

A social accounting matrix (SAM) of India for 2002-03, constructed by Pradhan, Saluja and Singh (2006), is the main source of data for this study. Modifications were done to this SAM for the purpose of this paper. The modified SAM (see Annex) consists of 27 rows and columns (accounts).The production account consists of 10 sectors - Agriculture, Mining, Manufacturing I (food and beverages, textiles, wood, minerals), Manufacturing II (plant and machinery), Electricity, Construction, Transport, Trade, Financial Services and Commercial Services. There are two factors of production - labour (rural and urban), and capital. The institutional accounts consist of nine types of households, public and private enterprises, and government. The last two accounts of the SAM are savings-investment (capital account) and rest of the world.

The main features of the SAM are presented in Table 4 and Table 5. The SAM is a snapshot of the economy in 2002-03. Agriculture accounts for about 24 percent, manufacturing (including mining) about 19 percent and services about 57, of the GDP, respectively. The value of GDP (at factor cost) is about 23,269 billion rupees. Manufacturing accounts for bulk of the exports (about 60 percent), followed by services (about 34 percent) and agriculture (about 6 percent). The manufacturing sector (including mining) accounts for about 77 percent of the imports. Since oil is a major import commodity, the share of mining in total imports is relatively high.

Table 5 presents the factor income shares of different institutions. As expected most of the rural labour income go to rural households while most of the urban labour income go to urban households. Among rural households most of the rural labour income goes to agricultural labour households (about 32 percent), while among urban households the major share of urban labour income goes to the salaried class (about 58 percent). Bulk of the capital income (about 29 percent) goes to the rural land owning group. Most of the rural population are engaged in agriculture (RH2 and RH4), while the urban population is dominated by the self-employed (UH1) and salaried (UH2) classes.

Results and discussion

In order to address the research questions of this study we ran seven simulations (denoted as SIM) each under the short (Section 4.1) and long run (Section 4.2) versions of the model. As mentioned before Research Questions 1 and 2 are related to the efficiency and equity implications of MGNREGA under alternative assumptions about financing the program. Further, the incremental benefit that could be associated with the creation of productive assets, due to MGNREGA, is another issue of interest (Research Question 3). Consumption smoothing is one of the main objectives of employment guarantee programs, and the extent to which MGNREGA could be successful in this regard is another research issue (Research Question 4). The final research question is related to the optimal allocation of scarce public resources (Research Question 5). Research Question 5 deals with investments in MGNREGA vis a vis investments in other sectors of the economy.

In order to address Research Question 1, the effects of higher transfers (0.5 percent of GDP) to poor rural households, according to their population shares based on Sundaram and Tendulkar (2003), were estimated (SIM 1). In SIM 2 the transfers to rural households are financed through direct taxes, and this simulation addresses Research Question 2. Research Question 3 is addressed by estimating the effects of higher agricultural productivity along with higher transfers to rural households (SIM 3). Two simulations were run to address Research Question 4 - first a scenario (SIM 4) with lower agricultural productivity is run, and then we compare it with a scenario (SIM 5) with lower agricultural productivity and higher transfers to rural households. A comparison of SIM 4 and SIM 5 provides estimates of the consumption smoothing benefits of MGNREGA. Finally, Research Question 5 is addressed by simulating the effects of higher subsidies (equivalent to transfers under MGNREGA) to agriculture (SIM 6) and to manufacturing (SIM 7). For each of the above simulations, the effects on GDP, welfare (aggregated and dis-aggregated), factor prices, factor income, factor supplies, fiscal deficit, production, and prices (consumer prices) are presented.

Short run effects

In this section the short run effects (Table 6 and Table 7) are presented. As discussed earlier, the short and long run versions of the model differ in the treatment of sectoral capital and the economy wide rental rate of capital. In the short run, sectoral capital and the economy wide rental rate are held fixed, and a sectoral distortion factor clears the capital market.

Effect on GDP

The results show that there is a positive effect on GDP in all the scenarios, except in SIM 4 where there is a decline in GDP. The highest increase in GDP is observed in SIM 6, where public investments (in the form of subsidies) are made in the agriculture sector, instead of investments in MGNREGA. In SIM 6 there is significant increase in agricultural output and lower agricultural prices. Thus, the critical role of public investments in agriculture for enhancing growth is revealed through SIM 6. It is interesting to note that changes in GDP are much lower, although positive, in SIM 2 and SIM 7, relative to the other scenarios. In other words, financing MGNREGA through taxes (SIM 2) or subsidizing the manufacturing sector instead of spending equivalent resources on MGNREGA are relatively inefficient policy options. There is loss in GDP in SIM 4, where the effect of lower agricultural productivity is modelled.

These results in general validate the results of previous studies. The main difference between our results and the literature (Narayana et al, 1988) is that we find that financing MGNREGA through taxes significantly reduces the benefits (GDP) to the economy relative to a scenario where tax rates are fixed, while the results are just the opposite in case of the Narayana, et. al. (1988) study. The differences arise due to different assumptions (closures) of the models. We assume that aggregate investment is unaffected (fixed investment) while the Narayana, et. al. (1988) study assumes that aggregate investment is affected (flexible investment) in the scenario where tax rates are fixed. In other words, we assume an investment driven closure while Narayan, et. al. (1988) assume a savings driven closure.

Effect on welfare

The effect on welfare is estimated for the different scenarios. Welfare is measured in terms of equivalent variation. Equivalent variation measures the amount of money we would have to give (or take) to provide the representative consumer with the same level of utility as he or she would have obtained after the policy reform. In other words, it is the money value of the policy change before it actually happens. If we want to compare many potential changes to the status quo, the equivalent variation is the best option since the price vector used in all comparisons is the same, that is, the status quo price vector.

There is increase in aggregate welfare (sum of welfare of different households) in all the scenarios, except in SIM 4, implying that all the scenarios are beneficial (Pareto efficient) for society. The highest increase in welfare is observed in SIM 3, where MGNREGA transfers are accompanied by increase in agricultural productivity, as a result of creation of productive assets. A dis-aggregation of the welfare effects across household groups reveals that rural household groups are better off in all the scenarios, except in SIM 4. Among the rural household groups the welfare effects are significantly larger for the rural labour categories (RH2 and RH3) in the scenarios where transfers take place (SIM 1, 2, 3 and 5). The implication is that MGNREGA has a huge potential to improve living standards and reduce inequality. However, the welfare benefits associated with these two household groups reduce if the program is financed through taxes (SIM 2). In SIM 2 all the urban households are worse off, as most of the tax burden is on these groups, and this in turn has a significant negative impact on rural consumption. Although the commonly held view in India is that rural consumption fuels urban consumption, SIM 2 shows that urban consumption also has a major role in determining rural consumption levels. Thus, financing the program through direct taxes could significantly reduce the benefits to the most vulnerable rural household groups. In SIM 6, where equivalent resources are spent of subsidizing agriculture instead of increasing transfers through MGNREGA, welfare benefits are observed for all household groups. The welfare gains are more or less evenly distributed among the different rural household groups. From an efficiency perspective SIM 6 is the best, however, from a welfare perspective subsidizing the agriculture sector is not the best option. In other words, investments in MGNREGA coupled with higher agricultural productivity gives the highest returns from a welfare perspective.

Effects on factor prices, factor income and factor supply

As mentioned earlier the economy wide wage rate of rural labour and capital are fixed, while the wage rate of urban labour is flexible, in the model. The results show that the wage rate of urban labour falls in all the scenarios, except in SIM 6 and 7, where subsidies are provided to agriculture and manufacturing, respectively. In SIM 1, 2, 3, and 5, where transfers to rural households are modelled, rural labour becomes relatively more expensive than urban labour. In other words, MGNREGA has an effect on the rural labour market by increasing rural wages. As a result there is a higher increase in rural labour income compared to urban labour income in the scenarios involving transfers. The increase in rural labour income has a relatively bigger impact on the rural labour household groups (RH2 and RH3). Berg et al (2012) have studied the effects of MGNREGA on agricultural wages at the district level in India and they find that the program leads to an average annual increase in real daily agricultural wages of 5.3 per cent. Interestingly, in SIM 6 and 7 the effects on wage rates are reversed. In these two simulations urban labour becomes relatively more expensive. Finally, there is a positive impact on the supply of both rural and urban labour in all the scenarios.

Effect on fiscal deficit

Fiscal deficit increases by a significant amount, ranging from 5 to 7 percent, relative to the baseline, in the scenarios involving transfers or subsidies. The increase in deficit is relatively higher in the scenarios involving subsidies. The effect on the fiscal deficit is almost negligible in SIM 2 where transfers are financed through taxes.

Effects on production and prices

The results show that there is increase in production in most scenarios and sectors. In SIM 4, however, there is negligible impact on production. Interestingly, the highest increase in production is observed in case of agriculture in all the scenarios except SIM 7 (subsidy to manufacturing), where a manufacturing sector (MANU 2) experiences the highest increase in production. The implication is that transfers to rural households and subsidies to agriculture stimulate agricultural growth, the effect being stronger in case of the latter. Further, transfers increase food prices, while subsidies to agriculture lower food prices.

Long run effects

In this section the long run effects (Table 8 and Table 9) are discussed. As mentioned earlier, in the long run, capital is mobile across sectors and the economy wide rental rate of capital adjusts to clear the capital market. The total supply of capital is fixed.

Effect on GDP

The results show that there is a positive effect on GDP in all the scenarios, except SIM 4 and SIM 7 where there is a decline in GDP. The highest increase in GDP is observed in SIM 6, as in the short run, where public investments (in the form of subsidies) are made in the agriculture sector, instead of investments in MGNREGA. Further, the results suggest that lower agricultural productivity (SIM 4) and subsidies to manufacturing (SIM 7) reduce efficiency in the economy.

Effect on welfare

There is increase in aggregate welfare in all the scenarios, except SIM 4, as in the short run. The highest increase in welfare is observed in SIM 3, where MGNREGA transfers are accompanied by increase in agricultural productivity, as a result of creation of productive assets. It is interesting to note that while subsidies to manufacturing are detrimental from an efficiency perspective in the long run, the same does not hold true from a welfare perspective. In other words subsidies to manufacturing have positive welfare effects in the long run. Manufactured goods form a sizeable part of household consumption, and subsidies to manufacturing lower the price of manufactured goods thus leading to improvement in welfare. In the short run, subsidies to manufacturing have positive effects on both efficiency and welfare. Rural households suffer welfare losses in SIM 4, while urban households suffer welfare losses in SIM 2 and SIM 4, as in the short run.

Effects on factor prices, factor income and factor supply

The results show that the wage rate of urban labour falls in all the scenarios, except SIM 6 and SIM 7,where subsidies are provided to agriculture and manufacturing, respectively. This result is similar to the result obtained in the short run. The rental rate of capital increases or remains the same across the scenarios. In general income increases for all the factors and in all the scenarios, except SIM 2, where urban labour is worse off, and SIM 4, where both urban labour and capital are worse off. Finally, there is increase in labour supply across both rural and urban labour markets in all the scenarios, although the magnitude of increase varies considerably across the scenarios.

Effect on fiscal deficit

Fiscal deficit increases by a significant amount, ranging from 5 to 7 percent, relative to the baseline, in the scenarios involving transfers (without higher taxes) or subsidies, while there is almost negligible effect in SIM 2 (transfers financed through taxes) and SIM 4 (lower agricultural productivity). Although the fiscal deficit increases crowding out is not observed because of the assumption of fixed investment in the model.

Effects on production and prices

The results show that in general there is increase in production across scenarios and sectors. In SIM 4 there is negligible impact on production. The highest increase in production is observed in case of agriculture in all the scenarios except SIM 7 (subsidy to manufacturing), where a manufacturing sector (MANU 2) experiences the highest increase in production. Food prices increase in all the scenarios, except in SIM 6, where agricultural production is subsidized. Again these results are similar to the short run case.

There is positive effect on growth and welfare under MGNREGA. The highest increase in aggregate welfare is observed when MGNREGA transfers are accompanied by increase in agricultural productivity, as a result of creation of productive assets. In general, MGNREGA leads to significant welfare gains for rural labour households relative to other households. The implication is that MGNREGA has a huge potential to improve living standards of the poorest, and reduce inequality in society. However, it is not the best option in terms of enhancing growth. The highest increase in GDP is observed when equivalent investments (in the form of subsidies) are made in the agriculture sector instead of MGNREGA.

The mode of financing MGNREGA affects the results. Financing the program through taxes significantly reduces growth and welfare gains relative to scenarios where the program is financed through government borrowings. Thus, financing MGNREGA through taxes is not a good policy option.

MGNREGA affects the rural labour market by increasing rural wages relative to urban wages. There is higher increase in rural labour income compared to urban labour income in the scenarios involving transfers. The program also leads to higher employment in both rural and urban areas. Finally, MGNREGA significantly increases the demand for food thus stimulating agricultural production and prices.

The results of the short and long run versions of the model, in general, are similar in direction but different in magnitude. In the long run the effects on GDP and welfare are stronger relative to the short run, mainly because there is more flexibility in terms of resource allocation (inter-sectoral mobility of capital). Therefore, effects on factor income and supply are stronger in the long run case. The implication is that MGNREGA could have significant effects on resource allocation in the economy in the long run. The effects of MGNREGA are not only confined to rural India but are spread throughout the economy. Even though MGNREGA is designed to provide short term relief to the rural poor, it has the potential to bring about long term structural changes in the economy.

Thus, our findings address the research questions of the study. First, we find that alternative ways of financing MGNREGA could lead to significantly different effects on the economy. Financing the program through taxes significantly reduces growth and welfare. Second, if the program leads to higher agricultural productivity, welfare gains are particularly large. Third, the consumption smoothing benefits of MGNREGA are very high. Comparison of a scenario of agricultural productivity shock with a scenario of agricultural productivity shock along with MGNREGA reveals that MGNREGA could be an ideal tool to smooth consumption in both rural and urban areas during times of distress. Finally, investments in MGNREGA could lead to equivalent or higher welfare gains relative to alternative investments in the economy.

Conclusions and policy implications

Public wage employment programs designed to provide employment in times of distress have a long history in India. MGNREGA was launched in February 2006, after the National Rural Employment Guarantee Act was passed in 2005, in the 200 most backward districts of India. The program guarantees 100 days of employment at a stipulated wage rate in rural areas. A static multi sectoral CGE model is used to estimate the economy wide effects of the program. Broadly, four types of effects could be associated with the program - effects on macro variables, spillover effects, direct and indirect effects on income, and effects on nutritional outcomes. The study clearly reveals that the program has significant macro level impacts in terms of growth, welfare and employment generation. The program has the potential to enhance growth, reduce inequality by increasing the income of poor rural households relative to other households, and generate employment in both rural and urban areas. However, the short and long run effects of the program differ considerably. In the short run, one rupee invested in the program increases national income by 0.80 rupee and household consumption by 1.02 rupee, while in the long run it results in the increase in national income by 1.07 rupee and in an increase in household consumption by 1.16 rupee. Therefore, the relevance of the program to the economy should be viewed from a long run perspective.

The analysis shows that the program has spillover effects as the program affects both the rural and urban populations. Both the rural and urban population are benefited by the program, although most of the benefits accrue to the rural population. Further, income redistribution by means of higher taxes (direct taxes) significantly lowers the positive impacts of the program. Since most of the direct taxes are paid by urban households, higher tax rates effectively leads to lower consumption by these households which in turn adversely affect the other macro variables. The benefits to rural households are also significantly reduced if the program is financed through the urban tax payers' money. Thus, the ideal method of financing the program should be through generation of more resources through higher growth or through higher tax collection, rather than through higher tax rates.

The program affects both the rural and urban labour markets by making rural labour relatively more expensive. In other words, the program increases rural wages relative to urban wages. Poor rural households benefit the most because of participation in the program (direct benefit) as well as due to relatively higher wages (indirect benefit) due to the labour market impact. By making rural labour relatively more expensive the program stimulates demand for urban labour. Therefore, the program could lead to migration of labour from urban to rural areas and/or reduce the migration of labour from rural to urban areas. Thus, the program could potentially reduce the stress on the resources of urban areas.

The program leads to higher food demand implying that the program could lead to better nutritional outcomes for the population. Food prices also increase due to the program, and therefore, the program could create inflationary pressures in the economy. Therefore, the implementation of the program should be simultaneously accompanied by the easing of supply side constraints in the agriculture sector.

MGNREGA is an effective tool to promote both efficiency and equity objectives. Higher growth is required to generate resources to finance the program as redistribution by means of higher tax rates could significantly reduce the benefits of the program. The program should be viewed not only in terms of providing short term relief to the poor, but in terms of promoting long term economic growth. The program should be a means to improve agricultural productivity because the program is likely to increase the demand for food in the face of deteriorating agricultural productivity growth. If agricultural supply constraints are not eased the program might lead to inflationary pressures and/or higher dependence on imports. Finally, investments in MGNREGA could lead to equivalent or higher welfare gains relative to alternative investments in the economy. In short, MGNREGA has the potential to transform India provided the country can generate enough resources to finance the program and there is an increase in agricultural productivity to meet the higher demand for food. Sustaining high levels of growth is a challenge for India and so is increasing agricultural productivity, and therefore, the objective should be efficient implementation of the program. Modern technology could play a key role in reducing leakages and in improving efficiency.

The model developed for this study is a single period model and therefore, dynamic effects are not captured. Additionally, the model also does not distinguish the regional effects of the program. Since there is considerable difference in the impacts of the program in different states a multiregional model consisting of different states/regions could give better insights into the potential benefits of the program across different states/regions. However, such extensions would require additional data and a different modeling framework, and these extensions are beyond the scope of the present study. Future research in this area could focus on these aspects.

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Table 1: Performance of MGNREGA (2006-07 to 2009-10)

	2006-07 (200 districts)	**2007-08** (330 districts)	**2008-09** (615districts)	**2009-10** (619 districts till Sep. 2009)
Households employed (crore)	2.10	3.39	4.51	3.26
Man-days of employment generated (crore)	90.50	143.59	216.32	128.24
Work provided per year to households who worked (days)	43.00	42.00	48.00	39.00
Central release (Rs crore)	8,640.85	12,610.39	29,939.60	16,006.23
Total funds available (including opening balance) (Rs crore)	12,073.55	19,305.81	37,397.06	28,664.31
Budget outlay (Rs crore)	11,300.00	12,000.00	30,000.00	39,100.00
Expenditure (Rs crore)	8,823.35 (0.21)	15,856.89 (0.32)	27,250.10 (0.48)	15,737.40 (0.24)
Average wage per day (Rs)	65.00	75.00	84.00	88.00
Total works taken up (lakh)	8.35	17.88	27.75	25.21
Works completed (lakh)	3.87	8.22	12.14	6.39

Source: Mid-term appraisal of the Eleventh Five Year Plan, Planning Commission (2010); figures in parentheses are percentages of current GDP

Table 2: Estimates of poverty and inequality impact of rural EGS during the lean season in India

	Headcount index (%)		**Poverty gap**	**Squared poverty gap**	**Gini**
	Lean season	**Annual**	**Index (x100)**	**Index(x100)**	**Index**
Pre-EGS	**37.3**	**34.0**	**8.3**	**2.7**	**0.261**
Post EGS at wage rate (Rs/day):					
25	34.8	33.4	7.4	2.3	0.255
30	32.5	32.8	6.7	2.1	0.251
35	29.8	32.1	6.0	1.8	0.247
40	26.9	31.4	5.3	1.6	0.246
45	24.4	30.7	4.9	1.5	0.247
50	22.7	30.3	4.5	1.4	0.250
55	21.4	30.0	4.3	1.3	0.256

Source: Murgai and Ravallion (2005). Notes: Poverty measures based on distribution of per capita expenditures from the 1999-00 Employment- Unemployment NSS survey and estimated using the Official Planning Commission poverty lines. Wage rates are in 1999-00 Rs.50 Rs/day is the comparator to the Rs.60 figure discussed for the national EGS in 2005.

Table 3: Estimated gross fiscal costs of full and lean season guarantees for India

EGS wage rate (Rs./day)	300 day guarantee (percent of GDP)	100 day guarantee (percent of GDP)
40	3.7	1.3
45	4.3	1.5
50	4.9	1.7
55	5.5	1.9

Source: Murgai and Ravallion (2005). Note: (i) wages in 1999-00 rupees (ii) assumes inelastic demand.

Table 4: Composition of output, exports and imports (percent)

Sector	Share of GDP (at factor cost)	Share of exports	Share of imports
Agriculture	23.76	5.79	2.37
Mining	2.60	1.03	25.57
Manufacturing 1	5.31	16.94	6.17
Manufacturing 2	11.04	41.99	51.02
Construction	6.39	0.00	0.00
Electricity	2.17	0.00	0.00
Transport	7.35	8.78	3.94
Trade	14.72	13.40	0.93
Financial services	11.02	0.45	0.91
Commercial services	15.64	11.62	9.08
TOTAL	100	100	100

Source: Pradhan et al (2006)

Table 5: Factor income and population shares of domestic institutions

	Rural labour (percent)	Urban labour (percent)	Capital (percent)	Share of total population ** (percent)	Share of rural/urban poor population** (percent)
Rural non-agricultural self employed (RH1)	18.57	2.21	6.56	10	12
Rural agricultural labour (RH2)	31.96	5.61	0.08	23	48
Rural other labour (RH3)	2.95	0.52	0.80	5	7
Rural agricultural self employed (RH4)	20.59	7.89	29.39	27	28
Rural other households (RH5)	11.25	11.48	8.11	7	5
Urban self-employed (UH1)	2.86	9.67	12.71	11	45
Urban salaried (UH2)	6.80	57.60	2.61	11	20
Urban casual labour (UH3)	4.22	3.59	1.14	4	31
Urban other households (UH4)	0.35	1.43	4.08	2	5
Private enterprises	0.00	0.00	6.80		
Public enterprises	0.00	0.00	3.48		
Government	0.00	0.00	3.39		
TOTAL	100	100	79.16*	100	

*Notes: Calculations based on Pradhan et al (2006); *Remaining capital income goes to rest of the world; **Based on Sundaram and Tendulkar (2003)*

Table 6: Short Run Macro Effects

	Unit	SIM1	SIM 2	SIM 3	SIM 4	SIM 5	SIM 6	SIM 7
Transfer/subsidy amount	billion rupees	116.30	116.30	116.30	NA	116.30	116.30	116.30
GDP change	billion rupees	93.36	8.57	98.18	-4.82	88.54	135.06	1.99
Aggregate welfare change (equivalent variation)	billion rupees	118.68	11.35	121.45	-2.76	115.92	113.54	41.64
Household welfare change (equivalent variation)								
RH1	billion rupees	12.15 (1.7)	3.24 (0.5)	12.35 (1.7)	-0.19 (0)	11.95 (1.7)	11.92 (1.7)	2.38 (0.3)
RH2	billion rupees	60.15 (3.5)	38.74 (2.3)	60.68 (3.5)	-0.53 (0)	59.62 (3.5)	29.87 (1.7)	6.57 (0.4)
RH3	billion rupees	8.56 (4.1)	6.13 (2.9)	8.60 (4.1)	-0.05 (0)	8.51 (4.0)	2.70 (1.3)	0.57 (0.3)
RH4	billion rupees	28.29 (2.1)	12.37 (0.9)	28.82 (2.1)	-0.53 (0)	27.75 (2.1)	20.46 (1.5)	4.77 (0.4)
RH5	billion rupees	6.86 (0.7)	-4.95 (-0.5)	7.16 (0.7)	-0.30 (0)	6.55 (0.6)	12.52 (1.2)	5.02 (0.5)
Rural	**billion rupees**	**116.01**	**55.53**	**117.61**	**-1.6**	**114.38**	**77.47**	**19.31**
UH1	billion rupees	0.08 (0)	-8.40 (-0.9)	0.40 (0)	-0.32 (0)	-0.24 (0)	8.10 (0.9)	1.99 (0.2)
UH2	billion rupees	1.86 (0.1)	-29.83 (-0.9)	2.62 (0.1)	-0.75 (0)	1.11 (0)	23.97 (0.7)	19.94 (0.6)
UH3	billion rupees	0.68 (0.2)	-3.60 (-1.2)	0.76 (0.3)	-0.08 (0)	0.60 (0.2)	3.57 (1.2)	1.45 (0.5)
UH4	billion rupees	0.07 (0)	-2.34 (-0.9)	0.07 (0)	-0.00 (0)	0.06 (0)	0.42 (0.2)	-1.03 (-0.4)
Urban	**billion rupees**	**2.69**	**-44.17**	**3.85**	**-1.15**	**1.53**	**36.06**	**22.35**
Wage rate								
Rural labour	percent change	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urban labour	percent change	-1.17	-0.10	-1.12	-0.05	-1.22	0.29	0.44
Capital	percent change	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Factor income								
Rural labour	percent change	0.78	0.18	0.76	0.01	0.79	1.46	0.42
Urban labour	percent change	0.01	-0.02	0.06	-0.04	-0.03	1.04	0.76
Capital	percent change	0.94	0.05	0.96	-0.03	0.91	1.71	0.90
Factor supply								
Rural labour	percent change	0.78	0.18	0.76	0.01	0.79	1.46	0.42
Urban labour	percent change	1.18	0.06	1.17	0.01	1.19	0.76	0.30
Capital	percent change	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fiscal deficit	percent change	5.20	-0.19	5.20	-0.02	5.20	5.90	6.60

**Figures in parentheses are equivalent variation relative to base level consumption expenditure in percent*

Table 7: Short run effects on production and prices (percent change relative to baseline)

	SIM1	SIM2	SIM 3	SIM 4	SIM 5	SIM 6	SIM 7
Production							
Agriculture	1.02	0.24	1.08	-0.05	0.97	1.45	0.18
Mining	0.26	0.01	0.26	0.00	0.26	0.14	0.06
Manufacturing!	0.97	0.19	1.00	-0.03	0.94	0.98	0.06
Manufacturing2	0.46	0.02	0.46	0.00	0.46	0.26	0.79
Construction	0.05	0.00	0.05	0.00	0.05	0.04	0.02
Electricity	0.80	0.09	0.81	-0.01	0.80	0.59	0.38
Transport	0.85	0.02	0.86	-0.01	0.84	0.64	0.30
Trade	0.76	0.02	0.77	-0.01	0.75	0.60	0.09
Financial services	0.65	-0.08	0.65	0.00	0.64	0.47	0.18
Commercial services	0.57	-0.02	0.57	0.00	0.57	0.39	0.09
Consumer price							
Agriculture	0.33	0.11	0.22	0.11	0.44	-1.52	0.11
Mining	0.00	0.00	0.00	0.00	0.00	0.46	-0.30
Manufacturing1	0.10	0.00	0.10	0.00	0.10	0.00	0.00
Manufacturing2	-0.20	0.00	-0.20	0.00	-0.30	0.49	-1.78
Construction	-0.32	-0.08	-0.32	-0.08	-0.40	0.24	-0.40
Electricity	0.00	0.00	0.00	-0.11	-0.11	0.76	0.11
Transport	-0.20	0.00	-0.10	0.00	-0.20	0.61	-0.20
Trade	0.25	-0.13	0.25	-0.13	0.13	0.89	0.38
Financial services	0.69	-0.35	0.69	0.00	0.52	1.38	0.69
Commercial services	-0.63	-0.08	-0.55	-0.08	-0.63	0.39	0.00

Source: Author

Table 8: Long run macro effects

	Unit	SIM1	SIM2	SIM 3	SIM 4	SIM 5	SIM 6	SIM 7
Transfer amount	billion rupees	116.30	116.30	116.30	NA	116.30	116.30	116.30
GDP change	billion rupees	123.99	11.28	127.58	-3.59	120.41	161.84	-14.19
Aggregate welfare change (EV)	billion rupees	134.48	12.05	136.72	-2.23	132.24	130.41	35.06
Household welfare change (EV)								
RH1	billion rupees	13.32 (2.1)	3.52 (0.5)	13.45 (2.1)	-0.14 (0)	13.18 (2.0)	13.34 (2.1)	1.93 (0.3)
RH2	billion rupees	63.22 (4.1)	39.43 (2.5)	63.60 (4.1)	-0.37 (0)	62.84 (4.0)	33.57 (2.2)	5.54 (0.4)
RH3	billion rupees	8.86 (4.5)	6.15 (3.1)	8.90 (4.5)	-0.03 (0)	8.83 (4.5)	3.07 (1.6)	0.47 (0.2)
RH4	billion rupees	30.32 (2.4)	12.83 (1.0)	30.69 (2.5)	-0.37 (0)	29.94 (2.4)	23.02 (1.8)	3.66 (0.3)
RH5	billion rupees	8.49 (0.9)	-4.86 (-0.5)	8.73 (0.9)	-0.24 (0)	8.24 (0.9)	14.28 (1.5)	4.33 (0.4)
Rural	**billion rupees**	**124.21**	**57.07**	**125.37**	**-1.15**	**123.03**	**87.28**	**15.93**
UH1	billion rupees	1.59 (0.2)	-8.34 (-0.9)	1.84 (0.2)	-0.25 (0)	1.34 (0.2)	9.73 (1.1)	0.90 (0.1)

UH2	billion rupees	7.10 (0.2)	-30.68 (-0.9)	7.84 (0.3)	-0.74 (0)	6.36 (0.2)	28.59 (0.9)	18.43 (0.6)
UH3	billion rupees	1.16 (0.4)	-3.56 (-1.3)	1.23 (0.5)	-0.07 (0)	1.10 (0.4)	4.08 (1.5)	1.28 (0.5)
UH4	billion rupees	0.43 (0.2)	-2.43 (-0.9)	0.44 (0.2)	-0.01 (0)	0.43 (0.2)	0.73 (0.3)	-1.48 (-0.6)
Urban	**billion rupees**	**10.28**	**-45.01**	**11.35**	**-1.07**	**9.23**	**43.13**	**19.13**
Wage rate								
Rural labour	percent change	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urban labour	percent change	-1.29	-0.10	-1.24	-0.10	-1.34	0.19	0.48
Capital	percent change	1.14	0.00	1.14	0.00	1.14	2.09	0.76
Factor income								
Rural labour	percent change	0.99	0.18	0.98	0.01	1.01	1.69	0.43
Urban labour	percent change	0.18	-0.01	0.22	-0.04	0.14	1.25	0.73
Capital	percent change	1.22	0.09	1.24	-0.02	1.20	2.07	0.87
Factor supply								
Rural labour	percent change	0.99	0.18	0.98	0.01	1.01	1.69	0.43
Urban labour	percent change	1.45	0.08	1.43	0.01	1.46	1.05	0.24
Capital	percent change	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fiscal deficit	percent change	5.10	-0.17	5.10	-0.02	5.10	5.80	6.50

Source: Author

Table 9: Long run effects on production and prices (percent change relative to baseline)

	SIM1	SIM2	SIM 3	SIM 4	SIM 5	SIM 6	SIM 7
Production							
Agriculture	1.32	0.32	1.36	-0.04	1.28	1.83	0.08
Mining	0.18	0.00	0.18	0.00	0.18	-0.07	-0.12
Manufacturing!	1.22	0.24	1.24	-0.02	1.20	1.23	-0.05
Manufacturing2	0.46	0.01	0.46	0.00	0.46	0.24	1.00
Construction	0.06	0.00	0.06	0.00	0.06	0.05	0.02
Electricity	0.91	0.10	0.92	-0.01	0.90	0.68	0.42
Transport	0.98	0.03	0.99	-0.01	0.97	0.77	0.27
Trade	0.95	0.02	0.96	-0.01	0.94	0.79	0.07
Financial services	0.91	-0.16	0.92	-0.01	0.90	0.72	0.23
Commercial services	0.65	-0.02	0.65	0.00	0.65	0.48	0.04
Consumer price							
Agriculture	0.23	0.00	0.12	0.12	0.23	-2.10	0.23
Mining	0.21	0.00	0.21	0.00	0.21	1.04	-0.62
Manufacturing1	0.10	0.00	0.10	0.00	0.10	0.00	0.10
Manufacturing2	0.00	0.00	0.00	-0.11	0.00	0.79	-2.60
Construction	-0.09	0.00	-0.09	-0.09	-0.09	0.54	-0.45
Electricity	0.11	0.00	0.11	-0.11	0.00	1.00	-0.11
Transport	0.00	0.00	0.00	0.00	-0.10	0.80	-0.20
Trade	0.11	0.00	0.22	0.00	0.11	0.89	0.56
Financial services	0.39	0.00	0.39	0.00	0.39	1.42	0.52
Commercial services	-0.50	0.00	-0.42	-0.08	-0.50	0.58	0.00

Source: Author

Table 10: Social Accounting Matrix for 2002-03 (billion rupees)

	AGR	MIN	MANU1	MANU2	CONS	ELEC	TRNS	TRD	FINSERV	COMSERV	RLAB	ULAB	CAP	RH1	RH2	RH3	RH4	RH5	UH1	UH2	UH3	UH4	PVTENT	PUBENT	GOVT	SAVINV	ROW	TOT
AGR	828	2	1285	145	97	8	27	277	2	134				438	734	99	1189	453	483	583	101	92			18	-32	227	7189
MIN	2	9	35	1067	162	142	2	11		95				2	3	1	3	3	2	3	1	2			2	304	40	1892
MANU1	54	6	684	173	101	8	32	132	28	172				264	435	63	704	296	324	422	68	71			29	189	665	4921
MANU2	338	68	353	2674	796	104	782	168	28	873				74	91	19	216	116	131	257	23	35			154	1550	1648	10498
CONS	23	9	14	18	21	31	76	17	102	54															89	2890		3344
ELEC	20	22	114	255	50	286	209	51	27	64				21	34	5	49	23	27	32	10	7			46	2		1353
TRNS	100	21	256	358	224	110	163	209	65	178				130	159	29	412	150	224	394	38	62			78	99	345	3806
TRD	151	11	374	490	200	70	177	84	33	232				172	211	38	547	199	296	523	50	82			33	261	526	4764
FINSERV	43	10	198	350	139	54	122	163	130	169				95	148	33	297	225	242	534	44	137			27	2	18	3180
COMSERV	-3	13	101	170	68	37	334	187	159	585				180	287	46	602	358	345	756	67	153			1619	77	456	6594
RLAB	2776	87	347	289	700	40	314	394	2	315																		5264
ULAB	691	63	339	932	452	153	560	805	425	2211																		6631
CAP	2062	454	550	1347	334	312	836	2225	2138	1114																		11374
RH1											977	146	746												138		27	2035
RH2											1682	372	9												119		39	2221
RH3											155	34	91												61		8	350
RH4											1084	524	3342												402		24	5376
RH5											592	761	923												97		77	2450
UH1											150	641	1446												213		275	2726
UH2											358	3820	297												300		196	4971
UH3											222	238	130												26		15	631
UH4											19	95	464												51		194	822
PVTENT													774												80			854
PUBENT													396															396
GOVT													386	28			274	126		158	198	43	590				-25	1777
SAVINV													2262	631	120	16	1082	500	652	1308	31	139	264	396	-1804		-255	5341
ROW	104	1117	270	2230			172	41	40	397	23		108															4370
TOT	7189	1892	4921	10498	3344	1353	3806	4764	3180	6594	5264	6631	11374	2035	2221	350	5376	2450	2726	4971	631	822	854	396	1777	5341	4370	

Source: Based on Pradhan et. al. (2006)

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