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REVIEW ON MEASUREMENT OF EXCHANGE RATE PASS-THROUGH IN INDIA

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ABSTRACT

Once the increasing openness of an economy is taken into account, the role of foreign exchange rate becomes critical in determining its macroeconomic behaviour and outcomes. Among the various channels through which foreign exchange rate can affect an economy, the process by which it can impact domestic inflation including the degree, scope, feedbacks and lags in this process, has been broadly called Exchange Rate Pass Through. The literature on this issue is vast in the international context and is also growing continuously in the Indian context. In particular, the dimension of measurement of Exchange Rate Pass Through plays a critical role in the empirical analysis in this area primarily because of the high-degree of sensitivity of the final results to the ways in which the major variables were conceptualized and measured in the first place. Thus, this paper undertakes a review of the major evidences on Exchange Rate Pass Through in the Indian context with a special emphasis on the definitional and applied theoretical issues that emerge through this survey. It was found that the measurement strategies in this area are diverse, complex and context-specific and that despite disagreements on the best way to measure Exchange Rate Pass Through, there are several broad patterns of analysis that are common to all the major studies in this area of research.

Keywords: Exchange Rate, Exchange Rate Pass Through, Inflation, Open Economy Macroeconomics.

1. INTRODUCTORY NOTE

An important outcome of the Keynesian revolution of the 1930s was the recognition of the fact that the presumption of strict theoretical independence between the real and nominal economic

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systems might not always hold once the underlying assumptions of the classical macroeconomic system were relaxed. In particular, in the short run, when price and information rigidities might be prevalent, the real and nominal spheres of economic life could interact closely with each other both theoretically and empirically. Furthermore, when the increasing openness of economies was taken into account, macroeconomic research globally had to account for the international linkages for more meaningful interpretation of policies. Operation of foreign exchange markets and rates thereof were such important links and their impact on and relationships with the domestic economy continue to be matters of intense research and debates.

Among the various channels through which foreign exchange rate could affect domestic economy, the ways in which the international prices of a country were affected by nominal exchange rates received considerable attention in the international macroeconomic literature roughly beginning with the landmark works of Magee (1973), Dornbusch (1985), etc. With time this framework of analysis took into account several other dimensions of the interconnections between exchange rate variations and domestic inflation. Hence, the empirical relationship between exchange rate and inflation, and the degree, scope, feedbacks and lags in this process, have been broadly called the process of Exchange Rate Pass-Through (ERPT[1]). Historically, ERPT was associated with the inter-connections between the exchange rate and international prices and in particular with the import prices, but off-lately the chain of impact of exchange rate changes have been extended to the movements in domestic inflation via the variations in import prices as well to the impact of exchange rate movements on the pricing behaviour of domestic exporters. International literature has termed the earlier framework as Stage I pass-through while the impact of import price movements on domestic inflation has been called the Stage II pass-through[2]. Consequently, the combination of these two processes that links exchange rate changes with domestic inflation[3] has been called ERPT.

Operationalization of ERPT in applied macroeconomic research has been another area of concern and continuous refinement. While the theoretical framework linking exchange rate and domestic inflation appears to be well-established, the strategies deployed in quantifying this concept have been multi-fold and ever evolving. The nature, measurement, scope, lags, determinants and other such facets of ERPT have been an area of intense debate globally while the evidences in the Indian context are still probably in an early stage of development. Moreover, ERPT is also closely related to numerous other macroeconomic issues such as the Balance of Payments adjustment process, monetary policy conduct, etc. and hence poses a challenging and gigantic task for any researcher in locating those economic forces that are more important for the analysis of ERPT and which do not overlap with the factors determining other macroeconomic phenomena. Thus, it becomes critical to understand the conceptual and empirical dimensions of ERPT as applicable to a small open economy like India and evaluate the evidences that have

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been accumulated so far. In particular, the dimension of measurement of ERPT requires special attention because not only is it the starting point for examining other related issues such as the determinants of pass-through, asymmetry and non-linearity in its response to various kinds of exchange rate changes, etc., but also because it is tightly anchored to the ways in which various macro policy measures are conducted.

The dimension of ERPT measurement poses at least two sets of closely inter-related issues. First, how have the various studies defined and measured exchange rate, import prices, export prices, domestic inflation, etc. and, what have been the period of analysis, frequency of data among other issues. Such concerns may be clubbed together as the "definitional considerations" in ERPT measurement; and second, what have been the theoretical and empirical links between these fundamental constituents of ERPT which may be called the "applied theoretical framework". These two frameworks are tightly linked because, for example, with a given conceptual framework, even a slight change in the definition of either of the constituents of ERPT can lead to sizeable differences in the estimated results. Thus the various approaches, issues and strategies utilized by the Indian evidences in conceptualizing and operationalizing ERPT provide the central organizing theme for this paper. After a brief introduction on this issue, Section 2 undertakes a detailed review of the various evidences on this matter in the Indian context. Thereafter, Section 3 examines the various conceptual and empirical dimensions that can be extracted from the review undertaken so far and finally the last Section concludes this paper.

2. EVIDENCES OF ERPT MEASUREMENT AND RELATED DIMENSIONS

What follows is a brief survey of the two major issues related to ERPT measurement as mentioned above namely the definitional and conceptual frameworks used for the estimation of ERPT. *Prima-facie* it can be noted that ERPT has basically been interpreted as an Elasticity measure showing the responsiveness of domestic prices to exchange rate variations. However, the use of different methods such as Vector Auto Regression (VAR), Simultaneous Equation Models, etc. make it difficult to strictly interpret the observed coefficients as measures of simple elasticities as is the case with traditional single-equation-based OLS regressions. Such concerns have primarily motivated the following review.

One of the earliest studies examining the phenomenon of ERPT was Krishnamurty and Pandit (1996). Within their larger aim of building a macroeconometric model for examining the determinants of international trade flows of India at a disaggregate level, the effects of the links between exchange rate, international prices and domestic prices, on trade deficit were investigated. The explicit inclusion of this inter-linkage, which was termed as ERPT in the paper, also signified a marked break from the trend of underplaying the importance of ERPT in the

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context of Indian trade flow analysis that had persisted so far. They measured exchange rate as a nominal bilateral exchange rate index with base year 1980-81. Domestic prices were measured by the Wholesale Price Index (WPI). Import and Export prices were measured by unit value indexes. The study period was from 1970-71 up to 1990-91. Various simulations were undertaken to understand the alternative scenarios of trade flow behaviour in India. It was found that devaluation of exchange rate decreased the trade deficit in domestic currency.

Dholakia and Saradhi (2000) investigated the extent of ERPT in both import and export sectors of India using quarterly data from 1980 to 1996 and analyzed the extent of ERPT to India's export and import volumes, export and import prices, and trade balance. In order to pursue these empirical objectives, the study analyzed the impact of exchange rate changes on the import price and export price separately. The coefficient of the logarithm of exchange rate with respect to import price index as a dependent variable signified the extent of direct-pass through to the importing country. Similarly, the coefficient of the logarithm of exchange rate with respect to export price as a dependent variable measured the extent of pass-through to the exporting country. The authors used unit value index as a measure for import and export prices respectively which were collected from official published data and was frequency of data was quarterly. For measuring the exchange rate variable, the study had constructed two different Nominal Effective Exchange Rate indexes using separate weights for each. The shares of the top four trading countries, namely the U.S., the U.K., Germany and Japan, in the total import and total export of India were used as weights to construct two series of NEER, namely one for aggregate export and the second for aggregate import. The index was based on geometric mean of bilateral exchange rates of Indian currency with the trading countries. It should however be kept under notice that the measure of ERPT in this study was a part of a larger equation consisting of many other determinants of Import and Export prices. A single equation framework was used with four separate equations for price of import, quantity of imports, price of export, and quantity of exports. Hence, the coefficient of interest here contained only partial information of the impact of exchange rate changes on the international prices while ignoring the effects of other variables. The extent of ERPT might have shown considerable divergence from achieved results were a simultaneous system to be used. On account of ERPT to import price, the study found that there was full pass-through with the concerned coefficient being 1.29 and not being significantly different from unity. Thus the authors concluded that at the aggregate level, Indian import sector was a price taker characterized by lack of any market power or 'pricing to market' phenomenon. However, exchange rate changes were found to have had no significant impact on import quantities. In case of export prices, the estimated pass-through was found to be 0.30 which worked out to be significantly less than unity but it increased to 0.7 after 1991. As the post-1991 value of ERPT to export prices was found to be not significantly different than 0.9 (with 0.1 being the adjustments in import intensity of exports and hence in total being full pass-through at

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1), the hypothesis of complete ERPT to export prices could not be rejected. Lastly, export quantities were found to be positively and significantly affected by exchange rate changes. The study thus focused on the Stage-I ERPT while ignoring the impact of international prices on domestic inflation and the direct effects of exchange rate changes on domestic inflation. This probably weakened the conclusiveness of the results obtained in the study though its findings were appreciable in the light of the then-prevailing data and methodological environments.

Patnaik, Kapoor and Dhal (2003) undertook an examination of the macro-interactions between output gap, inflation rate, interest rate, exchange rate depreciation, food-grain inflation and fuel price inflation for the period April 1993 up to March 2002 on monthly data. Within their broader Structural Vector Auto Regression (SVAR) framework, the study also focused upon the relationship between exchange rate and domestic inflation. Here, exchange rate was measured by nominal bilateral exchange rate between the Indian rupee and U.S. Dollar and the inflation rate as the year-on-year and seasonally adjusted monthly Wholesale Price Index. The analysis based on the initial impulse in exchange rate, i.e. a depreciation of nominal exchange rate, produced interesting results. The inflation rate actually declined for the initial few months. However, after around 6 months of lag, the inflation rate showed an increase and stabilized at a higher level than the initial level of inflation after around 34 months since the exchange rate depreciation. The analysis however did not examine the transmission channel via which exchange rate changes translated into inflationary movements. Import prices are generally considered to be the key channel for this transmission but its role in the process of ERPT was not examined. It is also important to point out that the study conducted an analysis of ERPT in a VAR framework and hence deriving a reliable measure of the elasticity of current domestic inflation to current exchange rate changes was not possible.

Mallick and Marques (2006) examined the extent of ERPT to import prices and export prices at sector specific levels. The analysis was focused on the Stage-I pass-through only, i.e. that of exchange rate changes to international prices and not to domestic inflation. This paper modified the traditional pricing-to-market models into a pricing-to-products variety with the variation of mark-ups embodied in export prices for each major sector of country's export industry being analysed. The study used panel regression model on annual data for two time periods, namely, 1980-1990 and 1991-2001. This was done to analyze any structural breaks after the package of economic reforms in 1991 and existence of differences between the extents of ERPT in the two time-periods. Further, ERPT to export prices was defined as the elasticity of export price (measured in domestic currency) to exchange rate changes, while ERPT to import price was measured as the elasticity of import price (measured in domestic currency) to exchange rate changes. The mark-up coefficient that was assumed to be embodied in the export price was expressed in terms of the local currency and was proxied by the constant term in the export

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equation. Exchange rate was defined as the nominal bilateral Rupee/Dollar exchange rate. Import and export prices were measured as Unit Value indexes of imports and exports. The study justified the use of bilateral exchange rate on account of dominance of U.S. as the trading partner particularly on the export side. On account of pass-through to import prices, the analysis found that there was no conclusive evidence on whether the pass-through to import prices was full or absent, but there was a decline in it in the 1990s compared to the 1980s. Moreover, the analysis at sectoral level for the 1980s revealed that there was full or more-than-full pass-through in three import sectors namely, Crude Materials, Inedible, Except Fuels (SITC 2), Food & Live Animals (SITC 0), and Animals and Vegetable Oils, Fats, & Waxes. This was so only for one sector i.e. the Crude Oils (SITC 2) sector for the 1990s. In case of the export price, the investigation revealed that pass-through to foreign currency export price was more than-than-full for the 1980s while it was partial for the 1990s. The sectoral analysis of pass-through to export prices showed that India was increasingly tending towards a price-making player in all the major export sectors except in case of Beverages & Tobacco (SITC 1), Chemicals and Related Products (SITC 5) and Crude Materials, Inedible, Except Fuels where it was probably evident that India was still a price-taker. The study could have utilized the NEER and the differences in the ERPT in both the cases, with the nominal bilateral exchange rate and NEER, could have been compared to see if statistically significant differences existed between them.

Ghosh and Rajan (2007) estimated the aggregate pass-through of exchange rate changes to aggregate domestic inflation for the period 1980 up to 2005 using quarterly data. Exchange rate was measured by both the nominal bilateral US dollar exchange rate as well as the NEER. Domestic inflation was defined as the quarterly aggregate Consumer Price Index for India. All the data were seasonally adjusted using the Census X-12 methodology. Regression analysis in double logarithmic form was employed with the first equation linking the logarithm of India's CPI with bilateral Rupee/U.S. Dollar exchange rate and the second equation linking the logarithm of India's CPI with NEER while both took into account other possible determinants of CPI too. ERPT was thus defined as the coefficient expressing the relationship between the logarithm of exchange rate variable and the CPI. Estimation of ERPT was done for three different periods in time. Primarily, it investigated for the whole period under consideration from 1980 up to 2005 and then the period was subdivided into 1980Q1 to 1990Q4 and 1992Q1 to 2005Q4. Long-run ERPT was estimated using regression in level form data despite evidences of non-stationarity. This was justified on the basis of the Johansen co-integration method which showed the existence of a stable linear relationship among the variables in level form itself. Error Correction Model (ECM) was used to estimate short-run ERPT to CPI. Estimated long-run pass-through of the bilateral exchange rate to CPI was 43 percent when US PPI was used to measure foreign cost while it reduced to 41 percent when US CPI was used instead. In case of NEER, statistically insignificant coefficients were found in all specifications and hence no evidence of

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pass-through was visible. Short-run pass-through in case of bilateral exchange rate with US PPI and US CPI respectively was found to be 10 percent and 9 percent respectively.

The analysis of the extent of ERPT to both WPI and CPI in India, within their larger aim of understanding the macro-connections between oil prices, output gap, exchange rate, monetary policy and domestic inflation, was undertaken by Bhattacharya, Pattnaik, Shah (2008) for the period September 1997 up to October 2007. The lags and the duration of the impact were also empirically scrutinized along with a focus on the long-run relationship between exchange rate movements and domestic inflation. A recursive VAR approach in the first difference form was utilized to investigate the above issues. The long-run relationship between the variables was accounted for by using Vector Error Correction Mechanism (VECM). Exchange rate was measured as the nominal rupee/Dollar bilateral exchange rate domestic inflation by WPI and CPI monthly data. ERPT was measured as the elasticity of domestic prices to the log of exchange rate. Seasonal adjustments in the relevant variables were undertaken by using X-11 ARIMA method. The authors found moderate pass-through to CPI and WPI both. Long-run ERPT to CPI was 3.7-17 percent while for WPI it was 28.6 percent. Not accounting for monetary policy in the VAR framework showed that a larger proportion of a 100 percent exchange rate shock was transmitted to CPI within a lag of two years. In case of WPI, only 1.3 percent of the 100 percent exchange rate shock was passed into after a lag of two years. Incomplete pass-through was thus found.

The advent of economic reforms marked a critical juncture in the international environment facing the Indian economy. It thus became important to understand the extent to which reforms affected the degree of ERPT and Khundrakpram (2008) focused on the analysis of the same. Exchange rate was defined as NEER and domestic inflation as WPI. Monthly data from January 1990 up to March 2005 were used. The author stressed that the data frequency of WPI, its popularity as the headline inflation, etc. motivated them to employ the same to measure domestic inflation. All the data were seasonally adjusted. There were four models employed with different combinations of the sum of current and lagged values of variables such as inflation rate, exchange rate, marginal cost of the exporting firm (measured as trade weighted foreign price), domestic demand conditions, food price shock, and money stock. The fourth model consisted of all the above variables. Both the short and long run pass-though coefficients were estimated. All variables were tested for non-stationarity and were found to be stationary in first difference form. Incomplete pass-through of exchange rate changes was observed to domestic inflation in all the models used. Short-run pass-through was in general found to be lower than long-run pass-through. The long-run pass-through was particularly found to have increased during the study period.

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While most of the above studies have focused on the extent of ERPT into import prices and domestic prices, Mallick and Marques (2008) investigated the extent of pass-through into export prices quoted in foreign currency by the Indian exporters. This analysis was undertaken at both aggregate and sectoral levels with 34 sectors being covered based on the Standard International Trade Classification (SITC). Annual (financial year) data from 1980-81 to 2001-02 were employed. Deriving their measure of coefficient of ERPT from a typical profit-maximizing function of a representative exporting firm, a value of zero for this coefficient indicated full pass-through in foreign currency terms while vice versa if the value were found to be one. A critical assumption underlying their construction of the coefficient of ERPT was that exchange rate changes did not affect the domestic exporters' cost of production. Exchange rate was measured as 36-currencies weighted NEER (weights being the relative shares of these currencies in India's total external trade) and export prices as unit value indexes of exports, both aggregate and sector-wise. For domestic inflation rate, WPI was utilized. Export data were free on board (f.o.b.) while import data was cost, insurance and freight (c.i.f.) based. The analysis used a panel regression framework. The final equation regressed the change in the log of export prices (in rupees) against the change in log of NEER, Marginal Cost and sectoral export shares, as well as against a macroeconomic policy index that was constructed using information on fiscal deficit, inflation and trade openness. Differentials in ERPT coefficient between 1980s and 1990s were also analyzed. The authors found incomplete pass-through of exchange rate changes into India's export prices quoted in foreign currencies. In terms of the disaggregated behaviour of ERPT, the results varied for different industries and for the two time-periods namely 1980s and 1990s, with many sectors showing incomplete to no pass-through, though some displayed evidence of full pass-through into foreign prices of Indian exports. This was found to be particularly true for the 1980s.

Dash and Narasimha (2011) analyzed ERPT to both import and export prices with reference to India using quarterly data for the period 1993 (Q2) up to 2004 (Q3). Import and Export prices were measured by unit value indexes. The authors pointed out the inherent limitations of unit value indexes and noted that the changes in the underlying composition of the index, the problem of appropriate weighting factors, heterogeneity of the products, etc. were the major limitations of these indexes, but were used due to data constraints. Other variables such as the foreign cost of production (proxied by weighted average of Producer Price Index of major trading countries), domestic cost of production (WPI for India), domestic demand pressure (measured by the difference between trend level GDP and actual GDP), foreign demand pressure (measured by the weighted average of Index of Industrial Productions for seven major foreign countries with trade-based weights), price of import competing goods (India's WPI), were appropriately constructed by the authors. Finally, the exchange rate variable was measured as 36-currency trade-whetted NEER. Imperfect competition-based price-setting behaviour of exporting and

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importing firms were used to derive the underlying theoretical specification of the estimated export and import price models. Regression models in double-logarithmic form were employed for estimating exchange rate pass-through to both import and export prices. Data were found to be stationary in their first difference form. Co-integration and error correction models were used to estimate the extent of both short-run and long-run ERPT coefficients. Evidences showed that ERPT to export prices was incomplete and positive in the long-run and its value was 0.36. Price of competing commodities and cost of production both, were found to have a positive impact on export price. Evidence on partial existence of bargaining power with Indian exporters was thus found. Based on the ECM estimations, export price index was found to have a faster response to foreign competitor's price (price of international substitutes) rather than NEER itself. Short-run estimates showed that ERPT was 0.30 to export prices and hence a larger proportion of exchange rate changes were absorbed by the profit margins of the Indian exporters. As far as import price pass-through was concerned, more than complete pass-through was found with the exchange rate coefficient's value being 1.76 in the long-run. In the short-run however, exchange rate was found to have had no significant effect on import prices. The coefficient of foreign cost of production showed that it significantly and positively affected import price and acted as an important variable in the import-price making process of foreign exporters to India. This also provided some evidence that import markets of India were not characterized by high competition to foreign exporters and hence changes in cost of production for foreign firms were largely pass over to import prices in Indian currency.

Roy and Pyne (2011) undertook an empirical evaluation of the extent of ERPT to aggregate and sectoral export prices of India for the period 1960-2000. The authors used a simultaneous equation model to estimate the ERPT relationship. Annual data was used to estimate ERPT coefficients. Export price and export volume functions were constructed taking into account variables such as export prices relative to world price, world demand, and domestic supply capability as measured by Gross Domestic Product among others. Exchange rate variable was defined as NEER as evident in their operational form of the theoretical model, while it was REER that was specified as a determinant of real export demand in the underlying real export demand function. Export prices were measured by unit value indexes in home currency. Pass-through of NEER to unit value indexes of exports both at aggregate and product-group levels were estimated. Three product-groups were covered by the study other than aggregate exports namely, manufactured exports, chemical and related products and engineering exports. They found evidence of incomplete pass-through to aggregate export prices with the value of the ERPT coefficient being 0.57. For the product-groups, all product-groups showed incomplete pass-through though there were differences in the extent of ERPT with chemical exports showing the highest pass-through (value of the coefficient being 0.95). The authors noted that their estimation did not account for the nature and structure of export markets as a source of

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incomplete pass-through and that their results on structural breaks in the model could have changed if further time-periods were incorporated into the study.

Kapur and Behera (2012) took the empirical analysis of monetary policy transmission mechanism in India as its aim and, among other issues; they estimated ERPT, conceptualized as the impact of a one-unit change in exchange rate on domestic inflation, in order to investigate the efficacy of exchange rate channel for transmission of monetary policy shocks to output, demand and inflation in India. They undertook the empirical work within the New Keynesian framework by estimating backward-looking IS and Phillips relationships and a forward-looking monetary policy rule. The data period was from 2nd Quarter of 1996 up to 1st Quarter of 2011. Within their analytical framework, inflation was measured by year-on-year (y-o-y) changes in the WPI, exchange rate variable by y-o-y changes in bilateral nominal exchange rate of rupees against the U.S. Dollar. It must be noted that this variable entered as a determinant in two equations: first as a determinant of y-o-y changes in aggregate WPI of India and second as a determinant of y-o-y changes in WPI of Non-Food Manufactured (WPI-NFMP). They found that as far as aggregate WPI inflation was concerned, both the short-run and long-run pass-through coefficients were incomplete with their values being 0.06 (60 basis points) and 0.12 (120 basis points) respectively. The results were found broadly the same even if y-o-y- changes in the 36-currency trade-weighted NEER were employed instead. With reference to the y-o-y change in WPI-NFMP, NEER was found to have had significant effect while bilateral nominal exchange rate was found to be insignificant. A 10 percent change in NEER was found to have had 0.03 (30 basis points) and 0.08 (80 basis points) impact on changes in WPI-NFMP in the short and long runs respectively.

Kumar (2014) was an analysis of ERPT relationship within a VAR framework for the period June 1995 up to February 2013 using Monthly data. ERPT was modelled as the relationship between exchange rate movements on the one hand and changes in WPI and CPI on the other. Exchange rate was defined as the bilateral Rupee/USD rate. WPI and CPI as published by the RBI were used as measurements of domestic inflation. The study found that ERPT was positive for both WPI and CPI with an exchange rate shock having relatively more impact on CPI. Interestingly, energy prices were found to have had a cumulatively larger impact on WPI and CPI than exchange rate. ERPT coefficients were found to be insignificant.

Yanamandra (2014) was a detailed analysis of several macroeconomic pass-through phenomena including ERPT. ERPT was conceptualized as the relationship between exchange rate changes and import prices. Empirical investigation was done both at the aggregate and disaggregate levels. Monthly data was employed for the period January 2003 up to March 2013. Exchange rate was measured using both the nominal bilateral USD/Rupee exchange rate and 36-currency

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Trade-weighted NEER[4]. Import prices were measured by the Import Unit Value Index. The author estimated both the short-run and long-run estimates of ERPT to import price inflation. Using a Vector Error Correction Model (VECM) with import price inflation being a function of world CPI, IIP and NEER, short-run ERPT coefficient was found to be -1.16 (given that NEER was defined as number of foreign currency units per rupee), while long-run ERPT was -2.29. The author justified the existence of more than complete pass-through to aggregate Indian import price inflation in the long-run on the basis of the possibility of high inflationary expectations. Alternative specifications with National Stock Exchange (NSE) turnover, and both NSE turnover and IIP were also estimated. The short and long run coefficients in these cases were found to be broadly the same with similar signs of the coefficients. Alternatively, an index of nominal bilateral exchange rate was also used instead of NEER and the results were found to be robust to changes in the definition of exchange rate. The results were strikingly different at the one-digit SITC-based sectoral estimates of short run and long run ERPT coefficients. Sector specific import value indexes were employed while aggregate level cost and other variables were used. Except for the miscellaneous manufactured goods, coefficients were insignificant for all other sectors and some even had incorrect signs. Similar results were found even when the NEER was replaced by the bilateral exchange rate. Lack of use of sufficient sectoral information in the models and lack of inclusion of sector-specific mark-ups in the model were cited as possible causes of these results at the sectoral levels.

Mendali and Das (2016) undertook an empirical exercise of estimating ERPT to domestic prices in India using a VAR framework. The data used were monthly ranging from April 1992 up to November 2013. Domestic inflation for India was measured by WPI. Exchange rate was measured by the 36-currency trade-weight based NEER. The study used five variables and in the following order in the VAR model namely: oil price index as available from the *International Financial Statistics* of the International Monetary Fund (IMF), output gap as measured using the Hodrick-Prescott method, Broad money supply (M_3), NEER and finally WPI. All variables were used in logarithmic form. The study finds low degree of ERPT to WPI. The short run ERPT was found to be 0.011 per month following an exchange rate shock of 10 percent depreciation. The long-run value of ERPT was 0.6 which again substantiated the existence of incomplete pass-through. In terms of the Variance Decompostion undertaken to analyze the primary drivers of the observed impulse responses in WPI, domestic price shock and oil price shock were the major factors.

The following study was not undertaken in the Indian context but provided a glance of ERPT estimation in a non-linear framework and supplied considerable insights into how ERPT could be conceptualized in non-linear models. Soon, Baharumshah and Wohar (2017) was an empirical analysis of ERPT in six major Asian countries namely Thailand, South Korea, the Philippines,

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Indonesia, Japan and China. It was based on a panel threshold regression model using Inflation Volatility as the threshold parameter to divide the sample into low inflation volatility and high inflation volatility countries. Basically, this allowed for the examination of ERPT when inflation is relatively stable and an inflation-targeting monetary policy was being pursued versus when inflation is considerably volatile and hence targeting of inflation was not practiced by the monetary authorities. Accordingly, ERPT was estimated for both low and high inflation volatilities. The study used Quarterly data ranging from Quarter 1 of 1980 up to Quarter 3 of 2014. The authors used CPI for measuring domestic inflations in the chosen countries, nominal bilateral US dollar rate for measuring exchange rate variable and US Producer Price Index for measuring foreign prices by basing it on the year 2005. All these data were obtained from International Monetary Fund's publications. The study found the existence of a single threshold with the value of threshold parameter being 4.17. They observed that ERPT was close to 1 (value being 0.91) if inflation volatility crossed the threshold value, but could not find any evidence of zero pass-through in case volatility of inflation was below the threshold value.

3. SOME ISSUES AND REFLECTIONS

ERPT continues to garner active attention of international economists primarily because of its criticality "for the conduct of monetary policy, choice of exchange regime and the transmission of external shocks" (Soon et al., 2017). The above review has pointed out some of the important works in this area and the extent of debate and disagreements are quite evident if one looks across the major conclusions of the studies in the Indian context. While some studies conclude that ERPT was more than complete in the recent past for India (e.g. Yamanadra, 2015); others conclude near-complete (e.g. Dholakia, 2000), incomplete (e.g. Bhattacharya, Pattnaik, Shah, 2008) or sometimes even near to zero pass-through (e.g. Kapoor and Behera, 2012). It is fascinating to see such diversity of empirical results and this fact motivates a closer examination of how ERPT was defined and conceptualized by various analysts. The following section attempts to organize the major issues and themes pertaining to ERPT measurement based on the review of evidences undertaken above.

3.1. Definitional issues

3.1.1. Exchange rate variables

Among the bilateral and effective varieties of exchange rate variables, NEER appears to be the most frequently employed measure in ERPT estimation. The construction of NEER by concentrating on factors such as basket of currencies, economically meaningful and dynamic weighting patterns, use of more economic information than bilateral rates, etc. seem to have been the possible reasons behind its popularity in the present context. However, several studies have

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employed bilateral Rupee/U.S. Dollar exchange rate also, though, it is clear that NEER remains a variable of choice for ERPT to both international and domestic prices. Further, the divergence in the behaviour of bilateral nominal exchange rate and the NEER have been quite pronounced which make the final results of ERPT estimation particularly sensitive to how exchange rate was defined and measured in the first place.

3.1.2. International price variables

The measurement of import and export prices at aggregate levels has been undertaken mainly by using unit value indexes. The most critical source of information on unit value indexes of imports and exports in India is the trade indexes of goods as released by the Directorate General of Commercial Intelligence and Statistics (DGCIS), Government of India. The quality of measurement, coverage, weighting pattern, etc. of these data would determine how good the estimation of ERPT would be. These indexes are estimated using chain-base method and they employ fisher's ideal index number method for calculating the index values. The major limitations of these indexes emerge from not only the possible debates on methodological issues but also from the fact that they ignore services. Despite the non-inclusion of services, these indexes are the best available source of information on aggregate import and export prices. Another justification for using these indexes could be on account of difficulties in constructing a credible price index using disaggregated information for aggregate imports and exports. In the Indian scenario, there is a considerable lack of disaggregated price indexes for major internationally traded goods and services. Moreover the data that are available on this account too are limited in terms of their coverage and uniformity for macroeconomic aggregation. Interestingly, we could not find any study that attempted to construct its own measure of aggregate import and export prices in the Indian scenario as far as the analysis of ERPT is concerned.

3.1.3. Domestic inflation variables

Inflation measurement in India continues to be an issue of intense debate and research. With increasing sophistication of data collection agencies in India and the improvements in data collection mechanisms, considerable degree of coverage and improvements in accuracy of inflation data have been achieved in the recent past. However, owning to several limitations such as retention pricing, minimum support pricing, administered prices, very information on the changes in prices and weighting methodologies, price indexes used for measurement of inflation continue to be mere estimates which are to be carefully scrutinized before employing them. In case of ERPT, it is quite clear the WPI dominates the empirical landscape as far as the measurement of domestic inflation is concerned. However, some studies have also looked at CPI and also at the effects on both WPI and CPI of exchange rate variations. Barring few studies

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however, most analysts have conceptualized ERPT to domestic inflation as the impact of exchange rate changes on WPI. The trickle down of the spread of exchange rate changes across the entire pricing chain has received limited attention in the Indian context. Furthermore, the ways in which variability in inflation can be linked to variability in exchange rates has also been an area that has considerable future scope.

3.2. Applied Theoretical issues

3.2.1. Links between exchange rate, international prices and domestic inflation

The theoretical connections between exchange rates and import and export prices have been primarily derived from various extensions of the basic pricing model of an imperfectly competitive exporting firm. With the advent of the new open economy macroeconomics literature, use of currency pricing models such as Local Currency Pricing (LCP) and Producer Currency Pricing (PCP) models to explain the degree of ERPT to major developed economies also became an important element of the international research in this context. Historically and even in the Indian scenario, the studies concentrating on measurement and impact of ERPT have varied between so-called Stage-I and Stage-II pass-throughs. An important issue that has repeatedly emerged in this context has been the estimation of short-run and long-run ERPT coefficients. The time-dimension inherent in this issue presumes critical importance not only for macroeconomic analysis in general but also for macroeconomic policies in particular for understanding micro-foundations. In India, RBI has been pursuing some measure of inflation targeting aiming for low and stable prices in the medium to long run. Such a policy goal, among other things, requires the knowledge of ERPT to domestic inflation across different time horizons. Information on ERPT to international prices is also a critical element of the complete ERPT process and hence the ways in which international prices react to exchange rate movements provide critical, though only partial, information on the impact of exchange rates on domestic inflation. Several studies have focused on this issue in the Indian context and have found that in general the long run ERPT is higher and near-complete compared to short-run ERPT. Supply side bottlenecks such as wage-rigidity in the short-run have contributed to the deviation between short-run and long-run elasticities. It is important to note that in the Indian context the monetary authority has been pursuing a discretionary intervention into the FOREX market to maintain price stability and this has probably complicated the impact of ERPT on inflation. Most of the findings on the account of lags in ERPT process seem to be suggesting that there are significant lags in the transmission of exchange rate movements to international prices in India. Analysts have also found that the length of these lags varies across time and space. A common finding in the Indian context has been that the aggregate ERPT shows lengthier lags than disaggregated measures of ERPT. Many of the studies have found that microeconomic

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forces such as wage-rigidities play a central role in explaining the existence of non-instantaneous response of international prices to exchange rate changes. Considerable scope remains open in analyzing the micro-market forces in conjunction with macroeconomic factors and their impact on ERPT in the Indian context.

3.2.2. Methodological patterns across studies

There are a host of methods that have been used in the Indian context for estimating ERPT to either international prices or domestic inflation. Considerations of data constraints, usage of popular models, underlying theoretical considerations, etc. seem to have been the major factors determining the kind of estimation methodology followed. Broadly, the methods used till now in the Indian context can be classified into three types namely, single-equation methods, VAR and related variants, and simultaneous equation models. VAR has been by far the most frequently employed method. Some studies have undertaken estimation in a Structural VAR framework, while others have used Recursive VAR approach. It is not readily evident whether the choice of such methods was dictated purely by statistical considerations or by a blend of both economic and econometric needs. In the case of single-equation based approaches, use of linear and non-linear regression models was found with non-linear regression models being mostly utilized for estimating the differential impact of large versus small exchange rate changes on international and domestic prices. The use of simultaneous equation models in estimating ERPT has been quite limited in the Indian context. An important implication of these findings is that the underlying concept of ERPT coefficient differs from method to method. For example an ERPT coefficient estimated using a single-equation OLS-framework will have different underlying economic interpretation than a simultaneous-equation-model based ERPT estimate. Such concerns require a more exhaustive comparative analysis of various approaches used in estimating ERPT both from economic and econometric points of view, and this remains to be investigated in a more detailed framework in the Indian context.

4. CONCLUSION

ERPT remains a critical element in the larger analysis of an open-economy macroeconomic system. In the international context, a large number of analytical insights ranging from individual-specific factors to larger macroeconomic issues have been unearthed and it continues to receive considerable priority from both analysts and policy-makers. In the Indian context also, ERPT has been a well-researched and debated issue. This survey of evidences has revealed the richness of insights that have been discovered by various studies. These insights include, among other things, the estimation of ERPT for varying time horizons, variations in ERPT across different methodologies, the determinants of ERPT and particularly the micro foundations of the same, and the role of ERPT in the inflation process and policies.

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While taking full cognizance of these contributions of available studies, it seems that the depth and probably the coverage of empirical dimensions of ERPT continue to throw good amount of scope for future research. Among these dimensions, the analysis of macroeconomic determinants of ERPT, the differences in the degree of ERPT across low and high frequency data, the estimation and analysis of disaggregate ERPT, building large-scale simultaneous equation systems for understanding the nature of ERPT and investigation of aspects of the ERPT process such as asymmetry and non-linearity, continue to require more intense and exhaustive analysis in the future. It is hoped that the present study motivates more efforts and academic exercises in the direction that are narrated.

NOTES

1. In order to examine the issues of leads, lags and other dynamic matters in the transmission of exchange rate movements to international prices and domestic inflation, the empirical frameworks undertaken have mainly employed VAR models and simultaneous equation systems.

2. As far as the inter-connections between exchange rates and domestic inflation are concerned, export prices happen to play a relatively less significant role in acting as causal links in the process of importing inflation from the external sector. Hence, the studies that have focused on ERPT to export prices of Indian exporters must be differentiated from the studies focusing on ERPT to import prices, volumes, and domestic prices and inflation.

3. Domestic inflation has been measured across the pricing chain including "consumer prices, producer prices, import prices and sometimes the prices set by domestic exporters" (Bhattacharya, Patnaik and Shah, 2008). However, import prices have generally been treated as the link between the exchange rate changes and the domestic inflation.

4. RBI has changed its exchange rate measurement convention from Rupees/foreign currency unit to foreign currency unit/rupee. Studies before 2017 that used the official bilateral and effective exchange rates would have employed the earlier definition. Even though it is just a matter of elementary arithmetic to convert from one quoting method to another, the interpretation of the ERPT coefficients must be undertaken with this recent change in mind.

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ARTICLE

Agricultural Labour Productivity and Its Determinants in India

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Abstract
This study attempts to modestly undertake an empirical analysis to understand the issues of agricultural labour productivity measured in different dimensions and their determinants and, accordingly, their implications for agricultural growth. Labour productivity is measured as the ratio of total agricultural output to total labour input which can be located in the broader framework of growth accounting method put forth by Solow. The labour productivity index is estimated across four different time-series dimensions. All the estimated productivity indices except labour productivity index based on seasonal and cyclical components show an increasing trend in labour productivity in agriculture though there are very negligible and marginal variations between various estimates across various dimensions of time-series measurements. It is argued here that probably the factors determining cyclical variations in the agricultural output could be different from what they appear to be for the productivity movements in trend. The estimated model clearly exemplifies that rural literacy, electricity consumption, gross capital formation and weather dummy are the most important determinants of labour productivity in the Indian agriculture during the sample period under study.

Keywords Productivity determinants · Partial factor productivity · Productivity indices · Rainfall index · Weather dummy

1 Introduction

Labour plays a critical role not only in the production process but also in the process of dynamically transforming skill formation and acquired knowledge to suit the appropriate technology under consideration. Theoretically, the role of labour is considered to be less complicated than that of capital though it becomes more

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complicated in practice while analysing and placing labour on production frontiers in terms of quality of labour, skill formation, education, experience on the job training and productivity. This issue becomes still more complicated when we analyse the role of agricultural labour as the production structure, products, specialized knowledge and use of technology vary across crops, products, soil, time and space.

India has been predominantly an agrarian economy since the very beginning of its planning period. In terms of the contribution of agricultural production to economic growth, the situation is now reversed, but in terms of labour force participation, agriculture sector continues to be a major source of employment. Wages for agricultural labour fluctuate across seasons, crops and production processes, thereby determining both vertical and horizontal migrations in India as the level of education goes up. It is also important to note that there are small and marginal farmers who continue to move into the labour markets and withdraw from the same for some time period under consideration for their farm management. Although there is no uniform pattern in labour force participation of small and marginal farmers, seasonal variations in the crops, peak seasons for cultivation and farm management could be partly explaining this phenomenon.

Any maladjustment and abnormal fluctuations in the rural labour market generate variability in production. Although there are several factors impacting production, productivity plays an extremely important role in Indian agriculture as the agricultural production process is still labour-intensive and a major portion of Indian population depends on agriculture for employment. According to the Economic Survey 2017–2018, the share of agricultural sector in gross value added (GVA) at current prices is 17.4 percent (provisional estimate), while its share in employment has been more than 50 percentage as per the Statistical Year Book 2017. This has an enormous implication for the rural wage rate, agricultural productivity, migration and underemployment. More alarming issue can be that of labour productivity in agriculture, which can substantially influence production and growth of agricultural sector. Owning to large-scale fluctuations in the segmented labour markets and skill variations required for specialized production in agriculture, the wage rates are altered and sometimes abnormal variations are noticed. It is well understood in the literature that clearing of the labour market is quick if not smooth in the rural economy, and therefore, it also poses different challenges in terms of skill formation, adoption of technology by labour and specialized informal education which largely influence agro-labour productivity. This generates wage rate differential probably leading to discontinuous and random migration of labour force from agricultural sector to non-agricultural sectors.

Variations in the wage rates, adoption of technology, learning while working, experience and education might have fundamental bearing on the very behaviour of labour productivity in agriculture as against the backdrop of changing pattern in the migration and the fluctuations in the agricultural growth rates. Theoretically, the behaviour of labour productivity can be directly linked to fluctuations in the wage rates and agricultural production. Therefore, it is important to understand the intricacies involved in the behaviour, magnitude and determinants of agricultural labour productivity in India. As against this background, this paper undertakes an empirical analysis to understand the issue of agricultural labour productivity measured in

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different dimensions and their determinants, and accordingly their implications for agricultural growth.

2 Review of Evidences

While the extent of evidences on aggregate labour productivity analysis for Indian agriculture has been limited, there are several theoretical and empirical investigations that have analysed many of the major facets of the behaviour and determinants of labour productivity in the Indian context.

One of the earliest evidences on this account was Rudra and Sen (1980) who found that the intensity of labour usage, particularly the use of family labour, increased as the farm size increased, though the paper did not venture deeper into the issue of labour productivity in general and family labour productivity in particular. An important study on labour productivity behaviour and its determinants was undertaken by Bhalla and Alagh (1983) who found that modern capital inputs such as tractors were the key determinants of labour productivity for high growth regions in their sample, while inputs such as fertilizers and gross cropped area were found to be the primary factors contributing to the movements in labour productivity of medium and slow agro-output growth regions. Rajaraman (1986) attempted to critically analyse the evidences on labour productivity by Bhalla and Alagh (1983) and found that the all-India estimates of agro-output growth as reported by Bhalla and Alagh (1983) were not reliably defined and that, even under alternative definitions of aggregate output, the observed output growth was larger than their reported estimates. Furthermore, the author found that their model for analysing the determinants of labour productivity was not properly checked for econometric issues such as multicollinearity and heteroscedasticity among the regressors.

Dev (1988a) investigated the inter-relationships between labour productivity, land-to-man ratio and land productivity for the crop sector and found that the primary force of changes in land-to-man ratio was the growth of agricultural workforce rather than that of land. Dev (1988b) was an attempt at empirically estimating the labour productivity and its determinants across fifteen major states divided into various regions, as well as for all-India level. The study found that growth in yield was the most important source of increase in labour productivity across the chosen regions. However, this study focused on the issues on comparative static framework as the inter-temporal dynamics were not modelled properly. Jha (2006) investigated agricultural labour productivity in India with special reference to variations in real wages for agricultural workers while examining shift in the agricultural employment. The author found that the female proportion of agricultural workers was continuously falling and that the trend in labour productivity had not increased the real wages sufficiently to compensate for labour market adjustments. This study did not specifically examine the determinants of labour productivity. Gupta (2011) argued that the observed low worker productivity was a result of a low-wage rate rather than productivity determining wages in case of Indian cotton textile mills for the late twentieth century. We preferred to quote this study as methodological construction of estimating labour productivity can also be applied logically for agricultural

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labour. Emerick (2016) examined the reallocation and adjustment in the Indian labour market by drawing upon the information from rural India by assuming an exogenous shift in the agricultural productivity. Among other insights, the author found that the non-tradable sector expanded more rapidly when an exogenous shift in agricultural productivity was caused, ultimately leading to a considerable increase in the labour share of agricultural income. Imai, Gahia and Bresciani (2018) analysed the labour productivity gap between agriculture and non-agriculture sectors and the panel model that they set out showed that over a period of time this gap had widened for all the chosen Asian countries including India.

A brief literature review stated here suggests that a very comprehensive analytical and empirical investigation, to the best of our knowledge, has not taken place approximately since last one decade on various key issues pertaining to agro-labour productivity, and probably Bhalla and Alagh (1983) and Dev (1986, 1988a, b) have dwelled the matter in intense details during the 1980s. Therefore, the issue of investigating labour productivity in Indian agriculture is not only important for both rural wages and incomes, but also for sectoral dynamics that can cut across productivity gap, wage gap, growth gap and terms of trade.

3 Methodology and Data

Productivity exemplifies the ability of factors of production to augment output given the appropriate technology. An empirical analysis can throw various concepts and measurements of productivities such as total factor productivity and partial factor productivities (PFPs) with varying degrees and dimensions of operationalization of conceptual frameworks and measurements for analysing the relationship between production, productivity and the dynamics in the factor markets. As this study concentrates on labour productivity in agriculture, the emphasis is given to partial factor productivity (PFP) analysis.

This study attempts to measure labour productivity through the ratio of total agricultural output to total labour input which can be located in the broader framework of growth accounting method popularized by Solow (1957). It is important to mention that this work introduces three dimensions of time-series behaviour of PFP over and above the traditional measurement. These include measurement of the PFP ratios of total agricultural output to total labour input, total agricultural output at level form to the trend in labour input, trend in agricultural output to the total labour input and, finally, seasonal and cyclical component of agricultural output to seasonal and cyclical component of labour input. Appropriate model is specified in the Indian context by accounting for variability, for heterogeneity in labour input and also for the possible autocorrelation. The model is estimated by using standard econometric methodologies. Trend, and seasonal and cyclical variations have been estimated by using appropriate statistical techniques which are analysed in the later sections.

The variables used in this study are all drawn from secondary data and have been obtained from official published sources. Agricultural workforce has been measured by the number of agricultural labourers as available from various volumes of Agricultural Statistics at Glance, published by the Ministry of Agriculture, various

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volumes of Economic Surveys and Population Census reports. Information for all the years on this variable for the time period under investigation was not available; hence, appropriate interpolation and extrapolation methods were used to generate continuous and consistent data so as to maintain the distributional characteristics[1]. Agricultural output has been measured by gross domestic product (GDP) of agriculture and allied activities at constant 2004–2005 prices as contained in the latest Handbook Statistics on Indian Economy published by the Reserve Bank of India as well as various volumes of both the Agricultural Statistics at Glance and Statistical year Book of India. Data on this variable have been adjusted to suit the common definition after the year 2011–2012 from the data on gross value added (GVA) at basic prices with base year 2011–2012, after appropriately adjusting them for subsidies and indirect taxes. This yielded the estimates of agricultural GDP (AGDP) for the sample period. Information on rural literacy was obtained from various population census reports, and for missing information, appropriate interpolation method was used to generate continuous data. Data on fertilizer consumption, capital formation which was measured by gross capital formation at constant prices with base year 2004–2005 and information on electricity consumption for the agriculture and allied sector were obtained from various volumes of the Agricultural Statistics at Glance. Rainfall data were obtained from the online monthly actual and normal rainfall database of Indian Institute of Tropical Meteorology (IITM) and India Meteorological Department (IMD). The rainfall index was constructed using the annual levels of rainfall data with the base year 2007–2008. The sample period chosen for this study is from 1991–1992 up to 2016–2017. This sample period has been chosen as agriculture sector has undergone considerable change after liberalization and to some extent availability of uniform information constrained the study to choose this particular period.

4 Descriptive Statistics

This study places descriptive statistics on the primary variables used for analysis to derive meaningful understanding of the issues under consideration based on their distributional characteristics. The estimates are presented first for the whole sample period (Table 1) and then after breaking the sample period into three sub-periods (Table 2), to facilitate the comparison and clear understanding of the distributional characteristics so that their interpretation provides a logical step towards constructing meaningful analysis. Given that the mean, high and moderate variabilities are observed in case of agricultural gross domestic product (AGDP), agricultural gross capital formation (AGCF) and electricity consumption of agriculture sector (AELC), and low variability is seen in agricultural workforce (AWF), gross irrigated

[1] There were also information related to labour in the India KLEMS database but it gives broader picture on labour employment rather than number of agricultural workers at a given point in time. KLEMS database is organized more in the macro-framework of obtaining information across industries rather than concentrating on labour markets and participation rate of labour.

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Table 1 Descriptive statistics of the key and major variables used in the study

Statistic	AGDP	AWF	RLIT	AGCF	AELC	GIA
Mean	5930.44	240.82	60.00	894.35	104,633.71	81.62
SD	1296.68	23.25	8.34	453.63	31,580.98	9.25
Variance	1,681,372.04	540.68	69.52	205,779.84	997,358,505.94	85.60
Coefficient of variation	21.86	9.66	13.90	50.72	30.18	11.34

AGDP agricultural GDP at constant 2004–2005 prices measured in rupees billion, *AWF* agricultural workforce measured in millions of labourers, *RLIT* rural literacy rate in india, *AGCF* agricultural gross capital formation measured in rupees billion at constant 2004–2005 prices, *AELC* agricultural electricity consumption in india measured in giga watt hour (GWh), *GIA* gross irrigated area measured in millions of hectares

Table 2 Descriptive statistics of the key variables for sub-periods in the study

Time period	Statistic	AGDP	AWF	RLIT	AGCF	AELC	GIA
1991–1992 up to 1999–2000	Mean	4595.71	214.87	50.31	422.78	80,111.89	72.48
	SD	442.56	17.19	3.85	97.30	13,300.63	5.10
	Coefficient of variation (%)	9.63	8.00	7.65	23.01	16.60	7.03
2000–2001 up to 2008–2009	Mean	5831.93	248.95	61.55	854.17	91,978.33	81.63
	SD	516.23	9.72	2.99	204.36	9364.02	5.64
	Coefficient of variation (%)	8.85	3.90	4.86	23.92	10.18	6.91
2009–2010 up to 2016–2017	Mean	7542.85	260.88	69.16	1470.05	146,458.04	91.89
	SD	449.70	8.62	1.24	98.04	16,774.67	3.41
	Coefficient of variation (%)	5.96	3.31	1.79	6.67	11.45	3.71

AGDP agricultural GDP, *AWF* agricultural workforce, *RLIT* rural literacy rate in India, *AGCF* agricultural gross capital formation, *AELC* agricultural electricity consumption, *GIA* gross irrigated area

area (GIA) and rural literacy (RLIT) as evident from coefficient of variation and standard deviation from Table 1.

Estimates provided in Table 2 on sub-periods throw considerable insights that can be organized as follows: Firstly, the mean value of all the variables shows an increasing trend indicating that with expansion of the agricultural sector, AGDP, AWF, RLIT, GCF and AELC have grown over the period of time even at an average level. Good amount of fluctuation is observed in the estimates of standard deviation across all sub-periods for most of the variables implying that the agricultural sector has been subjected to notable instability as indicated by both input and output variables in our study.[2] Secondly, it is interesting to observe that the data series contain

[2] The analysis of instability cannot be concluded based on the standard deviation. Though it gives some idea of variability, one has to construct a proper volatility model for this purpose. This study does not go into the details of this even though our observations are based on the standard deviation.

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Table 3 Correlations among key variables

Variables	AGDP	AELC	AWF	GIA	AGCF	RLIT	IRNFL
AELC	0.95***						
AWF	0.88***	0.78***					
GIA	0.98***	0.92***	0.90***				
AGCF	0.98***	0.92***	0.82***	0.94***			
RLIT	0.97***	0.87***	0.94***	0.96***	0.95***		
IRNFL	−0.43**	−0.41**	−0.38*	−0.36*	−0.50***	−0.48**	
FETC	0.95***	0.88***	0.83***	0.94***	0.96***	0.95***	−0.42**

AGDP agricultural GDP, *AWF* agricultural workforce, *RLIT* rural literacy rate in India, *AGCF* agricultural gross capital formation, *AELC* agricultural, electricity consumption in India, *GIA* gross irrigated area, *FETC* fertilizer consumption, *IRNFL* index of actual annual rainfall level with base year 2007–2008

***, **, * Estimated correlations are significant at 1%, 5% and 10% levels, respectively

some variability in AWF, AGCF and GIA through the sub-periods, suggesting that the consistency of data seems to be more coherent as it can be seen in the values of the coefficient of variations. Thirdly, therefore, the estimates of distributional measures of selected variables are consistently subjected to moderate variation with increasing trend in the mean itself. This gives a considerable platform to analyse and estimate the required information from the data. It is not surprising to see that while the standard deviation is fluctuating, the mean is increasing across all sub-periods and therefore the consistency in the series seems to be satisfactory. Relative rise in the mean across the sub-periods cannot be attributed to mere trend in the time series; probably, some moderate shift in the underlying growth is possible. This study does not venture into understanding structural shifts in the growth and other time-series characteristics.[3] Though the mean value of AWF has not shown considerable increase, the absolute level of workforce (millions of agricultural labourers) has gone up and should not be misinterpreted with the relative share of employment falling in the agricultural sector over a period of last 30 years in the overall employment in the country.

Some interesting observations can also be obtained by placing these variables for identifying proper correlations. The estimated correlation matrix is presented in Table 3, and one would note that all the correlation coefficients are significant at different levels of significances which are admissible up to ten percentage in our study. It is evident from the table that the annual rainfall seems to be having a negative correlation with all variables, though it is not very strong, indicating that the fundamental inverse association could be traced in the rainfall itself. Correlation of index of actual rainfall (IRNFL) with AGDP and AWF seems to be moderate and negative. Correlations among AGDP, AELC, AWF, GIA, fertilizer consumption

[3] Test for the mean difference across the three sub-periods based on the simple t-test indicates that they are statistically significantly different from each other and therefore increase in the values of mean across the sample period could be due to underlying shift in the trend. One has to note with caution that the degrees of freedom available here are relatively low.

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(FETC) and AGCF are estimated to be very high and significant indicating that there exists a strong coherent association among them though the underlying structural relationship cannot be purely inferred based on correlations. This makes sense as these variables are the key inputs for agricultural production. This strong association of variables could have improved the development and growth of agricultural sector had there been proper development and adoption of technology which is suitable for agro-climatic conditions and, appropriate agro-water management systems.[4]

5 Labour Productivity: Estimates and Analysis

Labour productivity is estimated as a ratio of agricultural output represented by AGDP at factor cost and labour as measured by total agricultural workforce. The proper definition and measurement of given variables are already narrated in the methodology, and the study merely reports the estimated ratios. The usual and standard methodology of PFP of labour is to estimate the ratio mentioned above and index them according to the proper base. We have selected the year 2006–2007 as base as this year happened to be a normal year in terms of agricultural production and agro-climatic conditions. Purely on statistical grounds, 2006–2007 seems to be very good as the value of agricultural production is quite closer to its mean value in 2006–2007 and annual rainfall is normal.

As stated earlier, the attempt is made in this paper to construct productivity indexes into various time-series components of labour and agricultural output, respectively. First, labour productivity index is estimated on the ratios of total agro-output to total agro-workforce (LPA). This implies actual labour productivity with both variables in level form. Second, in order to capture the idea of labour productivity in the presence of trend in the agricultural workforce (LPT), we estimated the index of AGDP to the trend in the AWF. Third, an attempt is made to examine the productivity behaviour in the context of trend in agro-output to labour (LPAL), and therefore, we have constructed the ratio of trend in AGDP to AWF. Finally, we wanted to understand how the seasonal and cyclical variations in both agro-output and agro-labour could have played a role in labour productivity behaviour, and accordingly, we have constructed the index of the seasonal and cyclical AGDP to seasonal and cyclical AWF (LPSC). This is done precisely to examine various dynamics that the productivity determination itself has got and to analyse the time-series dimension in terms of trend, and seasonal and cyclical variations. There are no studies in the Indian context to the best of our knowledge that analyse and estimate labour productivity in agriculture into various dimensions as attempted here.

The trend is estimated by the ordinary least squares (OLS) method via using a linear trend model as other various methodologies such as exponential smoothing techniques and dummy variables approach did not yield suitable statistical estimates. Chosen linear trend seems to be explaining the data well at least in terms

[4] For more details and in-depth analysis, one can refer to Bhalla and Alagh (1982), Dholakia and Dholakia (1993) and Emerick (2016).

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of coefficient of determination and t-test. We are fully aware of the fact that we are using annual series and residuals from the trend might not fully explain the seasonal variations but to a great extent can capture cyclical fluctuations. Although it is not purely a cyclical information, some amount of seasonal variation is obviously inbuilt even in the annual data. Smoothening of data through annual series might not take away all information of seasons contained in the series. Therefore, we call it as "seasonal and cyclical" fluctuations.[5] The study does not rule out the role of the random component in the seasonal and cyclical information, but we strongly feel that on an average the random variations in the information approximately may be approaching to zero mean asymptotically. Accordingly, the information obtained from trend and seasonal and cyclical variations is used for composing the labour productivity indexes along with total agro-output and total agro-workforce.

The productivity estimates for the various measures of PFP are produced in Table 4 and in Figs. 1, 2 and 3. A table showing labour productivity is produced along with the graphs for understanding the specific values of productivity movements across time during the sample period as the diagrammatic presentation may not throw specific information at a given point in time but can be quite useful in analysing the behaviour and movements of the same. All productivity indexes except LPSC show an increasing trend in labour productivity in agriculture though there are very negligible and marginal variations between three major productivity estimates, namely LPA, LPT and LPTAL. Upward movement in the productivity is not only smooth but also consistent over the sample period. It is important to mention that there are lots of alternatives for the selection of the base year as opposed to the one that we have chosen and even if alternatives are used, though they might qualify for the reasons that we have stated for choosing the base year, the basic upward movement in the labour productivity measured in different concepts is not altered. One can look at the graphs for the same inference. Figure 2 indicates that there is a clear smooth upward movement in the labour productivity by all the estimates of productivity measurements in all the three different measures of productivities, namely LPA, LPT and LPTAL. In order to know whether the trends are closer or not, the linear trend is estimated and produced in Table 5. The results suggest that estimated coefficient is significant at one percentage level and R^2 is very high. It is interesting to see that the trend coefficients are estimated to be around 1.6 in all three measures of labour productivity. The trend value, therefore, is the same irrespective of measurements of labour productivity and hence trends in both output and labour play a predominant role in explaining the behavioural movements of labour productivity in Indian agriculture. Even the intercept values turned out to be similar indicating that both trend coefficient and intercept throw the underlying productivity

[5] One might get it into more detailed study on this issue once the liberty and luxury of disaggregated data or high-frequency data or both are made available. This could throw some new dimensions to the analysis, and we are constrained to use the annual series as quarterly and monthly information on most of the variables that we have employed are not available. Therefore, the choice of this estimation is motivated by the availability and limitations of the data.

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Table 4 Estimates of labour productivity under different measurements

Year	LPA	LPT	LPTAL	LPSC
1991–1992	86.65	75.78	83.24	12.79
1992–1993	87.52	79.74	82.26	51.64
1993–1994	85.89	81.31	81.38	98.21
1994–1995	87.69	84.04	82.52	228.16
1995–1996	84.96	82.38	83.60	−284.15
1996–1997	91.16	89.41	84.64	−568.90
1997–1998	86.77	86.04	85.62	57.16
1998–1999	90.16	90.35	86.56	−52.41
1999–2000	90.51	91.63	87.46	−23.52
2000–2001	91.19	90.52	90.96	110.86
2001–2002	97.40	94.82	94.52	−557.80
2002–2003	87.44	87.52	93.60	327.55
2003–2004	91.78	94.33	92.74	67.05
2004–2005	88.63	93.41	91.95	79.64
2005–2006	94.58	97.10	95.92	77.69
2006–2007	100.00	100.00	100.00	100.00
2007–2008	107.42	104.62	104.21	−434.56
2008–2009	109.20	103.57	108.55	−89.62
2009–2010	111.83	103.27	113.03	−83.20
2010–2011	116.70	110.95	111.26	125.74
2011–2012	117.90	115.28	109.58	−1123.71
2012–2013	116.43	115.68	109.18	−231.26
2013–2014	125.66	119.87	115.10	429.49
2014–2015	119.96	114.55	116.32	42.01
2015–2016	120.64	114.32	118.54	−37.05
2016–2017	122.07	113.88	121.73	−70.13

LPA labour productivity index based on total output to total workforce, *LPT* labour productivity index based on total output to the trend of total workforce, *LPTAL* labour productivity index based on trend output and total workforce, *LPSC* labour productivity index based on seasonal and cyclical output to the seasonal and cyclical workforce

behaviour at least in terms of time. *Prima facie* it seems that the factors underlying labour productivity movement must be fully explaining the trend as well.

It is equally important to analyse the movement of labour productivity in terms of cyclical and seasonal variations as labour market adjustment, migration and wage differential are probably implicitly reflected. Figure 2 examines both the movement of seasonal and cyclical component in agricultural workforce measured on the right side and the behaviour of cyclical and seasonal AGDP depicted on the left side. The co-movement of the series seems to be quite similar except for the period ranging from 2000–2001 to 2006–2007. One can get same insight from Fig. 3 between the seasonal and cyclical AWF and the labour productivity index based on the seasonal

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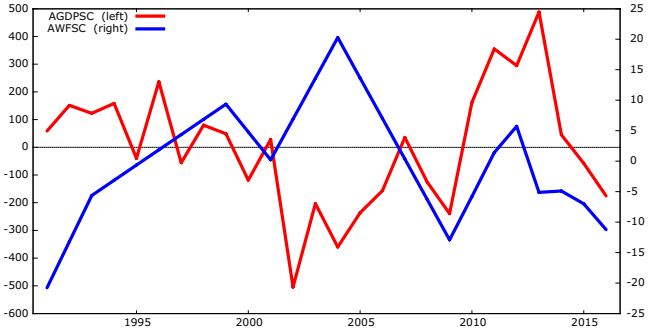
Notes: (1). LPA = Labour Productivity Index based on Total Agricultural Output and Total Agricultural Workforce.
(2). LPT = Labour Productivity Index based on Total Agricultural Output and the Trend of Actual Agricultural Workforce.
(3). LPTAL = Labour Productivity Index based on Trend of Agricultural Output and Total Agricultural Workforce.

Fig. 1 Estimates of three different labour productivity indexes. *LPA* labour productivity index based on total agricultural output and total agricultural workforce. *LPT* labour productivity index based on total agricultural output and the trend of actual agricultural workforce. *LPTAL* labour productivity index based on trend of agricultural output and total agricultural workforce



Notes: AGDPSC = Seasonal and Cyclical Agricultural Output; AWFSC = Seasonal and Cyclical Agricultural Workforce.

Fig. 2 Movements in the seasonal and cyclical agricultural output vis-à-vis the seasonal and cyclical agricultural workforce for the sample period. *AGDPSC* seasonal and cyclical agricultural output, *AWFSC* seasonal and cyclical agricultural workforce

and cyclical AGDP and AWF. It is important to note that during 2000–2001 to 2007–2008, productivity movement is reverse to that of seasonal and cyclical variation in data. It is argued here that probably factors determining cyclical variations in the agricultural output could be different from what they appear to be for the productivity movements in trend. It is critical to observe that the cyclical variations have a strong impact on the productivity movement. There are certain dynamics that

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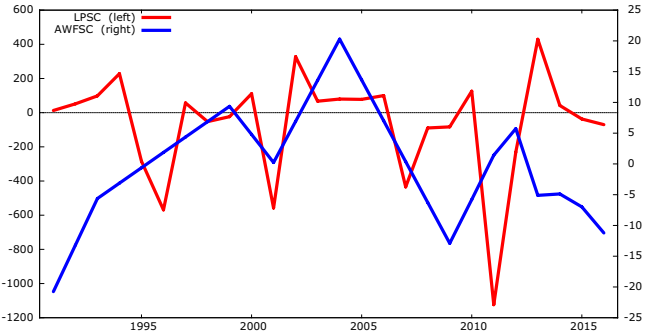

Note: LPSC = Labour Productivity Index based on Seasonal and Cyclical Output to the Seasonal and Cyclical Workforce and AWFSC = Seasonal and Cyclical Agricultural Workforce.

Fig. 3 Movements in the labour productivity index with seasonal and cyclical componenets and the seaonal and cylical agro-workforce for the sample period. *LPSC* labour productivity index based on seasonal and cyclical output to the seasonal and cyclical workforce, *AWFSC* seasonal and cyclical agricultural workforce

Table 5 Estimates of trend regression models for three different labour productivity measurements

Variable	Trend value	*t*-value	R^2	*F*-statistic
LPA	1.69	11.78	0.85	138.81
LPT	1.64	18.69	0.94	349.15
LPTAL	1.67	20.39	0.95	415.88

seem to be working at the aggregate-level scenario of labour productivity which could be strongly connected to labour migration and wage adjustments operating in the labour markets across the farm and non-farm sectors.

Figure 3 also suggests that the co-movement of the variables under consideration is quite smooth, and therefore, it is important to examine as to what extent agricultural labour force variations in cycle and season are impacting the seasonal and cyclical agricultural GDP. The attempt is not to dwell into various factors that determine the growth rate of GDP either for trend or for seasonal and cyclical variation. Our concentration is here on labour productivity, and therefore, the variation in labour alone is taken into account for focusing our analysis. We have attempted to analyse the impact of seasonal and cyclical AWF (AWFSC) on changes in the seasonal and cyclical AGDP by an estimated model.[6] The coefficient is significant at 10 percentage level and clearly this estimate indicates that there is a strong negative impact on seasonal and cyclical AGDP (AGDPSC). R^2 is expected to be low as the

[6] The estimated model on this account is as below:

$$\text{AGDPSC} = -0.002 - 7.62\,(\text{AWFSC}),$$
$$R^2 = 0.11, \quad t = 1.72, \quad F = 2.98.$$

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Table 6 Correlations among key variables including estimated labour productivities

Variables	LPA	LPT	LPTAL	LPSC	AGDP	AELC	GIA	RLIT
LPT	0.96***							
LPTAL	0.97***	0.95***						
LPSC	−0.16	−0.17	−0.08					
AGDP	0.96***	0.99***	0.97***	−0.14				
AELC	0.94***	0.94***	0.92***	−0.11	0.95***			
GIA	0.92***	0.98***	0.93***	−0.16	0.98***	0.92***		
RLIT	0.89***	0.96***	0.94***	−0.12	0.97***	0.87***	0.96***	
FETC	0.93***	0.95***	0.95***	−0.19	0.95***	0.88***	0.94***	0.95***

***, **, * Estimated correlations are significant at 1%, 5% and 10% levels, respectively. The abbreviations of the variables in this table have already been defined in the preceding sections

determination of AGDP for cycle and season could be influenced by a host of factors. The F-statistic is also significant indicating that the estimated model explains labour and agricultural GDP nexus.

It is important to net the ideas and estimates of productivities with those variables which are a key to the study of dynamics involved in the changes of various productivity measures. Therefore, the estimation of correlations is carried out for all measures of labour productivity along with agricultural GDP, agricultural electricity consumption, gross irrigated area, rural literacy and fertilizer consumption. The estimates suggest that LPSC is negative across all variables and also not significant. Almost all the correlation coefficients are significant indicating that there is a strong linear association among variables which necessarily may not mean the existence of indications of an underlying structural framework for determination of labour productivity (Table 6).

6 The Determinants of Labour Productivity

Growth rate of production is largely affected by productivity and particularly by labour productivity in the Indian economy. Essentially, variations in the productivity must also signal the appropriate and suitable rewards for labour in the adjustment of ongoing wage rates as agricultural production is subject to seasonal variations. As the focus here is on agricultural labour productivity, it is important to understand various determinants that shape the productivity behaviour. Output growth in agricultural sector and the underlying pattern of production are more complex issues at aggregate level. Before undertaking any such study, one has to be reasonably sure to accept and allow for the regional variations in the quality of labour force and the skill embodied in the labour. Inter-state migration precisely reduces the variations across time, and therefore, the consideration of the theoretical model has to be based on the assumption that data reflected at aggregate level are achieved through more complex variations at regional and local levels. By focusing on the framework under consideration and the availability of information, the underlying model of

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determinants for aggregate labour productivity (LPA) can be conceived as a vector of variables such as rural literacy rate (RLIT), electricity consumption of agriculture sector (AELC), fertilizer consumption (FETC), ratio of gross irrigated area to gross cropped area (IGCA), agricultural gross capital formation (AGCF) and dummy variable for weather conditions (D_1) which is expected to assume the value of one if agro-climatic condition is bad, otherwise zero and dummy for outliers in seasonal and cyclical agricultural workforce (D_2). Epsilon in the model that takes care of all the econometric conditions that are necessary as a result of OLS estimation.

$$\begin{aligned} \mathrm{LPA} = \beta_0 + \beta_1 \mathrm{RLIT} + \beta_2 \mathrm{AELC} + \beta_3 \mathrm{FETC} + \beta_4 \mathrm{IGCA} \\ + \beta_5 \mathrm{AGCF} + \beta_6 D_1 + \beta_7 D_2 + \beta_8 \mathrm{LPA}_{t-1} + \epsilon \end{aligned} \tag{1}$$

It is important to mention here that we are choosing LPA as other measures of labour factor productivity except seasonal and cyclical variations do have very high correlation and co-movements with LPA and, more importantly as stated earlier, have similar trend coefficients. Therefore, it is convenient to model LPA assuming that similar underlying variables must have caused the co-movements of LPA, LPT and LPTAL.[7] Rural literacy is expected to cause the labour productivity positively as education and experience do generate improvements in labour productivity. Presumably, change in AELC and FETC is also expected to directly enhance labour productivity. IGCA and AGCF can work in either directions towards labour productivity depending on whether they play a complimentary or a substitutable role. This model is well-articulated given the issues pertaining to agricultural labour productivity in India and the time-series behaviour of the data.

This study also tries to uncover an additional framework for examining the causes of seasonal and cyclical variations in aggregate agro-labour productivity. It is precisely because of this dimension that the information in seasonal and cyclical variations of labour productivity is composed. It is interesting to see that LPSC varies very significantly across time making good amount of additional information for analysis available for productivity inferences. Therefore, we presume that there must be some specific structural framework in aggregates that must be explaining the cause and movements of LPSC.

$$\mathrm{LPSC} = \beta_0 + \beta_1 \mathrm{CIRNFL} + \beta_2 \mathrm{AGCF}_{T-1} + \beta_3 \mathrm{D}_1 + \beta_4 \mathrm{D}_2 + \beta_5 \mathrm{CFETC} + \beta_6 \mathrm{LPSC}_{t-1} + \epsilon \tag{2}$$

After careful examination of the underlying process, the theoretical model is proposed that LPSC might be influenced by change in actual rainfall index (CIRNFL), lagged value of gross capital formation (GCF_{T-1}), change in fertilizer consumption (CFETC), dummy variable for weather conditions (D_1), dummy for outliers in seasonal and cyclical agro-workforce (D_2) and the lagged value of LPSC (LPSC_{t-1}) for inter-temporal dynamics in the model.

[7] The emphasis is not given to analyse the time series properties of co-integration here as our focus is on structural framework and modelling the behaviour of labour productivity with reference to long-run determinants.

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7 Estimated Models

The estimated model of determinants of LPA is presented below which has an excellent goodness of fit and the F-statistic is significant indicating that the model captures the underlying structural and behavioural phenomena quite well. Most of the coefficients have expected signs while there is no autocorrelation present in the model. The estimated coefficient of RLIT is negative at − 1.02, and this is surprising as we had expected positive relationship. This could be probably due to the fact that labour moves across different markets especially from farm to non-farm as education and literacy levels in the rural sector move upward. This is particularly because different vertical information on educational qualifications and literacy is composed together, and as a result we are not able to split the vertical migration of agro-labour force. This, along with the role pronounced in AGCF, probably must be responsible for the negative sign of RLIT as decrease in the labour must have been compensated by increase in capital across the agro-sector. The coefficients for AELC and AGCF turned out to be positive and significant, presumably seeming to be dominant factors in explaining the changes in labour productivity. FETC is not significant as change in the consumption of fertilizer may not be impacting labour productivity across regions and crops in synchrony with variations in the labour force. If one speculates with proper empirical wisdom, this variable can be a major factor either for total factor productivity or for capital productivity or for both.

$$\begin{aligned} \mathrm{LPA} = {} & \underset{(2.78)^{***}}{100.85} - \underset{(1.81)^{*}}{1.02}\,\mathrm{RLIT} + \underset{(2.27)^{*}}{0.26}\,\mathrm{AELC} + \underset{(1.28)}{0.056}\,\mathrm{FETC} + \underset{(0.48)}{1.62}\,\mathrm{IGCA} + \underset{(2.91)^{***}}{0.33}\,\mathrm{AGCF} \\ & - \underset{(1.76)^{*}}{0.041}\,\mathrm{D}_1 - \underset{(0.42)^{*}}{0.016}\,\mathrm{D}_2 - \underset{(0.42)^{*}}{0.376}\,\mathrm{LPA}_{t-1} \\ & \mathrm{R}^2 = 0.96, \quad \mathrm{F} = 0.96, \quad \mathrm{D.W} = 2.16. \end{aligned} \tag{3}$$

Notes

1. The dependent variable LPA is labour productivity index based on total agro-output and total agro-workforce.
2. Figures in the bracket indicate t-values. Three stars, two stars and one star indicate that estimated parameters are significant at 1%, 5% and 10% levels, respectively.

The weather dummy appears as an important and significant variable even for labour productivity. As the estimates suggest, the behaviour of Indian agricultural development and growth including that of labour productivity is largely affected by agro-climatic conditions. The lagged variable of LPA used for partial adjustment process is also significantly explaining the model[8]. The dummy used for outlier (D_2) is insignificant in the estimated Eq. (3). The estimated model clearly exemplifies that

[8] We have not ventured into data mining process but a careful attention is given to estimate the model with alternative specifications that could be possible within the available information. Estimates are arrived after properly scrutinizing them for asymptotic criteria.

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rural literacy, electricity consumption, gross capital formation and weather dummy are the most important determinants of labour productivity in Indian agriculture during the sample period under scrutiny.

The following estimated model is for the determinants of LPSC which has been theoretically specified in Eq. (2). Model is reasonably explaining the context and fitting the data moderately as R^2 is 0.51 and the F value is significant while there is no autocorrelation.

$$\begin{aligned} \mathrm{LPSC} = {} & \underset{(1.94)^{*}}{122.91} + \underset{(2.80)^{**}}{0.96\,\mathrm{CIRNFL}} + \underset{(1.77)^{*}}{0.097\,\mathrm{AGCF}_{t-1}} - \underset{(3.62)^{***}}{10.84\,\mathrm{D}_1} - \underset{(4.31)^{***}}{1137.13\,\mathrm{D}_2} \\ & + \underset{(0.43)}{0.003\,\mathrm{CFETC}} + \underset{(0.42)^{*}}{0.05\,\mathrm{LPSC}_{t-1}} \\ & \mathrm{R}^2 = 0.51, \quad \mathrm{F} = 5.45, \quad \mathrm{D.W} = 1.89. \end{aligned} \tag{4}$$

Notes

1. The dependent variable LPSC is labour productivity index based on seasonal and cyclical agro-output and agro-workforce.
2. Figures in the bracket indicate t-values. Three stars, two stars and one star indicate that estimated parameters are significant at 1%, 5% and 10% levels, respectively, and # indicates significance at 12% level.

All the estimated coefficients are significant except CFETC. The variation in CIRNFL, AGCF_{t-1} and dummy variables used is explaining the model properly. The dynamic feature introduced through lagged value of the dependent variable is also, though t-value is moderately low, significant. The dummy used for capturing outliers in seasonal and cyclical AWF is also significant as dummy assumes the value of outlier. Dummy for weather and rainfall behaviour as explained by CIRNFL is clearly and dominantly pronouncing the movements in LPSC. Fertilizer is not explaining the variations in LPSC. Therefore, the estimated structural model under consideration turned out to be excellent in the context for which it has been built. Accordingly, the key determinants of LPSC are identified as above.

8 Limitations

This paper attempts to capture various issues pertaining to agricultural labour productivity by focusing on aggregated levels of information and accordingly estimates are generated including those of the determinants of aggregate agro-labour productivity. Conceptually, one can define labour, output and other associated variables in a way that one can propose different dynamisms in the stated subject matter. Primarily the availability of data and subsequently their lack of continuity have placed constraints in operationalizing alternative conceptual frameworks that otherwise could have been possible. Ironically, it also implies that the attempt has not been made to

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argue the behaviour of labour factor productivity in terms of disaggregated data as the contextual framework and scope get widened much beyond the articulated and implied objectives. It is always possible to study the issues analysed here in terms of disaggregated data cutting across regional and local productivity dynamics. To the best of our knowledge, even disaggregation faces quite a good challenge in obtaining continuous information for variables under this study.

The statistical methodology that is applied for generating missing data could be subjected to different opinions depending upon the technique applied, context under which the issue is examined and cross-sectional sources from where the time-series data are obtained. Our description on data definitions and measurements is self-explanatory in this line. The only submission which can be made here is that the variations in the estimates obtained are possible depending on the consensus for both data generating methodology and estimation techniques used. The information on labour migration, wage rate differentials and education has not been properly articulated in India even on the methodologies related to data collection and sample surveys. Therefore, the information varies across the surveys, NSSO rounds and data definitions. This probably is the broader limitation of every study that can be undertaken on aggregate labour productivity.

We have used OLS technique which suits appropriately for the estimation but one can always employ different estimation techniques, of course, depending on how the information is shaped both quantitatively and qualitatively. Construction of dummy variables for the analysis is primarily guided by the non-availability of information on some qualitative aspects and our requirement for analysing labour factor productivity. Therefore, our modelling of labour productivity is limited accordingly and estimation is not carried out for the obvious reasons at disaggregated levels. As stated earlier, our intention of estimating only labour productivity is guided by the articulated objectives in our framework but one can always work in terms of partial factor productivities with reference to other factors and even estimate total factor productivity.

9 Concluding Remarks

In the context of very few specialized empirical works on aggregate labour productivity, a humble attempt made here throws some interesting inferences and empirical facets required for policy analysis. The increase in labour productivity additionally can be pushed upwards if proper capital formation, either in terms of private participation or in terms of government investment, is brought forth. There is a considerable amount of scope for public–private partnership (PPP) model in research and development efforts particularly with reference to the creation of new-generation high-yielding varieties consistent with environmental parameters and agro-climatic conditions. PPP model can also be implemented in the areas pertaining to agro-infrastructure including storage and warehouses, efficient water management programmes, informal education to farmers, proper part-time trainings, pamphlets and discussion groups for information on farm production, etc. Probably, these all will play a complementary role in enhancing the labour productivity. In fact, the

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migrations from both rural to urban and less developed regions to more developed regions are partly pushed by the variations in the rainfall and insufficient water for cultivation. Small and marginal farmers and agricultural labourers have been migrating across works and regions. Balanced regional development in agriculture that could be conceived of, by taking into account various heterogeneities that are inherent in the geographical and manpower distributions, will bring not only to some extent uniformity in the segmented labour markets and wage rates but also might produce similarities in agricultural incomes of the farmers and productivity of labour.

The present policy frameworks both at central and state levels neglect the importance of implications of labour productivity in Indian agriculture. Rural development programmes and measures aimed at promoting welfares schemes are more prominent for political economy considerations than the labour productivity enhancing measures. If the Government addresses this issue properly, then not only the real incomes and standard of living of rural population move up but also the poverty and unemployment can be reduced. In our opinion, the proper estimates for both aggregate labour productivity and regional productivity indices could be created and published and the labour productivity should be monitored to link the wages and returns. Otherwise, this issue will become a very serious concern for migration and urbanization. As our estimates suggest the variations in rainfall and water management remain key areas of concern for agro-growth and labour productivity. Designing of appropriate water management policy and frameworks in order to suit local conditions, with special reference to local rainfall levels and ground water table which are consistent with agro-climatic conditions, has to be more comprehensively addressed than the presently existing policies. A word of caution on fertilizer consumption and subsides for the same in the light of insignificant estimates obtained here is that, while certainly some rationalization on amount of subsidies is required on fiscal ground, we argue for optimization of consumption of fertilizer by linking labour factor productivity and agricultural growth. Finally, retaining educated farmers and farm labourers are keys to the success of policy to promote labour productivity. Probably this can be done by both monetary and non-monetary incentives that can impact their standard of living and welfare.

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COVID-19 Pandemic as a Set of Economic Shocks in India: A Short Note

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ABSTRACT

Socio-economic events that fall largely outside the purview of the direct control of a given economic agent allow much more rigorous quantitative modelling of effects that such events may have on that economic agent's decision-making and the consequent economic outcomes. The on-going Corona pandemic across the Globe presents a unique case study to extract operationally exogenous shocks that can be subjected to further rigorous research as well as to help students learn about applied economics using real-time events rather than abstract theoretical generalizations. This pandemic has thrown a huge challenge for the largest democracy in the World, namely India. The subsequent series of lockdowns in India and the consequent unlocking process have given rise to several economic shocks that require urgent attention from both the academic and policy-making circles. An overview of the microeconomic and macroeconomic events that have been sparked by the current pandemic and, the several rounds of lockdowns and social unlocking, can help the policy makers to better understand how future policy interventions can improve economic outcomes in the post-COVID era. A brief overview of various such economic shocks and their implications are highlighted in this note. The aim is to highlight the most important economic concerns so as to motivate teaching and research that is driven by real-time concerns and that can shed more light on the ways in which people and institutions react to such a crisis with some indications on the possible road ahead.

Highlights

- COVID-19 pandemic is translated into its microeconomic and macroeconomic implications using the largest democracy in the World as an analytical case study.

Keywords: Microeconomic shocks, macroeconomic shocks, natural experiments, natural shocks, corona pandemic

Exogenous variations in society and economy in the form of unpredictable natural or human-induced events provide a rich source of information for Economists and other social scientists in meaningfully analyzing the cause-and-effect relationships among various socio-economic phenomena. Analysis of socio-economic events that fall largely outside the purview of the direct control of a given economic agent allows much more rigorous quantitative modelling of effects that such events may have on that economic agent's decision-making and the consequent economic outcomes (Francesco, 2005). The on-going Corona pandemic across the world can provide important opportunities to Economists in studying the behavioural dynamics across economic agents in the light of this crisis, and may possibly help to better understand how government intervention can or cannot improve economic outcomes if events of similar nature occur in future.

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Theoretical Background

The genesis of such an approach to causal analysis in economics can be traced back to various seminal works, especially in the field of Behavioural and Experimental Economics, that attempted to examine the ways in which people and institutions react to events that were not optimally forecasted by them well-in-advance. Such events have been characterized by various synonyms such as "natural experiments" (Rosenzweig and Wolpin, 2000) and "exogenous shocks" (Francesco, 2005) among others. Generating such situations in the economic realm is quite difficult and even costly. Moreover, ethical considerations also make "creating" such events unrealistic and unacceptable. However, when natural events such as calamities occur, or when events occur that are not natural but are also not under direct control and foresight of a given country, its people and institutions, the variations in observed behaviour before and after such events can provide significant insights into underlying microeconomic and macroeconomic processes. Such an understanding may help policy-makers and analysts to better appreciate the existing socio-economic outcomes in a much more scientifically rigorous manner. The on-going Corona pandemic in India is one possible source to extract truly exogenous variations in various economic forces that govern both the individual and the institutional behaviours.

Indian society is experiencing the impact of this pandemic on multiple fronts. From a sudden overhaul of the healthcare system to the massive inter-state migration of wage-workers, the Corona pandemic has opened up a Pandora's box for Economists to better understand various socio-economic issues such as health outcomes, labour market outcomes, distributional inefficiencies, shock absorption capacities of various industries, and the nature of inter-state dependencies among others. Careful examinations of the events that have occurred in the last four months provide a set of economic shocks whose impact must be urgently evaluated so as to minimize the hardships that the post-pandemic normalcy might bring for the common masses. Several important events within the corona pandemic can be located that may serve as possible exogenous economic shocks for Economists and thus help both analysts and policy-makers to better understand the behavioural dynamics of individuals, institutions, the Government and their cross-interactions across the Globe.

Major Economic Shocks Due to COVID-19 in India

This section extracts the main subject matter of this analysis. The shocks faced by the Global and Indian economies are conceptualized in their microeconomic and macroeconomic dimensions. The attempt is to derive truly exogenous shocks pertaining to the rural, urban and the aggregate sectors of the Indian economy that can readily service as a rich case study for the Global community and policy makers.

Microeconomic shocks

Events that can be considered as sudden and unexpected for individuals, firms, industry or a particular sector are highlighted in this section. These economic shocks are highlighted with an emphasis on lending them meaningful to researchers in Economics and other allied social sciences.

Upward shift in the healthcare demand function

Indian healthcare system is dominated by state-owned suppliers, especially in the rural regions. The Government thus plays a pivotal role in improving the health outcomes of the Indian rural population. Given the general agricultural dependency and low income and productivity levels in rural sectors, the purchasing power required to afford basic healthcare facilities is limited in rural India. Thus, the Government needs to supplement this limitedness of purchasing ability with subsidized healthcare services. The current COVID-19 pandemic has resulted in a sudden increase in healthcare demand and it seems that the healthcare demand function may have shifted sizeably so as to put further stress on the already-scarce supply of health facilities in rural and even in several urban regions. An important issue that needs to be studied is how well our rural health infrastructure is prepared to handle a sudden demand-side shock and the factors that may improve our healthcare system's ability to provide quality and subsidized healthcare facilities if similar events occur in future.

Rise in the urban to rural push-migration

The ongoing pandemic saw massive inter-state push migration. It occurred with migrant wage-labourers shifting from urban regions toward rural regions. The initial twenty-one days lockdown announced by the Government of India saw a large number of urban migrant workers rushing to their villages at a scale that has hardly been observed in the recent past in India. Several research issues open up. Among others, estimation of the extent of this labour migration in terms of the socio-economic composition of migrant workers can serve as a valuable data set in itself. Another research issue in this context can be the quantitative estimates of labour-dependency of various formal and informal industries in urban India. The extent to which various industries in urban regions rely on quick and efficient supply of wage-workers is an important determinant of the supply-side efficiency of these industries and, their ability to efficiently and quickly match the demand and supply of goods. Estimation of labour supply-elasticities of output for such industries, among other possible matters, can be valuable for policy-makers in understanding the nature of the labour markets in urban regions across both formal and informal industries.

Downward shift in the wage-labour supply function in urban regions

A sizeable supply-side shock has been faced by the Urban informal and labour-intensive formal industries due to the massive inter-state migration on the one hand, and the continued production activities in the initial phases of the lockdown. Several industries were seen searching for wage-labour while continuing the production of essential goods. Some industries employed innovative solutions such as hiring migrant labourers who were stuck within their areas of production (Indian Express, 2020). These events provide a rich source for studying the impact of sudden unpredicted labour supply shock on production and distribution decisions of urban industries affected by these events.

Sudden fall in the incomes of daily-earners and its welfare impact

The sub-section of our society that has probably faced the most damaging impact of this pandemic is the daily-wage earners. Given their already uncertain labour market participation, the sudden halt of production in labour-intensive industries has and will have sizeable impact on their health, income and other outcomes. The ways in which the sudden halt in daily income will impact their consumption and savings behaviour must be urgently undertaken as soon as the ongoing situation normalizes. With high price-elasticities for consumption goods, the nature of substitution among basic necessities, the dependency on the Government for meeting basic needs and the ways in which households of such labourers share the burden of the fall in incomes can give critical data to the policy-makers in designing more efficient welfare schemes.

Intra-household conflicts and power distribution

Considerable literature on institutional economics has delved deeply into the ways in which households undertake sharing of scarce resources among the members of the family with special reference to the conflicts that may arise in designing efficient distribution designs. The fact that a large proportion of workforce is now working from home, implies increased time spent by spouses and other family members together within the household. News reports do show that reported domestic violence cases have increased during this lockdown (Outlook India, 2020). The nature of adjustment processes adopted by the key decision-makers in the household during the lockdown period, the changes that might have occurred in the allocation of key rights to make decisions inside the household, the possible tensions in managing the family budget and consumption in the light of spouses being together and a host of such issues can be analyzed to gain insights into the social fabric governing the microeconomics of households in India. This can be done with reference to both the urban and rural households and the differences in their reactions to the lockdown situation can be a source of valuable data on gender equality, gender empowerment and the reaction functions of urban versus rural households to the current crisis.

Cooperation mechanisms in various communities

Societies and colonies where people reside together in clusters such as a housing society, adopted

innovative mechanisms for handling the lockdown situation through different ways of cooperating and fulfilling their collective needs. While in some places, the representative of a typical housing society took into their hands the strict maintenance of social distancing, other places such as Gujarat saw people arranging for vegetables and other daily necessities via their local municipal corporations. Knowledge of local cooperation mechanisms among people in times of emergency can help municipal corporations in exploiting the self-governance model to implement important local laws once the situation normalizes. Municipal and other local governance bodies can utilize the data on how people cooperate in housing societies to utilize such mechanisms in enforcing important social changes such as spreading eco-friendly waste disposal practices among households.

Macroeconomic Shocks

While the above mentioned issues provide ideas for possible microeconomic research agenda, several issues have emerged that demand aggregative analysis and hence can be better subjected to macroeconomic analytical frameworks . Some of the most important issues in economic policy-making are essentially macroeconomic in nature such as unemployment, inflation and stable growth. Many macroeconomic aspects of the Indian economy are undergoing radical changes on account of both the Corona pandemic and the consequent lockdown. Some of these possible issues have been mentioned below.

Aggregate labour market adjustments

The lockdown period is an important source for studying the aggregate adjustment capabilities of the informal Indian labour market in the light of various industry and sector specific shocks as highlighted previously. Mainstream neo-classical labour market models suggest that adjustments to any exogenous economic shock should be quick and efficient given the free movement of labour and other resources across space. In the light of barriers to this free spatial movement of resources due to the lockdown, a detailed study of the ways in which various regional and sectoral labour markets have adjusted their labour demand functions to suit the increased scarcity of wage-labourers can go a long way in helping the policy-makers devise more efficient industrial policies while also helping them design more effective welfare schemes for the urban migrant labourers. Not only does this have implications for the welfare of labourers in rural and agricultural regions of India, but it also has larger ramifications on account of the inter-linked nature of the land, labour, credit, and product markets (Singh and Kaur, 2020)

Downward shift in the aggregate supply

The sudden collapse of the aggregate supply in India will go a long away in accentuating the recessionary momentum already built before the Corona pandemic. With aggregate demand being weak, the clearance of stocks already produced and built-up in the inventories of firms stands as a challenge for the captains of the industries whose production is most hit by the lockdowns. The Government has rightly come out with appropriate stimulus packages to boost the ailing aggregate demand. However, lags in the aggregate supply-demand adjustment process on account of different temporal reactions of aggregate consumption and aggregate investment to the current situation will inevitably occur on account of the uncertainty about the normalization of Indian economy to the pre-lockdown times. A detailed study of this process of adjustments between the aggregate goods and labour markets in light of the current pandemic may become useful for the Government to devise effective recovery plans. The policy-makers need to have detailed idea about the macroeconomic changes that have occurred throughout this lockdown so as to conceptualize and implement interventions that provide fast and efficient recovery in the times to come. Moreover, the sudden downward momentum in aggregate supply has implications for the growth momentum. With increasing focus on social sector, Indian growth story needs to translate into meaningful developmental outcomes so that India does not fall into the trap of an unbalanced growth trajectory (Sharma, A.D. 2014).

Current crisis and the efficiency of the public administration machinery

Various events that are unfolding during these demanding times are also a test of the ability of the Indian public administration machinery

to handle a crisis of an unprecedented scale in the recent past. While the Indian administration has been considerably effective in executing the lockdown in major areas of the country, there are some places that seem to be defying the lockdown rules. Moreover, reports of black-marketing of masks and sanitizers, increased bootlegging in some parts of the country and other such incidents have put pressure on the Indian administration at multiple fronts. It is commendable that our public administration has been handling these challenges with considerable efficiency. However, a detailed analysis of the performance of our administrative set-up in enforcing this lockdown while undertaking its regular administrative tasks such as continued policing and supplying essentials such water and electricity, among others, may help the current Government to mould the public administrative machinery to better suit the needs of modern times.

Changes in income distribution and inequality

Initial resource endowments can produce stark differences in the outcomes due to crisis such as the one being currently faced by India. While those who have sufficient wealth to deal with the economic losses associated with this lockdown will probably be able to bear the same, those sections of society whose wealth levels are already low and whose incomes are highly volatile, will possibly end up bearing considerable economic costs. These include costs such as the income forgone due to lack of employment, the opportunity cost of time spent without earning sufficient incomes, among several others. Inevitably, since the unlocking process began, the distribution of income and wealth has undergone a considerable shift against such vulnerable sections of the society. The degree of inequality has also worsened further due to these developments. Hence, exhaustive studies on these aspects are urgently required so that policy-makers can act promptly to help these vulnerable sections withstand the possibility of tremendous negative welfare impacts which are now emerging since the process of unlocking has begun.

CONCLUSION

Extracting pure exogenous variations in socio-economic variables and studying their impact on various macroeconomic and microeconomic processes has been a matter of rich debate and study since long in the realm of Economic analysis. Increasingly, the advent of modern econometric methods and the consequent developments in econometric technologies have allowed more rigorous examination of various macro and micro economic events. Occurrence of the Corona pandemic and the subsequent lockdowns in India have opened up several areas of research that need urgent attention of Economists, policy-makers and those teaching Economics. This is required not only for the sake of knowing about these issues in themselves but more importantly for devising an effective long-term exit plan and a suitable policy matrix to uplift the Indian economy out of this crisis and put it back to the trajectory of the five trillion dollar growth path. The note above provides a very broad outline of the research agendas that policy-makers and analysts can adopt in the times to come so that our understanding of the richness, complexity and dynamism of the Indian economy can be further enriched.

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