



## EXPORT LED GROWTH OR GROWTH LED EXPORT HYPOTHESIS IN INDIA: EVIDENCE BASED ON TIME-FREQUENCY APPROACH

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### ABSTRACT

*A plethora of research activity on the relationship between a country's export and economic growth has produced ambiguous and mixed results. We reinvestigate this relationship using the methodology of wavelets based correlation and cross correlation. Our results show that the relationship between export growth and output growth is not only positive in India but this relationship grows stronger as time horizons increases. Our results based on wavelet cross-correlation show that causal relationship is bi-directional at higher time scales.*

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**Keywords:** Export-lead growth hypothesis, Time-frequency approach, Wavelet cross-correlation, India

**JEL Classification Codes:** C40, O24, F43, F10

### INTRODUCTION

The proponents of *Exports led Growth hypothesis* (ELG) (Neoclassical school of economists) postulate that exports make a significant contribution to economic growth. Enhanced specialization, full capacity utilization of the plant size, getting benefits of the greater economies of scale, increasing the rate of investment and technological change are some of the benefits which can be reaped through exports (Krueger, 1978; Kavoussi, 1984; Ram, 1985). Furthermore, exports can provide foreign exchange that allows for more imports of intermediate goods, which in turn raises capital formation and thus, stimulates output growth in developing countries. The proponents

of *Growth led Export hypothesis* (GLE) like (Krugman, 1984) and Lancaster (1980) hold the contrary view that economic growth leads to enhancement of skills and technology, and with this, increased efficiency, thereby creating a comparative advantage for the country that facilitates exports. A vast body of literature is available on the empirical examination of the role of export performance in the economic growth process. The earlier studies used simple correlation coefficient between export and economic growth to verify the association. They have found some association between export and output (Emery, 1967; Kravis, 1970; Bhagwati, 1978; Krueger, 1978). Some studies like (Balassa, 1978; Tyler, 1981; Feder, 1982; Ram, 1985) examined the relationship between exports and output using the ordinary least squares (OLS) regression on cross-section data growth within a neoclassical production function framework. Other country-specific studies like (Jung and Peyton, 1985; Sung-Shen *et al.*, 1990; Bahamini-Oskooee *et al.*, 1991) examined the causality between export growth and economic growth using Granger or Sims causality tests. Recent studies test the ELG hypothesis using the cointegration and error-correction models (see (Ghatak and Stephen, 1997; Islam, 1998; Dhawan and Biswal, 1999; Ekanayake, 1999; Anwar and Sampath, 2000; Nidugala, 2000; Love and CHANDRA, 2004; Dash and Rajesh, 2007). Standard econometric methods like *co-integration and vector error correction models* generally employed in economics have been designed to take care of only short run and the long-run. Nevertheless, the recent developments in statistical techniques have made it possible to think of more than short run and long run. Wavelets given their ability to decompose the time series into different time scales can be useful to study relationships in the short run, medium run and long run. This study analyzes the relationship between export growth and output growth over different time scales using the methodology of wavelets for India. Our results based on wavelet correlation indicate that export growth and output growth are almost uncorrelated at lower time scales and share very small co-movement, however at medium and higher time scales the output and growth is correlated and this correlation grows stronger with time scales. Moreover, we unveil some causal relationships at medium and higher time scales. The rest of the article is organized as follows. Section 2 deals with theoretical framework on the relationship between exports and growth. Section 3 discusses the motivation and introduction to methodology. Section 4 discusses the data. Section 5 presents empirical findings of this study, while Section 6 concludes the results drawn.

### Theoretical Underpinnings

Four possible relationships could arise between exports and output: export-led growth, growth-driven exports, the two-way causal relationship and no relation and no causal effects between exports growth and economic growth. Studies like Krueger (1978), Feder (1982) and Thornton (1996) find that countries exporting a large share of their output seem to grow faster than other countries. The growth of exports stimulates the economy as a whole in the form of technological spillovers and other externalities. Barro and Xavier (1995), also hold the same view and argue that more export oriented economies have a greater ability to absorb technological advances generated in the leading countries. A GLE orthodoxy is argued by economists like Krugman (1984) and

Lancaster (1980); who advocate that economic growth leads to enhancement of skills and technology, and with this, increased efficiency, thereby creating a comparative advantage for the country that facilitates exports. A feedback relationship between exports and output can also hold under certain cases. For example, exports may rise from the realization of economies of scale due to productivity gains; the rise in exports may further enable cost reductions, which may result in further productivity gains Helpman and krugman (1985). Bhagwati (1988) argues that increased trade (irrespective of cause) produces more income, which leads to more trade, and so on. There is also potential for no causal relationship between exports and economic growth when the growth paths of the two time series are determined by other, unrelated variables (for example, investment) in the economic system (Pack, 1988). Theoretically all four results are possible, namely, (a) that export growth causes economic growth; (b) economic growth causes export growth; (c) that there is a bi-directional causality between export growth and output growth; and finally (d) that there is no relation and no causal effects between exports growth and economic growth.

**Motivation and Introduction to Methodology**

The research on the export-led hypothesis is mostly centered on the time-domain methodologies ignoring frequency-domain. Analyzing the issue in the time-frequency domain, however, may detect many appealing relations that operate exclusively at different frequencies. In fact, it is likely that the link between export growth and output growth may vary across frequencies, and such relationship may even change over time. The approach of wavelet, in this regard, proves very useful for its potentiality to decompose the aggregate time series data into different frequency-bands or time scales.

The basic wavelets are grouped into two different categories: the father wavelets given as;

$\int \phi(t)dt = 1$ , that is used for the low frequency smooth components parts of a signal and the other

one is the mother wavelet  $\int \psi(t)dt = 0$  applied for the high-frequency details components. A

time series, say  $f(t)$ , can be decomposed by the wavelet transformation, expressed as follows:

$$f(t) = \sum_k s_{J,k} \phi_{J,k}(t) + \sum_k d_{J,k} \psi_{J,k}(t) + \sum_k d_{J-1,k} \psi_{J-1,k}(t) + \dots + \sum_k d_{1,k} \psi_{1,k}(t)$$

(1)

where  $J$  is the number of multiresolution levels, and  $k$  ranges from 1 to the number of coefficients

in each level. The wavelet coefficients  $s_{J,k}, d_{J,k}, \dots, d_{1,k}$  are the wavelet transform coefficients

and  $\phi_{J,k}(t)$  and  $\psi_{j,k}(t)$  represents the approximating wavelets functions.

**The Discrete Wavelet Transform (DWT) and Maximal Overlap DWT (MODWT)**

Assuming wavelet filter coefficients  $h_1 = (h_{1,0}, \dots, h_{1,L-1}, 0, \dots, 0)^T$  of a Daubechies (1992) compactly supported wavelet for unit scale and zero padded to length N; defined by  $h_{1,j} = 0$  for  $l > L$ , a wavelet filter must satisfy three properties viz;

$$\sum_{i=0}^{L-1} h_{1,i} = 0; \quad \sum_{l=0}^{L-1} h_{1,l}^2 = 1 \quad \sum_{l=0}^{L-1} h_{1,l} h_{1,l+2n} = 0 \quad \text{for all non zero integers } n.$$

Thus, the wavelet filter must sum to zero or have zero mean along with unit energy and orthogonal to its even shifts.

Given the zero padded scaling filter coefficients as  $g_1 = (g_{1,0}, \dots, g_{1,L-1}, 0, \dots, 0)^T$ , a time series defined as  $X_0, \dots, X_{N-1}$ , can be filtered using  $h_j$  to obtain the wavelet coefficients for the scale

$$\text{of } N \geq L_j \text{ as: } W_{j,t} = 2^{j/2} \tilde{W}_{j,2^j(t+1)+1}, \quad \left[ (L-2) \left( 1 - \frac{1}{2^j} \right) \right] \leq t \leq \left[ \frac{N}{2^j} - 1 \right],$$

The Orthogonal discrete wavelet transform (DWT) is, however, subjected to two major drawbacks: First, the dyadic length requirement, that is, a sample size need to be divisible by  $2^j$ , and second, the wavelet and scaling coefficients are shift variant due to their sensitivity to circular shifts following the decimation operation.

The non-orthogonal variant of DWT, defined as the maximal overlap DWT (MODWT), does not decimate the coefficients and thereby ensures the number of scaling and wavelet coefficients at every level of transform to same as the number of sample observations. The MODWT although foregoes orthogonality and efficiency in computation, however, is free from any sample size restriction and is invariant to shift. The wavelet coefficients,  $\tilde{W}_{j,t}$  and scaling coefficients  $\tilde{V}_{j,t}$  at levels  $j; j = 1, \dots, J$ , under MODWT can be obtained as:

$$\tilde{W}_{j,t} = \sum_{l=0}^{L-1} \tilde{g}_l \tilde{v}_{j-1,t-1 \bmod N} \quad \text{and} \quad \tilde{v}_{j,t} = \sum_{l=0}^{L-1} \tilde{h}_l \tilde{v}_{j-1,t-1 \bmod N}.$$

Moreover, the wavelet and scaling filters  $\tilde{g}_l, \tilde{h}_l$  are rescaled as  $\tilde{g}_j = g_j / 2^{j/2}, \tilde{h}_j = h_j / 2^{j/2}$ . Apart from ensuring all the functions of the DWT, the MODWT confers additional benefits, e.g. (a) it handles any sample size, (b) is shift invariant as shift in the signal does not change the pattern of wavelet transform coefficients and (c) produces higher resolution at lower scales. and finally, (e) produces a more asymptotically efficient wavelet covariance estimator than the DWT.

### The wavelet correlation and cross-correlation

The wavelet correlation is composite of (a) the wavelet covariance for  $\{x_t, y_t\}$  and (b) the wavelet variances for  $\{x_t\}$  and  $\{y_t\}$ . For a random process X, the wavelet variance are estimated employing MODWT coefficients for scale  $\tau_j = 2^{j-1}$  following,

$$\hat{\sigma}_x^2(\tau_j) = \frac{1}{\hat{N}_j} \sum_{k=L_j-1}^{N-1} (\hat{W}_{j,k}^x)^2 \quad (2)$$

On the other hand, the wavelet covariance at scale  $\tau_j$  is defined as:

$$\gamma_{XY}(\tau_j) = \text{COV}_{XY}(\tau_j) = \frac{1}{\hat{N}_j} \sum_{k=L_j-1}^{N-1} \hat{W}_{j,k}^x \hat{W}_{j,k}^y \quad (3)$$

On the basis of wavelet covariance and wavelet variances defined above, the MODWT estimator of wavelet correlation is presented as follows:

$$\hat{\rho}_{xy}(\tau_j) = \frac{\text{Cov}_{xy}(\tau_j)}{\hat{\sigma}_x^2(\tau_j) \hat{\sigma}_y^2(\tau_j)} \quad (4)$$

Following the same line, the cross-correlation between two time series is decomposed on a scale-by-scale basis by the wavelet cross-correlation, which enables us to analyze the relationship between a set of time series along the time horizons. Following [Gençay et al. \(2002\)](#) the wavelet cross-correlation is defined as:

$$\hat{\rho}_{x,k}(\tau_j) = \frac{\gamma_{x,k}(\tau_j)}{\hat{\sigma}_1(\tau_j) \hat{\sigma}_2^2(\tau_j)} \quad (5)$$

The wavelet cross-correlation provides the lead-lag relationship at different time scales.

### DATA

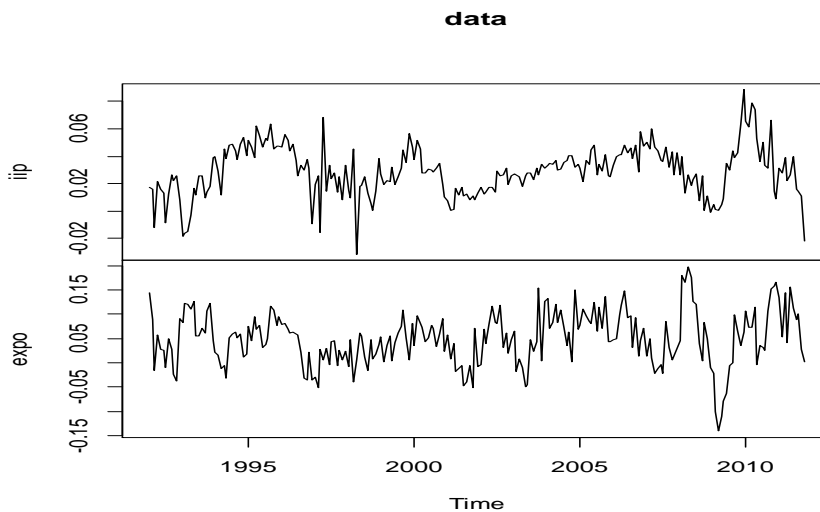
For the empirical estimation monthly data over the period January 1992 to October 2011, of index of industrial production and exports were utilised so that we have sufficient observations over the period which coincides with the liberalized era in India. Both the variables have been obtained from IMF CD-ROM (2012). Exports were adjusted to inflation to consider real exports. We transformed both variables into monthly growth rates and their plots are presented in Figure 1. The share of the industrial sector is low in overall economic activity; industrial production therefore may not be the most reliable indicator of real economic activity in industrial countries. However,

we choose to use it mainly because it is the only aggregate output series available on a monthly basis.

## RESULTS AND DISCUSSION

Prior to estimation we analyse the descriptive statistics of each time series; presented in Table.1. As evident, the sample mean for both series are positive. Moreover, the measure of skewness indicate that the series are skewed negatively. The estimated kurtosis exhibits value higher than *three*, implying both the series are leptokurtic relative to a normal distribution. The Jarque-Bera naormality test accept the normality of both the series.

**Fig-1.** Plot of Export growth and output growth



We then decompose the time series of output growth and export growth (Fig.1) into 5 different time scales using the MODWT.<sup>1</sup> The wavelet correlation and cross correlation is then calculated on the decomposed series. In Fig. 2, we report the MODWT-based wavelet correlation coefficients, with the corresponding approximate confidence intervals for all scales, where each scale is associated with a particular time period. For example, scale 1 is associated to 2–4 month periods, scale 2 to 4–8 month periods, scale 3 to 8–16

<sup>1</sup> This produces 5 detail components and one approximation. All details show the time dynamics given in table.1 of the appendix. Further the decomposed series are shown in Fig. 1 and 2 in appendix.

**Table-1.** Descriptive statistics of Output Growth and Export Growth

|              | Output Growth | Export Growth |
|--------------|---------------|---------------|
| Mean         | 0.028875      | 0.049436      |
| Median       | 0.029054      | 0.049178      |
| Maximum      | 0.088512      | 0.196814      |
| Minimum      | -0.031555     | -0.140994     |
| Std. Dev.    | 0.018316      | 0.055008      |
| Skewness     | -0.144207     | -0.132863     |
| Kurtosis     | 3.700758      | 3.33633       |
| Jarque-Bera  | 5.694596      | 1.821978      |
| Probability  | 0.058001      | 0.402126      |
| Observations | 238           | 238           |

month periods, and so on. In particular, the correlation coefficient of the output growth at time  $t$  is plotted against the value of export growth. At the shortest scales, i.e. scales 1 to 2, the magnitude of the association between the two variables is close to zero, while on the other hand at coarsest scales, particularly at scales 3, 4 and 5 such relationship is positive and becomes stronger with scales. At detail level 3 we find correlation is roughly equal to 0.2 with correlation increasing (0.4 and 0.8 at level 4 and level 5 respectively) as scales increase.

**Fig-2.** Wavelet based correlation between export growth and output growth

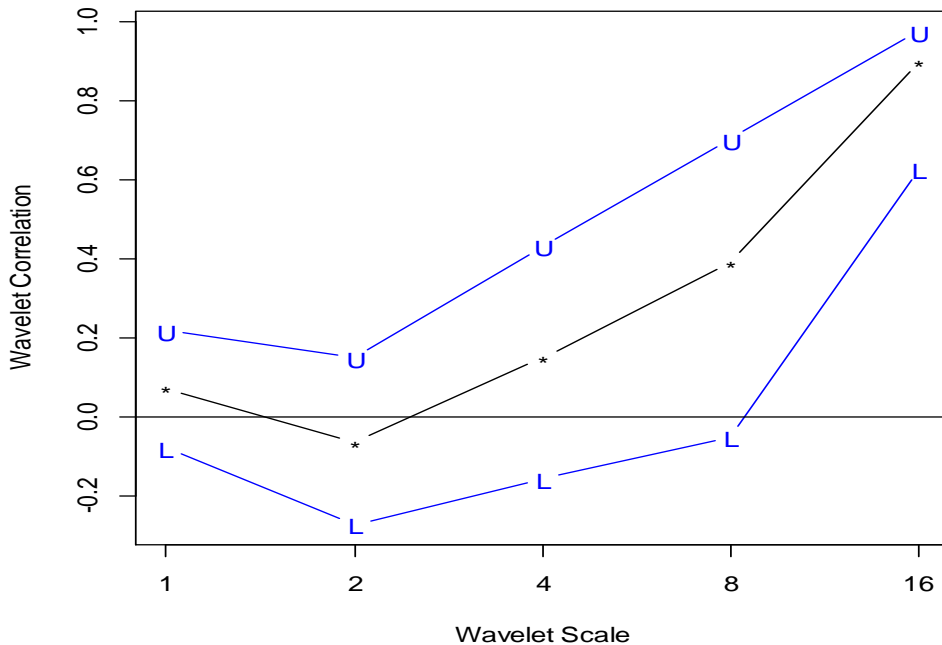
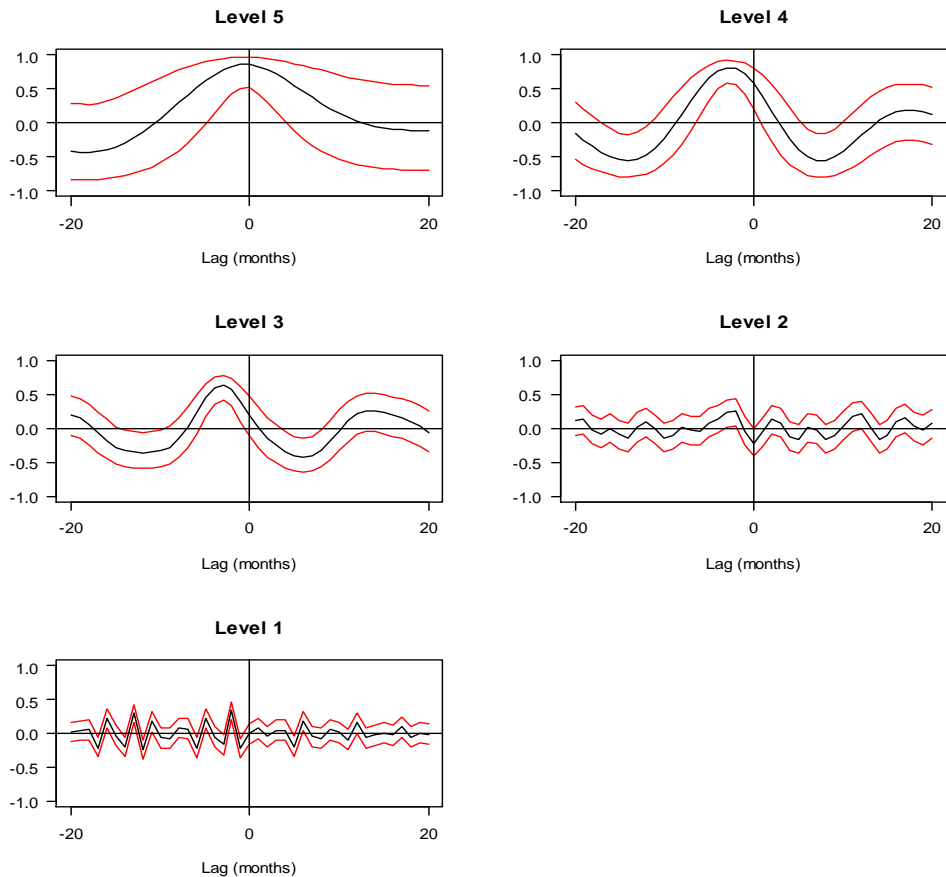


Fig. 3 gives the results of wavelet cross correlation for export growth and output growth. At detail levels 1 and 2, we find that the lead- lag relationship is insignificant. However for coarser scales, 3, 4 and 5, we find there are bidirectional relationships. On the other hand, the cross-correlation wavelet coefficients reveal that at the coarsest scales there is a high positive leading as well as lagging relationship between export growth and output growth rate, with the leading period as well as lagging period increasing as the time scale increases. It can also be seen that this lead lag correlation increases with time scales. Our results based on wavelet correlation show that exports and output are not related at lower time scales (D1 and D2 scales) which can be interpreted as short run, but they are related in medium run (D3 scale) and long run (D4 and D5 scale). Our results based on wavelet cross correlation in Fig.3 show that there are no significant causal relationships at D1 and D2 scales. At scales D3 and D4, the lags of export growth are significant thereby meaning that exports lead economic growth at scales D3 and D4. At the highest time scale D5, the relationship is bi-directional.

**Fig-3.** Wavelet based cross- correlation between export growth and output growth





**CONCLUSION**

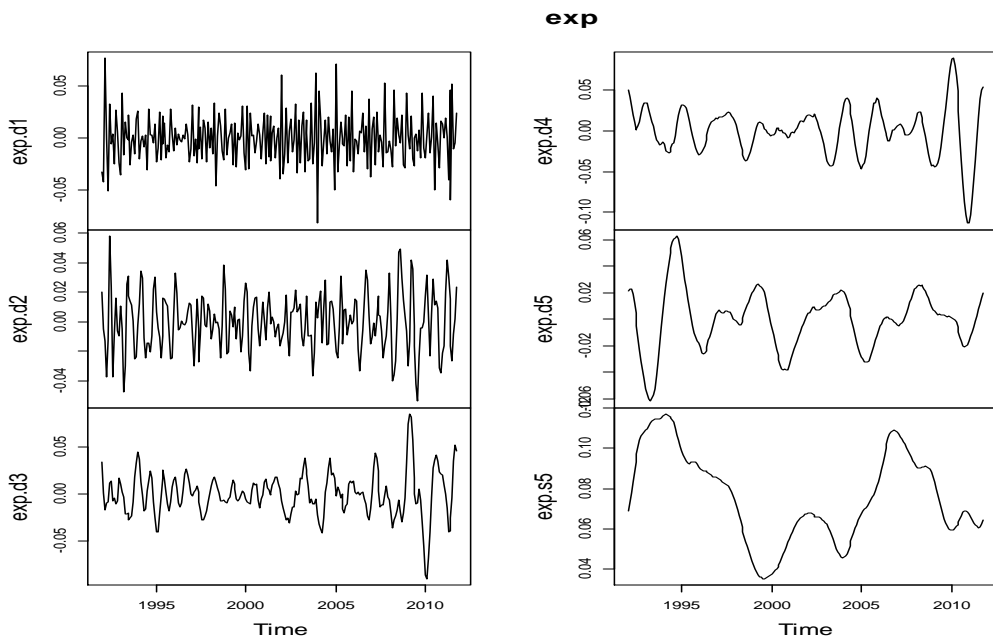
This article revisited the export-growth nexus over the reform period ranging from January 1992 to October 2011 in India. Using the methodology of wavelet correlation and cross correlation it was found that export growth and output growth do not share any significant co-movement at lower time scales of D1 and D2. However, for time scales D3, D4 and D5 it was found that there is a positive association between exports and output and this association was found to be growing stronger with time scales. Our results based on wavelet cross correlation showed that there is no causal relationship between exports and output at D1 and D2 scales, whereas, causal relationships were found to be unidirectional from exports to output at scales D3 and D4. At the highest time scale D5, we found the relationship is bi-directional. Over all we found that exports and output are not related in the short run but are related in medium and long run.

**Appendix:**

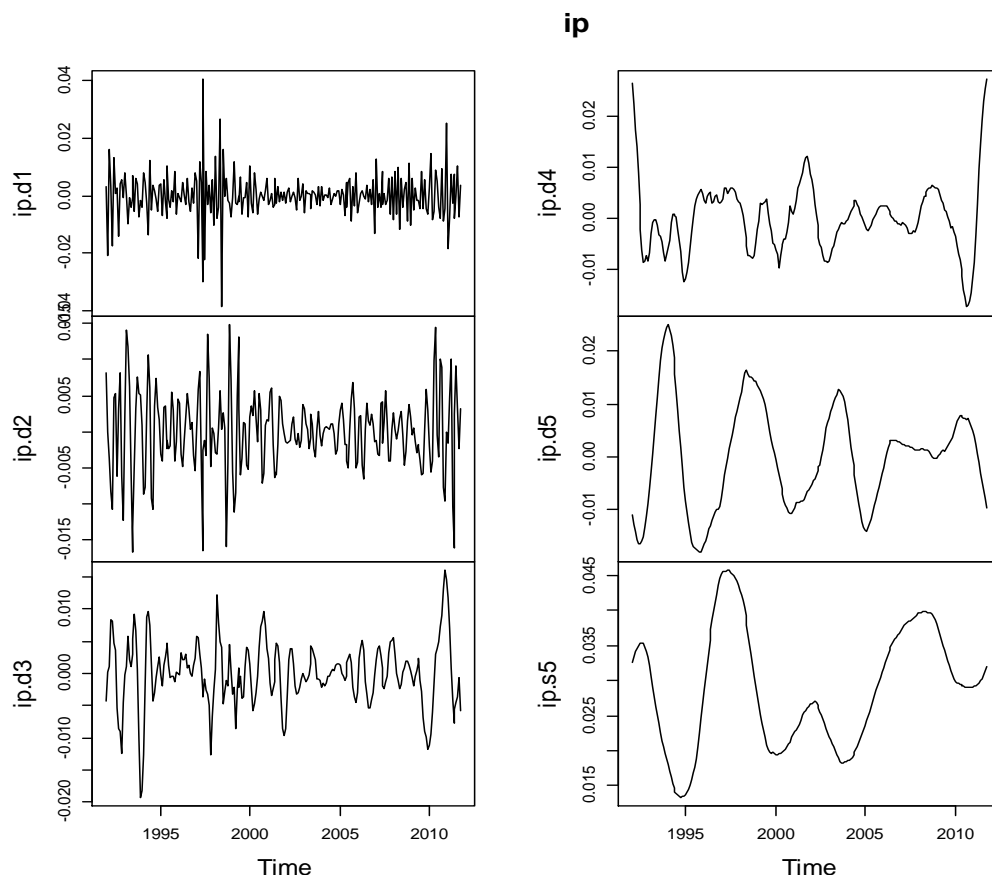
**Table-1.** Time interpretation of different scales

| Scale | Monthly frequency | Period definition |
|-------|-------------------|-------------------|
| D1    | 2-4 months        |                   |
| D2    | 4-8 months        | Short run         |
| D3    | 8-16 months       | Medium run        |
| D4    | 16-32 months      |                   |
| D5    | 32-64 months      | Long run          |

**Figure-1.** Plot of wavelet decomposed results of Export growth into different frequency bands



**Figure-2.** Plot of wavelet decomposed results of output growth into different frequency bands



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