DOES FDI PROMOTE ENERGY EFFICIENT TECHNOLOGY IN INDIAN INDUSTRY?

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Abstract

The paper analyzes the specific and co-effects of FDI inflows on energy intensity (EI) in India using data for 1986-2017 and employing fully modified ordinary least square (FMOLS) co-integration. The paper finds that FDI inflows, share of industry and services are co-integrated with energy intensity. The results indicate that the impact of FDI inflows on energy intensity in India does not conform to the theory of heterogeneity of firms in international trade. The specific effect of FDI and its co-effects with industry do not lower energy intensity in India. The co-effects of FDI and services sector are found to be marginal. As FDI inflows do not promote transfer of energy-efficient technologies, there is a need to incorporate EI as a parameter in FDI policy and strengthen its linkages with National Mission for Enhancement of Energy Efficiency.

Keywords: *Energy intensity, FDI, Industry, Services, Technology, FMOLS.*

I Introduction

India aspires to be a USD 10 trillion economy by 2032 (Economic Survey, 2019) for which it requires a sustained annual growth of 8 per cent and yearly investments to the tune of USD 200 billion. It also seeks to increase the share of manufacturing to 25 per cent of the gross domestic product (GDP) by 2022 under the Make in India initiative of the Prime Minister of India (DPIIT, 2015). It is pertinent to note that India is a signatory to Paris accord and it intends to cut the emissions intensity of GDP by 33 to 35 per cent by 2030, as per nationally determined contribution under the accord (Government of India, 2019). The only way India can reduce emissions

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intensity and have a high growth economy is by facilitating Indian industries to adopt advanced energy frugal technologies. Foreign direct investments (FDI) will play a critical role in shaping the technological flows to industrial and services sector.

The latest empirical theory of heterogeneity of firms in international trade postulates that greater FDI inflows lead to transfer of advanced technologies thereby increasing productivity and efficiency of the sectors receiving such inflows. It propounds that firms that choose to engage in foreign trade do it either by doing exports or else by making a direct investment and manufacturing in those markets. It further finds that only the most productive firms choose to enter foreign markets through FDI commitments (Melitz, 2003 and Helpman, Melitz and Yeaple, 2004). Therefore, increased inflows of FDI rearrange the structure of industry towards more productive firms, using more advanced and efficient technologies, leading to lowering of energy intensity. In a recent study, Bu, Li and Jiang (2019), using firm level data of China find that firms receiving FDI are more productive compared to their domestic counterparts. While these studies provide validation to the tenets of theory of heterogeneity of firms in international trade, however, the impact of FDI in lowering energy intensity depends on whether or not FDI inflows promote transfer of energy efficient technology.

Given the importance of FDI in inducing transfer of technology, the focus of this paper is to find how FDI inflows have impacted energy intensity (EI) in India. In doing so, the specific effects of FDI on EI along with its co-effects, in terms of joint interaction with the share of industry and services, are analyzed. The rest of the paper is organized as follows. An overview of the prevailing scenario is presented at section II. The literature review is at section III. Data, methodology and model are outlined in section IV. Results are presented in section V. Section VI concludes

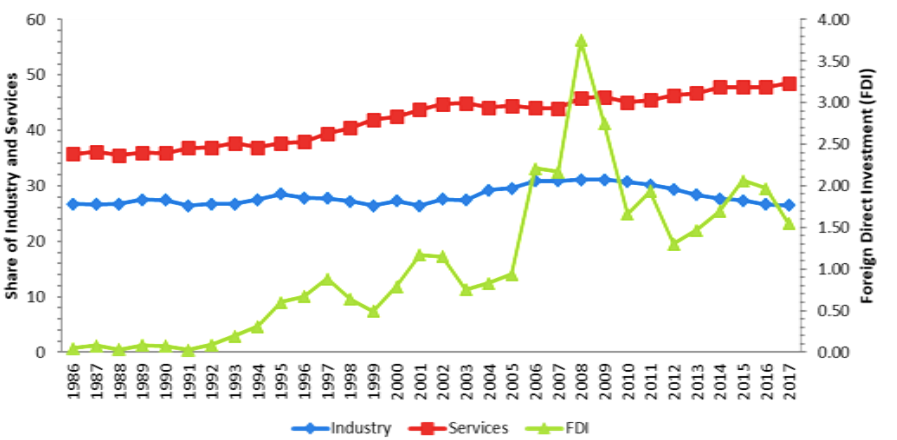
II. The Prevailing Scenario

2.1 Overview of FDI, economic structure and EI

The FDI inflows and the structure of the economy, in terms of share of industry and services in GDP, are critical factors impacting EI. Fig 1 presents the trends in FDI and the changing economic structure for 1986-2017 in

India. The share of FDI inflows in GDP was 0.05 per cent in 1986 and increased to 1.55 per cent in 2017. This is more than thirty time increase in volume terms. The FDI flows in India, given the size of the economy, have been rather low. There have been a slew of FDI policy reforms to attract more investments. The big ticket reforms of the FDI announced in 2016 by the Department of Promotion of Industry and Internal Trade (DPIIT, 2016) and the most recent FDI liberalization in coal, contract manufacturing and single brand retail trade (DPIIT, 2019) indicates the endeavors of the government to attract FDI. Most of the FDI in India is presently routed to industrial and services sector.

Fig 1: Share of FDI, Industry and Services



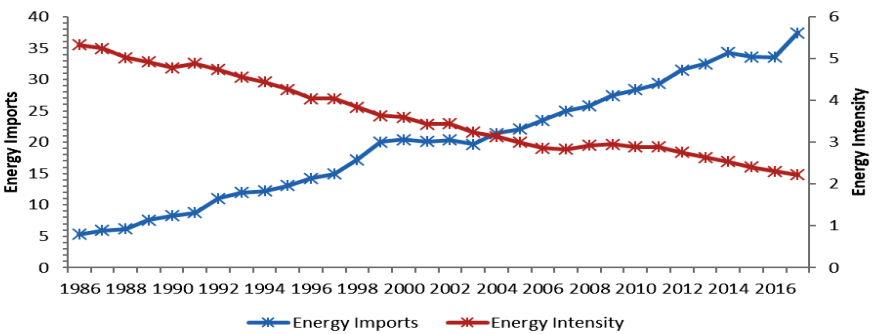
Source: Author's calculations based on data from World Bank for share of industry and services.FDI data is from UNCTAD (Values in per cent.).

The structural transition of Indian economy is marked by rising share of the services sector. The share of services in GDP has increased from 35.7 per cent in 1986 to 48.5 per cent in 2017. The share of industry in GDP, however, has remained stagnant. The share of industry in GDP was 26.7 per cent in 1986 and remained the same in 2017. The rising share of services and stagnating industrial share coupled with increased FDI flows in both these sectors provide an opportunity to reduce energy intensity, if the FDI inflows are accompanied with transfer of advanced technology.

The energy intensity of India is among the highest in the world. According to International Energy Agency (IEA, 2019) India along with China and USA

accounted for 70 per cent rise in the global energy demand. India is also a net importer of energy resources. Fig 2 presents India's energy imports and energy intensity for 1986-2017.

Fig 2: India's energy imports (as per cent of energy use) and energy intensity



Source: Author's calculations based on IEA data. Energy imports in %. Energy intensity in ktoe/ ten million USD

The share of energy imports in total energy use has been constantly rising in India. The share of energy imports was 5.3 per cent in 1986 and it rose to 37.4 percent in 2017. The surging import dependence of India on energy resources raises concerns regarding sustainability. It presents a challenge for sustaining the high growth ambitions of the economy. The EI of India has been declining over the years. EI was 5.3 ktoe per ten million USD in 1986 and declined to 2.2 ktoe per ten million USD in 2017. The declining EI is mostly on account of India's GDP growth outpacing the rate of energy consumption. However, the EI of India is still very high compared to other advanced and emerging economies. The Committee on Estimates (2018) while reviewing inter alia the performance of National Mission for Enhanced Energy Efficiency (NMEEE) found its impact to be limited. Using data of IEA (2019) on energy balances and World Bank (2019) on GDP at 2010 constant USD, we find that EI of South Korea (1.36), Canada (1.04), US (0.88), Singapore (0.61), Germany (0.58) and Australia (0.53) is much lower compared to India. It is an indication of opportunities available to reduce EI in India by facilitating transfer of energy efficient technologies through FDI inflows. This forms the core focus of this paper i.e. to analyze whether FDI flows in India have reduced EI or not?

III. Literature Survey

The literature linking EI and FDI gained traction with the study conducted by Mielnik and Goldemberg (2002) in which they found that FDI reduced EI, for twenty developing countries analyzed by them. Using different methodologies, similar results were obtained by He, Gao and Wang (2012), Adom (2015), Rajneesh (2017) and Bu, Li and Jiang (2019). He, Gao and Wang (2012) used multivariate vector auto regression method employing data over 1985-2010 for Shanghai and found that FDI led to energy savings. Adom (2015) used data for Nigeria in a multivariate econometric model using single structural break and found that FDI led to reduction of energy intensity. Rajneesh (2017) used data over 1973-2013 in an auto regressive distributive lag model for India and found that FDI reduced energy intensity. Bu, Li and Jiang used firm level data for China and found similar results. However, the EI reducing linkages with FDI were challenged by Hubler and Keller (2010), Hossain (2011) and Omri and Kahouli (2014).

There are several studies linking FDI with technological spillovers. Glass and Saggi (2002) analyzed firm level data and their results show that FDI brings greater productivity to the domestic firms and there is an incentive for the government to facilitate technology transfer through FDI. Sinani and Meyer (2004) found that FDI led to technological transfer spillovers thereby making the firms which received FDI inflows more productive. Mattoo, Olarreaga and Saggi (2004) studied cost of technology transfer and demonstrated that when cost of technology transfers are low, the government has more incentive in facilitating direct entry of foreign firms via FDI rather than through equity participation and acquisition of the domestic firms. Damijan, Knell, Majcen and Rojec (2003) studied 8000 firms for ten advanced transition countries and found that the direct technological spillover effects of FDI were the most important in increasing productivity of the recipient firms. In a study of Indian firms, Ghosh and Roy (2018) found that foreign firms are more productive compared to domestic firms and imported technology acts as substitute for R&D by domestic firms. Using panel data for Chinese provinces, Xin-gang, Yuan-feng and Yan-bin (2019) find that FDI inflows promote convergence of energy intensity. Chen, Du, Huang and Huang (2019) also find that that foreign innovation in terms of foreign direct investment reduced energy intensity in Chinese industry. Most of these

studies only analyze the association between FDI and industry, whereas the share of services sector has generally been ignored. Further, studies analyzing the co-effects of FDI and services jointly could not be found at the time of writing this paper.

There are two specific contributions that the instant study intends to make to the existing literature. First, it uses most recent data for India spanning 1986-2017. Second, it incorporates co-effects of FDI with the services sector besides incorporating co-effects with industry and specific effects of FDI.

IV. Data, Methodology and Model

4.1 Data and Methodology

The study uses time series data for 1986-2017. Data on energy consumption is sourced from International Energy Agency (IEA, 2019) and for GDP (2010 USD constant), share of industry and services World Development Indicators (WDI) database of the World Bank (2019) is used. The share of FDI inflows in GDP is taken from UNCTAD data. EI is calculated as share of total final primary energy consumption in GDP and is reported as tons of oil equivalent (toe) per thousand USD at constant price.

A three step methodology is used for analyzing long run relationship between FDI, economic structure and EI. Since time series data is involved, we first check for presence of unit root in the variables using augmented Dickey and Fuller (1979) and Phillips-Perron (1988) technique. Thereafter, Johansen (1995) co-integration test is used to find whether a long term co-integrating relation exists between the variables. Finally, using fully modified least squares (FMOLS) regression methodology developed by Phillips and Hansen (1990) and Phillips (1995) the elasticity of EI w.r.t. FDI and economic structure is estimated. FMOLS is a semi-parametric model which modifies variables and estimates directly to eliminate the existing nuisance parameters. FMOLS methodology successfully tackles the problem of serial correlation and endogeneity in context of non-stationary time series making it most appropriate for use in the study. For a n + 1dimensional I (1) process (y_t, x'_t) the co-integrating system in its triangular form can be represented as:

$$y_t = x'_t\beta + D_{1t}'\gamma + v_{1t} \quad (1)$$

$$\triangle y_{2t} = \varepsilon_{2t} \quad (2)$$

where $\varepsilon_t = (v'_{1t}\ \varepsilon'_{2t})$ are assumed to be strictly stationary with zero mean and infinite covariance matrix Σ and Σ is not block diagonal and ε_t is weakly dependent. The ordinary least square estimate of β is consistent but not efficient. The approach by FMOLS is to use a transformation process to produce a consistent and efficient estimate of β. If we let $D_t = (D'_{1t}, D'_{2t})'$ represent deterministic trends, then the x_t regressors are governed by;

$$x_t = \Psi'_{21}D_{1t} + \Psi'_{22}D_{2t} + \varepsilon_{2t} \quad (3)$$

$$\triangle\varepsilon_{2t} = v_{2t}, \quad (4)$$

if we let $\hat{v}_{1t}$ be the residuals obtained from eq (1), then we can obtain $\hat{v}_{2t}$ directly from the difference eq (5) or indirectly from eq (6).

$$\triangle x_t = \widehat{\Psi}_{21}'\triangle D_{1t} + \widehat{\Psi}_{22}'\triangle D_{2t} + \hat{v}_{2t} \quad (5)$$

$$\hat{v}_{2t} = \triangle\hat{\varepsilon}_{2t}, \quad (6)$$

Now if we let $\widehat{\Omega}$ and $\widehat{\Lambda}$ be the long-run covariance matrices computed using the residuals $\hat{v}_t = (\hat{v}_{1t}, \hat{v}_{2t})'$, then the modified data can be expressed as equations (7) and (8).

$$y_t^+ = y_t - \widehat{\omega}_{12}\widehat{\Omega}_{22}^{-1}\hat{v}_2 \quad (7)$$

$$\hat{\lambda}_{12}^+ = \hat{\lambda}_{12} - \widehat{\omega}_{12}\widehat{\Omega}_{22}^{-1}\hat{\Lambda}_{22} \quad (8)$$

y_t^+ and $\hat{\lambda}_{12}^+$ are the correction terms for endogeneity and serial correlation, respectively. The resulting FMOLS estimator is then given as eq (9).

$$\hat{\theta}_{\text{FME}} = \left(\sum_{t=1}^{T} z_t z_t'\right)^{-1} \left(\sum_{t=1}^{T} z_t y_t^+ - T\begin{bmatrix}\hat{\lambda}_{12}^{+'} \\ 0\end{bmatrix}\right) \quad (9)$$

4.2 Model

The following log-linear model is used to determine the specific effects of FDI on EI:

$$\ln EI_t = \alpha + \beta\ln FDI_t + \gamma\ln IND_t + \delta\ln SER_t + \varepsilon_t \qquad t \in (1,2\ldots,31) \quad (10)$$

where ε_t denotes random error term and t is time. All variables are in natural log represented by ln. EI is the share of primary energy consumption in gross domestic product (GDP) at constant prices; FDI, IND and SER are shares of FDI, industry and services in GDP of India.

The parameter α is a constant, whereas β represents specific effects of FDI on EI i.e. elasticity of energy intensity w.r.t. FDI. The sectoral effects of industry and services are captured by γ and δ respectively. γ is elasticity of energy intensity w.r.t. share of industry in GDP and δ is elasticity of energy intensity w.r.t. share of services in GDP. The sign of β is expected to be negative because an increase in share of FDI is likely to lead to inflows of more productive and efficient technology, thereby reducing EI. As the sectoral shift from agriculture to industry, as pointed out earlier, has only been marginal in India, therefore, the sign of γ will be negative only if more energy efficient technology crowds out less energy intensive domestic capital and vice versa. The sign of δ will depend upon the net impact of sectoral intensity and structural change in services sector (Boyd and Golden, 2015; Voigt et al. 2014).

4.2.1 Co-effects of FDI on EI

The paper also examines the co-effects of FDI, with industry and services, on EI. The idea is to understand how the joint interaction of FDI and structural change has impacted EI in India. According to theory of heterogeneity of firms in international trade, more efficient technology associated with FDI is expected to flow into the industrial and services sector. The extent to which the FDI inflows will impact EI depends upon the changing shares of industry and services and also the technological improvements brought about by transfer of technology likely to be associated with FDI inflows. It is important to understand that FDI inflows do not necessarily imply that transfer of technology will happen. Therefore, it is important to analyze the co-effects of FDI with industry and services sector by discerning the joint interaction of these variables and their impact on energy intensity. Eq (11) captures the co-effects of FDI and share of industry while controlling for other variables. Eq (12) models the co-effects of FDI and services on EI.

$$\ln EI_t = \alpha_0 + z\ln(FDI)_t * \ln(IND)_t + \gamma \ln(SER)_t + \varepsilon_t \qquad (11)$$

$$\ln EI_t = \alpha_0 + v\ln(FDI)_t * \ln(SER)_t + \beta\ln(IND)_t + \varepsilon_t \quad (12)$$

The joint interaction of FDI with industry and services yields co-effects on energy intensity. The coefficients z and v reflect the long run elasticities of energy intensity to the co-effects of FDI with industry and services respectively. Though FDI is expected to lower energy intensity, the sign of z and v cannot be determined a priori because they are dependent upon the extent and direction of the impact of share of industry and services, in GDP, on energy intensity.

V. Results

5.1 Unit Root

The results of ADF and PP unit root tests are presented at Table 1. All variables are non-stationary at levels, whereas they become stationary at first difference. The stationarity of all variables is confirmed at first difference using ADF and PP is at 1 per cent significance level. The results imply that all variables are integrated of order 1 i.e. I(1).

Table -1 Unit Root Test

	ADF		PP		
Variables	Level	First Difference	Level	First Difference	Conclusion
LnEI	-1.77	-4.61***	-2.06	-4.61***	I(1)
LnFDI	-1.84	-6.33***	-1.75	-6.33***	I(1)
LnIND	-2.77	-2.28***	-1.13	-5.31***	I(1)
LnFDI/I	-1.64	-6.47***	-1.71	-5.18***	I(1)

*** Indicates 1% significance level

5.2 Johansen Co-integration

Table 2 shows the results of Johansen co-integration test. Using the trace and maximum eigenvalue test statistic, we find that null of no cointegration is rejected at 1 per significance level. The results clearly imply that EI, FDI, share of industry and services have a long run unique co-integrating relationship.

Table -2 Johansen Cointegration Test

Hypothesized no. of CE(s)	Trace test	Maximum eigenvalue test
None	63.48***	35.50***
At most 1	27.98	14.64

*** Indicates 1% significance level

5.3 Specific and Co-effects of FDI on EI

As the variables are co-integrated, we use FMOLS to estimate the specific and co-effects of FDI on EI. The results of specific effects of FDI, along with sectoral effects of industry and services, on EI are reported at column M1 of Table 3. The findings on co-effects of FDI and industry on EI is at M2 of Table 3. The results for co-effects of FDI and services are presented at M3 in Table 3.

Table -3 Specific and Co-effects of FDI on EI

	Fully modified least squares estimates		
Variables	M1	M2	M3
FDI	-.007	-	-
Share of Industry	.636***	-	-.587
Share of Services	-2.588***	-3.010***	-
FDI* Industry	-	.023	-
FDI* Service	-	-	-.096***
Constant	3.815***	5.435***	1.344***
R-square	.919	.918	.709
Adjusted R-square	.911	.912	.689
Long-run variance	.0003	.001	.018

All variables are in log. Dependent variable: Log (EI). Cointegration equation deterministic: constant
Long-run covariance estimate (Lag specification – Auto AIC, Bartlett Kernel, (Newey-West fixed bandwidth)
*** Indicates 1% significance level

The results indicate that the specific effect of FDI on EI (-0.007) is negative but insignificant. It implies that FDI inflows have not resulted in lowering EI in India. The findings are in line with Hubler and Keller (2010), Hossain

(2011) and Omri and Kahouli (2014). The lack of significance of FDI in impacting EI implies that Indian experience does not conform to the tenets of theory of heterogeneity of firms in international trade. The sectoral effect of industry on EI is positive and significant while for services it is negative and significant. It implies that an increase in the share of industrial sector leads to increasing EI, while rising share of services sector in economy reduces EI. A 10 per cent increase in share of industry is expected to increase EI by 6.36 per cent. Whereas, a 10 per cent rise in share of services is associated with 25.8 per cent decline in EI. The results indicate that services sector has been a major contributor in reducing EI in India and FDI inflows have been unable to bring about technological improvements to reduce energy intensity. The results contradict the tenets of theory of heterogeneity of firms in international trade as far as specific effects of FDI on EI are concerned.

The co-effects of FDI and industry on EI (0.023), as presented at M2, are insignificant. It implies that FDI inflows in industrial sector do not impact EI at all. This is a clear indication that India has not been able to attract energy efficient technology in industrial sector. On the contrary, the co-effects of FDI and services (-0.096), as at M3, reduce EI and are significant. A 10 per cent joint increase in FDI and share of services is expected to lower EI 0.9 per cent. Though the associated elasticity is negative yet its value is small. It indicates that FDI inflows in services sector do contribute to lowering EI but as the magnitude of impact is only 0.96 per cent, it indicates that lowering of EI is associated more with structural shift rather than improvements in sectoral intensity associated with services sector. Thus, FDI inflows in services sector have only marginal impact on lowering EI.

VI. Conclusion

FDI inflows are expected to bring in efficient and advanced technologies. However, the results obtained, by using data on FDI, economic structure and EI for 1986-2017 indicate that specific effects of FDI on EI are insignificant. The reduction in EI in India is largely attributable to rising share of the services sector in the economy. A 10 per cent increase in services sector results in 25.8 per cent decline in EI. The share of industry, though stagnant, leads to 6.36 per cent increase in EI. These results contradict the tenets of

theory of heterogeneity of firms in international trade which postulates that increasing FDI would bring in more efficient technologies and restructure the economy towards more efficient firms. Insignificant specific effects of FDI raise a concern for policy makers as FDI inflows are not inducing transfer of appropriate technologies.

The finding of the study regarding insignificance of co-effects of FDI and industry, again is an indication of non-impact of FDI in bringing technological improvements in industrial sector. The study finds that co-effects of FDI and services sector reduce EI but only by 0.96 per cent. This is again a pointer towards the lack of effectiveness in FDI inflows to bring in technological advancements in India. The National Mission of Enhanced Energy Efficiency (NMEEE), which is being implemented by Bureau of Energy Efficiency (BEE), is presently involved in demand and supply side management of energy related issues. NMEEE must incorporate a focused vision on including FDI as an instrument in reducing EI by bringing in efficient technologies. Presently, the FDI Policy does not include EI or energy efficient technologies in its ambit. BEE must work closely with Department of Promotion of Industry and Internal Trade (DPIIT), the custodian of the FDI Policy in India, and make endeavors to get EI included as a policy parameter in the FDI policy.

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