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Globalization and India's international trade: does distance still matter?

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Abstract This paper attempts to capture the missing 'distance' puzzle in the globalization process driven by trade flows. It is widely recognized that the growing global economic integration process play a major role in the spatial restructuring of many countries at varying geographical scales. The paper illustrates a model of international trade flows that builds upon existing research on the geographies of global trade. Empirical results of the current study indicate that the basic and augmented gravity model provides a useful framework for understanding international trade. The evidence of map pattern in residuals across temporal scale is noted. The results further indicate the importance of distance in the Indian context. An identification of the patterns and determinants of India's international trade with 87 countries suggests that potentially important differences in regional demands and country specific factors may impact the trade interaction over the years.

Keywords Globalization · Distance decay · Gravity model · India · International trade · Regression · Residual mapping

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Globalization and India

The globalization process driven by international exchange has revealed a very distinct spatial pattern. According to UNCTAD (2008), twnetyfirst century witnessed an unprecedented growth in the globalization process, and noted "Integral to this trade expansion has been rise of the dynamic south and a rapid expansion in trade among developing countries. The world is witnessing the evolution of South–South trade and investment models in sectors and areas such as minerals, metals, fuels, manufacturing, services, trade logistics, and facilitation." Since the 1950s, Dicken (2011) noted, there are two major characteristics of the world economy: (i) greater volatility of total economic growth and (ii) the growing interconnectedness between the different parts of the world. Similarly, Rodrigue et al. (2017) have written that closer the economic entities are, the more likely they are to trade, due to lower transport costs, fewer potential delays in shipments, common customs procedures, and linguistic and cultural affinities". The more intense trade relations are within Western Europe and North America, with a more recent trend involving trade within Asia, particularly between Japan, China, Korea, and Taiwan, as these economies are getting increasingly integrated.

Interestingly, the difference in the nature and structure of this integration sheds light on the evolving complex interdependencies visible in the spatial structure and behavior of the entities participating in

the globalization process. So the popular wisdom supporting the idea that globalization has led to homogenization of the space is contentious. In this backdrop, it would not be wrong to say that trade is the primary manifestation of this increasing integration and changing organizational structure of the global economy which has been much more extensive than in the past involving more countries and regions. In the similar way, it is also much more intensive as foreign trade became a key component of most countries economic activities. Over the years, emerging nations like China, India, Brazil, Mexico, and South Africa have made their presence felt in the global market and have come forth as new key drivers of global growth. Among other emerging countries, China and India are the fastest growing economies. Because of this reason, the paper primarily focuses on how India has responded to the globalization process and the reforms undertaken in this line of approach. India with its distinct development strategy has the potential to influence economic activities of the global economy in the years to come. Although economic reforms initiated in 1991 were crisis driven, they were expected to bring about a rapid and substantial economic growth and over a time to integrate Indian economy with the global economy. In this context, Yadav (2012) noted that India has cautiously initiated its liberalization program in July, 1991 which was comprehensive but gradual.[1] Political and economic reforms over the past 10 years have paved the way for developing India into a truly global marketplace. Till the early 1990s, the average tariff exceeded 200%, quantitative restrictions on imports were extensive, and also there were strict restrictions on foreign investment. Nonetheless the opening of the economy to international trade has remarkable results which could be seen in the increasing share of trade in gross domestic product (*GDP)* from 13% in 1990 to 31% in 2015. India's share in world trade increased from 0.58% in 1990 to about 2% in 2015. India plays a pivotal role among the developing economies in global trade negotiations.

[1] Also refer https://www.researchgate.net/publication/325809249-External-Sector-Reforms-in-India-An-Overview.

The theoretical context

According to Thomas and Hugget (1980), flows in human geography are often termed as spatial interactions, and a spatial interaction model is an equation which predicts the size and direction of some flow (the dependent variable) using independent variables which measure some structural property of human landscape. The original spatial interaction models are called gravity models because their mathematical assumptions are similar to those embodied in Isaac Newton's law of gravitational attraction. Indeed, gravity models have a long geographical pedigree. The most simple model uses the distance between the trading partners as a proxy for transportation costs. The core gravity equation has been used for empirical analysis since the econometrics studies of trade by Tinbergen (1962) and Pöyhönen (1963), the theoretical foundations to the model are of more recent origin. The most classic and early application of the model to international trade was perhaps by Linnemann (1966). Gravity model of spatial interaction has long been the point of extensive study in the literature, and has been derived from numerous points of view.

According to Yeats (1969), international trade could be examined as a 'special form of interaction' and involves study of movements between places that are politically independent and physically separated. The gravity model of bilateral trade is of primary significance in empirical analyses of the patterns of trade. The simplest version asserts that trade interactions between two geographically defined entities (varying spatial scale such as either countries or regions) are proportional to the size of these entities and inversely related to the distance between them (Arribas et al. 2011). According to Sneller et al. (2013), gravity models, sometimes also called spatial interaction models, represent a class of models that utilize origin–destination flow data to explain mean frequencies of interactions across space. Origin–destination flow data reflect (aggregate) interactions from a set of origin locations to a set of destination locations in some relevant geographic space. Such interactions may represent movements of various kinds. Examples include migration flows, journey-to-work flows, traffic and commodity flows, as well as flows of information such as telephone calls or electronic messages, and even the transmission of knowledge. Locations may be either area or point

units. Sellner et al. (2013) further noted that the gravity model specification has a benefit of simplicity although it assumes independence of origin–destination flows. In addition to earlier studies, Fischer and Griffith (2008) gave theoretical and empirical arguments supporting spatial dependency underlying flows. On similar lines, LeSage and Pace (2009) highlight that in contrast to the gravity model assumption, spatial autocorrelation operates because observations are not mutually independent.

According to empirical studies, proximity is a key driver of trade between spatially distinct economic units. However, it could appear as a redundant view in the era of globalization with a popular belief in "death of distance" or "global village". As per Leamer and Levinsohn (1995), the effect of distance on trade pattern is not diminishing over time. In contrast to the popular belief, the world is not dramatically shrinking. Scholars have referred to this phenomenon as missing globalization puzzle–Coe et al. (2002, 2007), "conservation of distance in international trade"–Berthelon & Freund (2008), "the puzzling persistence of the distance effect on bilateral trade"—Disdier and Head (2008). Several such studies have been conducted on the issue. Disdier and Head (2008) provided a very useful comprehensive summary and found that halving of distance increased the trade by 45%. In their metaanalysis, they concluded that the estimated negative impact of distance on trade rose around the middle of the twentieth century and has remained persistently high since then, with the result holding even after the heterogeneity in samples and methods across the studies were controlled. Arribas et al. (2011), in contrast to cited studies, attempted to capture the effect of distance to vary across countries, considering them individually. Head et al. (2009) suggested that the effect of distance has actually increased in recent years. On the other hand, Borchest and Yotov (2016) have said that on an average the distance affect has fallen whereas that of proximity and regional trade agreements have increased over the years; they noted considerable cross-country heterogeneity in distance elasticities. The study further stressed that countries in middle income group have experienced sharp dip in distance coefficients, and on the contrary in the case of low income countries distance friction is still relevant that certainly risk their integration into world economy.

Studies, such as, McCallum (1995), Leamer and Levinsohn (1995), Poon and Pandit (1996), Rose (2000), Anderson and Van Wincoop (2003), Greenaway and Milner (2002), and Neogi (2014) further lend support to gravity model.

Beckerman (1956) highlights the role of distance and has written that about the importance of distance in the pattern of trade has, of course, always been recognized. The assumption of "no transport costs", which has always been necessary in expositions of theories of international trade, is a recognition of the fact that transport costs, that is, the costs of covering distance, exist and are significant; so that abstraction from them has to be made quite explicitly in order to analyze other elements such as factor endowments. According to Garner (1967), locational analysis begins with the assumption that the spatial distribution of human activity highlights an "ordered adjustment" to the distance factor. Gordon (1976), in this context, suggested that geographical variations in activity levels should depend essentially on the relative accessibility. The distance effect could vary across countries over the years. Redding and Venables (2004), and Boulhol and de Serres (2010) argued that cost of remoteness remains significant even in the context of advanced countries, and assert that developed countries have not escaped the "curse of distance". According to their analysis, distance continued to mould trade across economies to the same extend it did 30 years ago, notwithstanding the overall evolution of transport costs. As a result, remote countries are still penalized relative to more centrally located ones. The impression derived from Redding and Venables (2004) that distant developed countries, such as Australia and New Zealand, had largely escaped the "curse of distance" is due to the inability to adequately control for heterogeneity in technology levels in cross-section samples that mix both developing and developed countries. They suggested that with the focus on a more homogenous panel sample, it was seen that the negative impact of distance to markets contributes considerably to GDP per capita even for the most developed economies.

Cliff et al. (1974) have evaluated the distance friction parameter in gravity models. They discussed how spatial autocorrelation among the population values, in constrained and unconstrained gravity models, calibrated by least squares regression restricts the interpretation of the co-efficient of the distance

term. Cliff et al. (1974) concluded that except in certain cases which are most likely to arise in intra-urban as compared to inter-urban models, no real problem of interpretation should occur. They also pointed out that how Johnston (1976) has suggested an empirical method of controlling for the influence of map pattern, and from some limited experiments concluded place variations in regression coefficients for distance that are strongly influenced by the spatial location of the places involved. Gordon (1976), had analyzed the spatial stability of the gravity model relationship between regional trade flows and distance costs. The paper re-examined the British freight flow data and suggested that any spatial variation is attibuted to the commodity composition of traffic.

The degree of economic internationalization can best be estimated by starting with a simple model. The first and most simple model tries to explain the trade flows between all countries by their geographical distance. In this first iteration of "stepwise approximation" we use the (log) distance as a single explaining variable for all countries. Geographic distance is a crude but very basic indicator for transportation cost (Krempel and Plumper 2002). With increasing geographical distance the volume of trade should decrease. The choice of the logarithm of the distances is consistent with the fact that transport is a combination of fixed and variable cost. The loading and unloading of freight is more costly than the actual transport. Choosing the log distance as a proxy for the variable cost reflects the diminishing increase of the variable cost with long distance transport according to the "iceberg model" of economic geography (Krugman 1998).

There is a widespread dependence on the gravity model primarily due to (i) its solid theoretical underpinnings drawn from several underlying theories (Anderson 1979; Deardorff 1998; and Evenett and Keller 2002), and (ii) the fact that it has proved empirically successful in explaining much of the variation in the volume of trade over time and space. Needless to add that there exists a vast and rich economic literature on gravity model. The idea is not new to the geographers, it has barely been explored in the context of trade. As such, the geography of international trade is dynamic, even within short time spans. Because of this dynamic nature of trading regions, there are not only geographies of trade based on different scales of analysis, but also based on different time frames of analysis. Despite this geographic nature of international trade, it is a relatively unexplored topic by economic geographers. This is not to say that economic geographers do not investigate international economic activity, only that they do not study the more general processes of international trade (Andresen 2010). Some attempts in the geographical literature to study trade are: Fotheringham (1981), Johnston (1976), Curry et al. (1975), Sheppard (1979), Poon (1997), Poon and Pandit (1996), Helliwell (1996, 1998), Brown (2003), Andresen (2009), Boulhoul and de Serres (2010), and Yadav (forthcoming).

In light of the preceding discussion, the present study contributes to the limited pool of literature on the question of whether distance matter in the globalisation era. The thrust of the study is on the theoretical context and its applicability at different points of time. In particular, the paper reflects on the debate pertaining to this crucial question of distance decay with particular reference to India, which is quite meagre. Hence it is expected to fill the gap existing in the geographical research on international trade and 'missing globalisation puzzle.' Furthermore, unlike the existing literature, the present study sheds light on the theoretical rationale of selecting exponent values with regard to distance decay and its application in the Indian context, certainly distinguishes this attempt from the existing ones in the field of geographical enquiry.

Objectives

In a recent paper, Yadav (2017) discussed world system approach to understand core-periphery relationship in the context of merchandise international trade across two time periods 1990 and 2015 for the sample of 87 countries. It was noted that there is persistence of traditional developed cores in the global trade. However, in 2015 China and India did emerge as cores among other traditional trade nodes.[2] Hence, the present paper attempts to go further in understanding global trade network with reference to India. In this

[2] Yadav (2017) 'Core & Periphery: An analysis of the spatial patterns of international trade' (Conference Paper). http://www.regionalstudies.org; https://www.researchgate.net/publication/325809247_Core_Periphery_An_analysis_of_the_spatial_patterns_of_international_trade.

direction, the paper attempts to capture the spatial interaction via trade flows between India and her 87 trading partners with particular focus from 1990. The year 1990 is chosen since this was the time that India initiated the new economic policies. The 87 countries are those that account for more than 0.01% of world trade in 1990 and rest of the countries are dropped from the purview of the study. The paper attempts to study the significance of distance on trade interaction in the Indian context. Further, attempts were made to estimate bilateral trade using basic and augmented gravity model.

Database and methodology

In order to capture the temporal change, the study is undertaken for two points of time i.e. 1990 and 2015. A basic unconstrained gravity model[3] has been used to estimate trade flows between India and other countries. To inspect the factors influencing trade flows within a set of countries a regression analysis is performed on the volume of merchandise trade occurring between India and her 87 trading partners. Some other variables have been incorporated in the augmented gravity model for a better understanding of the trade flow. Explanatory variables considered in the augmented gravity model are GDP, GDP per capita, distance, and a regional dummy (common membership of regional trade agreement-RTA). Dependent variable is the total merchandise trade. Natural logarithm of distance is used for reasons discussed earlier in the paper. A popular method of calibrating gravity models is to make use of regression for estimation of parameters, and the present paper has adopted the same. All estimates are tested for heteroscedascity using Breusch–Pagan/Cook–Weisberg test (Please refer "Appendix 1"). The test results give clear indication to reject the null hypothesis of homoscedasticity and accept the alternative hypothesis that we do in fact have heteroscedasticity in the regression model. There are two popular ways to deal with heteroscedastiocity-first, respecifying the model/transform the variables; second, use robust standard erros.[4] The available literature on heteroscedasticity says that its presence cause standard errors to be biased. Ordinary least square method assumes that the errors are both independent and identically distributed, so robust standard errors relax either or both of these assumptions. Therefore in the presence of heteroscedasticity, robust standard errors tend to be more reliable. Hence the same has been used for the analysis.

Furthermore, residual mapping is also done in order to shed light on the relative significance of different factors on the spatial imprints of India's trade over the years. Also it is a useful tool to detect systemic error components and identify map pattern. Data is mainly extracted from UNCTADstat, Direction of Trade Statistics (DOTS)-IMF, and World Bank (WITS database); distance between the capitals of two nations is taken for the gravity models.

The basic gravity model equation is as follows:

$$T_{ij} = W_i W_j / d_{ij}^{a},$$

[3] The present paper relies on the non-linear version of the gravity model. There exists vast literature that lends support to the use of non-linear gravity model estimations. Cesario (1975) in his work on linear and non-linear regression models on spatial interaction model has pointed that estimates of the gravity equation "can be performed by either linear or non-linear regression, and that in either case the calculations can be made in an efficient and straightforward manner." White (1980) has also written "The method of nonlinear least squares is a popular method of estimating the parameters of the model." Over the years there have been concerted efforts to debate different estimation methods (linear and nonlinear) to accurately predict trade flows. It is worth noting that the results obtained vary with different estimation methods. Silva and Tenreyro (2006) have noted that the "log-linearisation of the gravity equation changes the property of the error term, thus leading to inefficient estimations in the presence of heteroskedasticity. If the data are homoskedastic, the variance and the expected value of the error term are constant but if they are not -as usually happens with trade data, the expected value of the error term is a function of the regressors. The conditional distribution of the dependent variable is then altered and OLS estimation is inconsistent. Heteroskedasticity does not affect the parameter estimates; the coefficients should still be unbiased, but it biases the variance of the estimated parameters and, consequently, the t-values cannot be trusted. Hence, the recent literature concerning estimation techniques has opted to use nonlinear methods as well as two parts models for estimating the gravity equation." So there are different estimation methods for gravity equation. In this context Herrera (2013) has written "Every method has advantages and disadvantages and it cannot be asserted that any one of them absolutely outperforms the others. For that reason, it has become a frequent practice in the literature to include several estimation methods for the same database".

[4] https://www3.nd.edu.
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where T_{ij} = size of the predicted flow (here merchandise trade), W = flow generating capacity of the region (here GDP), i = subscript identifying the place where flow originates, j = subscript identifying the place where flow ends, dij = distance between i and j.

As stated earlier in the paper, other factors that may impact India's merchandise bilateral trade have also been included in the model. Hence the augmented gravity model equation is as follows:

$$T_{ij} = \text{GDP}_{ij} + \text{GDP per capita income}_j + \text{RTA} + \text{Log } d_{ij}^{a}$$

There are two ways to broadly capture the size of the economies-GDP and population of the country in question. Alternatively some studies have used area of the country, although it does not have much of relevance in the context of the present analysis. Due to multicollinearity issue between GDP and population size, the latter is dropped from the gravity equation. A general view is that larger the size of the economy (GDP in this case), larger is the expected quantum of trade between two countries. To capture geographical friction, physical distance is considered that has been discussed in detail earlier in the paper. Further, a good proxy indicator for gauging the level of development and infrastructural facilities is GDP per capita. Therefore the same has been incorporated in the considered version of the augmented gravity model. Several explanations have been given in the literature stressing its relevance in the estimation.

Dummy variable

To capture the regional impact on bilateral trade of India and her trading partners, dummy variable is included. Presently, Regional trading agreements (RTAs) cover more than half of global trade and has emerged as a characteristic feature of the multilateral trading system. Rise of RTAs has been popularly referred to as having a spaghetti bowl effect.[5] Bhagwati (2008) had also called them 'termites in the trading system'. Nevertheless, RTAs between two countries is expected to encourage, expand and deepen trade ties between the signatories. Given its significance in the changing trajectory of trading network, membership of RTA is considered as a dummy variable in the present study. The dummy variable is equal to one when India and partner country belong to the same regional group in the considered time period and zero otherwise.

Analysis

Section I: distance decay effect

As stated earlier, the paper attempts to comprehend the spatial structure of India's international trade and is gauged by the relationship between mass and interaction, since interaction is a function of mass and distance. In light of the preceding discussions, a study of the role played by distance and other related factors affecting commodity trade flow patterns would provide an important insight into the nature and structure of the spatial interdependencies. A preliminary attempt is made to identify the impact of distance decay on merchandise trade across temporal scale in the Indian context.

Thomas and Hugget (1980), have provided a very comprehensive discussion on the spatial interaction models, as stated earlier in the paper. With reference to the simple gravity model, among other assumptions and notation, they have discussed the concept of distance decay and stated that empirical characteristic of spatial interactions is usually described by the term *distance decay*. Similar to other spatial interaction models, basic gravity model also predicts the size of the flow between a pair of spatial units i.e. origin (i) and destination (j). One of the key components of the model is distance between the origin and destination (d_{ij}). The assumption asserts that the quantum of interaction (T_{ij}) decreases in proportion with the square of the distance (d_{ij}^2) between two places. The assumption is validated by the examples across types of interaction suggesting that as compared to long distance, short distance flows happen more frequently. However, there is no theoretical rationalization of the same, apart from drawing the analogy with the Newton's Law.

[5] According to Bhagwati (2008), "With proliferating preferential trading agreements, one has worldwide crisscrossing of preferences defined by different rules of origin and different tariff rates on identical products depending on where a product originates." He called the resulting chaos a 'spaghetti bowl'.

$T_{ij} \propto 1/d_{ij}^2$

It is in this backdrop, Thomas and Hugget (1980) have suggested that it will be more meaningful in the geographical context to let distance be raised to some power *a*, and hence can generally denote as

$T_{ij} \propto d_{ij}^{-a}$

The effect of varying the value of the distance exponent is illustrated in the Figs. 1A–C and 2A–C for 1990 and 2015. The figures show the changing relationship between T_{ij} and $d_{ij}$for the values of a = 1,2 and 3. The Figs. 1 and 2 reveal that with the raising *a* to progressively higher powers clearly steepens the slope of the curve. It is for this reason the value of *a* is said to capture the frictional effect of distance.

The distance-trade relationship cannot be a smooth distance decay pattern, the Figs. 1A–C to 2a–c, reveal series of 'troughs' and 'peaks' when total merchandise trade is plotted against distance.

The degree of correspondence between distance category and merchandise trade can be measured mathematically by the correlation coefficient (refer Table 1). A negative and statistically significant correlation would show the existence of distance decay effect. Since the correlation coefficient between distance and the volume of commodity trade is negative, an inverse relationship between distance and trade is consistently indicated. However, the degree of significance varies across values of distance exponent across time. For instance, the correlation is found to be insignificant in 1990 for exponent values of 1 and 2; for the value of 3 it is significant at 50% level. In the year 2015, for 1 it is significant at 10% level and for the latter two exponent values it is significant at 50% level. It is important to note that a detail analysis is required to gain more meaningful insight of the relationship. Further, it is worth noting that the degree of distance decay effect may significantly vary across different commodity groups requiring further detail analysis, and that is beyond the gamut of the present paper. The results are indicative in nature, and capture only the macro picture for the total merchandise trade, and hence drawing strong conclusions may be misleading at this stage. In line with this, Krempel and Plumper (2002) aptly pointed out that single factor explanations of global economic integration are presumably misleading.

Section II: basic gravity model

For the purpose of this paper, the value of distance exponent is taken as 2. There was no significant difference in the predicting potential of the gravity model with varying distance exponent, and hence results of a = 2 is retained for the analysis. The degree of economic internationalization can best be estimated by starting with a simple model. Table 2 essentially inspects the accuracy of the trade estimates based on basic gravity model. The first and most simple model tries to explain that the trade between two countries depends proportionally on their economic masses generally measured by GDP and inversely on the distance between them. In the Indian context, Table 2 illustrates the correlation values for actual total merchandise trade, and export and import with gravity model estimates. The results assert strong positive and statistically significant values for both the years, indicating that the basic model fits the data well. The basic model has proved empirically successful in explaining much of the variation in the volume of trade over time; it explains about 66% variation in India's bilateral trade across the sample of countries in 1990, and 62% in 2015. The results reiterate the usefulness of the model in predicting trade flows in the globalized era.

Section III: augmented gravity model

The augmented version of the model explains 70 and 65% variation in the bilateral trade of India with the sample 87 countries, in 1990 and 2015 respectively.[6] In line with the popular wisdom, larger economic size of the trading partner and geographical proximity does influence the bilateral trade in the Indian context. It can be inferred that beside other factors, distance still matter in trade interaction. The results assert persistent statistical significance of distance in explaining trade patterns; the expected negative sign and increasing value of coefficient do indicate its continuing influence on spatial interaction via trade flows; higher negative estimate of distance indicates that distance

[6] The augmented gravity model estimates pertain to total merchandise trade.

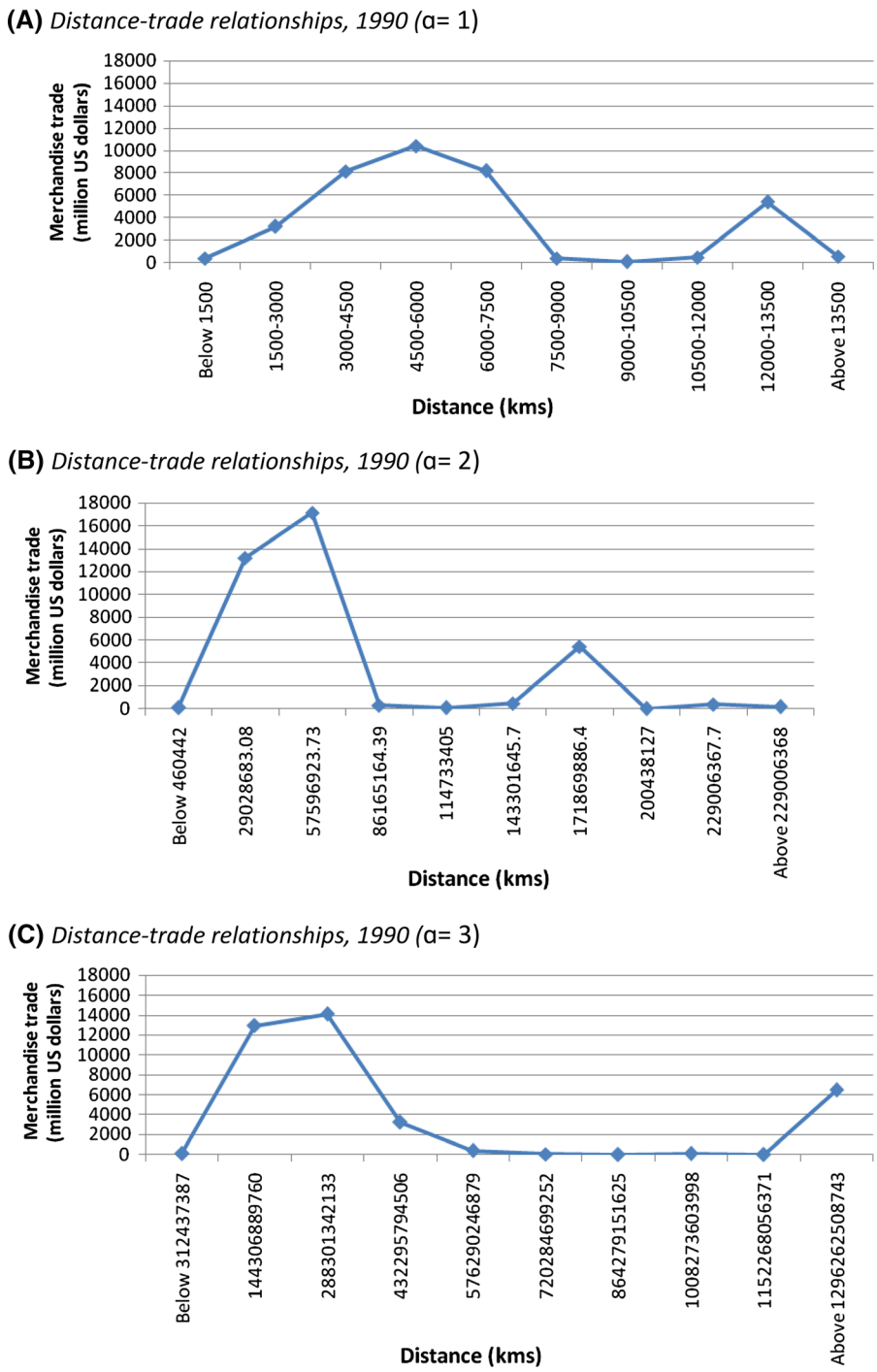

Fig. 1 **A** Distance-trade relationships, 1990 (a = 1). **B** Distance-trade relationships, 1990 (a = 2). **C** Distance-trade relationships, 1990 (a = 3). *Source*: Based on author's calculations

and transport cost still matters. This result is in tandem with the meta analysis of Disdier and Head (2008) on the distance puzzle. Coe et al. (2002) questions "Can this puzzle of stable or increasing distance coefficients be explained or explained away?" In this context, Leamer and Levinsohn (1995) viewed that it is odd to

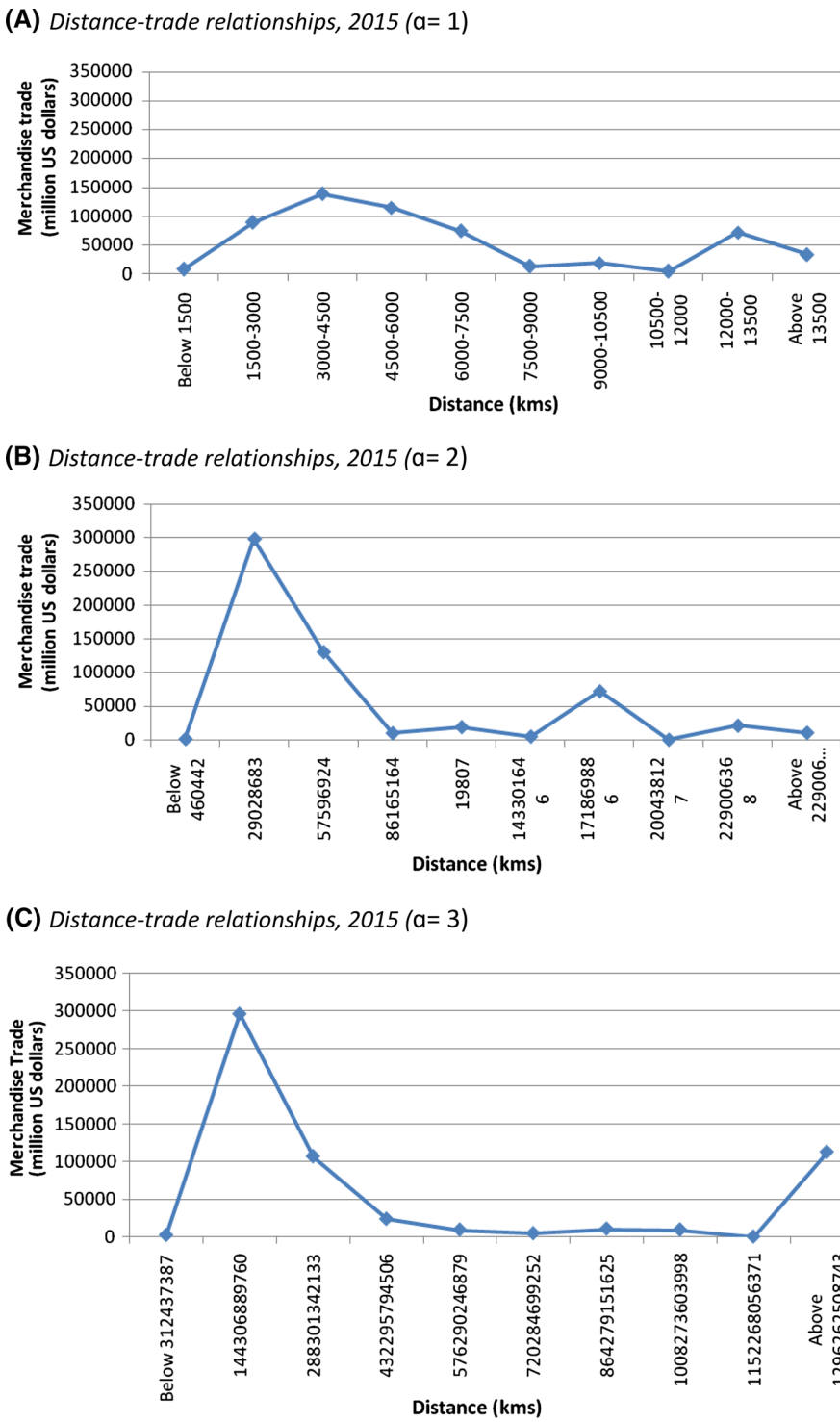

Fig. 2 **A** Distance-trade relationships, 2015 (a = 1). **B** Distance-trade relationships, 2015 (a = 2). **C** Distance-trade relationships, 2015 (a = 3). *Source*: Based on author's calculations

Table 1 Interdependence of merchandise trade and distance

Years	Distance exponent values (a)	Correlation coefficients of merchandise trade with distance
1990	1	− 0.15
	2	− 0.16
	3	− 0.17*
2015	1	− 0.19#
	2	− 0.17*
	3	− 0.17*

Source: Based on author's calculations

*Significant at 50% level of significance

#Significant at 10%

Table 2 Correlation between actual trade and gravity model estimates

Variables	1990	2015
Merchandise trade and gravity model estimates (GEM)	0.82*	0.79*
Merchandise export and GEM	0.80*	0.72*
Merchandise import and GEM	0.77*	0.67*

Source: Based on author's calculations

*Significant at 1%

explain this steadiness of the distance elasticity. They said "it seems appropriate to mention that the effect of distance on trade patterns is not diminishing over time. Contrary to popular impression, the world is not getting dramatically smaller." Coe et al. (2002) discussed four possible explanations for the distance puzzle- first decline in the average costs as compared to the marginal costs of trade over time; second rising dispersion of economic activity; third change in the trade composition; and fourth significance of relative over absolute costs affecting bilateral trade.[7] This partly explains the value of coefficient. The other plausible reason behind such a high coefficient is tied with methodological approach used in the paper. This could be because of the form of the non-linear gravity model used and also due to the considered value of the distance exponent in the model. To check this effect, gravity model estimations were made with different exponent values for 1990 (Please refer "Appendix 2"). It is noted that with the increasing value of distance exponent, the value of the coefficient declines.

GDP is other key determining factor considered in the model, and found to be statistically significant at 1% level of significance in 2015. In the augmented gravity model, as stated earlier in the paper GDP is considered to capture the size of the economy. It is expected that larger the size of the country, larger is the volume of trade with India. Naturally the expected sign of the coefficient of GDP will be positive and the same could be seen in the present analysis. Table 3 shows coefficients for GDP which is positive, and statistically significant at 1% level of significance in 1990 and 2015. Similarly, expected sign of estimated coefficient for GDP per capita is positive and the same can be seen in the Indian context (Table 3). However, it is statistically insignificant with reference to its impact on India's trade interaction for the considered years.

Further a regional dummy, i.e., common membership of RTA is also considered in the augmented gravity model. Countries often enter into RTAs with the intention of facilitating bilateral trade. The estimated co-efficient will then indicate how much of the trade can be attributed to a special regional effect. In 1990, the coefficient is negative and statistically insignificant; the coefficient became

[7] For detail discussion on these possible factors please refer Coe et al. (2002). The Missing Globalization Puzzle. Working paper 02/171. Washington, D.C.: International Monetary Fund.

Table 3 multiple regression results (augmented gravity model)

Variables	1990 Coefficients	1990 t Stat	2015 Coefficients	2015 t Stat
GDP	0.001	8.31*	0.004	5.35*
GDP per capita	0.016	1.40	0.042	1.28
Distance (log)	− 110.340	− 2.68*	− 1898.232	− 2.15*
RTA	− 22.429	− 0.19	1165.799	0.81

Source: Based on author's calculations

*Significant at 1%

positive in the year 2015, however, remained statistially insignificant in terms of its effect on India's bilateral trade. In this reference Batra (2006) has noted in her paper that the dummy variable for intra-regional trade is highly significant statistically. However, the regional dummy when separated into individual RTA dummies does not seem to have the same impact. This is even more apparent when the trade creating and trade diversion effects of these preferential trading arrangements are separated out. The regional dummy does not seem to have the same effect as other considered factors. However, there are few exceptions to these findings, as revealed by the map pattern of residuals in 1990 and 2015.

Figures 3 and 4 illustrate mapping of the standardized residuals of the augmented gravity model for 1990 and 2015. It is a very useful tool to locate systematic patterns and will provide information that otherwise is difficult to infer from the aggregate regression results. The observations are confined to extreme values i.e. high positive and high negative group. The map pattern of residuals across time is quite evident. Examination of the residuals show that over the years there is a visible change in the country composition of the high positive and high negative group. The results indicate that although independent variables considered in the paper provides a reasonable degree of explanation, but the residual maps reveal that the impact could vary across spatial and temporal scale, such as, high negative and positive residual groups. In 1990, greater than expected trade is seen with predominantly developed countries such as, United Kingdom, Belgium, Luxembourg, Germany, and USSR (former), and fuel-based economies such as Saudi Arabia, UAE, and Singapore. The negative residual group comprises of Pakistan, China, Finland, Sweden, Norway and United States. Relatively speaking, the importance of the set of determinant factors could be country and time specific. In order to understand the country level factors, detail analysis is required and that goes beyond the scope of the current paper. For example, with Pakistan, India's trade is restricted despite being geographically proximate, and it is primarily to do with the historical background these countries share, and the resultant weak geopolitical ties. Over the years, Asian economies seem to record more than potential trade, predominantly key ASEAN economies: - Singapore, Malaysia, and Indonesia; China and UAE are other Asian countries falling in the group. India's economic reforms and its Look East policy have given major impetus to its bilateral trade with East Asian economies. The changing trajectory of India's trade policy and increasing South–South trade can also be inferred from the map pattern. In 2015, New Zealand, South Africa, and Senegal are other new trading partners occurring to trade more than the potential. As stated earlier, this might be attributed to the shift in trade policy and tilt in the favor of new potential trade partners, or special trade and diplomatic treaties. It is essential to add that to further improve the gravity model estimates it would be useful to modify the analysis to include more explanatory factors, such as, linguistic links, historical/colonial ties, institutions, degree of openness, geographical uniqueness (landlocked or maritime), and others.

Conclusion

The paper attempts to capture the distance decay effect on the pattern and structure of India's international trade in the changing global and economic scenario since 1990s. It is quite interesting to see how India has

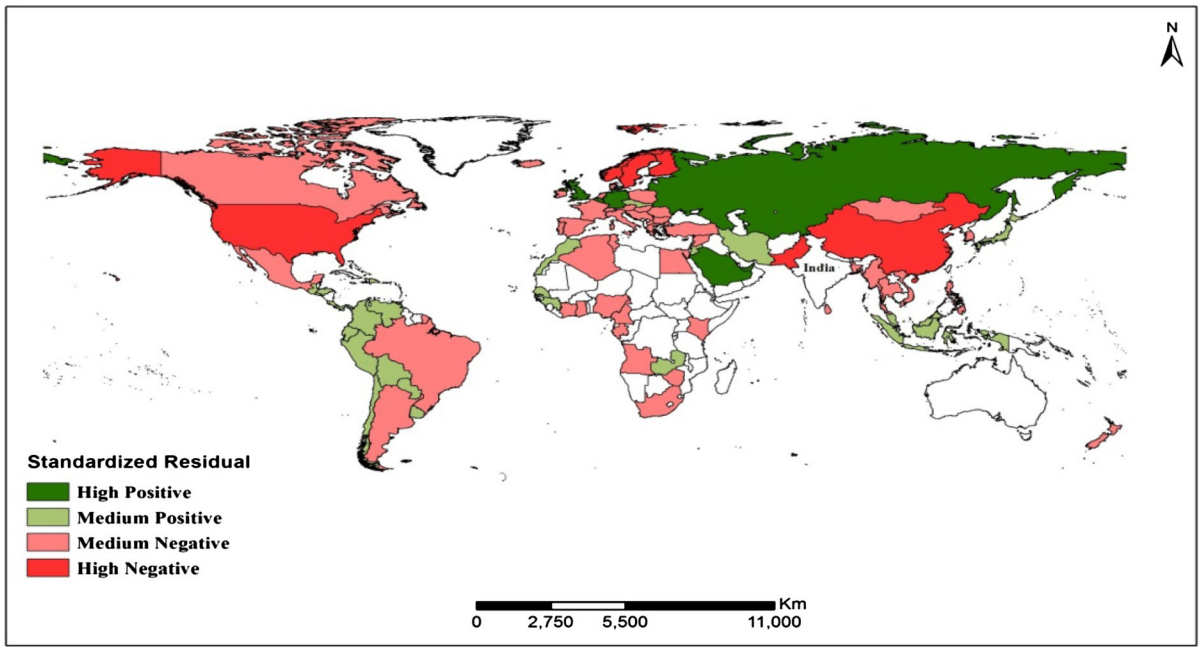

Fig. 3 Spatial distribution of Residuals from regression, 1990. *Source*: Based on author's calculations

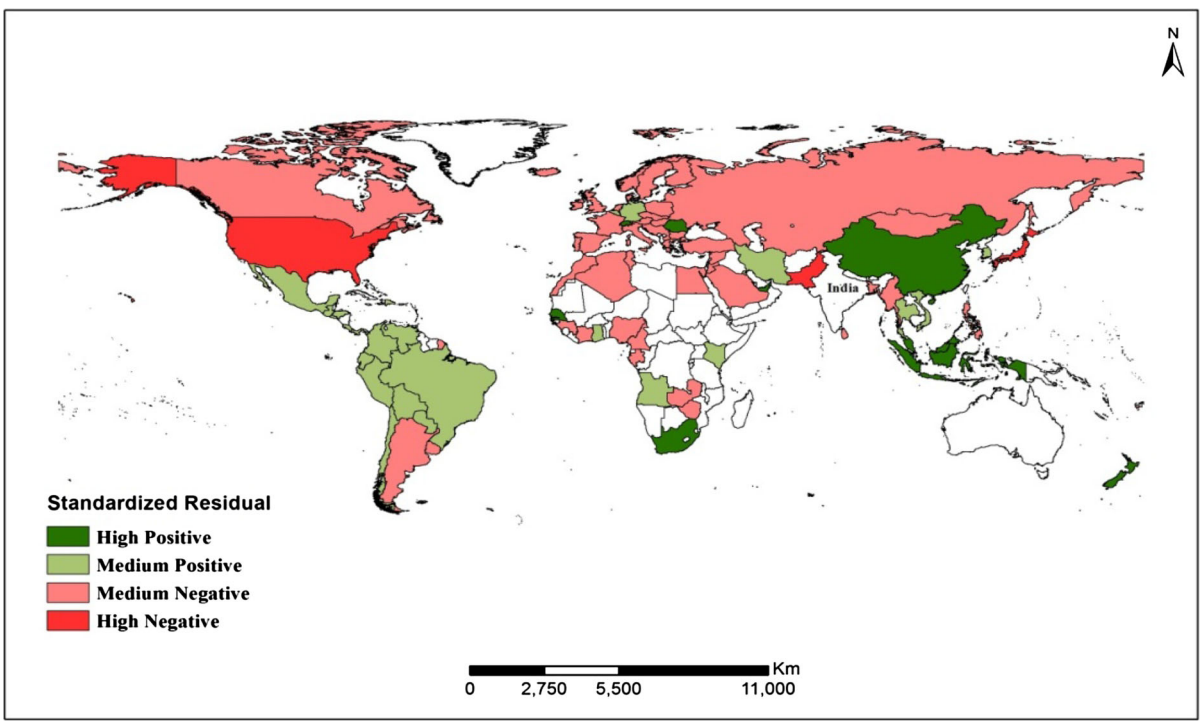

Fig. 4 Spatial distribution of Residuals from regression, 2015. *Source*: Based on author's calculations

responded to its crisis-driven economic reforms that led to opening up the economy to the global market. The tectonic shift in the trading system with the evolving dynamism of global economic

interdependencies is worth understanding from the geographical perspective, and the resultant spatial imprints unearth the underlying complexities of spatial interaction via flows. The paper attempts to ask a basic question "What is the significance of distance in determining the pattern of India's international trade." It is interestingly noted in the graphical representation that with the varying values of distance exponent the rate of trade flow does change. The inverse relationship is quite evident, however level of statistical significance vary over the years. Of course, it could be misleading at this stage to conclude that distance is the only factor affecting trade pattern. For instance, the impact of distance on trade that has brought out in the analysis can be altered through changes in freight costs although the physical distance between the countries cannot be changed, the cost can be manipulated by policy intervention. Thus one of the important implication of the study is as long as the distance influence trading pattern, one important way of influencing this impact is through reduction in freight cost.

To further investigate the relative role of distance in the Indian trading system or to say shed some more light on the *"missing (distance) puzzle in globalization process"* basic and augmented gravity model were made use of. It is found that the model for both basic and augmented version fits the data well. In line with the popular wisdom, larger economic size of the trading partner and geographical proximity does influence bilateral trade in the Indian context. Distance still matter as the results assert persistent statistical significance of distance in explaining trade patterns. GDP is the other key determining factor considered in the model. However, there are few exceptions to these findings, as revealed by the regional distribution of residuals in 1990 and 2015. Thus, from the empirical findings cited, it would seem that the model presented above provides a reasonable statement of some geographic patterns existing in the India's global trade network.

It is worth noting that the findings are limited in scope and require further detail analysis to better understand the underlying dynamics of India's global trading landscape. It would be useful to further extend the analysis to include more explanatory factors, such as, language, historical/colonial ties, institutions, degree of openness, geographical uniqueness (landlocked or maritime) and others. The current study is confined to a sample of 87 countries, and therefore extending the spatial coverage will definitely have an effect on the results. Furthermore, it is possible to analyze the disaggregate data into commodity groupings to determine the effect of distance on the flow of individual goods. The results also suggest that to understand the complex trade system of India it is worthy to further the scope of the research aiming at more complete explanation and questions. The study is certainly at the initial stages of that system. Nevertheless, it is hoped that the present analysis will encourage more research in examining the emerging patterns of international trade from the spatial perspectives.

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Appendix 1

See Table 4.

Table 4 Breusch–Pagan/Cook–Weisberg test for heteroscedasticity

Years	Chi^2 (1)	Prob > chi^2
1990	25.38	0.0000*
2015	34.89	0.0000*

*Significant at 0.05 level

Appendix 2

See Table 5.

Table 5 Distance exponent and coefficient (1990). *Source*: Based on author's calculations

S. no.	Value of distance exponent (a)	Value of coefficient
1	1	− 220
2	2	− 110
3	3	− 73.56

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