

Understanding BRIICS' trade performance: analysis of unobserved heterogeneity in the gravity model of international trade

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Introduction

What have been the main driving forces behind the rising trade of large emerging economies such as China, India or Brazil? What is driving the phenomenal trade growth rates in China? Why India's trade seems to be growing less dynamically? Why is Brazil's trade lingering around 1% of world trade since the beginning of 1970s? Are the fastest growing emerging economies trading above or below their potentials? These are the questions that often underpin discussions about the opportunities and threats associated with the increasing presence of large emerging economies in the world economy.

This paper presents an approach to analyzing bilateral trade data based on the gravity model of international trade and the fixed effects approach to analyzing panel data and applies it to the analysis of trade of Brazil, Russian Federation, India, Indonesia, China and South Africa (BRIICS). First, the gravity model of aggregate bilateral trade, which is a basis for specification of a fixed effects empirical panel data model of bilateral trade estimated here, is introduced and issues associated with its application to inference about countries' trade performance are discussed. Subsequently, an empirical gravity-based model is devised and estimated on a panel data of unidirectional bilateral merchandise trade flows between 46 countries including all the OECD countries plus Brazil, India, Indonesia, China, Russian Federation and South Africa (BRIICS) and a number of other countries that are relatively significant players in world trade or are important trading partners of any of the BRIICS.² The analysis covers the 1985-2006 period and is conducted for total trade as well as four broad product categories including raw materials, intermediate goods, consumption goods and capital goods.

² These countries are: Chile; Hong Kong, China; Singapore; Thailand; Chinese Taipei; Malaysia; Philippines; Venezuela; Israel; Colombia; Argentina and South Africa.

The principal econometric methodology employed in this paper is the gravity model of international trade and what was once named a full interaction effects panel data approach to modeling trade flows (Baltagi et al., 2003). *A sentence here on what the full interaction effects panel data approach is.* While the full interaction effects approach was advocated as a way of dealing with potential econometric endogeneity caused by unobserved effects in the gravity model of international trade, it also constitutes a convenient way to econometrically decompose historical trade trends into a number of distinct components some of which are countries' and policies' specific and some of which are not. These include:

- time effects that may be common to all trading country pairs (e.g. periods of global slowdown of world trade)
- country pair-specific time-invariant fixed effects reflecting time-invariant bilateral and geographical factors (e.g. distance, common language, colonial relationship etc.)
- the time-variant fixed effects for exporting and importing countries (e.g. effects of country-specific policies that affect trade of a given country with all other partners, MFN liberalization for instance)
- time-invariant fixed effects for exporting and importing country
- residuals that capture the part of variation in bilateral trade flows that is not explained by any of the explicitly specified fixed effects.

Methodology: the gravity model and fixed effects

The popularity of the gravity model in empirical analysis of trade flows has once been summarized by Deardorff (1998) as follows: “I suspect that just about any plausible model of trade would yield something very like the gravity equation...”. The idea that international trade can be modeled in analogy to the Newtonian gravity force is attributed independently to Tinbergen (1962) and Pöyhönen (1963).³ In its simplest form, the gravity model posits that bilateral trade is larger the larger are the trading economic masses (measured either by GDP or population) and the smaller is the distance (or more generally the trade-inhibiting factors) between them.⁴

As Baier and Bergstrand (2005) report, the early applications of the gravity equation (Tinbergen, 1962; Linneman, 1966; Aitken, 1973; and Sapir, 1981) to international trade flows were not grounded in formal theoretical foundations, which was regarded as problematic. Yet, this has changed and for some time now the gravity equation has been well established theoretically as a reduced form of a general equilibrium model of international trade in final goods (Baldwin, 1994). This is an achievement of a strand of research that has emerged since early applications of the gravity model with an objective to better account for its theoretical underpinnings. The most important contributions to this literature include Anderson (1979), Bergstrand (1985) and (1989),

³ In addition to trade, the gravity equation has been recognized for its empirical success in explaining many different types of flows such as migration, tourism, investment flows or spatial location of economic activity.

⁴ Linnemann (1966) included population as an additional measure of country size and initiated the so-called “augmented gravity” model. The inclusion of the population variable was later also justified by the need to account for non-homothetic preferences in the importing country and to proxy for the capital/labour ratio in the exporting country (Bergstrand, 1989).

Helpman and Krugman (1985), Helpman, (1987), Evenett and Keller (1997), Deardorff (1998), Baier and Bergstrand (2001), Eaton and Kortum (2002) Anderson and Wincoop (2003 and 2004).⁵

Indeed, the strength of the gravity equation reflects its consistency with several generic trade theories. Indeed, the gravity equation has been so far derived as a reduced form of the Ricardian, Heckscher-Ohlin and monopolistic competition trade models. Helpman and Krugman (1985) have shown that the gravity equation can be derived from the monopolistic competition model embodied within a Heckscher-Ohlin framework.⁶ Deardorff (1998) has shown that the gravity equation can be derived from the Heckscher-Ohlin model without the assumption of product differentiation. Eaton and Kortum (2002) have derived the gravity equation from a Ricardian type of model of trade in homogeneous goods. A review of contributions on theoretical foundations of the gravity equation is provided by Harrigan (2002).

The gravity model of international trade has since been used extensively as a baseline model for estimating the impact of a variety of factors affecting trade such as trade barriers, regional trading agreements, political blocks, institutional arrangements, exchange rate regimes, geographical or even cultural factors. Typically, the impacts of these factors are modeled as deviations from the volume of trade predicted by the baseline gravity model consisting of measures of economic size and trade inhibiting factors (Cheng and Wall, 2005, Bussiere and Schnatz, 2006). Recent studies of trade integration of the BRIICS countries that make a use of the gravity methodology include: Bussiere and Schnatz (2006) on China; Bussiere and Mehl (2008) on China and India;

⁵ Surveys of gravity model literature are contained in Baldwin (1994), Oguelo and MacPhee (1994) and Frankel (1997, Ch. 4).

⁶ The model predicts Heckscher-Ohlin type of trade pattern as far as net trade flow are concerned.

Eichengreen et al. (2007) on China; Lederman et al. (2007) on China and India as they affect the trade of Latin America and the Caribbean.

The status of the gravity equation is related to its consistently high statistical explanatory power. Nevertheless, as pointed out by Cheng and Wall (2005) “the perceived empirical success of the gravity model has come without a great deal of analysis regarding its econometric properties, as its empirical power has usually been stated simply on the basis of goodness of fit (i.e. relatively high R^2)”. There is now substantial deal of evidence that suggest that certain specifications of the gravity model used in specific contexts yield biased results either because they do not control for heterogeneity in trading relationships, deal inadequately with the omitted variables problem or are estimated in incorrect functional forms (Baldwin, 2005). Solutions to these specification problems can often be found in theoretical underpinnings of the gravity model as well as appropriate econometric specification of the empirical model. Panel data techniques in particular provide an attractive way of dealing with unobserved heterogeneity and misspecification.

Nevertheless, inclusion of various fixed effects, which is often pursued with a view to address econometric endogeneity and appropriately account for certain so-called ‘confounding factors’ that for some reasons cannot be measured directly, is necessarily a second best option. Firstly, the estimated fixed effects have limited information content. Secondly, such an approach often results in empirical specifications to which the term "gravity" can no longer be applied since the GDPs and distance are captured by generic fixed effects. Thirdly, and perhaps most importantly, despite its efficacy in tackling various sources of econometric endogeneity, the full interaction effects approach has an inconvenient feature of “robbing the data of a substantial part of their variety”. A question can be asked whether fixed effects approach is preferred to specifications that retain the

explicit gravity features at the cost of lower explanatory power or econometric endogeneity. The next section elaborates on theoretical underpinnings of the gravity model and on fixed effects approaches to its estimation. Subsequently, advantages and disadvantages of various empirical specifications of the gravity equation are addressed.

The version of gravity model form which we depart in this analysis is based on the organic derivation by Anderson & Van Wincoop (2003, 2004) which was employed earlier in a similar context by Kowalski and Shepherd (2006). It takes the following form:

$$(1) \log(X_{ij}) = \log(Y_j) + \log(Y_i) - \log(Y) + (1-\sigma)\log(t_{ij}) - (1-\sigma)\log(P_j) - (1-\sigma)\log(\Pi_i) + \varepsilon_{ij}$$

where time subscripts are excluded for the time being to save on notation and:

X_{ij} = exports from country i to country j

Y_i = GDP of country i

Y_j = GDP of country j

Y = aggregate (world) GDP

σ = elasticity of substitution

t_{ij} = trade costs facing exports from country i to country j

$$P_j^{1-\sigma} = \sum_{i=1}^N \Pi_i^{\sigma-1} \omega_i t_{ij}^{1-\sigma}$$

$$\Pi_i^{1-\sigma} = \sum_{j=1}^N P_j^{\sigma-1} \omega_j t_{ij}^{1-\sigma}$$

ω_i = country i's expenditure share

ε_{ij} = random error term

Compared to earlier works the principal innovation of the Anderson & Van Wincoop (2003, 2004) model is the inclusion of the two “resistance” terms (P and Π), which (roughly speaking) take account of the fact that it is relative prices that matter for trade. In other words, it is not just prices and, say, tariffs in country j that determine exports from country i to country j , but rather those prices and tariffs compared with prices and tariffs imposed by all other importers.

The trade cost function, in line with Anderson & Van Wincoop (2003, 2004) and much current work, is specified as follows:

$$(2) \quad t_{ij} = d_{ij}^{\rho} \tau_{ji}^{\theta} \prod_{m=1}^M (b_m^{z_{ij}^m})$$

$$\Leftrightarrow \log(t_{ij}) = \rho \log(d_{ij}) + \theta \log(\tau_{ji}) + \sum_{m=1}^M \log(b_m) z_{ij}^m$$

where:

ρ = elasticity of exports with respect to distance

θ = elasticity of exports with respect to bilateral tariffs

τ_{ji} = tariffs imposed by country j on exports from country i

b_m = set of m constants

z_{ij} = set of observable bilateral determinants of trade costs

Putting (1) and (2) together gives a fully specified model:

$$(3) \quad \log(X_{ij}) = \log(Y_j) + \log(Y_i) - \log(Y) + (1 - \sigma) \left[\rho \log(d_{ij}) + \theta \log(\tau_{ji}) + \sum_{m=1}^M \log(b_m) z_{ij}^m \right] - \dots$$

$$\dots - (1 - \sigma) \log(P_j) - (1 - \sigma) \log(\Pi_i) + \varepsilon_{ij}$$

To facilitate the interpretation of results and, specifically, to ensure comparability of estimated coefficients across various trading country pairs it is convenient to rearrange (3) to an algebraically equivalent formulation:

$$(4) \quad \log\left(\frac{X_{ij}}{Y_i Y_j}\right) = -\log(Y_i) + (1-\sigma) \left[\rho \log(d_{ij}) + \theta \log(\tau_{ji}) + \sum_{m=1}^M \log(b_m) z_{ij}^m \right] - \dots \\ \dots - (1-\sigma) \log(P_j) - (1-\sigma) \log(\Pi_i) + \varepsilon_{ij}$$

(4) can be referred to as a *relative model* as it expresses exports relative to the combined (multiplicative) GDP of the two trading partners.. Therefore the dependant variable in (4) can be interpreted as a measure of trade intensity as opposed to the value of trade in (3). This dependent variable is more comparable across country pairs and so are the estimated regression coefficients. Formulation (4) has also been advocated in the literature as a way of dealing with the criticism that GDP is endogenous.

While in principle it is possible to estimate (4) directly using non-linear methods (Anderson & Van Wincoop, 2003), it is far simpler to use exporter and importer fixed effects. Such an approach still produces consistent and unbiased estimates and this is the approach taken here, leading to equation (5) (with the deltas indicating fixed effects):

$$(5) \quad \log\left(\frac{X_{ij}}{Y_i Y_j}\right) = \mu + \beta_1 \log(d_{ij}) + \theta \log(\tau_{ji}) + \sum_{m=1}^M \gamma_m z_{ij}^m + \sum_{i=1}^N \delta_i + \sum_{j=N+1}^{2N} \delta_j + \varepsilon_{ij}$$

The Sectoral Model is a natural analogue to the aggregate model, broken down by sector (k):

$$(6a) \quad \log(X_{ij}^k) = \log(Y_j^k) + \log(Y_i^k) - \log(Y^k) + (1 - \sigma) \left[\rho_k \log(d_{ij}) + \theta_k \log(\tau_{ji}) + \sum_{m=1}^M \log(b_m^k) z_{ij}^m \right] - \dots$$

$$\dots - (1 - \sigma) \log(P_j^k) - (1 - \sigma) \log(\Pi_i^k) + \varepsilon_{ij}^k$$

$$(6b) \quad \log(X_{ij}^k) = \mu^k + \beta_1^k \log(d_{ij}) + \chi_k \log(\tau_{ji}) + \sum_{m=1}^M \gamma_m^k z_{ij}^m + \sum_{i=1}^N \delta_i^k + \sum_{j=N+1}^{2N} \delta_j^k + \varepsilon_{ij}^k$$

$$(6c) \quad \log\left(\frac{X_{ij}^k}{Y_i^k Y_j^k}\right) = \mu^k + \beta_1^k \log(d_{ij}) + \chi_k \log(\tau_{ji}) + \sum_{m=1}^M \gamma_m^k z_{ij}^m + \sum_{i=1}^N \delta_i^k + \sum_{j=N+1}^{2N} \delta_j^k + \varepsilon_{ij}^k$$

To sum up, equation (5) and its sector version (6c) are the specifications we estimate and interpret.

In a panel data setting where we have yearly observations on exports from country i to country j country fixed effects need to be allowed to vary in time (Baltagi et al, 2003; Baldwin, 2005). Additionally, time-invariant country-specific, country-pair and year fixed effects are often included to prevent econometric endogeneity. Very often the final estimated model includes an extensive list of fixed effects and a limited number of policy variables that vary by exporter, importer and in time and are subject of direct investigation, such as an existence of a regional trading agreement or a currency union between the trading partners. In this respect the estimated models are often very close to a ‘pure fixed effects’ specification of bilateral trade function:

$$(5) \quad \log\left(\frac{X_{ijt}}{Y_{it} Y_{jt}}\right) = \mu + \sum_{t=1}^T \lambda_t + \sum_{i=1}^N \delta_i + \sum_{j=N+1}^{2N} \delta_j + \sum_{p=1}^{(N^2-N)/2} \delta_{ij} + \sum_{i=1}^N \delta_{it} + \sum_{j=N+1}^{2N} \delta_{jt} + \varepsilon_{ijt}$$

Specified in this way, the model allows one to distinguish between various types of factors underlying trade. $\sum_{t=1}^T \lambda_t$ terms isolate the time effects that are common to all trading country pairs.

One example that can be given here is the worldwide dip in trading intensity observed after 9/11 or inventions on a global scale that affect trade such as for example the development of the internet.

$\sum_{i=1}^N \delta_i$ and $\sum_{j=N+1}^{2N} \delta_j$ pick up time-invariant fixed effects for exporting and importing countries, respectively. $\sum_{p=1}^{(N^2-N)} \delta_{ij}$ are country pair-specific time-invariant fixed effects that account for factors such as the time-invariant bilateral trading costs (i.e. those associated with bilateral distance) or long-standing cultural or political ties. It is worth mentioning that the model is specified as a unidirectional export function and thus for example distinguishes between exports from Brazil to Chile and exports from Chile to Brazil. With such a specification two pair-specific time-invariant fixed effects are estimated for the country pair Brazil-Chile: one for Brazil as an importer from Chile and one for Brazil as an exporter to Chile.

$\sum_{i=1}^N \delta_{it}$ and $\sum_{j=N+1}^{2N} \delta_{jt}$ are the time-variant importer and exporter-specific fixed effects that pick up the GDP and country-specific price effects along with time-varying factors specific to an exporting or importing country such as opening up to trade on an MFN basis or country-specific reforms and policies. These types of fixed effects are potentially most interesting from an exploratory point of view as they tell us how the propensity of a country to export or import has been evolving over time. Additionally, their magnitude relative to the magnitude of other time-invariant fixed effects may be indicative of the permanent and evolving factors underlying trading relations. Our analysis in this paper focuses on the information we can extract from this type of fixed effects.

ε_{ijt} is the error term which picks up all trade unexplained by the previously mentioned factors, including bilateral and time-varying trade policies and random factors affecting trade. In particular, none of the above specified fixed effects captures bilateral effects that vary in time.

As an introduction to the interpretation of results it is worth mentioning that the fixed effects are essentially coefficients on dummy variables and, as Kennedy (1998) bluntly put it, "reflect ignorance – they are inserted merely for the purpose of measuring shifts in the regression line arising from unknown variables." One might dispute the degree of such assessment—after all the gravity model outlined above provides quite a few suggestions as to what these 'unknown' variables may be—but, in fact, by including dummy variable coefficients we do not know which of the unobserved variables and to what extent are actually being reflected in the estimated coefficients.

Additionally, implementation of the fixed effects approach effectively means 'disembowelling' the underlying structural model. Inclusion of exporter-by-time and importer-by-time fixed effects necessitates exclusion of GDP and price terms in the same way the inclusion of exporter-by-importer fixed effects requires dropping distance or any other time-invariant trade cost variables. Such a model can be used to decompose a large number of bilateral trade flows into the underlying components which are more easily interpretable in the context of country-specific developments but at the same time it can hardly be called a 'gravity equation'; no statistical inference about the key 'gravity forces', economic masses and distance, is possible.

Data

The presented model is estimated on a sample of data for 46 countries including all the OECD countries plus Brazil, India, Indonesia, China, Russian Federation and South Africa (BRIICS) and a number of other countries that are relatively significant players in world trade or are important trading partners of any of the BRIICS. These countries are: Chile; Hong Kong, China; Singapore; Thailand; Chinese Taipei; Malaysia; Philippines; Venezuela; Israel; Colombia; Argentina and South Africa. The dataset covers period 1985-2006 though for a few countries some observations are missing either at the beginning or towards the end of the period. Data sources and definitions are given in Table 2 in the end of this paper.

Results and interpretation

Ordinary least squares with Huber/White heteroskedasticity adjusted standard errors are used to estimate (5) for total trade and (6c) for four broad sectors: raw materials, intermediate goods, consumption goods, capital goods. In statistical terms, the estimated fixed effect models are strong performers: they explain a very high proportion of observed variation in trade flows (adjusted R^2 of above 90%, depending on the category of good considered), which is far from surprising with such an extensive specification of fixed effects.⁷

In our approach the estimated fixed effects are essentially coefficients on dummy variables and their interpretation needs a careful explanation. The regressions include a constant which necessitates dropping certain fixed effects to fulfill the requirement of non-colinearity between sets of explanatory variables. To take the example of exporter fixed effects that remain constant in

⁷ However, the dataset also allows estimation with a more extensive specification of the “geography” variables- some of the results for the 1986-2002 subset of this dataset are presented in Kowalski and Shepherd (2005). When this is done the variables are significant both from economic and statistical points of view and the estimated parameters have signs and magnitudes that accord with basic theory.

time, one out of forty six such effects needs to be dropped since the set of dummy variables representing them in the model can be expressed as a linear combination of the constant. To take the example of year fixed effects, for the same reason, one of the years also needs to be dropped. With an exclusion of one exporter fixed effect the fixed effects estimated for other exporters capture differences in interception relative to the country that is dropped. Similarly, the year fixed effects capture differences in interception relative to the year that is dropped. For reasons that will become clearer towards the end of this section in this paper we choose to drop a dummy variable for the first year in the database (1988) and chose the United States to be our reference exporter and importer for fixed effects that are constant in time and for exporter and importer fixed effects that vary in time.

To explain what this means for the interpretation of estimated fixed effects let us write the expressions for values predicted from our model for relative exports by China to Germany in three consecutive years 1988, 1989, 1990:

$$(7a) \hat{x}_{USA,CHN,88} = \hat{\mu} + \hat{\delta}_{CHN}^E + \hat{\delta}_{CHN,88}^E$$

$$(7b) \hat{x}_{USA,CHN,89} = \hat{\mu} + \hat{\lambda}_{89} + \hat{\delta}_{CHN}^E + \hat{\delta}_{CHN,89}^E$$

$$(7c) \hat{x}_{USA,CHN,90} = \hat{\mu} + \hat{\lambda}_{90} + \hat{\delta}_{CHN}^E + \hat{\delta}_{CHN,90}^E$$

where $\hat{x}_{USA,CHN,88}$ is the log of the relative measure of exports from China to the US.

Subtracting (7c) from (7b) and rearranging we get:

$$(7d) \delta_{CHN,90}^E - \delta_{CHN,89}^E = \hat{x}_{USA,CHN,90} - \hat{x}_{USA,CHN,89} - (\hat{\lambda}_{90} - \hat{\lambda}_{89})$$

Equation (7d) gives us the interpretation of a change in the exporter time-varying fixed effect for China as the predicted change in the exports of China to the reference country United States,

corrected for the overall increase in exports between 89 and 90 picked up by the $(\lambda_{90} - \lambda_{89})$ term that is common for all trading partners. Additionally we can do the same calculation for a trade flow between two non-reference countries, for example China and Germany.

$$(7d) \hat{x}_{DEU,CHN,89} = \hat{\mu} + \hat{\lambda}_{89} + \hat{\delta}_{DEU}^I + \hat{\delta}_{CHN}^E + \hat{\delta}_{CHN,89}^E + \hat{\delta}_{DEU,89}^I$$

$$(7e) \hat{x}_{DEU,CHN,90} = \hat{\mu} + \hat{\lambda}_{90} + \hat{\delta}_{DEU}^I + \hat{\delta}_{CHN}^E + \hat{\delta}_{CHN,90}^E + \hat{\delta}_{DEU,90}^I$$

$$(7f) \hat{\delta}_{CHN,90}^E - \hat{\delta}_{CHN,89}^E = \hat{x}_{DEU,CHN,90} - \hat{x}_{DEU,CHN,89} - \left[(\hat{\delta}_{DEU,90}^I - \hat{\delta}_{DEU,89}^I) + (\hat{\lambda}_{90} - \hat{\lambda}_{89}) \right]$$

Where the last term in square brackets can be expressed as:

$$(7g) \hat{\delta}_{CHN,90}^E - \hat{\delta}_{CHN,89}^E = \hat{x}_{DEU,CHN,90} - \hat{x}_{DEU,CHN,89} - (\hat{x}_{DEU,USA,90} - \hat{x}_{DEU,USA,89})$$

So that from (7g) a change in the exporter time-varying fixed effect for China can be interpreted as a change in China's exports to Germany less the change in United States' (reference country) exports to Germany. Note that a set of expressions equivalent to (7d-7g) hold for China and any trading partner reflecting implying that a change in the exporter time-varying fixed effect estimated for China equals an average predicted change in China's exports across all its trading partners less the average predicted change in United States exports across the same trading partners. Hence, (7g) gives an expression for China's export performance relative to the export performance of the US.

It is also worth noting that that (7a) and (7b) can be rearranged to get an expression for the year fixed effect of 1989:

$$(7h) \lambda_{89} = \hat{x}_{USA,CHN,89} - \hat{x}_{USA,CHN,88} - (\delta_{CHN,89}^E - \delta_{CHN,88}^E)$$

Equation (7h) expresses the fixed effect for 1989 as the increase in US imports from China corrected for the change that is due to an increase in China's exports across all trading partners. Again (7h) can be rewritten for any partner country of the US as an exporter or importer which

implies that λ_{89} captures an average increase in the US's exports and imports in 1989, corrected for all the fixed effects specific to its trading partners, in other words this is a US-specific increase in its trade. In this context the constant can be interpreted as an average of US's exports and imports to all the trading partners corrected for an average exporter and an average importer fixed effect for year 1988.

The above analysis implies that the interpretation of actual values of estimated fixed effects is specific to the omitted reference country. At the same time, because of the common benchmark, the results can be compared across all the non-reference countries in the sample.

Estimation results for terms that isolate the time effects or, alternatively the average US-specific increases in US total trade $\hat{\lambda}_t$ are presented graphically in Figure 1, including the range of the estimated 95% confidence intervals. In all figures that follow the scale of the vertical axis measures the logarithm of relative trade value. Missing fixed effects should be interpreted as those dropped from the estimation because of missing observations. The evolution of the estimated year fixed effects in Figure 2 suggests that, despite the gently negative trend in point estimates, on average US's trade with its trading partners has not been significantly different from the situation in 1988 until 2001. In 2001 a significant and gradually deepening decrease is estimated most likely reflecting the slowdown in US' commerce following 11th September 2001 events.

The $\hat{\delta}_i^E$ and $\hat{\delta}_j^I$ terms that pick up time-invariant fixed effects for exporting and importing countries that are statistically significant are presented in Figure 2 and 3. They are not

particularly meaningful as they indicate whether $\log\left(\frac{X_{ijt}}{Y_{it}Y_{jt}}\right)$ has been on average (over the investigated period) higher or lower for a given country as compared to the US. There is a group of countries that were estimated to be on average importing more intensively (controlling for the sizes of exporting and importing country) than the US. Interestingly, to this group belong four of our BRIICS economies: India, South Africa, China and Brazil. Japan, Canada and Australia, on the other hand, have been importing relatively less than the US. On the export side the list of countries with exporter fixed effects significantly different from zero is longer but all these fixed effects are smaller than zero indicating that countries like Indonesia, South Africa, Russia and China have all been exporting on average less relative to the US.

As noted earlier $\hat{\delta}^E_{it}$ and $\hat{\delta}^I_{jt}$ are the time-varying fixed effects for exporting and importing countries that pick up the relative price effects along with time-varying factors specific to an exporting or importing country such as the opening up to trade on an MFN basis or trade effects of country-specific reforms and policies (e.g. product and factor market reforms). Because differences in these fixed effects with respect to time are indicators of average change in relative exports or imports of a given country across all trading partners net of the equivalent change for the US they can be compared across countries as a measure of export or import *performance over time*. However, if we want to say something about the state of integration (relative to the US) these fixed effects have to be taken into account together with the time-invariant fixed effects $\hat{\delta}^E_i$ and $\hat{\delta}^I_j$ discussed in the previous paragraph.

Graphs of $\hat{\delta}^E_{it}$ and $\hat{\delta}^I_{jt}$ for total trade for each of the BRIICS are presented in Annex Figures

14-25 and, for comparison, for Germany and Japan in Annex Figures 26-29. In addition, Figure 4-13 at the end of this paper present a comparison of point estimates across the BRIICS for total trade and four broad product categories. Table 1 is the most telling as it reports average annual changes in the estimated exporters' and importers' fixed effects, telling us for which country has the exports and imports integration has been evolving most dynamically.

Considering total trade, as expected, some of the BRIICS have been expanding their total exports much faster than the G3 countries (US--comparison with the horizontal axis in Figure 1, Japan--comparison with Annex Figure 21 and Germany--comparison with Annex Figure 19). More surprisingly, while China's estimated strong performance is in line with the headlines reports about its increasing domination of world markets, countries like India, South Africa, Indonesia or Russia have been performing equally as well or even better. This may be seen as somewhat at odds with the headline analysis of trade which is much more 'alarming' when it comes to merchandise exports of China. Yet, the headline reports are often either based on the observed large increases in the value of exports, a statistic that does not account for the growing sizes of the exporting or importing economy, or they are based on the ratio of exports to GDP of the exporting country, a measure that does not account for the size of the exporting country. The relative export

performance measure $\left(\frac{X_{ijt}}{Y_{it} Y_{jt}} \right)$ investigated in this paper does take into account both of these

issues. It turns out that if we take the size of exporting and importing economies into account, China is not the only BRIICS country that has been dynamically deepening its trade links, nor is it the best performer. This is an insight that cannot be easily made on the basis of descriptive statistics of trade data.

Another interesting result is that Brazil lags behind other members of the BRIICS grouping in the sense that its export performance is noticeably below that of other BRIICS as well as that of the US or G3 countries. In this context Brazil can hardly be called a dynamic exporter.

It is also interesting to compare the relative export performance of BRIICS (Figure 4) with their relative import performance (Figure 5). Lines representing point estimates of importer fixed effects are concentrated more tightly around the horizontal axis and the average annual changes reported in Table 1 are much smaller, which means that the relative import performance of BRIICS was closer to the relative import performance of the US (and other members of the G3). Brazil is again an outlier as its imports fixed effects have been growing faster than in any other member of the grouping. The differences between overall export and imports performance across BRIICS could suggest more of an export-led rather than a broad openness-based scenario of BRIICS emergence though such a hypothesis can be countered with generally positive time-invariant importer fixed effects presented in Figure 2 and generally negative time-invariant exporter fixed effects presented in Figure 3.

The remaining rows in Table and Figures (3-10) summarize the estimation results for the four broad product categories. While classification of trade data at 6 or 8 digit level of harmonized system into such broad product categories is bound to be based on some subjective judgments it can help to understand what may be driving the results for total trade.⁸ On these sectoral graphs we can see that time-varying fixed effects for BRIICS exporters of consumption goods broadly mimic these for total trade (Figure 3) though the list of strongest performers (South Africa, Russia

⁸ In this paper we use the classification and concordance available from the World Integrated Trade Solution (WITS) database.

and India) is different from that for total trade (Russia, China, India and Indonesia). As far as imports are concerned there is more heterogeneity within the group with Indonesia's and Russia's import fixed effects actually declining on average over the considered period.

The biggest changes over time are observed for capital goods where Indonesia comes out as the strongest relative export performer, followed closely by China and India and South Africa. This is also accompanied by strong imports of capital goods of these countries although, for example, Indonesia has been actually decreasing import integration in this category of goods. As far as raw materials are concerned China is an outlier in the sense that it is the only country that has not been increasing its export presence in this category of goods over time. All other BRIICS have been increasing its exports presence in raw materials over time, a change that on average was remarkably uniform across countries. On the import side China has been the most dynamic destination market for raw materials which is consistent with the discussed export performance and with the needs of this rapidly industrializing economy.

Country pair-specific time-invariant fixed effects $\hat{\delta}_{ij}$ tell us with which countries BRIICS were trading particularly intensely through the investigated period, having accounted for all country specific and time factors. One observation that can be made at the outset is that the magnitude of these effects is much larger than the magnitude of the time-varying exporter effects for total trade which are insignificant. This means that BRIICS exports are to a large extent influenced by bilateral factors rather than by country-wide factors that have evolved over the investigated period. *More on country pair fixed effects here*

Conclusions

This paper presents an approach to analyzing bilateral trade data based on the gravity model of international trade and the fixed effects and applies it to the analysis of trade of Brazil, Russian Federation, India, Indonesia, China and South Africa (BRIICS). The analysis covers the 1985-2006 period and is conducted for total trade as well as four broad product categories including raw materials, intermediate goods, consumption goods and capital goods. The econometric approach presented in this paper turns out to be a convenient way to econometrically decompose historical trade trends into a number of distinct components some of which are countries' and policies' specific and some of which are not.

The results indicate that, as expected, some of the BRIICS have been expanding their total exports much faster than the G3 countries. More surprisingly, while China's estimated strong performance is in line with the headlines reports about its increasing domination of world markets, countries like India, South Africa, Indonesia or Russia have been performing equally as well or even better. This may be seen as somewhat at odds with the headline analysis of trade which are much more 'alarming' when it comes to merchandise exports of China. Yet, the headline reports are often either based on the observed large increases in the value of exports, a statistic that does not account for the growing sizes of the exporting or importing economy, or they are based on the ratio of exports to GDP of the exporting country, a measure that does not account for the size of the exporting country. The relative export performance measure employed in this paper does take into account both of these issues. It turns out that if we take the size of exporting and importing economies into account, China is not the only BRIICS country that has been dynamically deepening its trade links, nor is it the best performer. This is one of the insights gained from this paper that cannot be easily made on the basis of more conventional analysis of trade data.

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ANNEX: FIGURES AND TABLES

Table 1. Summary of average annual change in exporter and importer fixed effects

exporter	CHN	BRA	IND	IDN	RUS	ZAF
Total trade	0.08	0.03	0.07	0.07	0.11	0.06
Consumption goods	0.06	0.02	0.09	0.06	0.11	0.12
Raw materials	0.00	0.08	0.07	0.07	0.09	0.08
Capital goods	0.22	0.07	0.13	0.28	0.03	0.11
Intermediate goods	0.05	0.01	0.06	0.07	0.12	0.09
importer	CHN	BRA	IND	IDN	RUS	ZAF
Total trade	0.01	0.06	0.03	-0.07	0.01	0.04
Consumption goods	0.03	0.12	0.04	-0.02	-0.02	0.04
Raw materials	0.06	0.02	0.05	0.00	-0.04	0.01
Capital goods	0.09	0.09	0.07	-0.09	0.02	0.05
Intermediate goods	-0.01	0.06	0.05	-0.06	0.08	0.00

Note: based on point estimates of fixed effects

Source: authors calculations based on estimation results.

Table 2. Variable definitions and sources

Variable	Description	Year	Source
Trade _{ij}	Bilateral exports from i to j (mirror data) in US\$000	1985-2002	Comtrade
GDP _i , GDP _j	Nominal GDP in US\$	1985-2002	World Development Indicators
Protection _{ij}	Ad valorem tariff equivalent affecting exports from i to j, MAcMap weighting scheme	2001	MAcMap database
Protection-tw _{ij}	Ad valorem tariff equivalent affecting exports from i to j, trade-weighted	2001	MAcMap database
Distance _{ij}	Great circle distance from i to j	-	www.cepii.fr
Distance-w _{ij}	Distance from i to j, weighted by city-level population distribution	2004	www.cepii.fr
Distance-cap _{ij}	Great circle distance from the capital of i to the capital of j	-	www.cepii.fr
Border _{ij}	Dummy = 1 if i and j share a common border, else 0	-	www.cepii.fr
Common language _{ij}	Dummy = 1 for common language spoken by at least 9% of the population in i and j, else 0	-	www.cepii.fr
Common official language _{ij}	Dummy = 1 for common official language for i and j, else 0	-	www.cepii.fr

Common coloniser _{ij}	Dummy = 1 for common post-1945 coloniser for i and j, else 0	-	www.cepii.fr
Colonial relationship _{ij}	Dummy = 1 for colonial link between i and j, else 0	-	www.cepii.fr
Same country _{ij}	Dummy = 1 for i and j same country, else 0	-	www.cepii.fr

Figure 1. Year fixed effects.

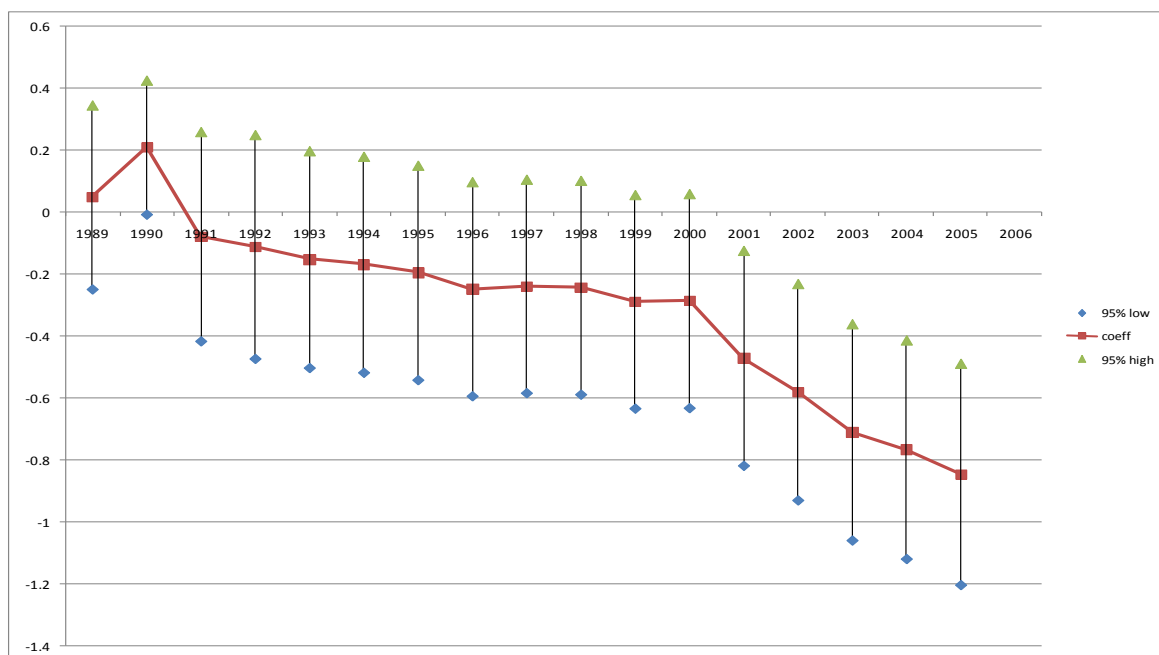


Figure 2. Importer fixed effects—total trade

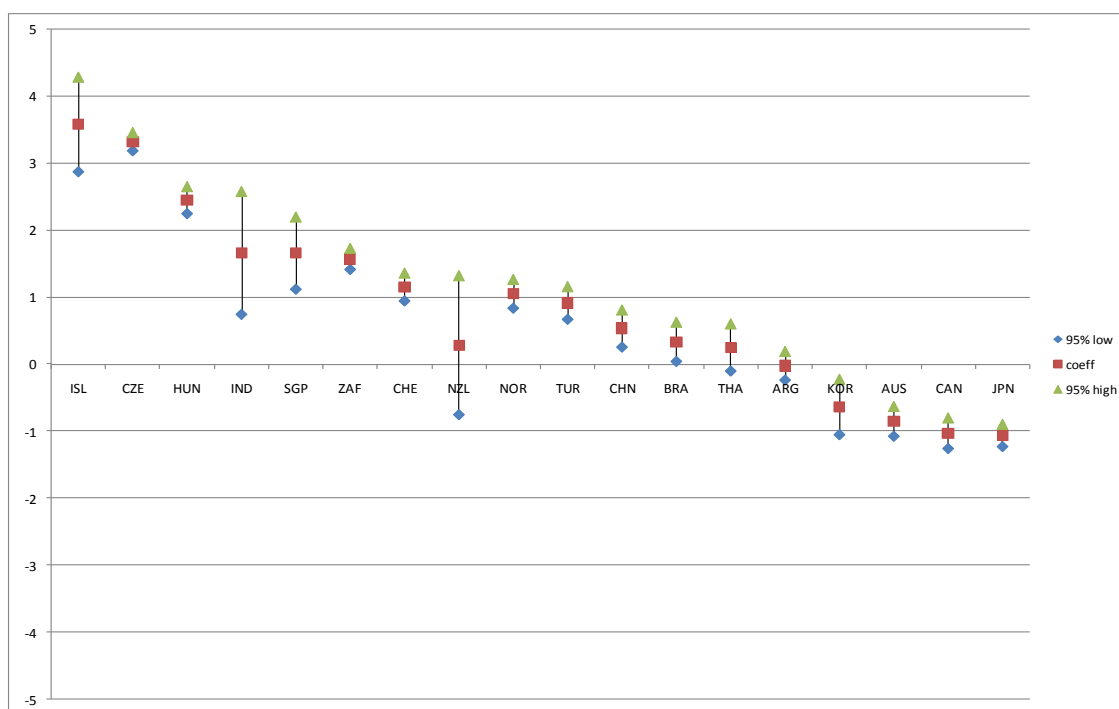


Figure 3. Exporter fixed effects—total trade

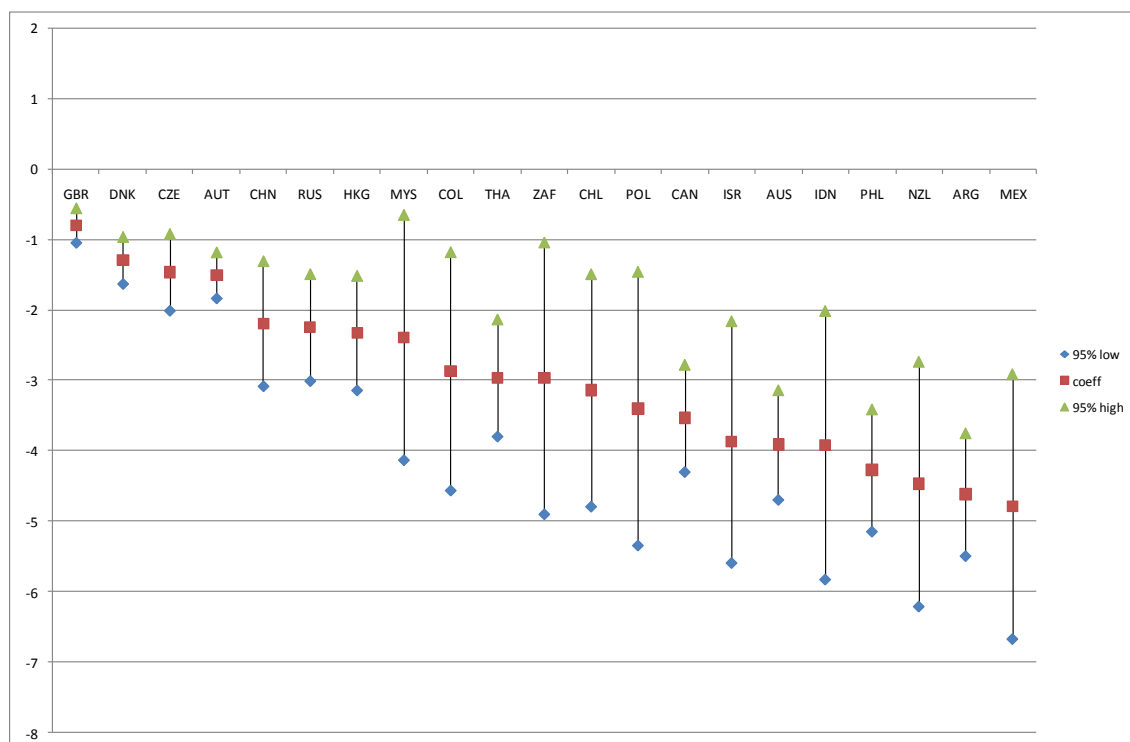


Figure 4. Time-varying fixed effects for BRIICS as exporters (total trade).

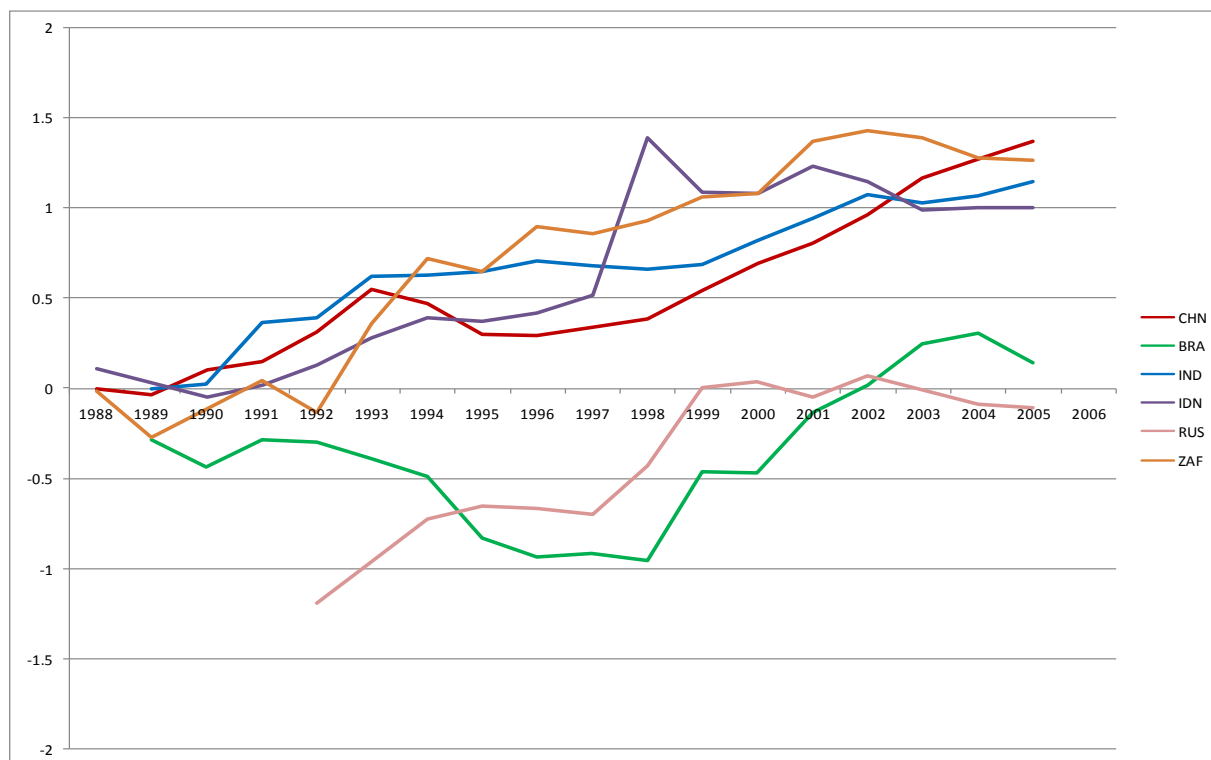


Figure 5. Time-varying fixed effects for BRIICS as importers (total trade).

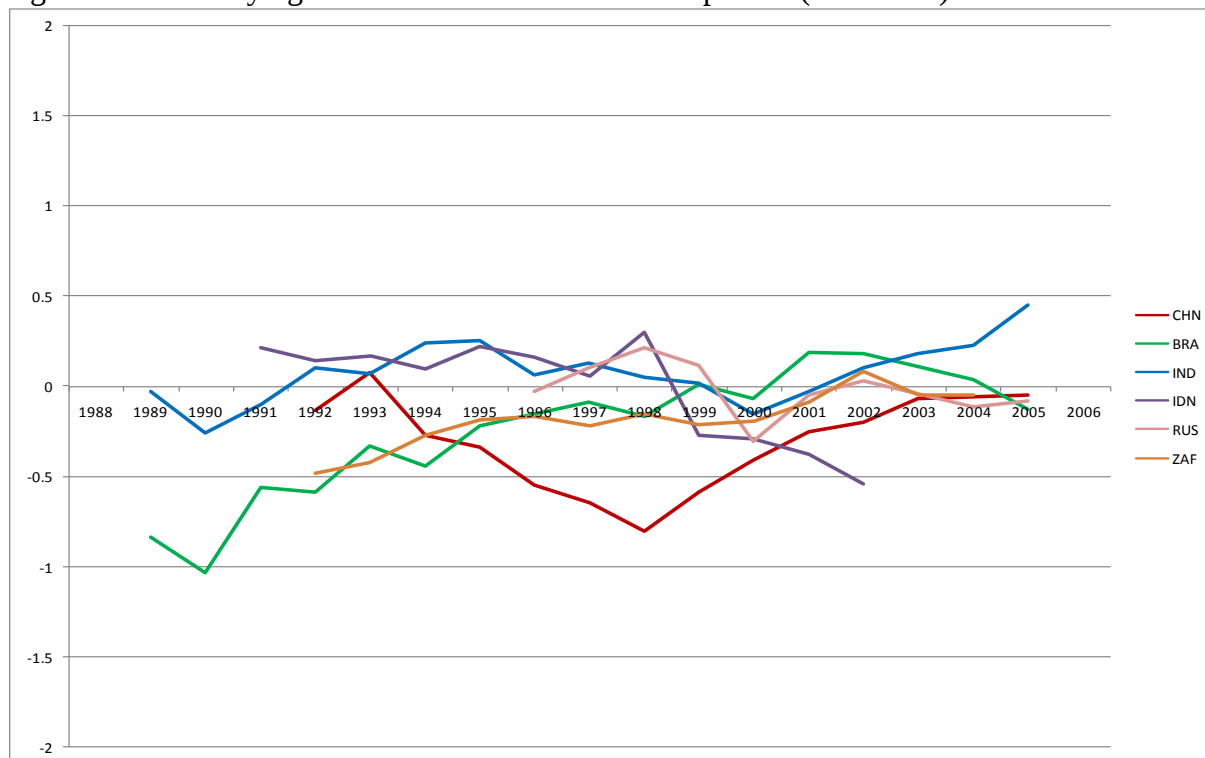


Figure 6. Time-varying fixed effects for BRIICS as exporters (consumption goods).

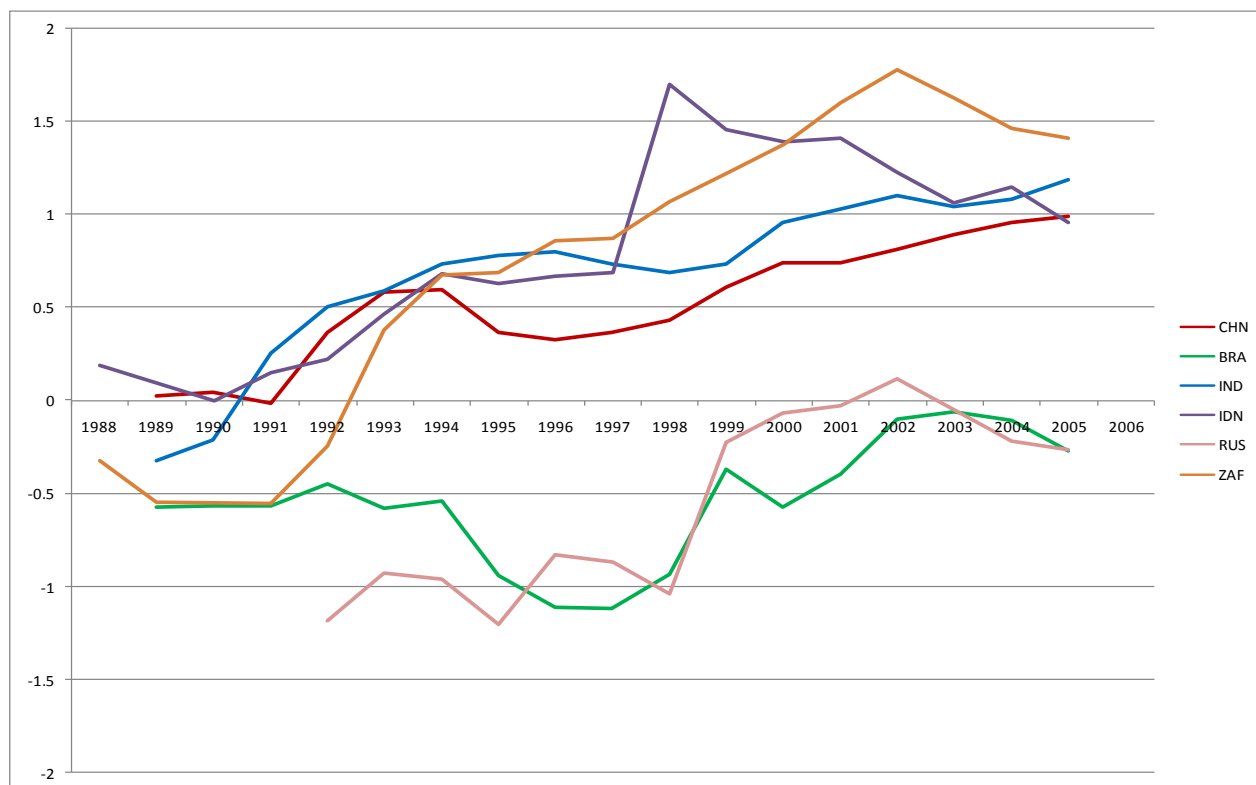


Figure 7. Time-varying fixed effects for BRIICS as importers (consumption goods).

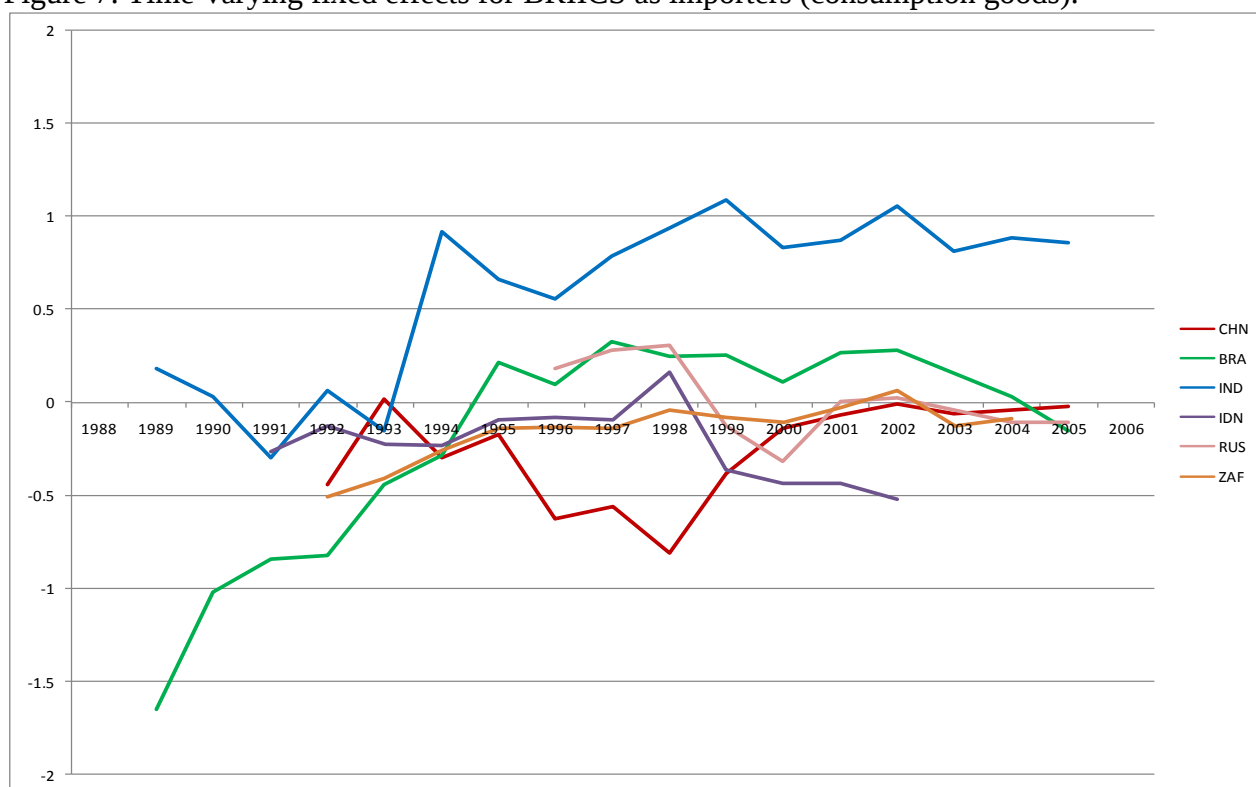


Figure 8. Time-varying fixed effects for BRIICS as exporters (raw materials).

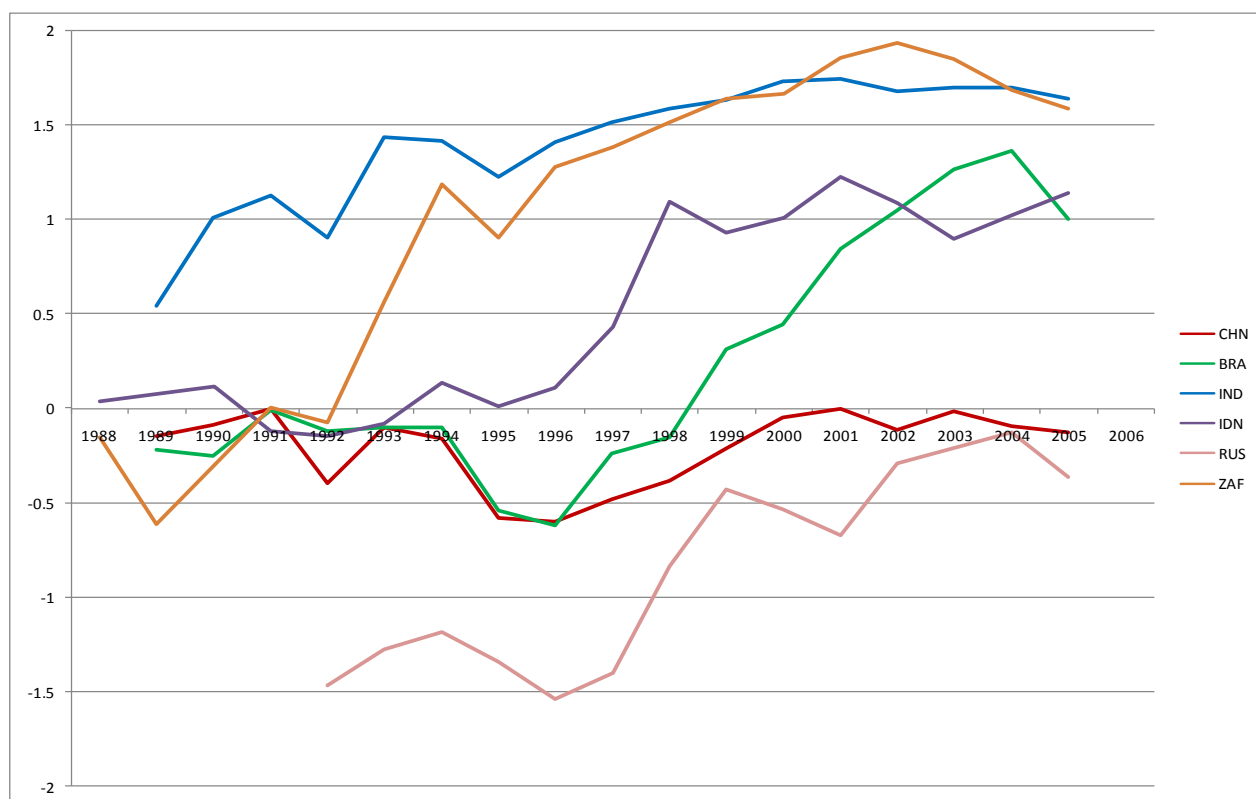


Figure 9. Time-varying fixed effects for BRIICS as importers (raw materials).

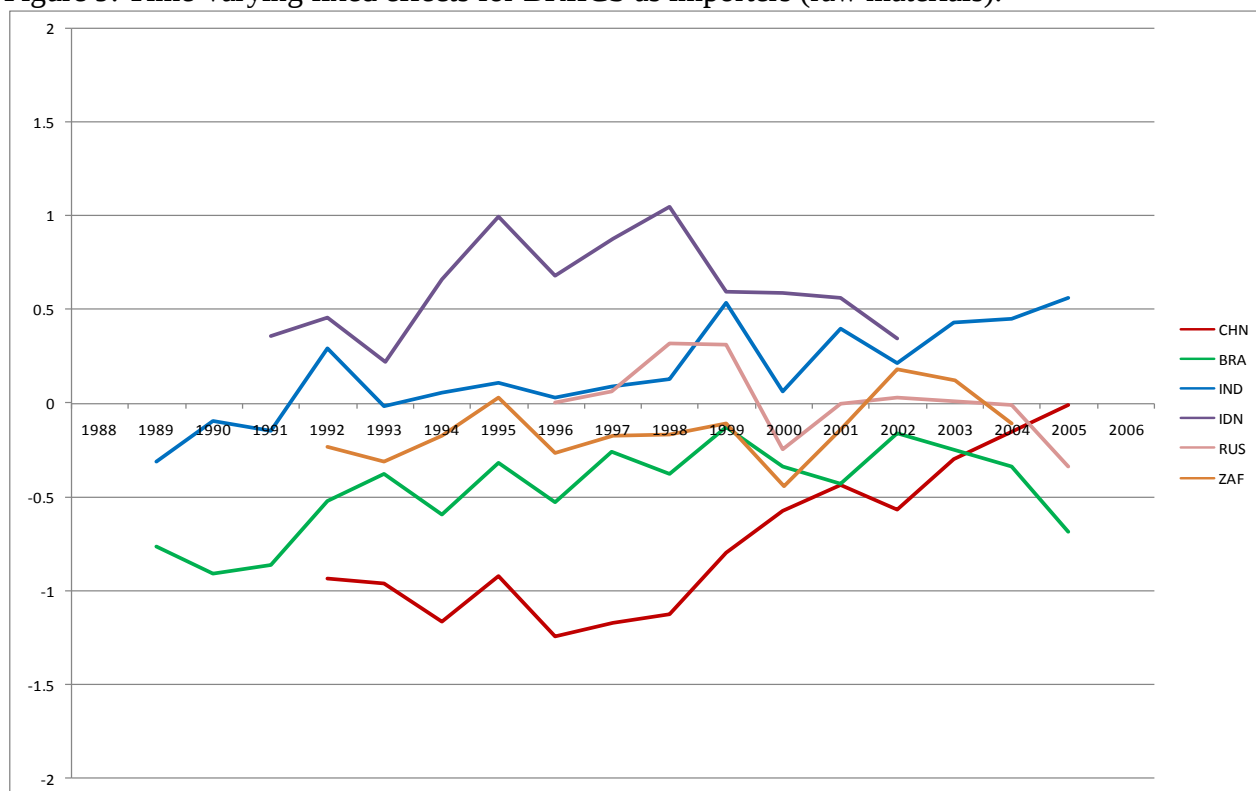


Figure 10. Time-varying fixed effects for BRIICS as exporters (capital goods).

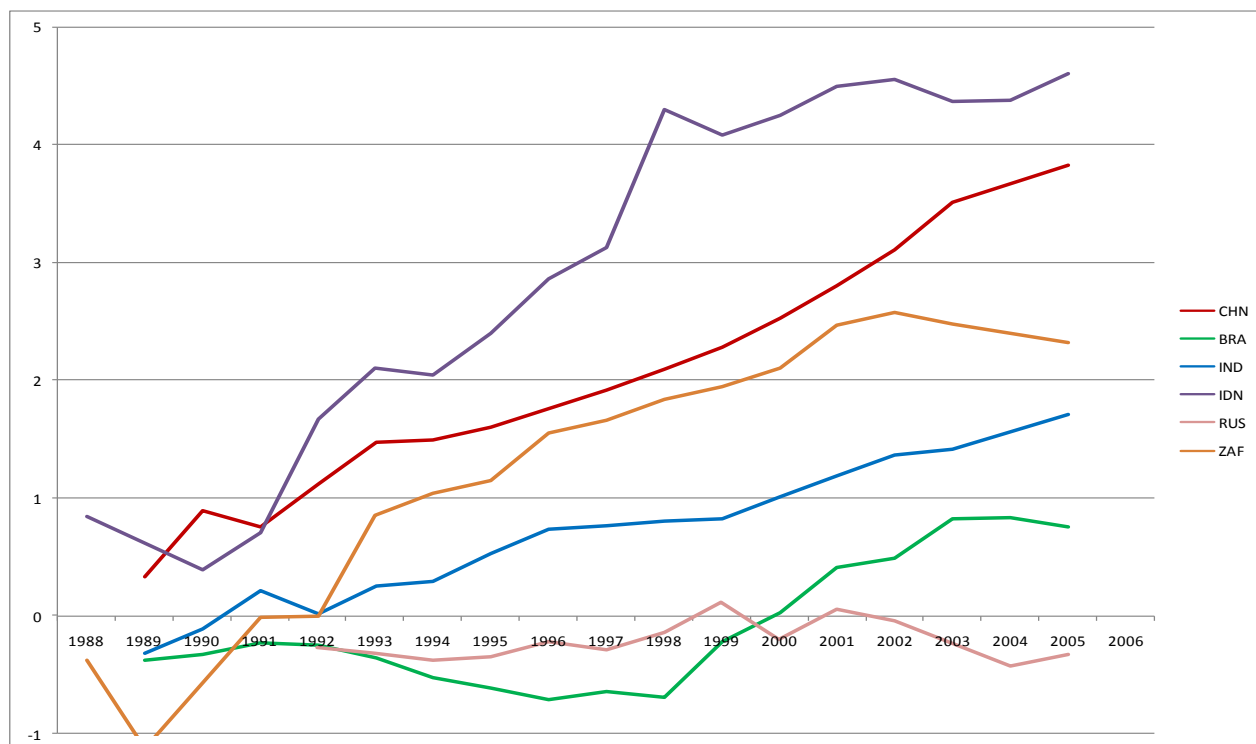


Figure 11. Time-varying fixed effects for BRIICS as importers (capital goods)

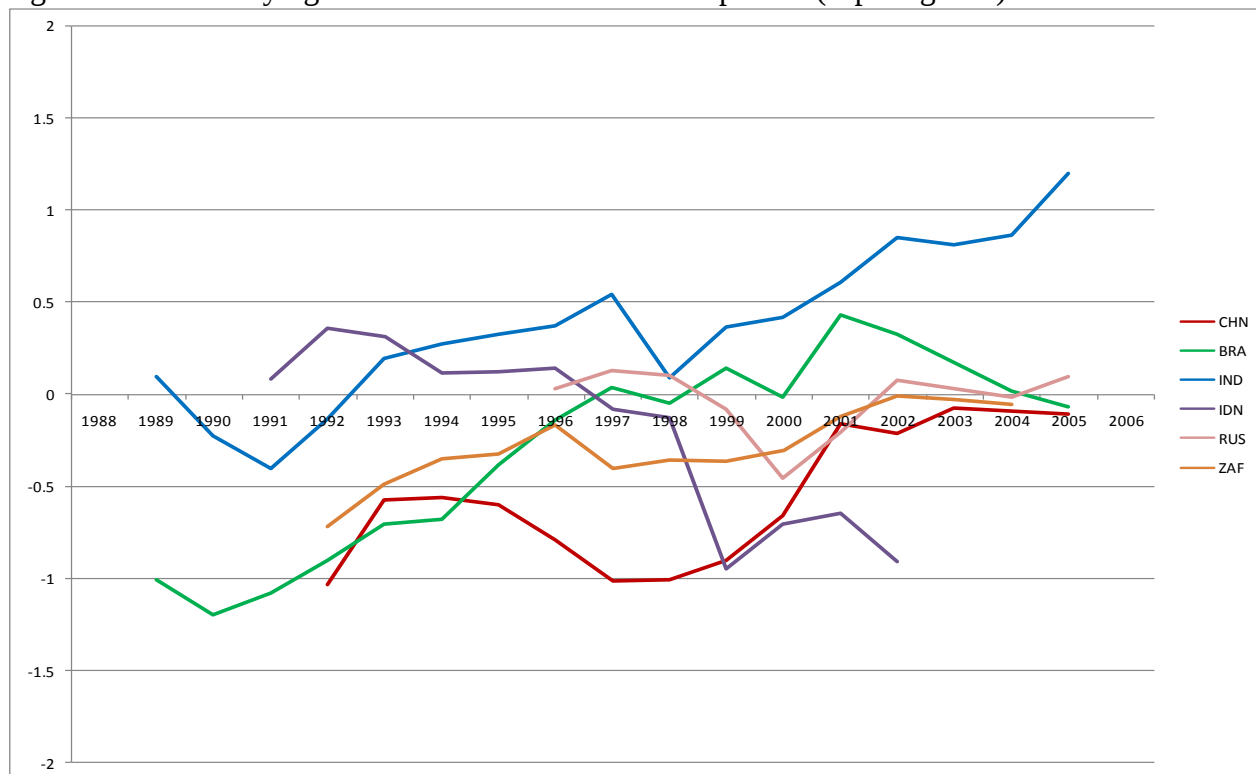


Figure 12. Time-varying fixed effects for BRIICS as exporters (intermediate goods).

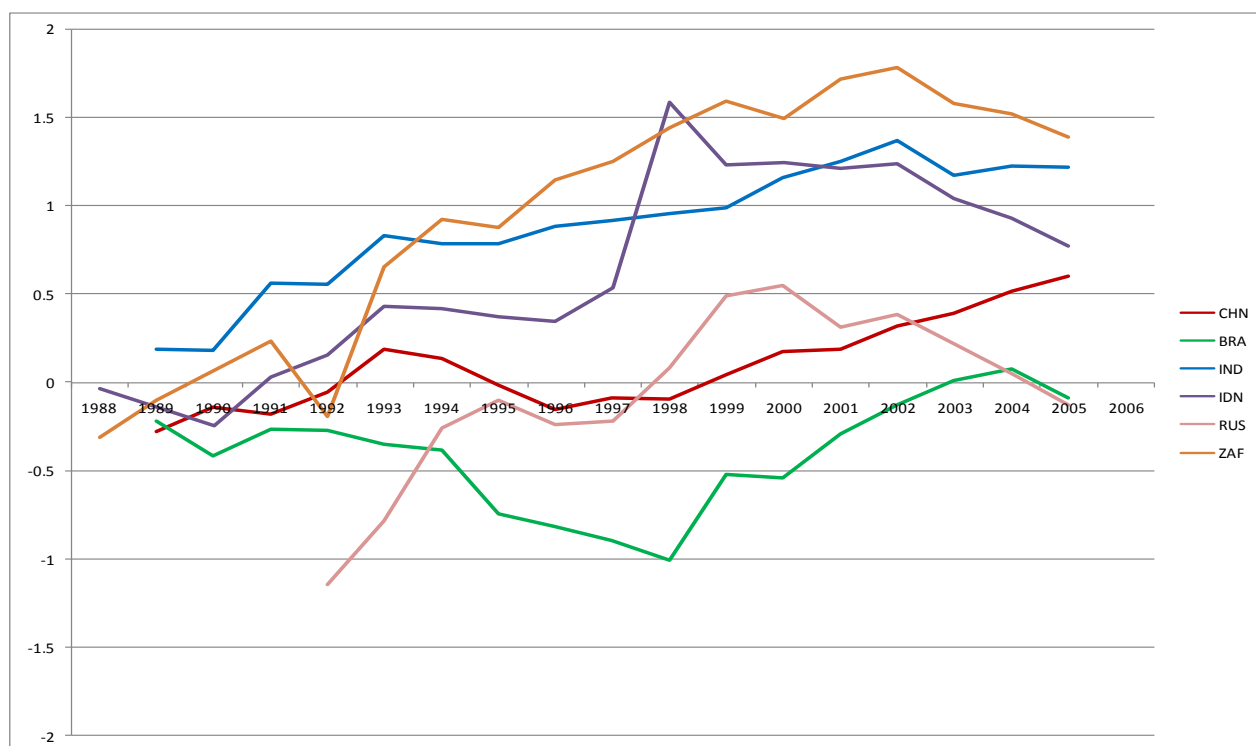


Figure 13. Time-varying fixed effects for BRIICS as importers (intermediate goods).

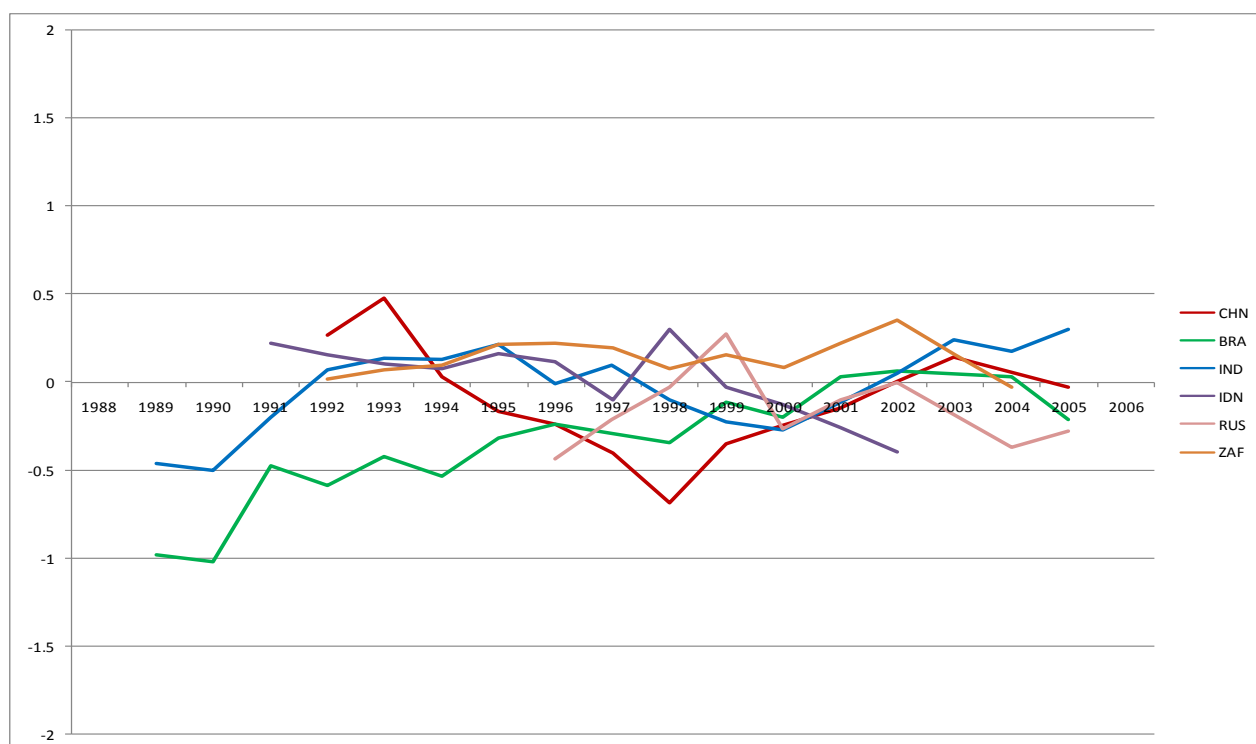


Figure 14. Time-varying importer fixed effects for Brazil as an importer

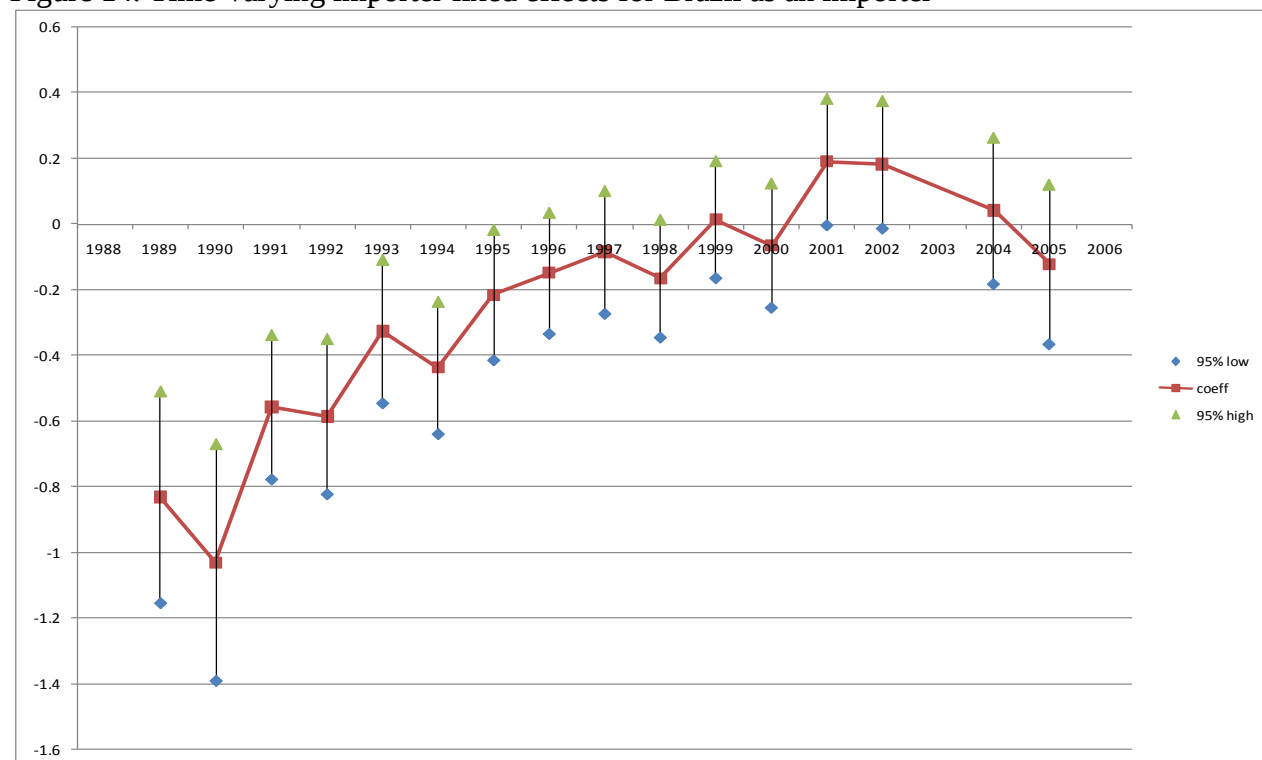


Figure 15. Time-varying importer fixed effects for Brazil as an exporter

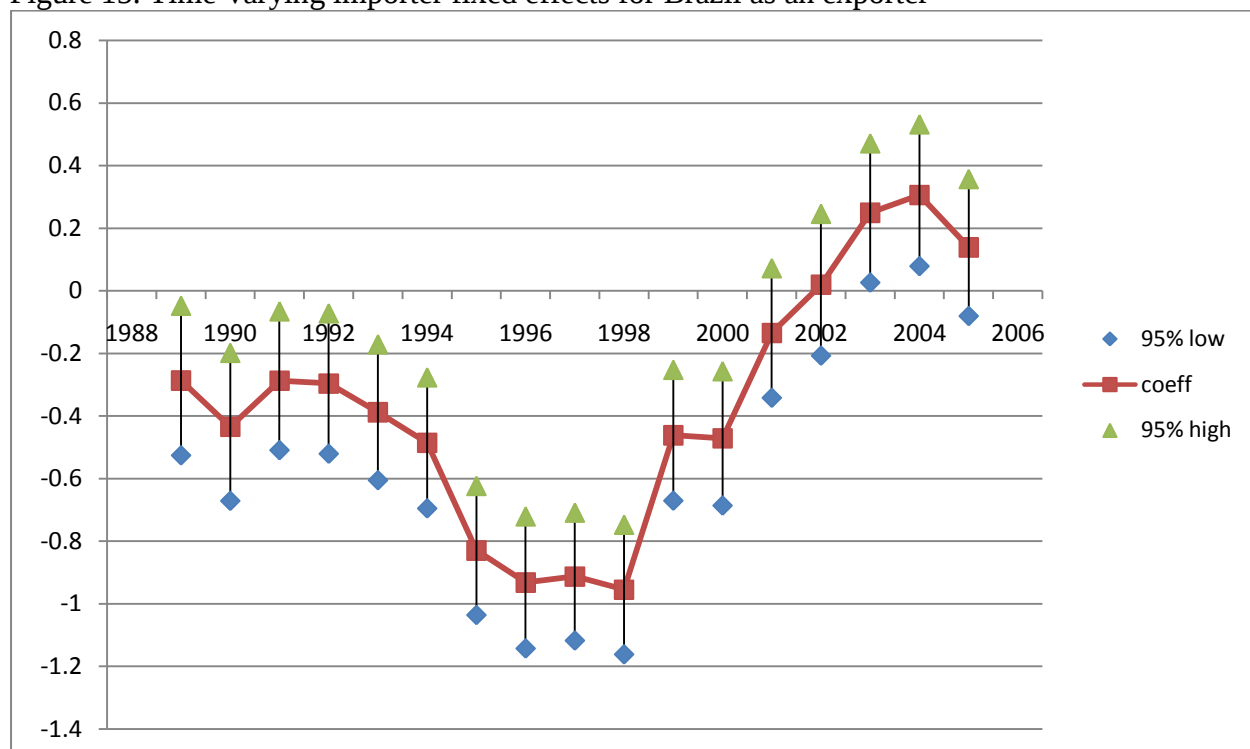


Figure 16. Time-varying importer fixed effects for Russia as an importer

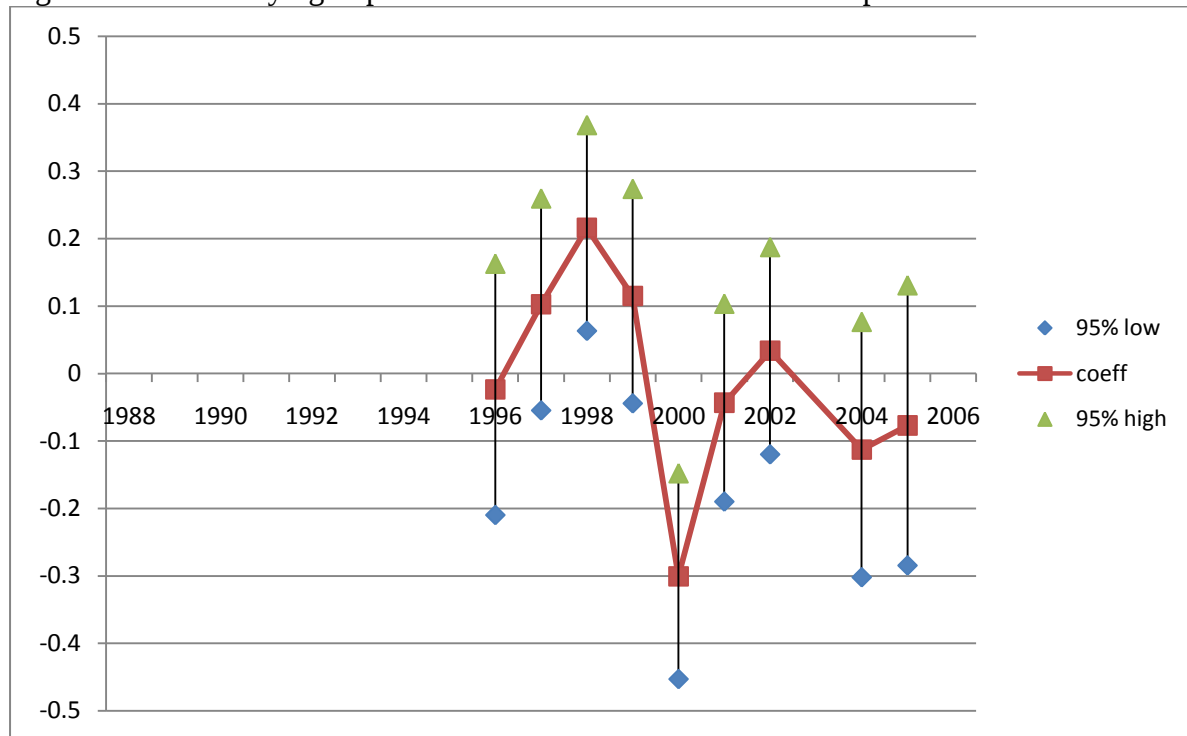


Figure 17. Time-varying importer fixed effects for Russia as an exporter

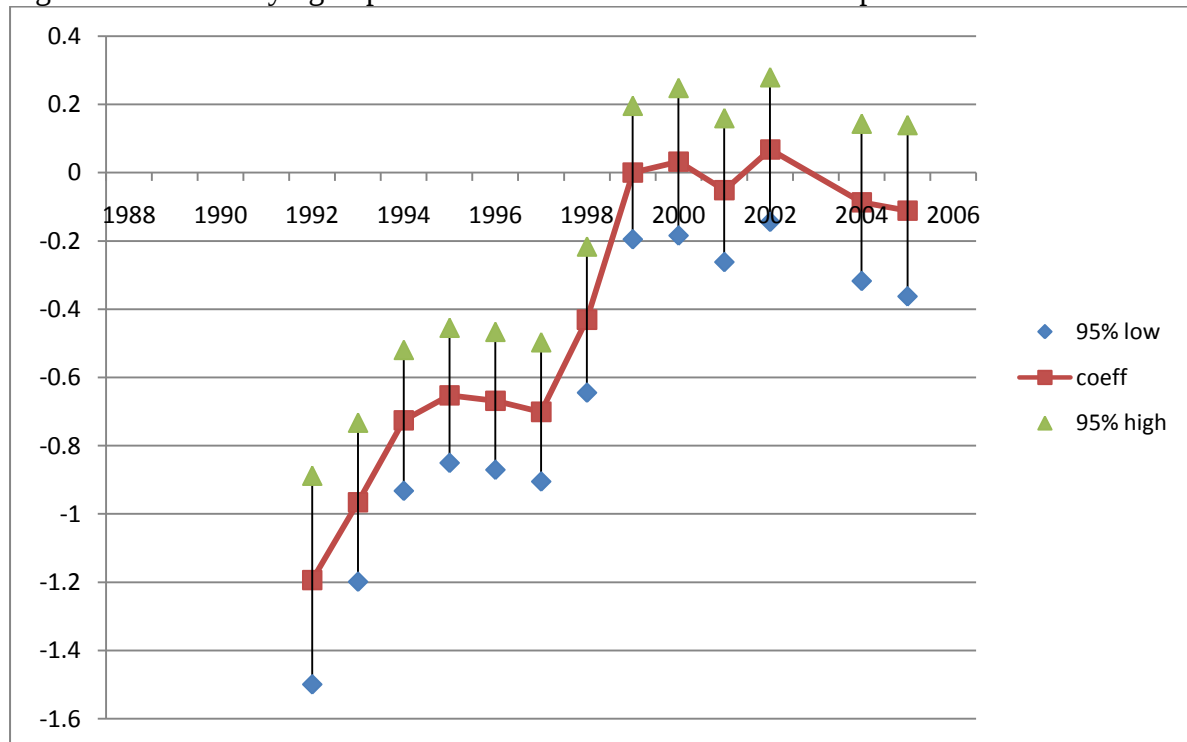


Figure 18. Time-varying importer fixed effects for India as an importer

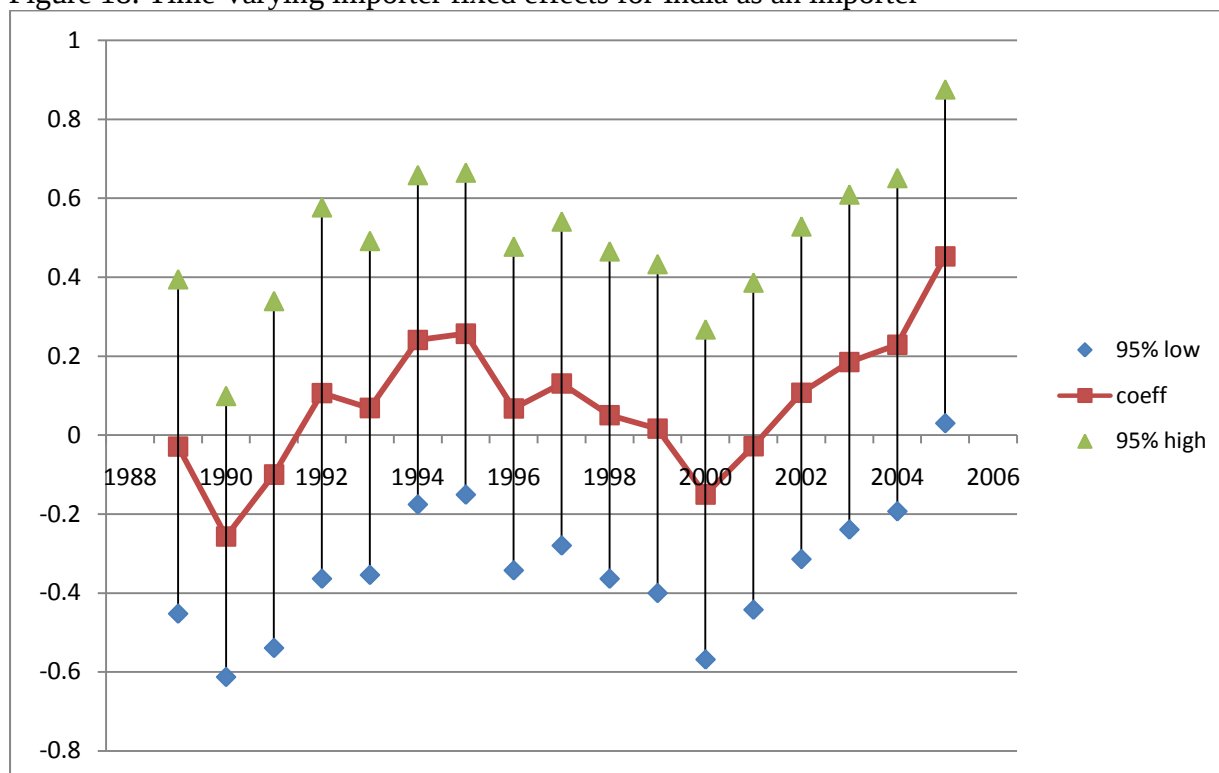


Figure 19. Time-varying importer fixed effects for India as an exporter

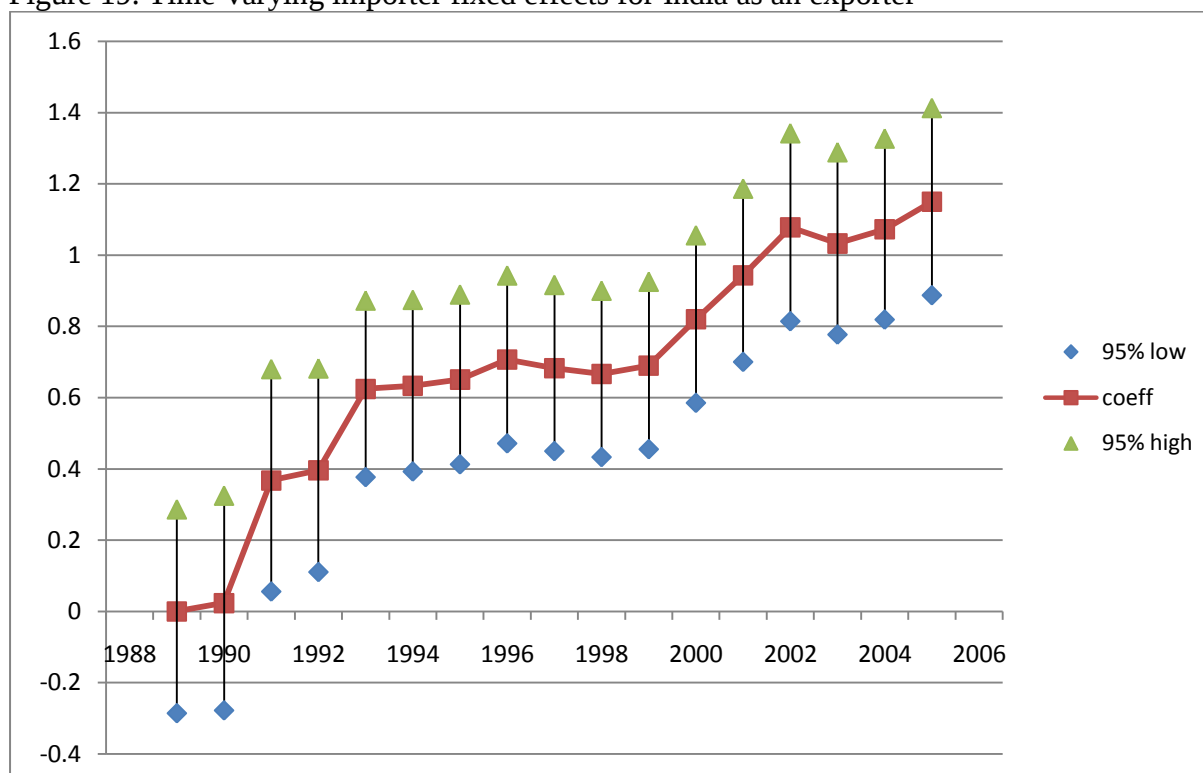


Figure 20. Time-varying importer fixed effects for Indonesia as an importer

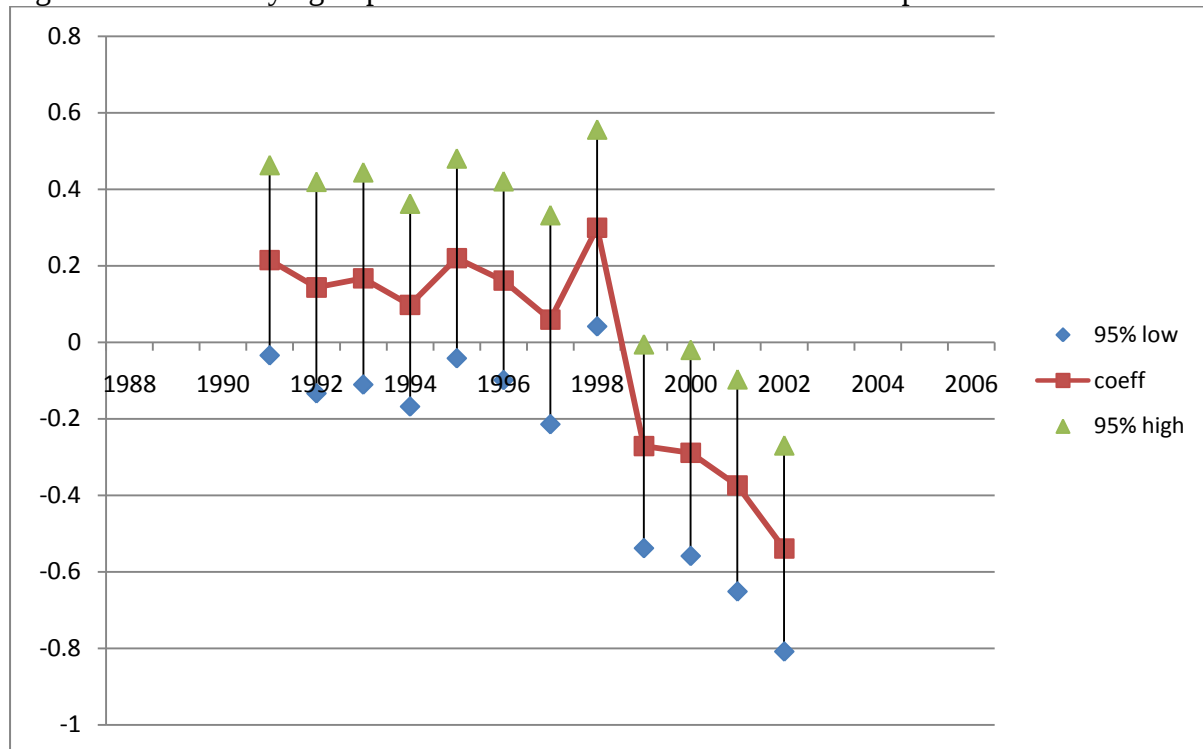


Figure 21. Time-varying importer fixed effects for Indonesia as an exporter

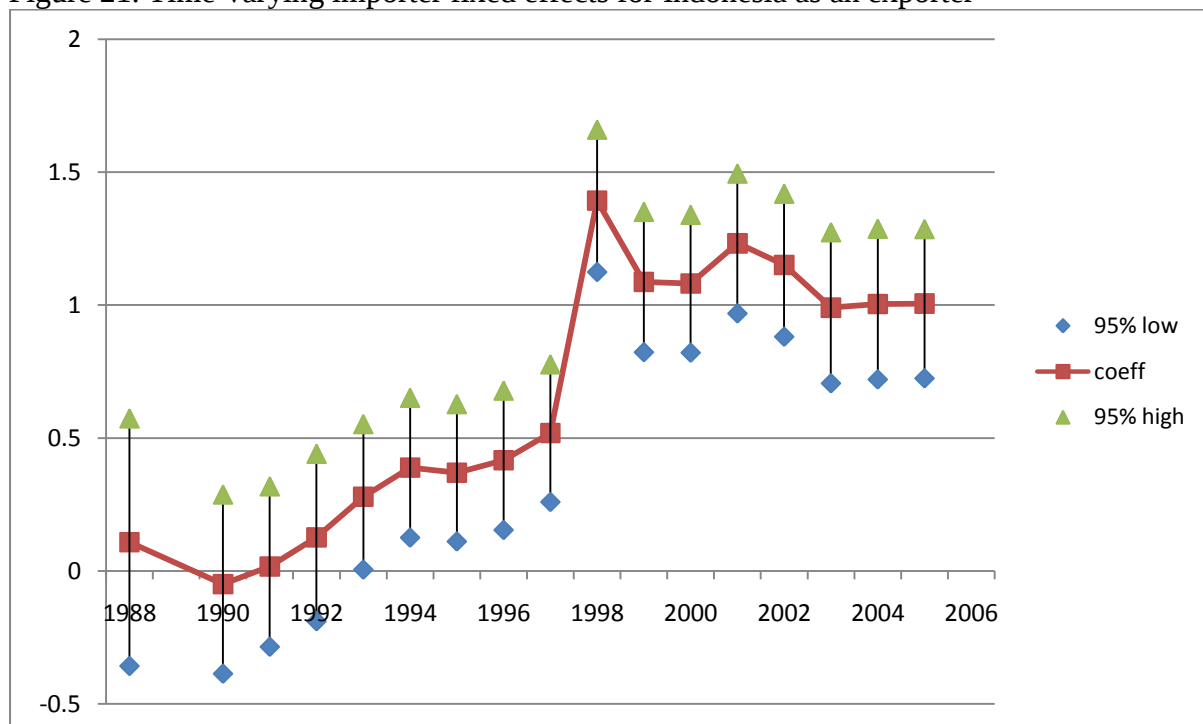


Figure 22. Time-varying importer fixed effects for China as an importer

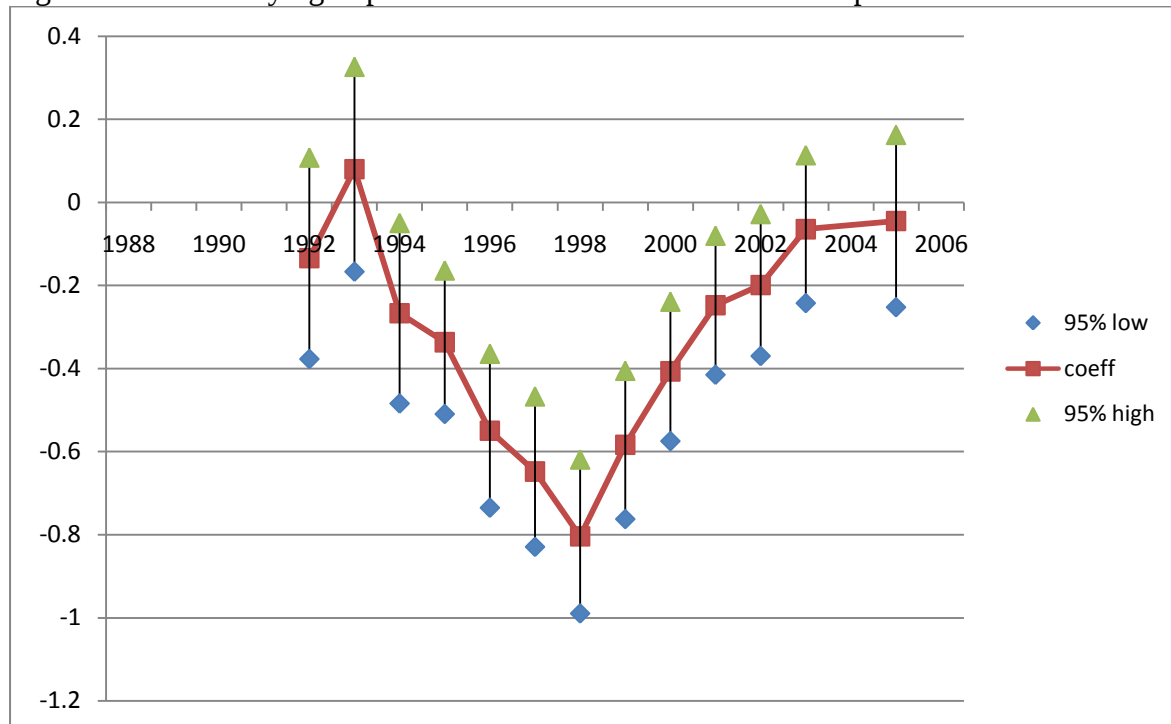


Figure 23. Time-varying importer fixed effects for China as an exporter

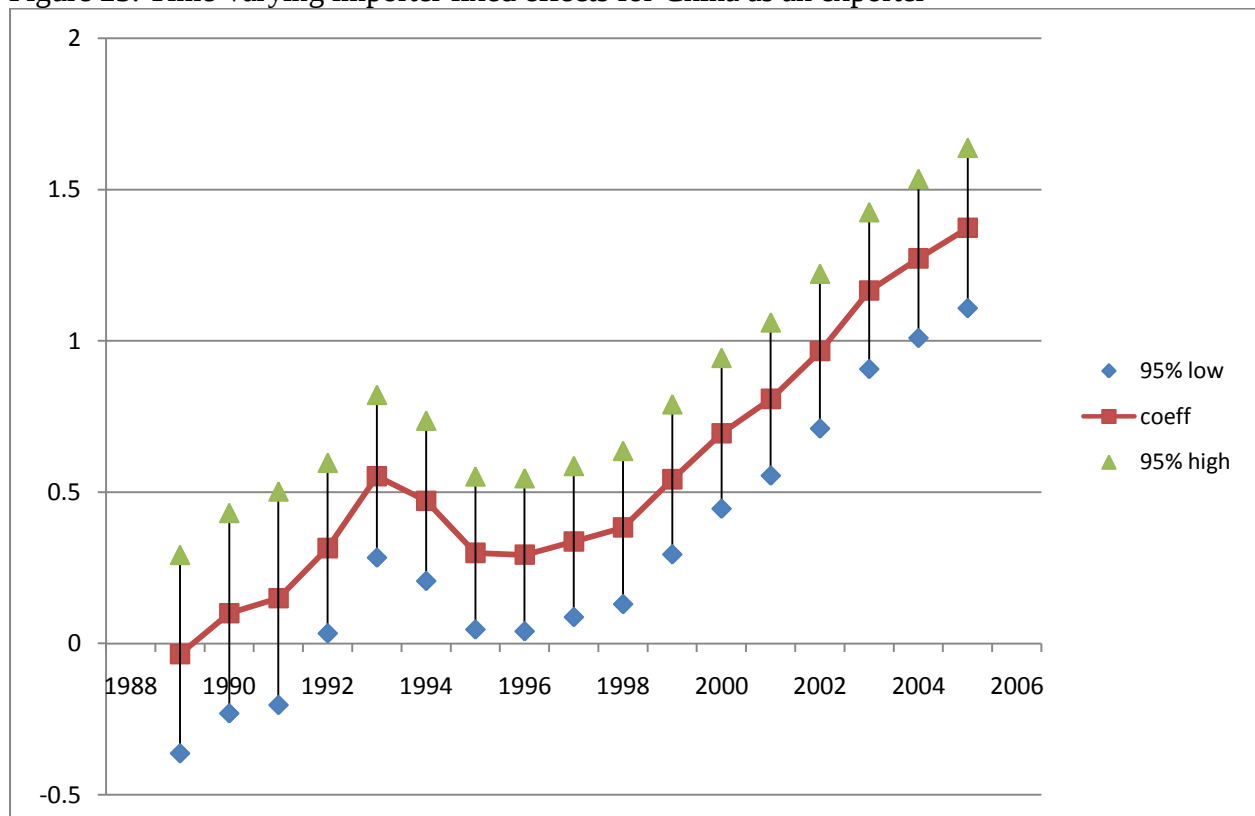


Figure 24. Time-varying importer fixed effects for South Africa as an importer

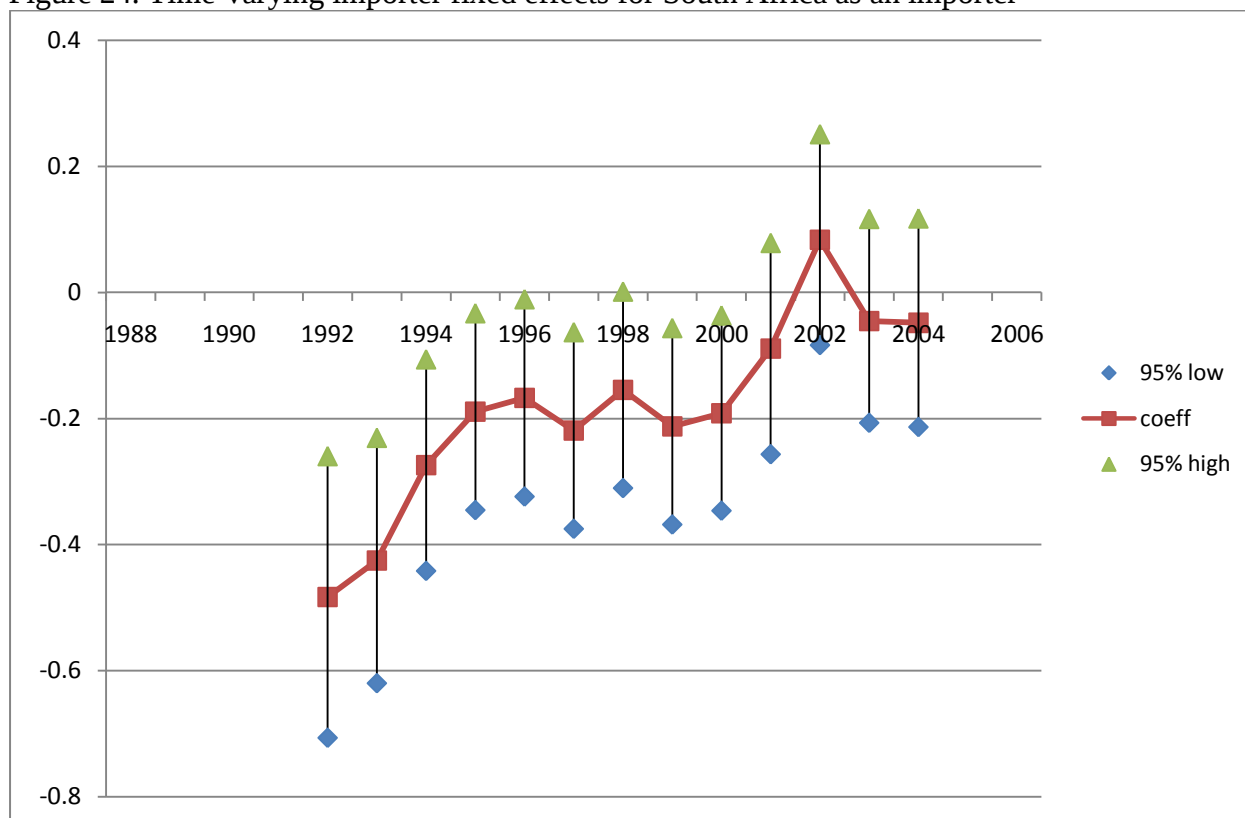


Figure 25. Time-varying importer fixed effects for South Africa as an exporter

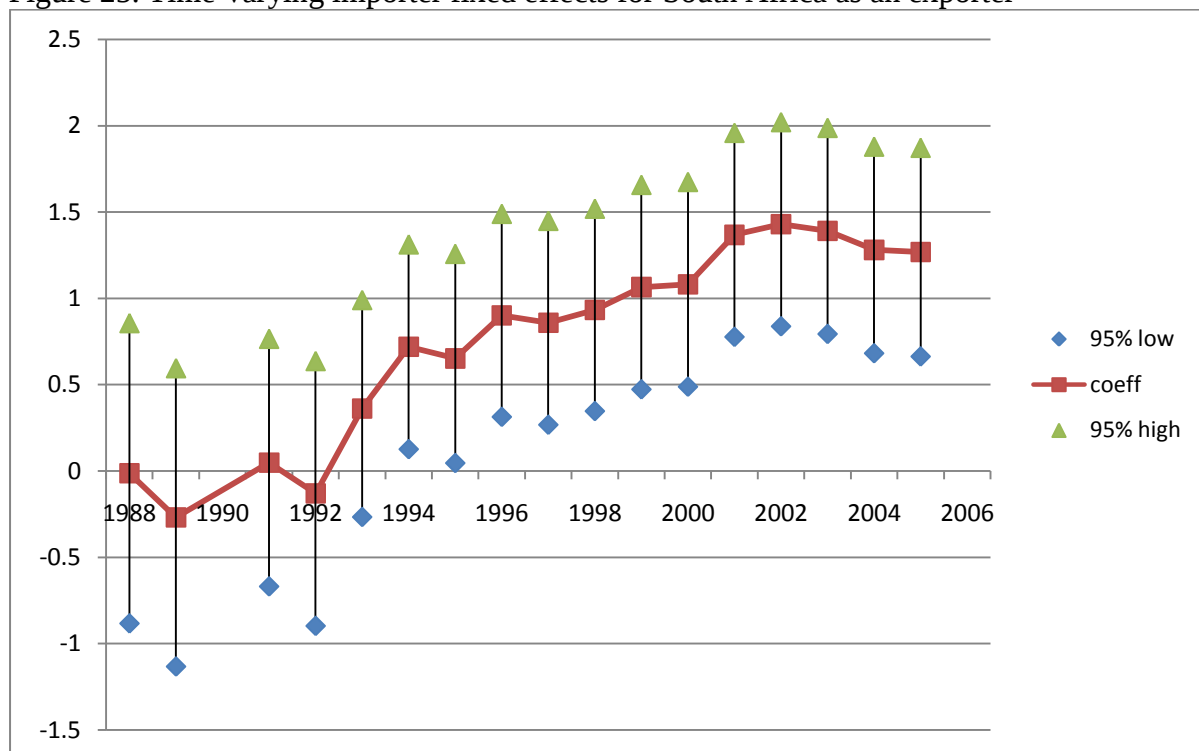


Figure 26. Time-varying importer fixed effects for Germany as an importer

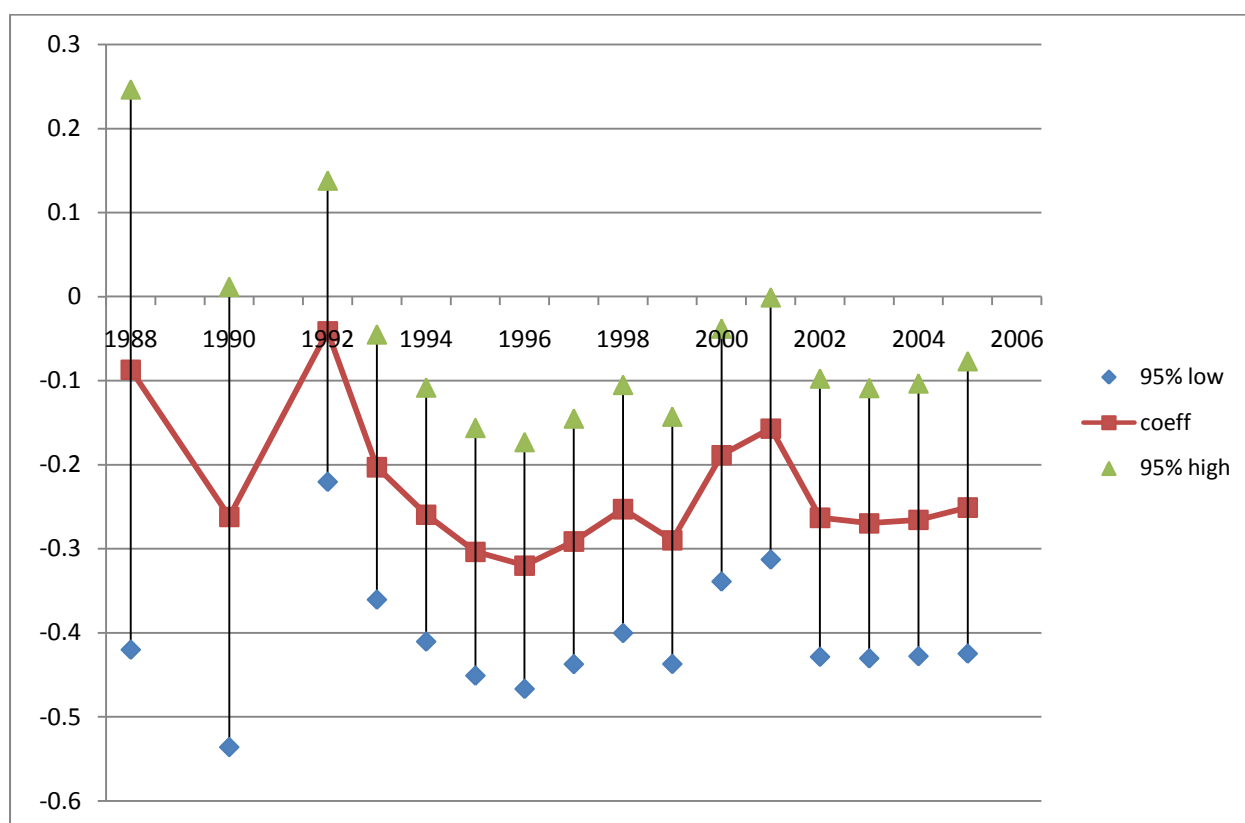


Figure 27. Time-varying importer fixed effects for Germany as an exporter

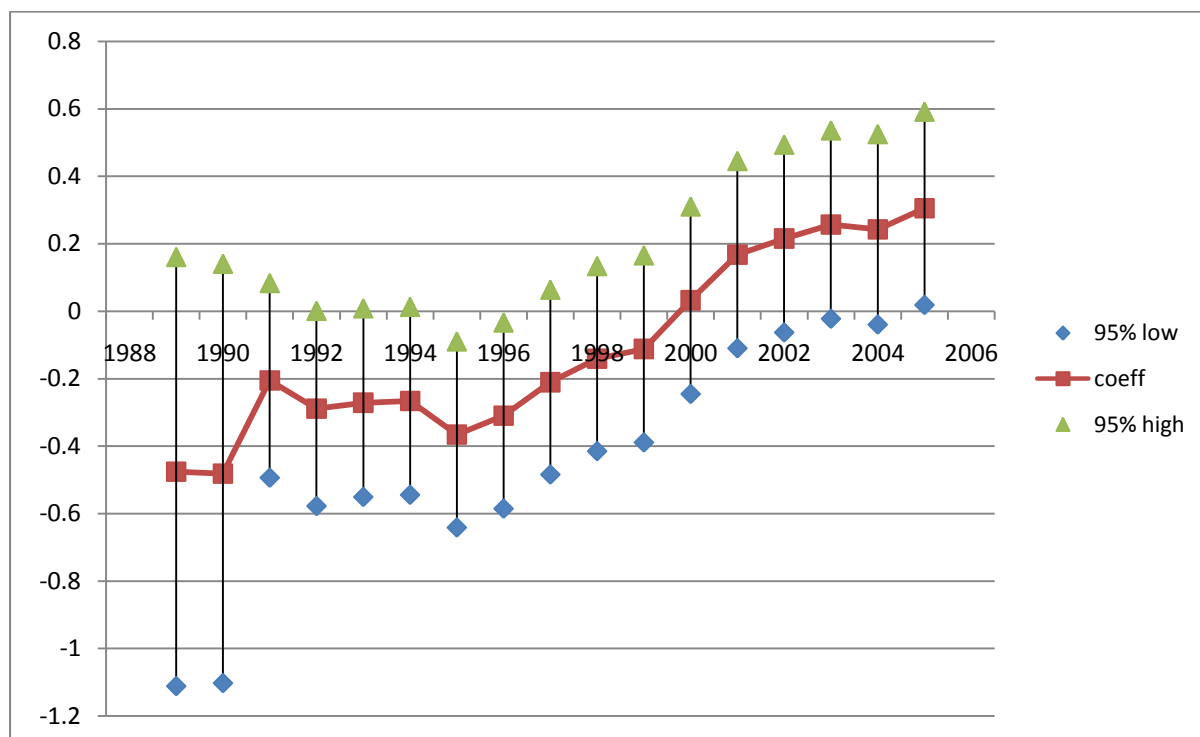


Figure 28. Time-varying importer fixed effects for Japan as an importer

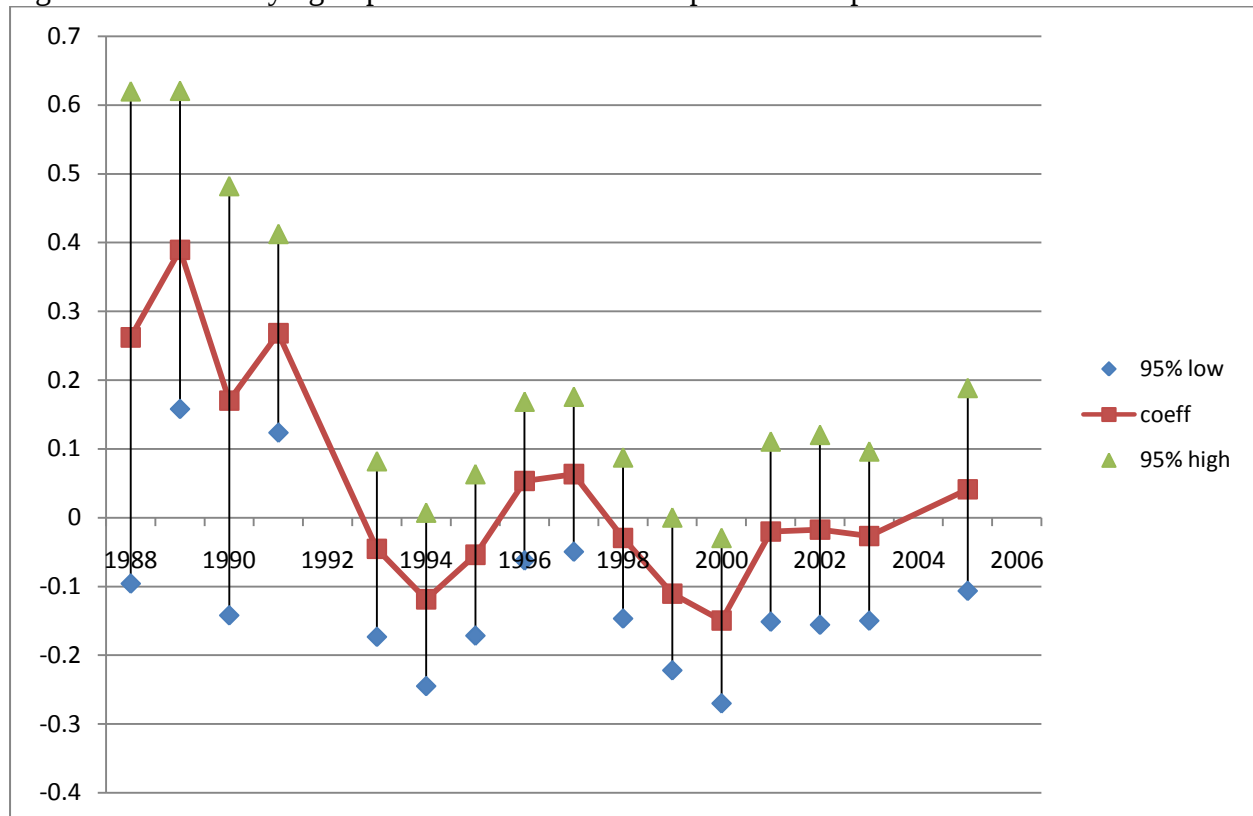


Figure 29. Time-varying importer fixed effects for Japan as an exporter

