Trade Openness Reduces Growth Volatility When Countries are Well Diversified

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December 4, 2009

Abstract

This study addresses the mechanisms by which the trade channel affects growth volatility. Using a diverse set of export diversification indicators, we find that while the effect of trade openness on growth volatility is positive on average, there is strong evidence pointing to an important role for export diversification in reducing the vulnerability of countries to global shocks. We also identify positive thresholds for product diversification at which the effect of openness on volatility changes sign. This result is shown to be robust to both explicit accounting for endogeneity as well as the inclusion of a host of additional controls.

KEYWORDS: Export diversification, growth volatility, trade openness
JEL CLASSIFICATION: F15, F43, O24

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"Your mother called to remind you to diversify."

1 Introduction

The global economic downturn has led to a renewed interest in the relative merits of export-led growth strategies for developing countries (Harrison & Rodríguez-Clare 2009; Rodrik 2009). Such strategies, in turn, are often inspired by the desire to promote superior economic growth (Sala-i-Martin 1997) or to spark growth accelerations (Jones & Olken 2008). This strategy of trade liberalization is often pursued alongside a policy that promotes export diversification, which is also believed to be a positive driver of growth (Al-Marhubi 2000; Hesse 2009).

While trade openness and export diversification are positively associated with growth outcomes, relatively less is known about the effects that exports and trade have on the (second-moment) issue of growth volatility, and how these two related factors play off each other in affecting growth fluctuations. After all, one may reasonably expect an open economy with a concentrated export structure to be more economically vulnerable when their major exports are threatened. Conversely, the cushioning effects of a diversified export base would likely be muted if the economy's growth dynamic is reliant mainly on domestic rather than international sources. But while the growth effects of the volatility (Ramey & Ramey 1995) and terms of trade (ToT) (Easterly & Kraay 2000) have been well explored, there has been comparatively little work that examines how first moment effects, such as trade openness and export diversity, have on the variability of growth outcomes.

This study seeks to address the mechanisms by which the trade channel affects growth volatility. Our questions regarding these effects are twofold: First, does the effect of trade openness on growth volatility vary with the degree of diversification of a country's export basket? Second, given that such variability exists, is there a threshold in terms of a given export diversification measure above which the total effect of trade openness on growth volatility changes from negative to positive?

In considering these issues, we use, as our point of departure, the notion that the vulnerability of countries to (some types of) external shocks should

be reduced when they are better diversified in their exports, both across products and markets. More specifically, the effect of trade openness on growth volatility—whether negative or positive—is likely to be exacerbated when the country in question exports either a relatively small set of products or sells its goods to a small number of export markets. This is driven, in turn, by how a higher degree of concentration in exports would imply that any idiosyncratic price shock experienced is more likely to have a substantial impact on the country's ToT, and this would then induce greater fluctuations in a country's growth process. Furthermore, a higher degree of diversification would suggest that a country is more likely to be involved in a larger number of both implicit and explicit international insurance schemes.

A better understanding of these mechanisms carries significant policy relevance, especially in the context of the current economic crisis. One of the chief arguments voiced against export-led growth strategies for developing countries is the vulnerability of economically-open countries to external shocks, such as those in the ToT, interest rate, foreign growth, and capital flows due to sudden stops. On the positive side, trade openness has been credited for the promotion of international risk sharing via joint ventures, production diversification, and explicit insurance arrangements. Disentangling the manner by which trade affects growth volatility is thus a first-order concern for policymakers contemplating the way forward out of the crisis, and can serve as an important buffer against rising protectionist sentiment (Baldwin & Evenett 2009).

Our empirical strategy begins with the computation of a variety of export diversification indicators, which we use as measures of the extent of export diversification in any given country, across both products and markets. In addition, we calculate measures of openness to both trade (ratio of trade to GDP) and financial (ratio of FDI and portfolio liabilities to GDP) flows, are indicators intended to capture the exposure of a country to international markets. We then utilize these measures to explore the relationship between diversification, openness, and volatility, while controlling for important additional sources of income volatility that stem from domestic and external sources. We also obtain standard errors for the joint effect of the openness indicator and its interaction with diversification, and establish confidence-bound threshold values whereby the total effect of the openness variable on growth volatility switches sign.

One major empirical concern is the possible simultaneity in the link between growth volatility and trade openness. While we have postulated a direct effect stemming from openness to volatility, the converse is also possible that trade policy responds over time to the perceived risks of increased globalization on the domestic economy. While we regard such effects as less plausible than reverse causality arising from growth *per se*, we nonetheless take the charge of endogeneity seriously. We complement the fixed and random effects regressions in our baseline with the system GMM procedure (Arellano & Bond 1991; Arellano & Bover 1995; Blundell & Bond 1998), which controls for additional unobserved country-specific factors and potential endogeneity in our benchmark specification.

Our results are generally supportive of our priors. With regard to the first

question of interest—whether the effect of openness is moderated by the extent of diversification—we find that while the effect of trade openness on growth volatility is positive on average, there is strong evidence pointing to the important role that export diversification plays in reducing the vulnerability of countries to global shocks. In addition, while we were agnostic about the relative importance of product versus market diversification *ex ante*, we find that product diversification clearly moderates the effect of trade openness on growth volatility, while the market diversification measures yield much more mixed results.

For our second research question—concerning the existence of a threshold level—we are able, for the most part, to identify positive thresholds in terms of our product diversification indicators at which the effect of openness on volatility changes sign. On the basis of our preferred model—the system GMM estimator—this threshold occurs at the upper part of the distribution of the respective diversification indicators. This suggests, given the current levels of diversification in the export baskets of the countries in our sample, the majority of countries benefit from increased openness, insofar as it reduces their vulnerability to external shocks.

We also conduct a battery of checks to test whether our results are sensitive to changes in the sample or model specification, and we verify that our findings are indeed very robust. One interesting result arising from our robustness checks is the fact that the main findings do not change markedly when high-income economies are excluded from the analysis—the estimated threshold values are almost unchanged—even though the sample size falls substantially. In contrast, the relationship completely breaks down when we exclude low-income economies from the analysis, and this is irrespective of the diversification indicator we employ (while the main variables of interest still carry the correct signs in their coefficients, none of the interaction terms is significant). This suggests that much of the action indeed lies with low- and middle-income economies, for which export diversification matters more in shielding their economies from external shocks. One possible explanation for this outcome is that developed economies possess other means of insuring their economies against shocks, whereas developing countries depend more strongly on implicit insurance as represented by a more diversified export basket.

The channels through which openness enhances growth are well established in the theoretical literature, and include the stimulative effects that trade can have on knowledge spillovers and investments in innovation (Grossman & Helpman 1991), improved productivity due to intra-industry (Melitz 2003) or intra-firm (Bernard, Redding & Schott 2006) resource reallocation, and the reduction in a country's vulnerability to idiosyncratic sectoral shocks due to the diversification of its production and export base (Acemoglu & Zilibotti 1997). It is this final channel that is of particular interest to our study, since we are concerned with understanding how the effect of openness on volatility is conditioned by the extent of export diversification.

On the empirical front, early efforts that have claimed a causal effect of openness on growth (Frankel & Romer 1999; Sachs & Warner 1999) have increasingly

come under challenge. Rodríguez & Rodrik (2000), in particular, have made a strong case against this line of literature, claiming that omitted variable biases are often inadequately addressed, and that trade policy variables are not well proxied by the measures customarily employed. To be fair, advocates of openness have not been ignorant of the important caveat that market or institutional imperfections can play in moderating or even reversing the positive growth effects arising from increased integration; indeed, (Sachs & Warner 1995) and (Frankel & Romer 1999) allude to the possibility that institutional (property rights) and policy (infrastructure) choices may complicate the interpretation of their results.

This idea—that the growth-enhancing effect of trade requires complementary institutions and policy action—has been taken up in more recent work. Chang, Kaltani & Loayza (2009) show, using a cross-country panel, that the growth effect of openness may indeed depend on a variety of structural characteristics, while Calderón & Fuentes (2006) consider how trade liberalization interacts with human capital policies as well as the quality of existing institutions to determine actual growth outcomes. trade openness has also been found to be a factor reducing the likelihood of a sudden stop-style crisis (Cavallo & Frankel 2008).

There is a much more uncertain relationship between openness and growth volatility. The available evidence suggests that the effects are mixed; while ToT volatility appears to be an important driver of growth volatility, especially for smaller states (Easterly & Kraay 2000).[1] A number of papers—including Bevan, Collier & Gunning (1993), Dehn (2000), and Kose & Riezman (2001)—have documented important effects of commodity price shocks on growth volatility. In a recent paper, Raddatz (2007) applies a VAR methodology to show that external shocks—such as those transmitted to prices, foreign growth, and real interest rates—impose a substantial and significant impact on the volatility of real activity in low income economies. In general, while external shocks are indisputably crucial in accounting for external sources of variation, such shocks can only explain a small fraction of the long run variance of real per capita GDP (Ahmed 2003; Becker & Mauro 2006). The underlying institutional and policy environment cannot be ignored (Easterly, Islam & Stiglitz 2001).

The closest study in spirit to ours is that of Jansen (2004), who uses a cross section of countries to show that export concentration determines ToT volatility, and that ToT volatility in turn drives income volatility. However, the paper does not directly test how the link between openness and income volatility is affected by different levels of diversification, nor does it utilize both market and product conceptions of diversification. Furthermore, it fails to take into account the variation over time in the key indicators, which we do in this paper.

The rest of this paper is organized as follows. In Section 2, we describe the dataset we use and present some descriptive information for the key variables of interest; this section also outlines the econometric approach that we adopt.

[1] In contrast to our approach, Easterly & Kraay (2000) argue that the high income volatility typically experienced by small economies is due mainly to their openness, and that export concentration plays only a minor role.

Section 3 reports our main results, along with a discussion of our main findings, especially pertaining to calculated threshold levels. Section 4 subjects the results in the previous section to a range of robustness checks, and a final section concludes with some thoughts on policy implications.

2 Data and Methodology

2.1 Description of Data

Our data set comprises an unbalanced panel of 77 developing and developed economies over the period 1976–2005. The variables included in the data set are described in Appendix Table A.1, and the full set of countries for which data on all our variables of interest are available for at least one 5-year period is presented in Appendix Table A.4 (along with the average index values for selected key variables for the last five-year period). We compute five-year period averages (standard deviations in the case of volatility measures) for all the variables listed in Table A.1.

We do so for three main reasons. First, the measures of export diversification that we employ are potentially subject to short term fluctuations that do not necessarily reflect a true diversification trend in the export basket, but rather temporary aberrations in export patterns. Taking the five-year average reduces the amount of noise present in these data. Short-term fluctuations may also be present in other control variables—for example, the per capita growth rate is subject to possible business cycle variations—and five-year averaging serves as a filter that would mute such cyclical elements. Second, taking the five-year average normalizes the basis with which second-moment measures—which is computed over a five year period—can be matched with the first-moment variables. Finally, one of the econometric tools that we employ (system GMM) was designed to work with data that include a large cross sectional and a short time series dimension. Taking 5-year averages yields a maximum of 6 time periods for any given country, which would then satisfy this short time-series requirement.

Due to the large number of variables included in the dataset, we limit our discussion here to the key dependent and independent variables, leaving details of the construction of other variables to the technical appendix. Our main dependent variable is output growth volatility, measured as the standard deviation of GDP per capita across each 5-year period. While it is entirely plausible to substitute *output* for growth volatility, we refrain from doing so for three main reasons. First, even a stable growth path at a constant annual rate of growth will generate a positive volatility measure, even though this is both a desirable and perfectly forecastable outcome. Second, policymakers are generally more concerned with maintaining a stable growth rate, as opposed to stable output levels, since it is the former that directly affects the planning horizon. Third, we follow the standard approach in the literature on the effects of volatility, and these papers (Easterly & Kraay 2000; Ramey & Ramey 1995) have generally

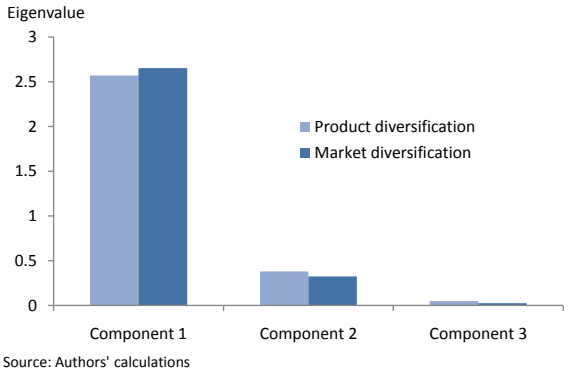


Figure 1: Eigenvalues obtained from principal components factor analysis applied to product and market diversification, computed from Herfindahls and 5/10 product and market shares, respectively. The first principal components for each measure accounts, respectively, for 88.4% and 85.6% of the underlying variation.

focused on growth rather than output volatility.

The two main dependent variables of interest are export diversification and trade openness. Because we do not hold any *ex ante* preferences toward either product or export concentration, we include a variety of export diversification measures that capture both dimensions in any given country. These are fairly standard, and include the top five and top ten shares of products and markets (5/10 Product and 5/10 Market) as well as Herfindahl-Hirschman indexes for products (Product Herfindahl) and markets (Market Herfindahl).

We supplement these direct diversification measures with synthetic ones that we construct using principal components analysis, which extracts the first principal component of the three product (PC Product) and three market (PC Market) diversification measures. By capturing information common to each set of indicators—which are high correlated by not perfectly so—we will have obtained an alternative measure of diversification that may be interesting in its own right. As can be seen from Figure 1, the calculated eigenvalues support a reliance on the first principal component alone, with the constructed measure capable of explaining more than four-fifths of all variation in the market and product diversification indicators.

Openness is measured primarily with the ratio of the sum of exports and imports to GDP (trade openness), and secondarily with the ratio of FDI and portfolio liabilities to GDP (financial openness), both of which provide different measures of the actual exposure of a country to international markets. Our choice of openness measures also means that they reflect both structural and policy-related characteristics of a country.

Table 1 reports summary statistics for the key explanatory and control variables. The technical appendix reports additional descriptive statistics that may

be of interest, including cross correlations between the different export diversification measures (Table A.2), as well as the n-th percentile means for the main explanatory variables of interest (Table A.3). Unsurprisingly, the three product diversification measures and the three market diversification measures are highly correlated within each of the two groups, whereas the correlation across groups is low and mostly below 50%. This correlation structure for diversification is well known, and serves as a motivation for our interest in deploying both market and product indicators to uncover whether it is both diversification across products and markets, or just one of the two, that matter in reducing the vulnerability of economies to external shocks.

Table 1: Summary statistics for main variables of interest

Variable	**N**	**Mean**	**Std Dev**	**Min**	**Max**
Growth volatility	356	2.686	2.09	0.340	11.438
Trade openness	356	4.009	0.58	2.248	5.787
Product diversification					
Product Herfindahl	356	0.121	0.16	0.007	0.919
5 product	356	0.477	0.24	0.100	0.987
10 product	356	0.589	0.23	0.172	0.992
PC product	362	-0.753	1.37	-2.873	3.069
Market diversification					
Market Herfindahl	356	0.163	0.14	0.046	0.755
5 market	356	0.634	0.13	0.385	0.985
10 market	356	0.782	0.10	0.566	0.996
PC market	362	-0.496	1.36	-2.654	3.450
Financial openness	356	0.279	0.28	0.000	1.989
Capital flow volatility	356	0.195	0.59	-1.973	1.492
Inflation volatility	356	7.429	18.58	0.191	168.127
Exchange rate volatility	356	14.228	75.41	0.049	1400.066
Terms of trade volatility	356	6.667	6.34	0.000	42.117
Foreign growth volatility	356	-0.148	0.43	-1.543	0.891
Crisis	356	0.026	0.05	0.000	0.182

The percentile decomposition (Table A.3) further reveals that both diversification measures appear to vary systematically across different slices of the distribution, in a manner that is asymmetric around the median. This points to the importance of establishing clear threshold breaks in the data. In addition, the nontrivial differences in means of the different key measures for the full sample versus the latest five-year period (2001–2005) also suggests why it is helpful to rely on a panel dataset, rather than just the latest data.

While we defer a rigorous analysis of our key questions to the next section, it is helpful at this point to consider the plausibility of the hypotheses by examining the pattern of volatility to openness, contingent at various points in the distribution of the diversification measure. We do so by plotting the growth

volatility data from the lower, middle, and upper quartiles of two basic product and market concentration measures—5 Product and 5 Market—against trade openness. The plots are shown in Figure 2.

Although awaiting formal econometric verification, the plots do appear to suggest that the effect of openness on growth volatility is negative when exports are well diversified across products, close to zero when product diversification is at an average level, and positive when export concentration is in the upper quartile of the distribution. This finding holds irrespective of whether we consider product or market diversification (although the relationship in markedly weaker in the latter). Furthermore, this finding appears to be reasonably robust to alternative measures of diversification within each class (not reported).

2.2 Empirical Model and Estimation Strategy

The benchmark linear dynamic panel data model that we estimate in this study is given by

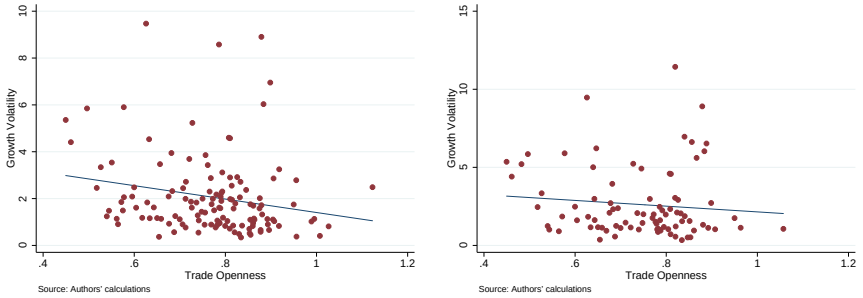
$$\begin{aligned} GDPVOL_{i,t} = \alpha_i + \beta_1 OPEN_{i,t} + \beta_2 DIV_{i,t} + \beta_3 OPEN_{i,t} \times DIV_{i,t} \\ + \gamma \mathbf{X}_{i,t} + \epsilon_{i,t}, \end{aligned} \tag{1}$$

where the dependent variable, $GDPVOL$, is the standard deviation of real GDP per capita, $OPEN$ is trade openness measured as total trade share of GDP, DIV is a given measure of export diversification, $OPEN \times DIV$ is the interaction of the two previous variables, and $\mathbf{X}$ is a $(1 \times m)$ vector of control variables; α_i and $\epsilon_{i,t} \sim N\left(0, \sigma_\epsilon^2\right)$ are the individual-specific effects and i.i.d. disturbance terms, respectively. Depending on the specific estimation approach adopted, the individual-specific effects captured by α_i may or may not be correlated with the error structure of (1).

Our theoretical priors would suggest that, for any given country, the effect of trade openness on growth volatility would be positive when export concentration is high, but that this effect decreases and eventually becomes negative as the country becomes more diversified. This would imply that $\beta_1 < 0$ and $\beta_3 > 0$ is necessary to validate this hypothesis.

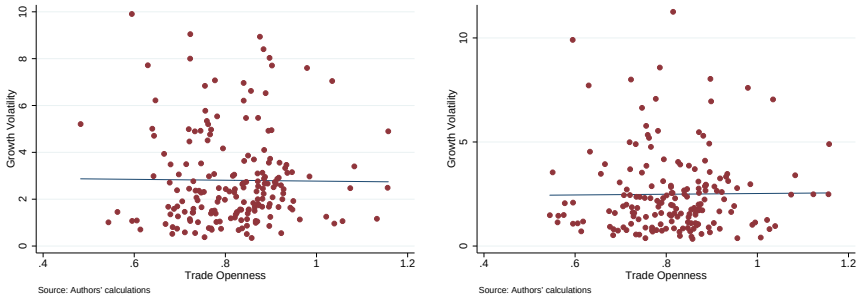
In addition, (1) also allows, for a given export diversification measure, the determination of a threshold value at which the impact of openness on growth volatility changes sign. This would require the computation of joint standard errors for these coefficients (based on a null of $H_0 : \beta_1 = \beta_3 = 0$), followed by setting the total effect of openness on growth volatility to zero, in order to back out the value of the diversification measure that a country needs to attain in order to be able to have a net benefit—via a reduction in growth volatility—from a marginal increase in openness.

We isolate these effects by including in the vector $\mathbf{X}$ a range of confounding variables that have been shown to be among the main sources of growth volatility. These include inflation volatility, exchange rate volatility, the volatility of capital flows to the region, an indicator for the frequency of systemic banking crises, as well as the volatility of foreign shocks, such as foreign growth volatility



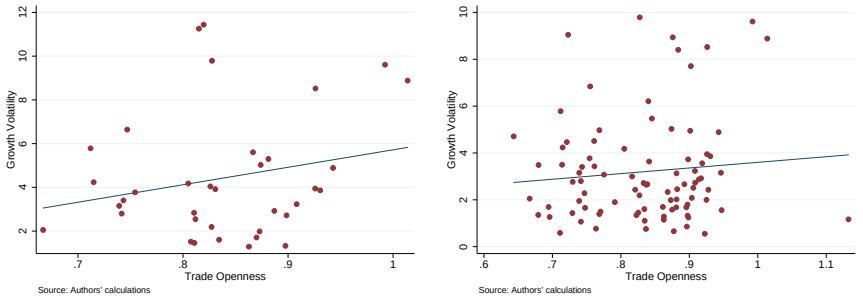
(a) 5 product share is low

(b) 5 market share is low



(c) 5 product share is medium

(d) 5 market share is medium



(e) 5 product share is high

(f) 5 market share is high

Figure 2: Plots of standard deviation of GDP per capita growth against trade openness, with each row of the left (right) column capturing country-year observations from low, medium, and high levels of product (market) concentration, with fitted (navy) regression lines. The pattern of a negative (positive) relationship between volatility and openness when diversification is high (low) is evident for both classes of diversification measures.

and ToT volatility. These variables are the most parsimonious form that we are comfortable with in our benchmark models. The robustness checks in Section 4, however, expands this set to include several additional controls that may also potentially affect volatility.

Our baseline empirical estimates apply a simple error components approach to GLS estimation of the coefficients in (1). In these cases, while fixed effects has the advantage of eliminating dynamic panel bias without excessive restrictions on the cross-sectional error structure, this comes at the cost of reduced efficiency (vis-à-vis the random effects) due to the removal of the all between-group variation in the data. This consideration is perhaps of particular importance in our study, as between-group variations in the diversification measures may be more reliable as an actual measure of relative differences in export diversification than within-group variations. As a consequence, while we report diagnostics from the standard Hausman test as a basis for choosing between the consistency-efficiency tradeoff, we take pains to stress that any systematic differences in coefficients revealed by the test (involving a rejection of the null) occurs in an environment where imposing a fixed effects model can lead to the loss of important information embedded in a key variable of interest (the diversification variable). This leads us to be relatively more agnostic than most about the choice of one estimator versus the other.

As discussed in the introduction, endogeneity is generally of concern in regressions of growth on trade openness, as there is little doubt that current and past realizations of growth can be important factors in driving both exports and imports—and hence trade openness—through its influence on policy choices. When the dependent variable in our case is not (first moment) growth, but rather its second moment, this concern is alleviated but not removed. In particular, political economy arguments may explain why a higher level of growth volatility can lead to a less open economy.[2] Thus, while endogeneity is generally less of a concern in empirical estimates of (1), we believe that it is sufficiently pressing to warrant a model specification that tackles the issue directly.

A consistent estimator that does allow for the joint (weak) endogeneity of all explanatory variables including the lagged dependent variable is the GMM difference estimator was derived by Arellano & Bond (1991). However, this estimator has at least two important shortcomings. First, it requires the model to be differenced, implying that information on cross-country variation is lost. Second, instrument weakness of lags of the explanatory variables can influence the asymptotic and small sample performance of the estimator. Based on the work of Arellano & Bover (1995), Blundell & Bond (1998) develop a system GMM estimator that combines the regression in differences with the regression in levels that attenuates these shortcomings. This system estimator allows for the weak endogeneity of our explanatory variables. However, system GMM works best in a context where the explanatory variables are not affected by unexpected changes in the dependent variable (while being correlated with current

[2]This can occur along the lines of policymakers that choose policies with regard to the degree of openness, but are also generally concerned with minimizing the volatility of growth and inflation.

and past realizations of the dependent variable); this requirement is best met when the dynamic panel possesses a large number of cross-sectional units with as few time periods as possible.

3 Estimation Results and Discussion

3.1 Main Results

We begin our analysis with a preview of the direct, independent effects of openness and diversification on volatility. Following an empirical strategy that we will employ throughout the paper, we run: (a) fixed effects; (b) random effects; and (c) system GMM on these two main independent variables. This set of preliminary estimates replicate, in a limited fashion, some of the main results that have been established in the growth volatility literature (Chang *et al.* 2009; Jansen 2004; Malik & Temple 2009).

Table 2 reports the baseline results of regressions of growth volatility on trade openness and, independently, on diversification (both with controls).[3] Across the three econometric models we employ—fixed effects, random effects and system GMM—we consistently find a positive coefficient on the openness variable, with point estimates that are statistically and economically significant (columns *D1–D3*).[4] Openness to trade increases the exposure of countries to external shocks, and this is translated into increased growth volatility to the order of between 0.55–1.83 standard deviations (for each marginal increase in openness). Greater openness, therefore, has a deleterious impact on growth volatility that dominates any alleviating impact generated by the greater promotion of international risk sharing via mechanisms.

In contrast to trade openness, the coefficient on product and market diversification across the three models are statistically insignificant (columns *D4–D6* for products, *D7–D9* for markets), although they are (with one exception) positively signed as well. Regardless of the significance of these coefficients, the estimates of the effect of diversification are likely to be biased, since the effect of export diversification on growth volatility is expected to operate through the channel of actual trade flows, and thus excluding trade openness as an independent variable is likely to lead to omitted variable problems.[5] In any case, absent an openness to trade, export diversification has no effect on growth volatility.

[3] For concision, we report only one measure of diversification for each—Product Herfindahl and Market Herfindahl—noting that alternative measures of diversification yield qualitatively similar results.

[4] We are not, unfortunately, able to correct for cluster effects in our regressions. Recent work by Stock & Watson (2008) has shown that the commonly applied Huber-White robust errors are inconsistent for samples with $T > 2$ (which is the case for our data), and clustering on country is not possible for our unbalanced sample given the large number of covariates that we maintain in the baseline specification. The estimates presented in Table 2 and subsequent results corresponding to the error components model should therefore be interpreted with some degree of caution, especially with regard to the statistical significance of the coefficients.

[5] Theoretically, one would expect the standard errors to be smaller as a consequence as well, although this does not, in any case, guarantee that they will be statistically significant.

Table 2: Error components and system GMM regressions for growth volatility on (independently) openness and product diversification†

	(*D1*)	(*D2*)	(*D3*)	(*D4*)	(*D5*)	(*D6*)	(*D7*)	(*D8*)	(*D9*)
Trade	1.137	0.554	1.835						
openness	(0.44)**	(0.23)**	(1.03)*						
Product				-0.349	0.877	0.839			
Diversification				(1.50)	(0.79)	(2.17)			
Market							1.923	1.120	1.344
Diversification							(1.33)	(0.83)	(3.41)
Financial	-0.034	-0.159	-0.514*	-0.045	-0.132	-0.372	0.025	-0.136	-0.260
openness	(0.13)	(0.09)*	(0.27)*	(0.12)	(0.09)	(0.19)**	(0.13)	(0.09)	(0.29)
Capital flows	0.717	0.801	0.206	0.640	0.715	0.134	0.715	0.797	0.310
volatility	(0.21)***	(0.19)***	(0.67)	(0.22)***	(0.19)***	(0.54)	(0.22)***	(0.20)***	(0.58)
Inflation	0.006	0.008	0.005	0.005	0.008	0.011	0.002	0.005	-0.008
volatility	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Exchange rate	0.000	-0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
volatility	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)**
Terms of trade	0.044	0.056	-0.040	0.037	0.039	-0.058	0.043	0.047	-0.036
volatility	(0.02)**	(0.02)***	(0.04)	(0.02)*	(0.02)**	(0.05)	(0.02)**	(0.02)***	(0.05)
Foreign growth	0.827	0.681	1.724	0.947	0.802	1.243	0.964	0.756	1.733
volatility	(0.38)**	(0.36)*	(1.42)	(0.38)**	(0.35)**	(1.01)	(0.39)**	(0.36)**	(1.06)
Crisis dummy	5.196	5.019	-0.838	5.029	4.651	1.024	6.109	4.988	5.089
	(1.99)***	(1.85)***	(7.88)	(1.95)**	(1.79)***	(8.29)	(2.10)***	(1.96)**	(7.10)
Lagged			-0.013			-0.119			0.049
volatility			(0.19)			(0.18)			(0.22)
R^2	0.199	0.261		0.218	0.249		0.184	0.219	
F	5.89***			5.29***			5.54***		
Wald χ^2		110.66***			104.35**			93.98***	
Hansen J			18.34			16.23			15.85
AR(2) z			-0.362			-0.784			-0.163
N	383	383	361	384	384	364	368	368	346

† Notes: Error components estimates report standard errors in parentheses; system GMM estimates report heteroskedasticity and autocorrelation-robust (asymptotic) Windmeijer (2005)-corrected standard errors. * indicates significance at 10 percent level, ** indicates significance at the 5 percent level, and *** indicates significance at the 1 percent level. Period dummies and a constant were included, but not reported.

The Hausman test (not reported) applied to the mixed models fails to reject the null of non-systematic differences in coefficients between the fixed and random effects models, and so the the greater efficiency we obtain from the random effects estimates (*D2*, *D5*, and *D8*) does lend greater precision to this latter specification (although as noted above the importance of between-group variations in the diversification measures leads us to be somewhat agnostic regarding the two estimates). The Hansen J and AR(2) z scores also indicate that the internal instruments used for the system GMM specifications (*D3*, *D6*, and *D9*) are valid.

By and large, the coefficients on the remaining control variables enter with the expected signs, and are statistically significant. For example, volatility in the ToT is positively related to growth volatility, a finding that echoes others in the literature (Easterly & Kraay 2000; Raddatz 2007). Similarly, the experience of a banking crisis is associated with increased growth volatility (which, although seemingly tautological, emphasizes the fact that the preponderance of financial crises spillover to the real economy).

Of particular interest is the coefficient on financial openness, which enters with a negative sign and is statistically significant (at the 10 percent level) in three of the nine specifications. This is not entirely surprising, given the mixed results obtained in the literature concerning this relationship (Kose, Prasad, Rogoff & Wei 2006). We offer an additional explanation, tied to the central message of our paper: while trade openness, at least initially, may induce production specialization and concentration through competitive advantage, financial openness may result in *production* diversification, which reduces growth volatility. This argument is similar in spirit to the central message of our paper, namely that *export* diversification reduces growth volatility through an improved shielding of a country's exports against adverse external shocks, and a better integration of a country into a range of global value chains and implicit or explicit insurance schemes.

We move on to considering the interaction between openness and volatility in our regressions in order to answer our main question of interest. Since the measure of diversification is central to our analysis of this question, we report results for the baseline specification using a range of alternative product and market diversification measures. In the case of product diversification, these correspond to: (a) the Product Herfindahl; (b) 5 Product; (c) 10 Product; and (d) PC Product, and are reported in columns *P1–P4* in the upper (fixed effects) and lower (random effects) halves of Table 3. Table 4 reports the analogous results using the respective indicators of market diversification (in columns *M1–M8*).

In general, the coefficient on the product diversification variable is negative throughout the specifications we run, while the interaction terms carry positive coefficients and the coefficient on the trade openness variable is, for the most part, negative. The point estimates for openness are mostly not statistically significant, whereas the interaction terms and the diversification indicators are sta-

Table 3: Error components regressions for growth volatility, openness, and product diversification[†]

	(*P1*)	(*P2*)	(*P3*)	(*P4*)
Product	-18.274	-8.191	-7.314	-1.679
diversification	(8.88)**	(6.00)	(6.22)	(1.07)
Trade	-0.222	-0.566	-0.644	0.674
openness	(0.57)	(0.92)	(1.10)	(0.47)
Openness ×	4.378	1.965	1.749	0.406
diversification	(2.13)**	(1.47)	(1.53)	(0.26)
Financial	-0.110	-0.106	-0.106	-0.110
openness	(0.12)	(0.13)	(0.13)	(0.13)
Capital flows	0.683	0.698	0.694	0.702
volatility	(0.21)**	(0.22)***	(0.22)***	(0.22)***
Inflation	0.005	0.005	0.005	0.005
volatility	(0.01)	(0.01)	(0.01)	(0.01)
Exchange rate	0.000	0.000	0.000	0.000
volatility	(0.00)	(0.00)	(0.00)	(0.00)
Terms of trade	0.044	0.043	0.042	0.043
volatility	(0.02)**	(0.02)**	(0.02)**	(0.02)**
Foreign growth	0.932	0.901	0.904	0.912
volatility	(0.37)**	(0.38)**	(0.38)**	(0.37)**
Crisis dummy	5.258	4.846	4.880	4.919
	(1.94)***	(1.95)**	(1.95)**	(1.94)**
R^2	0.250	0.255	0.250	0.254
F	4.88***	4.68***	4.64***	4.73***
N	378	378	378	378

	(*P5*)	(*P6*)	(*P7*)	(*P8*)
Product	-12.179	-6.732	-0.617	-1.209
Diversification	(5.68)**	(3.79)*	(0.59)	(0.66)*
Trade	0.003	-0.533	-5.660	0.620
openness	(0.28)	(0.49)	(3.85)	(0.27)**
Openness ×	3.156	1.845	1.617	0.332
diversification	(1.37)**	(0.92)**	(0.94)*	(0.16)**
Financial	-0.166	-0.153	-0.149	-0.152
openness	(0.09)*	(0.09)*	(0.09)*	(0.09)*
Capital flows	0.739	0.750	0.746	0.745
volatility	(0.19)***	(0.19)***	(0.19)***	(0.19)***
Inflation	0.008	0.008	0.008	0.008
volatility	(0.01)	(0.01)	(0.01)	(0.01)
Exchange rate	0.000	0.000	0.000	0.000
volatility	(0.00)	(0.00)	(0.00)	(0.00)
Terms of trade	0.043	0.041	0.040	0.040
volatility	(0.02)***	(0.02)**	(0.02)**	(0.02)**
Foreign growth	0.790	0.778	0.781	0.784
volatility	(0.35)**	(0.35)**	(0.35)**	(0.35)**
Crisis dummy	5.056	4.946	4.976	4.961
	(1.78)***	(1.78)***	(1.78)***	(1.78)***
R^2	0.274	0.275	0.273	0.275
Wald χ^2	114.05***	113.29***	112.32***	113.80***
N	378	378	378	378

[†] Notes: Standard errors reported in parentheses. * indicates significance at 10 percent level, ** indicates significance at the 5 percent level, and *** indicates significance at the 1 percent level. Period dummies and a constant were included, but not reported.

Table 4: Error components regressions for growth volatility, openness, and market diversification[†]

	(*M1*)	(*M2*)	(*M3*)	(*M4*)
Market	-12.540	-8.055	-12.533	-1.228
diversification	(8.69)	(9.12)	(11.84)	(0.91)
Trade	0.121	-0.279	-1.399	0.920
openness	(0.63)	(1.61)	(2.46)	(0.47)*
Openness ×	3.343	1.763	2.853	0.303
diversification	(2.04)*	(2.27)	(2.98)	(0.22)
Financial	-0.028	-0.037	-0.044	-0.047
openness	(0.13)	(0.13)	(0.13)	(0.13)
Capital flows	0.680	0.705	0.714	0.703
volatility	(0.22)***	(0.22)***	(0.22)***	(0.22)***
Inflation	0.003	0.003	0.003	0.003
volatility	(0.01)	(0.01)	(0.01)	(0.01)
Exchange rate	0.000	0.000	0.000	0.000
volatility	(0.00)	(0.00)	(0.00)	(0.00)
Terms of trade	0.045	0.044	0.045	0.045
volatility	(0.02)**	(0.02)**	(0.02)**	(0.02)**
Foreign growth	1.026	0.977	0.977	1.000
volatility	(0.39)***	(0.39)**	(0.39)**	(0.39)**
Crisis dummy	5.986	5.707	5.777	5.809
	(2.10)***	(2.11)***	(2.10)***	(2.10)***
R^2	0.222	0.206	0.213	0.220
F	5.10***	4.86***	4.88***	4.93***
N	364	364	364	364
	(*M5*)	(*M6*)	(*M7*)	(*M8*)
Market	-14.591	-10.731	-14.297	-1.290
Diversification	(6.69)**	(6.21)*	(7.74)*	(0.62)**
Trade	-0.061	-1.106	-2.099	0.757
openness	(0.33)	(0.99)	(1.50)	(0.26)***
Openness ×	3.795	2.650	3.474	0.327
diversification	(1.62)**	(1.55)*	(1.94)*	(0.15)**
Financial	-0.173	-0.183	-0.186	-0.182
openness	(0.09)**	(0.09)**	(0.09)**	(0.09)*
Capital flows	0.784	0.824	0.835	0.814
volatility	(0.20)***	(0.20)***	(0.20)***	(0.20)***
Inflation	0.007	0.006	0.006	0.006
volatility	(0.01)	(0.01)	(0.01)	(0.01)
Exchange rate	0.000	0.000	0.000	0.000
volatility	(0.00)	(0.00)	(0.00)	(0.00)
Terms of trade	0.048	0.051	0.052	0.050
volatility	(0.02)***	(0.02)***	(0.02)***	(0.02)***
Foreign growth	0.799	0.803	0.801	0.805
volatility	(0.36)**	(0.36)**	(0.36)**	(0.36)**
Crisis dummy	5.256	5.042	5.069	5.128
	(1.95)***	(1.96)***	(1.95)***	(1.95)***
R^2	0.253	0.246	0.247	0.249
Wald χ^2	106.61***	101.34***	101.89***	103.39***
N	364	364	364	364

[†] Notes: Standard errors reported in parentheses. * indicates significance at 10 percent level, ** indicates significance at the 5 percent level, and *** indicates significance at the 1 percent level. Period dummies and a constant were included, but not reported.

tistically[6] and economically significant: the former has a range $[-18.27, -1.21]$ and the latter $[0.33, 4.38]$.

The total effect of openness on volatility is the sum of the coefficients on the openness variable and the product of the interaction term with a given level of diversification. Without further information on the level of diversification that we are considering, therefore, it is not possible to calculate the total effect that pertains to these respective variables. It is, however, illustrative to consider the effect of openness on volatility for a completely diversified economy ($DIV_{i,t} = 0$) as opposed to a totally non-diversified economy ($DIV_{i,t} = 1$). In these cases, the total effect of openness on volatility is the coefficient on the openness variable alone, versus the sum of the coefficients on the openness variable and interaction term. Since the coefficient of the latter dominates the former,[7] we can infer that openness does in fact reduce volatility in diversified economies, and it is in poorly diversified economies where openness has the opposite effect.

To draw further conclusions from these estimates requires us to establish a threshold in terms of the respective diversification indicator at which the effect of openness on volatility switches sign; this is an issue that we take up in greater detail in Subsection 3.2. In any case, the statistically significant coefficient on the interaction term points to the fact that openness is conditioned by the degree of export diversification, a result that confirms our prior hypothesis. The signs and coefficients of the other variables generally enter, as before, with the expected signs, but only ToT and foreign growth volatility, along with the financial crisis dummy, are consistently statistically significant across the different models (financial openness is marginally significant in all the random effects regressions).

As discussed earlier, endogeneity is a potential concern for our estimates. To the extent that weak endogeneity exists in our error components models, the estimates obtained with system GMM are potentially more precise than the error components specifications. These estimates are reported in Table 5 for all eight variants of export concentration, including product (*B1*–*B4*, upper row) and market (*B5*–*B8*, lower row) diversification. Since these specifications explicitly account for possible reverse causality issues, we treat the results in Table 5 as our favored benchmark.

The results are qualitatively very similar to those reported in Tables 3 and 4. However, while the (statistically significant) coefficients on the product diversification measure are usually amplified—point estimates are up to four times larger, with a similar increase for coefficients of the interaction variable (the range is now $[0.73, 5.86]$)—the market diversification indicators are insignificant except in the case of one of the measures we employ (with the coefficient on the

[6] In the cases where the coefficients of interest for the fixed effects regressions are not always significant, we reiterate the point raised earlier regarding the importance of preserving between-group variations given the relatively small sample size. In addition, while the coefficients are not significant at standard levels, we note that they do approach statistical significant in many cases ($p < 0.15$).

[7] With the exception of the PC Product/Market regressions; since these diversification variables are not bound by $[0, 1]$, the discussion does not apply to these specifications.

Table 5: System GMM regressions for growth volatility, openness, and product diversification[†]

	(*B1*)	(*B2*)	(*B3*)	(*B4*)	(*B5*)	(*B6*)	(*B7*)	(*B8*)
Lagged	0.213	0.150	0.148	0.151	0.053	0.195	0.175	0.028
volatility	(0.11)**	(0.16)	(0.17)	(0.15)	(0.17)	(0.18)	(0.20)	(0.20)
Product	-24.033	-23.424	-21.458	-3.044	-33.911	-6.732	11.326	-0.465
diversification	(11.55)**	(7.54)***	(7.56)***	(1.56)*	(20.40)*	(19.75)	(26.53)	(1.48)
Trade	-1.098	-2.723	-3.116	0.716	-1.014	-0.533	3.265	1.103
openness	(0.81)	(1.12)**	(1.35)**	(0.59)	(1.01)	(3.15)	(5.27)	(1.03)
Openness ×	5.861	5.645	5.170	0.725	7.435	1.845	-3.086	-0.006
diversification	(2.79)**	(1.82)***	(1.83)***	(0.37)**	(4.70)	(4.84)	(6.52)	(0.35)
Financial	-0.260	-0.325	-0.320	-0.331	-0.271	-0.153	-0.138	-0.256
openness	(0.18)	(0.22)	(0.25)	(0.19)*	(0.25)	(0.24)	(0.24)	(0.27)
Capital flows	-0.240	0.151	0.283	0.226	0.715	0.151	0.829	0.847
volatility	(0.33)	(0.42)	(0.46)	(0.42)	(0.47)	(0.45)**	(0.94)*	(0.49)*
Inflation	0.010	0.005	0.002	0.001	-0.002	0.008	-0.001	0.003
volatility	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
Exchange rate	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
volatility	(0.00)*	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Terms of trade	0.006	0.036	0.037	0.045	0.046	0.041	0.052	0.060
volatility	(0.04)	(0.06)	(0.05)	(0.05)	(0.06)	(0.07)	(0.07)	(0.06)
Foreign growth	2.735	2.685	2.542	2.670	0.679	0.778	-0.050	0.933
volatility	(1.04)***	(0.99)***	(1.03)**	(0.94)***	(0.83)	(0.96)	(0.94)	(0.90)
Crisis dummy	-1.622	0.566	2.353	3.486	-0.177	4.946	3.620	1.685
	(5.14)	(6.38)	(6.72)	(5.16)	(4.29)	(5.31)***	(5.33)	(4.31)
Hansen J	34.63	35.26	35.33	40.28	33.81	43.40	37.36	33.42
AR(2) z	0.26	0.32	0.29	0.33	0.63	0.86	0.71	0.62
N	358	358	358	358	342	342	342	342

[†] Notes: Heteroskedasticity and autocorrelation-robust (asymptotic) Windmeijer (2005)-corrected standard errors reported in parentheses. * indicates significance at 10 percent level, ** indicates significance at the 5 percent level, and *** indicates significance at the 1 percent level. Period dummies and a constant were included, but not reported.

interaction term uniformly insignificant). Thus, although Table 5 corroborates our claim regarding the moderating effect of product diversification, the same cannot be said of market diversification.

Through all the specifications, the Hansen J test of overidentifying restrictions confirms that the (internal) instruments are valid, and the Arellano-Bond test rejects significant second-order serial correlation in the error term. Several control variables fall out of significance, although the volatility of foreign growth and capital flows remain influential.

In sum, we find strong evidence for an important role of export diversification in reducing the vulnerability of countries to global shocks, allowing us to answer the first part of our research question—whether the effect of trade openness on growth volatility varies with the level of export diversification—with a clear affirmation. It does appear, however, that the role of product diversification is more important in this context than that of market diversification.

Given that our preferred model (Table 5) suggests that market diversification is not a significant determinant of the impact of trade openness on growth volatility, in what follows, we focus solely on the results obtained from product rather than market diversification measures.

3.2 Discussion of Findings

Given that our preferred model (Table 5) suggests that market diversification is not a significant determinant of the impact of trade openness on growth volatility, in what follows, we focus solely on the results obtained from product rather than market diversification measures.

For the five product index (specification *B2*), taking the quotient of the coefficient of trade openness on the interaction term yields the result that the effect of openness on volatility is negative as long as the 10 Product measure remains below a value of 0.60. Placing a 90 percent confidence band around this threshold level—as has been done in Figure 3—shows that the distribution includes statistically significant portions both above and below zero, indicating that at the given threshold value, there is indeed a change in the total effect of openness from negative to positive. Let us put this threshold into context.

It is possible to determine the share of countries in the sample that would cross the diversification threshold on the basis of their latest value on the indicator—that is, for the last five-year period—by cross-referencing this threshold to data that has been broken down into percentiles. This is calculated in the final column of Table 7, which shows that 53 percent of all countries lie below the threshold (and should thus benefit from trade openness). Moreover, even if we were to apply the stricter criteria of utilizing the lower bound of the confidence interval for the threshold (0.34), close to a quarter of all countries will nonetheless fall below this value (Table 6). The upper bound further indicates that only countries with a level of product concentration in the upper 10–25 percent of the distribution are likely to become more vulnerable as a result of trade liberalization.

Table 6: Summary statistics for key explanatory variables in the last five-year period

	Percentile	**N**	**Mean**	**Std Dev**	**Min**	**Max**	**Percentile**	**N**	**Mean**	**Std Dev**	**Min**	**Max**
			Product Herfindahl						Market Herfindahl			
10%	0.016	64	0.120	0.17	0.008	0.819	0.067	64	0.155	0.138	0.052	0.755
25%	0.029						0.083					
50%	0.051						0.112					
75%	0.127						0.174					
90%	0.312						0.236					
			5 Product						5 Market			
10%	0.204	64	0.464	0.22	0.132	0.974	0.487	64	0.630	0.12	0.409	0.966
25%	0.292						0.531					
50%	0.415						0.615					
75%	0.612						0.712					
90%	0.769						0.783					
			10 Product						10 Market			
10%	0.309	64	0.577	0.21	0.212	0.983	0.651	64	0.777	0.10	0.566	0.989
25%	0.395						0.699					
50%	0.581						0.770					
75%	0.755						0.850					
90%	0.828						0.914					
			PC Product						PC Market			
10%	-2.305	64	-0.882	1.29	-2.706	2.788	-2.000	64	-0.604	1.302	-2.765	3.256
25%	-1.884						-1.560					
50%	-1.082						-0.767					
75%	-0.139						0.120					
90%	0.951						0.704					
			Openness									
10%	3.421	64	4.205	0.54	3.087	5.663						
25%	3.956											
50%	4.284											
75%	4.489											
90%	4.750											

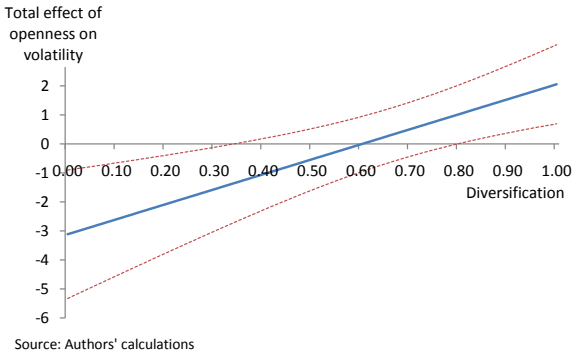
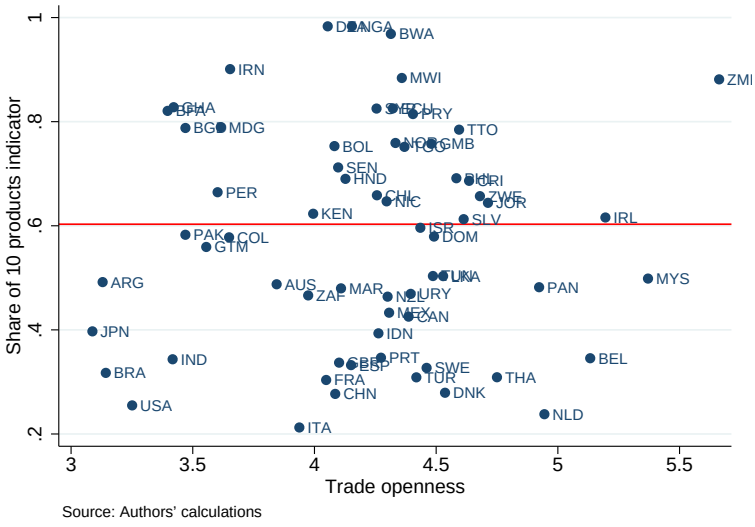


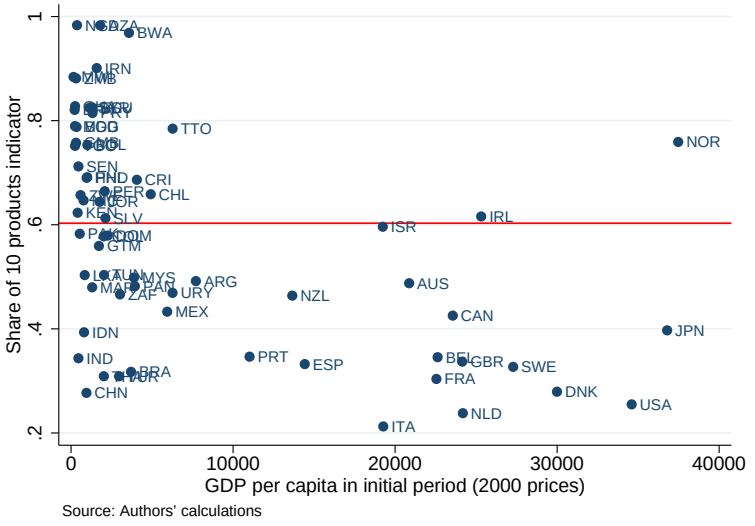
Figure 3: Effect of diversification on volatility, after moderating for effect on openness, based on the 10 product index. The threshold diversification value of 0.60 has a 90 percent confidence band that is positive, with parts of the distribution significantly above and below zero. 53 percent of countries in the final five year period fall under this critical threshold level of diversification, indicating that increased openness will decrease their growth volatility.

The threshold level of diversification can also be understood relative to levels of trade openness (Figure 4(a)) and initial levels of income per capita (Figure 4(b)). When compared to trade openness, the distribution of countries below the diversification threshold appears to be relatively even; in contrast, countries above the threshold appear to be largely clustered around moderate levels of openness (with the exception of outliers such as Zimbabwe). This suggests that countries that currently experience reduced volatility as a consequence of diversification are certainly not limited to the most open economies (and, conversely that economies that do not benefit from the diversification effects of reduced volatility are not necessarily closed economies). The vast majority of countries above the diversification threshold are also low income countries, although a large number of low income economies also fall below the threshold. On the basis of Figure 4(b), therefore, it is somewhat difficult to draw strong conclusions regarding the effects of diversification on developing countries. Given the importance of the implications, however, we revisit this issue in greater detail in the subsample studies below.

Repeating this exercise for the other market diversification indicators yields Table 7. As can be seen, the equivalent threshold value obtained for the ten product index (specification *B3*) is 0.60 (contrast this to the results from the fixed and random effects estimators, which imply a threshold value of around 0.36–0.38). Comparing the distributions from Table 6 again suggests an interpretation similar (but slightly more guarded) when compared to the case of the 5-product variable; the threshold value now lies slightly above the median of the distribution (whereas the error components estimators would point to about three quarters of the distribution of countries experiencing a positive effect of



(a) Openness



(b) Income per capita

Figure 4: Distribution of countries by (10 product) diversification and (a) openness (b) initial GDP per capita. The maroon line indicates the threshold level of diversification, with countries below the line benefitting from increased openness.

openness on growth volatility).

Table 7: Error components and system GMM regressions for growth volatility on (independently) openness and product diversification[†]

Indicator	**Threshold**	**Joint significance**	**CI**	**Share**
Herfindahl	0.187	4.56^{*}	$[-0.113, 0.378]$	0.828
Product 5	0.482	10.11^{***}	$[0.279, 0.636]$	0.563
Product 10	0.603	8.32^{**}	$[0.340, 0.798]$	0.531
PC Product	-0.988	3.94	$[-3.804, 0.726]$	0.500

[†] Notes: χ^2 values calculated from Wald tests of joint significance of coefficients of the openness and interaction terms. * indicates significance at 10 percent level, ** indicates significance at the 5 percent level, and *** indicates significance at the 1 percent level. Confidence interval reports (local) 90 percent intervals about the threshold level, calculated from the standard error of the threshold level of diversification. Share reports number of countries in final period distribution falling below the threshold.

We hesitate to extent the analysis to the case of the Herfindahl index as well as for the PC Product composite, because the relevant variables are not significant in the case of the system GMM estimator (although they are in the case of the fixed and random effects models); for the case of PC Product, the threshold value itself is also not significant (Table 7, third column). Notwithstanding this fact, we nonetheless see a similar picture emerge as before: the established threshold that lies somewhere between the 75th and 90th percentiles, suggesting that a large share of the distribution benefits from openness.[8]

4 Robustness Checks

We perform a sequence of robustness checks to ensure the stability of our results. These are: (a) the inclusion of additional controls (to the benchmark reported in Table 5) that have been identified by a subset of the literature as potential additional influences on volatility; and (b) subsample analysis of the benchmark specifications with the selective exclusion of specific time intervals and country types. In the interest of space, we report results pertaining to only two product diversification indicators—Product Herfindahl and 5 Product—noting that the results obtained from the Product Herfindahl and PC Product, and between 5 and 10 Product indicators, demonstrate significant overlap.

Table 8 systematically adds the following variables to our analysis: institutional quality (*R1* for Product Herfindahl and *R2* for 5 Product); the level growth rate (*R3* and *R4*); the level of human capital (*R5* and *R6*); an index of government quality (*R7* and *R8*); the volatility of government expenditures

[8] Although the fixed and random effects estimators, which *are* jointly significant, implies thresholds that are very low; these are at the 5th percentile and negative, respectively. The principal component variables also yield a negative threshold value (along with non-jointly significant coefficients).

(*R9* and *R10*), and the initial value (for each five-year period) of level GDP per capita (*R11* and *R12*).

In general, we find that the relevant coefficients carry the correct signs and are statistically and economically significant, both individually and jointly, across most of the specifications. Moreover, the estimated threshold values are not markedly different from those found in our preferred benchmark. Moreover, most of the coefficients of the newly-introduced variable are statistically insignificant, with the exception of the level growth rate when we use the 5 Product diversification measure (specification *R4*). In this case, a fast-growing country is more likely to experience a reduction in its growth volatility; this is reasonable, since high-growth nations are more likely to enter into the league of high-income countries, which, as discussed before, have available to them more mechanisms for smoothing growth fluctuations.

We choose to restrict the sample from either end by deleting the final (2001–2005) (Table 9, columns *S1* (Product Herfindahl) and *S2* (5 Product) measures) and first (1976–1980) (*S3* and *S4*, respectively) periods from the sample. The first restriction, which deletes the most recent period, examines the importance of recent history in influencing the outcomes of the analysis. The second restriction pares the earliest period of the sample, and, although we do not report them, yields qualitatively similar results to eliminating up to two of the earliest sample periods; doing so tests the robustness of the sample to the period of increased global trade integration in the late 1970s and early 1980s, which followed the end of the Tokyo Round and led up to the important Uruguay Round of the GATT.

The subsample without the first period (and, by extension, the first two periods) does not change the results in any significant way. In contrast, deleting the last period increases the thresholds notably. Although this does not change the conclusion that the threshold values are located between the 50th and the 75th percentiles of the distribution, it emphasizes the importance of changes in the global pattern of trade liberalization and diversification since the turn of the 21st century, when the world economy experienced an extended period of economic calm.

An alternative restriction of the sample we experiment with is to limit the sample to purely developing (columns *S5* and *S6*) versus developed (columns *S7* and *S8*) economies. The allows us to tease out whether the contribution of diversification and openness to growth stability is driven by patterns in the developed or developing world. As can be seen, our results do not change markedly when high income economies are excluded from the analysis although the sample size falls substantially. Even the estimated threshold values are almost unchanged. On the other hand, the relationship completely breaks down when we exclude developing countries from the analysis. Irrespective of the diversification indicator we use, there appears to be no significant relationship between diversification and the effect of openness on growth volatility when these countries are excluded from the sample. While the variables of interest still carry the correct signs on their coefficients, none of the interaction terms are significant. This suggests that much of the action indeed lies with low and mid-

Table 8: System GMM regressions for growth volatility with additional controls[†]

	(*R1*)	(*R2*)	(*R3*)	(*R4*)	(*R5*)	(*R6*)	(*R7*)	(*R8*)	(*R9*)	(*R10*)	(*R11*)	(*R12*)
Lagged	0.273	0.145	0.232	-0.004	0.212	0.141	0.294	0.189	0.197	0.112	0.207	0.124
volatility	(0.12)**	(0.14)	(0.13)*	(0.17)*	(0.11)**	(0.15)	(0.16)*	(0.19)	(0.12)	(0.171)	(0.12)*	(0.16)
Product	-19.323	-15.45	-27.70	-13.995	-18.98	-23.064	-34.234	-19.578	-23.699	-27.74	-20.287	-22.061
diversification	(17.39)	(8.63)*	(9.98)***	(6.98)**	(12.82)	(7.52)***	(11.6)***	(7.10)***	(10.85)**	(8.71)***	(11.29)*	(7.42)
Trade	-0.881	-1.727	-1.304	-1.298	-0.492	-2.75	-1.696	-2.463	-1.105	-3.24	-0.986	-2.705
openness	(0.98)	(1.08)	(0.82)	(1.16)*	(0.78)	(1.13)**	(0.91)*	(1.20)**	(0.79)	(1.26)***	(0.77)	(1.07)
Openness ×	4.670	3.61	6.466	2.846	4.465	5.601	8.170	4.401	5.808	6.694	5.070	5.509
diversification	(4.14)	(2.06)*	(2.39)***	(1.72)*	(3.14)	(1.84)***	(2.78)***	(1.72)**	(2.62)**	(2.13)***	(2.77)*	(1.79)
Financial	-0.244	-0.012	-0.084	-0.309	-0.175	-0.317	-0.376	-0.508	-0.255	-0.340	-0.218	-0.338
openness	(0.24)	(0.06)	(0.26)	(0.28)	(0.16)	(0.21)	(0.28)	(0.30)*	(0.18)	(0.23)	(0.16)	(0.21)
Capital flows	-0.063	-0.305	-0.125	0.295	-0.016	0.323	-0.083	0.139	-0.199	0.241	0.145	0.254
volatility	(0.41)	(0.00)	(0.38)	(0.36)	(0.37)	(0.43)	(0.39)	(0.37)	(0.32)	(0.37)	(0.34)	(0.39)
Inflation	0.013	0.014	0.001	0.006	0.007	0.002	-0.001	-0.000	0.011	0.010	0.009	0.010
volatility	(0.02)	(0.42)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)
Exchange rate	0.006	0.010	0.000	0.000	0.000	0.000	-0.000	0.000	0.000	0.000	0.000	0.000
volatility	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)*	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Terms of trade	-0.017	-0.012	0.041	0.082	0.001	0.045	0.059	0.083	0.009	0.062	0.027	0.045
Volatility	(0.05)	(6.38)	(0.03)	(0.04)**	(0.05)	(0.06)	(0.05)	(0.05)*	(0.04)	(0.06)	(0.05)	(0.06)
Foreign growth	2.117	2.432	3.430	2.288	1.895	2.322	3.884	2.845	2.716	2.778	1.417	2.068
volatility	(1.06)**	(0.99)**	(0.93)***	(0.91)**	(0.88)**	(0.84)***	(1.02)***	(0.95)***	(1.10)**	(0.99)***	(0.87)	(0.84)
Crisis dummy	-6.432	-0.146	-2.302	-3.942	-0.708	1.476	-1.144	-2.415	-0.900	1.235	-0.699	1.301
	(5.22)	(0.00)	(4.78)	(5.22)	(4.99)	(6.00)	(4.67)	(5.79)	(5.22)	(6.69)	(4.68)	(5.41)
Additional	0.008	-0.18	-0.253	-0.332	-0.352	0.138	0.161	0.042	-0.004	-0.027	0.153	0.171
variable	(0.38)	(0.22)	(0.20)	(0.18)*	(0.56)	(0.56)	(0.23)	(0.22)	(0.03)	(0.04)	(0.26)	(0.24)
Hansen J	33.25	34.22	21.69	25.12	39.87	36.42	25.46	24.34	0.14	0.32	0.85	0.50
AR(2) z	-0.03	0.23	0.47	0.29	0.14	0.32	0.85	0.50	39.87	36.42	25.46	24.37
N	337	337	294	294	358	358	294	294	358	358	358	358

[†] Notes: Heteroskedasticity and autocorrelation-robust (asymptotic) Windmeijer (2005)-corrected standard errors reported in parentheses. * indicates significance at 10 percent level, ** indicates significance at the 5 percent level, and *** indicates significance at the 1 percent level. Period dummies and a constant were included, but not reported.

dle income economies for which export diversification matters more in shielding their economies from external shocks. A likely explanation is that developed economies have other means of insuring their economies against shocks, whereas developing countries depend more strongly on implicit insurance as represented by a more diversified structure in their exports.

5 Conclusion

This study addresses the mechanisms by which the trade channel affects growth volatility. More specifically, we have sought to ascertain whether the effect of trade openness on growth volatility varies according to the extent of export diversification, as well as to establish the threshold—if one exists—in which the effect of openness on volatility switches signs. We find that the volatility-reducing effect of openness does indeed depend on the extent to which a country has a diversified export base. More specifically, our results point to a clear role that product diversification plays in moderating the effect of growth volatility in open economies, while market diversification does not appear to play an as important role.

In addition, we were able to identify positive thresholds for product diversification where the effect of openness on volatility switches sign; with these thresholds mostly falling in the upper parts of the distributions of the diversification indicator, we can point to how the majority of countries in our sample will experience reduced volatility should they choose to pursue increased openness. These findings survive a range of additional robustness tests, both to the inclusion of additional controls, as well as taking subsamples of the data.

The only circumstance where our main results fail to go through is when we strip out the low-income economies from the sample. This implies that the volatility-reducing effects of trade openness matters much more for low- and middle-income economies, which are often the ones that are most resistant to trade liberalization. This has important policy implications for the developing world.

In particular, our findings suggest that a more phased approach toward introducing trade reform, with countries pursuing an expanded production base and export diversification strategies prior to broad tariff removal. This sequencing of liberalization efforts—especially for countries that currently have a very concentrated export base—may be important for minimizing the disruptive effects that expanded trade may imply with regard to growth volatility. Of course, this raises additional endogeneity issues where increased openness may itself stimulate a greater amount of diversification.

Although we have identified an important channel by which openness operates to reduce growth volatility, our research remains silent on other possible channels in which trade can operate, such as through technological transfer or learning by doing, as well as other major variables which diversification may affect, such as the terms of trade. We leave these explorations for future research.

Table 9: System GMM regressions for growth volatility for selected subsamples[†]

	(*S1*)	(*S2*)	(*S3*)	(*S4*)	(*S5*)	(*S6*)	(*S7*)	(*S8*)
Lagged	0.287	0.110	0.212	0.149	0.253	0.279	0.072	0.072
volatility	(0.15)*	(0.19)	(0.11)**	(0.16)	(0.10)**	(0.15)*	(0.11)	(0.11)
Product	-35.54	-21.223	-23.70	-23.375	-29.723	-29.344	-15.72	-15.753
diversification	(11.95)***	(8.00)***	(11.59)**	(7.54)***	(11.63)**	(9.16)***	(11.1)	(11.08)
Trade	-1.812	-2.657	-1.082	-2.715	-1.579	-3.428	-0.789	-0.789
openness	(0.97)*	(1.32)**	(0.81)	(1.11)**	(0.92)*	(1.47)**	(0.81)	(0.813)
Openness ×	8.278	4.822	5.781	5.632	7.204	7.015	2.993	2.994
diversification	(2.84)***	(1.96)**	(2.80)**	(1.83)***	(2.84)**	(2.21)***	(2.81)	(2.81)
Financial	-0.326	-0.579	-0.260	-0.325	-0.330	-0.178	-0.462	-0.462
openness	(0.25)	(0.31)*	(0.17)	(0.22)	(0.21)	(0.27)	(0.17)***	(0.17)***
Capital flows	-0.359	-0.058	-0.241	0.147	-0.132	0.259	-0.212	-0.212
volatility	(0.47)	(0.43)	(0.32)	(0.42)	(0.54)	(0.59)	(0.25)	(0.25)
Inflation	0.000	0.004	0.010	0.005	0.009	0.006	0.002	0.001
volatility	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Exchange rate	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
volatility	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Terms of trade	0.038	0.081	0.006	0.036	0.020	0.048	0.049	0.049
volatility	(0.04)	(0.05)*	(0.04)	(0.06)	(0.04)	(0.05)	(0.05)	(0.05)
Foreign growth	3.965	3.008	2.723	2.690	2.792	3.009	2.415	2.415
volatility	(1.07)***	(1.05)***	(1.03)***	(0.99)***	(1.20)**	(1.17)***	(0.91)***	(0.91)***
Crisis dummy	-1.902	-4.245	-1.664	0.504	1.975	2.941	-2.679	-2.679
	(4.88)	(6.43)	(5.15)	(6.37)	(5.14)	(5.43)	(3.29)	(3.29)
Hansen J	23.50	22.14	34.61	35.22	39.52	28.94	34.54	36.30
AR(2) z	0.68	0.44	0.26	0.32	0.27	0.53	0.05	-0.18
N	294	294	285	285	251	251	268	268

[†] Notes: Heteroskedasticity and autocorrelation-robust (asymptotic) Windmeijer (2005)-corrected standard errors reported in parentheses. * indicates significance at 10 percent level, ** indicates significance at the 5 percent level, and *** indicates significance at the 1 percent level. Period dummies and a constant were included, but not reported.

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Technical Appendix

Table A.1: Definitions and sources of variables

Variable	**Definition and construction**	**Source**
GDP per capita growth volatility	Standard deviation of log difference of GDP per capita	Authors' construction using World Bank WDI
Product Herfindahl	Herfindahl Index HS-4 Digit	World Bank diversification database
5 Product	Share of 5 largest products in overall exports	World Bank diversification database
10 Product	Share of 10 largest products in overall exports	World Bank diversification database
PC Product	First principal component of 3 product diversification measures	Authors' construction
Market Herfindahl	Herfindahl Index for destination markets	Authors' construction with UN COMTRADE
5 Market	Share of 5 largest destination markets in overall exports	Authors' construction with UN COMTRADE
10 Market	Share of 10 largest destination markets in overall exports	Authors' construction with UN COMTRADE
PC Market	First principal component of 3 market diversification measures	Authors' construction
Trade openness	Total trade (exports + imports) divided by GDP	Chang *et al.* (2009)
Financial openness	Financial openness as defined in Chinn & Ito (2008)	Chang *et al.* (2009)
Capital flow volatility	Capital flows to the region as share of GDP (Calderón *et al.* 2005)	Chang *et al.* (2009)
Inflation volatility	Standard deviation of annual log differences of CPI	Chang *et al.* (2009)
Exchange rate volatility	Standard deviation of real effective exchange rate (REER)	Authors' construction based on IMF IFS
TOT volatility	Standard deviation of terms of trade (ToT)	Chang *et al.* (2009)
Foreign growth volatility	Standard deviation of growth rate of main trading partners	Chang *et al.* (2009)
Number of financial crises	Number of years a country underwent a banking crisis	Chang *et al.* (2009)
GDP per capita growth	Log difference of GDP per capita in constant USD	Chang *et al.* (2009)
Education	Initial value of % ratio of secondary gross enrollment	Chang *et al.* (2009)
Government	Index constructed from governance indicators	Chang *et al.* (2009)
Volatility of government spending	Standard deviation of government spending	Chang *et al.* (2009)
Initial GDP per capita	Log of the value of GDP per capita in the initial period	Chang *et al.* (2009)

Table A.2: Correlation matrix for diversification variables

	Product Herf	5 Product	10 Product	Market Herf	5 Market	10 Market	PC Product	PC Market
Product Herf	1.000							
5 Product	0.820	1.000						
10 Product	0.743	0.983	1.000					
Market Herf	0.240	0.226	0.233	1.000				
5 Market	0.450	0.460	0.457	0.815	1.000			
10 Market	0.499	0.542	0.540	0.698	0.959	1.000		
PC Product	0.879	0.992	0.971	0.243	0.478	0.555	1.000	
PC Market	0.429	0.443	0.443	0.881	0.987	0.947	0.460	1.000

Table A.3: Percentile decompositions for diversification variables

Percentile	**Mean**	**Mean**
	Product Herfindahl	Market Herfindahl
10%	0.014	0.067
25%	0.027	0.081
50%	0.061	0.114
75%	0.158	0.177
90%	0.306	0.327
	5 product	5 market
10%	0.193	0.477
25%	0.276	0.527
50%	0.450	0.623
75%	0.659	0.707
90%	0.832	0.822
	10 product	10 market
10%	0.289	0.651
25%	0.383	0.702
50%	0.589	0.779
75%	0.791	0.857
90%	0.920	0.925
	PC product	PC market
10%	-2.356	-2.001
25%	-1.900	-1.542
50%	-0.962	-0.668
75%	0.245	0.225
90%	1.212	1.345

Table A.4: Average diversification index values in final 5-year period[†]

Country	Product Herfindahl	5 Product	10 Product	Market Herfindahl	5 Market	10 Market
Algeria	0.444	0.958	0.983	0.119	0.695	0.894
Argentina	0.035	0.355	0.492	0.072	0.509	0.651
Australia	0.035	0.326	0.488	0.078	0.536	0.707
Bangladesh	0.088	0.616	0.788	0.154	0.683	0.837
Belgium	0.024	0.279	0.345	0.099	0.637	0.779
Bolivia	0.105	0.583	0.753	0.151	0.735	0.890
Botswana	0.632	0.935	0.969	0.643	0.966	0.989
Brazil	0.016	0.197	0.317	0.073	0.442	0.595
Burkina Faso	0.396	0.753	0.821	0.245	0.819	0.938
Canada	0.033	0.338	0.425	0.738	0.914	0.941
Chile	0.108	0.538	0.659	0.071	0.487	0.683
China	0.012	0.180	0.277	0.102	0.607	0.720
Colombia	0.068	0.474	0.578	0.206	0.653	0.759
Costa Rica	0.127	0.598	0.686	0.236	0.650	0.794
Denmark	0.013	0.204	0.279	0.071	0.504	0.711
Dominican Republic	0.051	0.398	0.579	0.205	0.764	0.878
Ecuador	0.246	0.769	0.825	0.209	0.694	0.836
El Salvador	0.069	0.485	0.613	0.153	0.783	0.917
France	0.016	0.230	0.304	0.065	0.512	0.687
Gambia, The	0.127	0.609	0.758	0.214	0.820	0.931
Ghana	0.202	0.681	0.828	0.096	0.588	0.780
Guatemala	0.042	0.392	0.559	0.175	0.720	0.846
Honduras	0.081	0.503	0.690	0.201	0.728	0.849
India	0.028	0.256	0.344	0.057	0.409	0.566
Indonesia	0.027	0.292	0.393	0.090	0.568	0.724
Iran, Islamic Rep.	0.691	0.882	0.901	0.199	0.844	0.914
Ireland	0.057	0.447	0.616	0.112	0.658	0.834
Israel	0.142	0.508	0.596	0.162	0.584	0.721
Italy	0.008	0.132	0.212	0.058	0.484	0.618
Japan	0.032	0.294	0.397	0.103	0.573	0.726
Jordan	0.051	0.432	0.644	0.117	0.623	0.761
Kenya	0.080	0.518	0.623	0.069	0.507	0.672
Madagascar	0.112	0.637	0.789	0.225	0.777	0.887
Malawi	0.312	0.811	0.884	0.075	0.540	0.732
Malaysia	0.043	0.365	0.499	0.093	0.585	0.761
Mexico	0.029	0.303	0.433	0.755	0.919	0.944
Morocco	0.030	0.298	0.480	0.153	0.669	0.807
Netherlands	0.010	0.167	0.238	0.095	0.598	0.738
New Zealand	0.031	0.320	0.464	0.084	0.555	0.686
Nicaragua	0.055	0.443	0.647	0.160	0.716	0.879
Nigeria	0.819	0.974	0.983	0.168	0.666	0.823
Norway	0.256	0.699	0.759	0.097	0.603	0.812
Pakistan	0.050	0.396	0.583	0.084	0.492	0.644
Panama	0.052	0.382	0.482	0.255	0.690	0.812
Paraguay	0.170	0.682	0.815	0.155	0.707	0.848
Peru	0.077	0.528	0.664	0.105	0.537	0.694
Philippines	0.132	0.590	0.691	0.111	0.629	0.863
Portugal	0.019	0.231	0.347	0.115	0.669	0.839
Senegal	0.095	0.556	0.712	0.114	0.603	0.789
South Africa	0.031	0.351	0.466	0.052	0.444	0.589
Spain	0.029	0.265	0.332	0.083	0.590	0.725
Sri Lanka	0.041	0.351	0.503	0.163	0.635	0.755
Sweden	0.017	0.230	0.327	0.055	0.443	0.680
Syrian Arab Republic	0.431	0.772	0.825	0.147	0.667	0.821
Thailand	0.016	0.212	0.309	0.075	0.516	0.682
Togo	0.109	0.637	0.752	0.092	0.594	0.742
Trinidad and Tobago	0.173	0.723	0.785	0.327	0.737	0.828
Tunisia	0.037	0.357	0.503	0.175	0.747	0.884
Turkey	0.015	0.198	0.309	0.055	0.445	0.620
United Kingdom	0.017	0.238	0.337	0.067	0.508	0.694
United States	0.011	0.177	0.255	0.086	0.521	0.671
Uruguay	0.040	0.349	0.469	0.088	0.527	0.703
Zambia	0.255	0.766	0.881	0.194	0.762	0.892
Zimbabwe	0.093	0.541	0.657	0.096	0.539	0.724

[†] Notes: 5-year period beginning 2001–2005, inclusive.