Export Diversification and Price Uncertainty in Developing Countries: A Portfolio Theory Approach

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Abstract

We evaluate the export diversification structure of developing countries using a large cross-country panel of detailed exporting activity and constructed world market prices in the context of modern portfolio theory. We find that there are considerable welfare gains from moving towards a more 'optimal' export structure on the mean-variance efficient frontier, although the extent of this differs widely across countries. Our econometric analysis also shows while in general greater openness has increased the expected earnings from exports, it has also resulted in greater variability. Whether this has thus resulted in increases in expected welfare depends crucially on the level of risk aversion of countries.

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SECTION I: INTRODUCTION

Under classical international trade theory it is beneficial for countries to specialise in and export those goods in which they have a comparative advantage, i.e., in which they will have greater average returns. Such specialization then arguably leads to greater welfare and consequently growth, see Feeny (1999), Devereux and Smith (1994), and Acemouglu and Zilibotti (1997). However, specialisation in production and exposure to world markets may realistically also make nations more vulnerable to shocks. As a matter of fact, as early as Prebisch (1950) and Singer (1950) economists have warned of the detreminental effects of terms of trade shocks in developing countries that depend on a few products for their export earnings, leading to a widespread adoption of import substitution and export diversification strategies. While since then more outward oriented trade policies have become prominent[1], there is still general concern about the high vulnerability of many developing countries to negative shocks.; see Collier ().

The theoretical trade literature has long recognized the need to incorporate uncertainty into its frameworks, as was initially proposed by Brainard and Cooper (1968). Since then a number of theoretical works have examined in greater detail the possibility of how some stochastic component of trade may alter the conclusions of the classical models. For instance, an array of models in the 1970s (see Anderson et al (1976), Batra (1975), Kemp And Liviatan

[1] See World Bank (1987, 1993).

(1973), Ruffin (1974), and Turnovsky (1974) showed that the basic implications of international trade theory, such as the law of comparative advantage and Hecksher-Ohlin theory, may no longer be valid when considered within the context of uncertainty and risk aversion.[2] In many instances the introduction of uncertaintity may then result in some `diversification' to mitigate the ill effects of uncertainty. As a matter of fact, there may even be some cases where free trade is no longer the optimal policy for a small country at all; see, Turnovsky (1974), Batra and Russel (1974).

It must also be noted, however, that several authors have shown that trade in risk-free bonds can mitigate the 'ill' effects of uncertainty due to risk aversion by allowing intertemporal consumption smoothing opportunities and thus undermine the need for diversification; as, for instance, in Helpman in Razin (1978 a, b, and c) and Chang (1991). In a more general framework Grossman and Razin (1984) showed that under certain conditions even just free trade in equities can achieve such an outcome.[3] While theoretically appealing one must note that in practice complete integration into world `insurance' markets are even today not yet likely to be a significant feature for most developing countries and thus arguably the dilemma of the tradeoff between the greater returns due to specialization and the greater exposure to shocks on the world market continues to be of concern; see Cuddington et al (1995).

[2] See Cuddington et al (1995) for an excellent review.
[3] See also Obstfeld (1994).

Despite the advancement in theory there is little direct empirical evidence on the actual tradeoff between the return and variability of developing countries' export structures. One possible way to approach this is to consider it in the context of modern portfolio theory, where a risk averse investor faced with choosing among various risky assets will choose that combination that minimizes a 'portfolio's' variance for a given return by taking advantage of the lack of perfect correlation among returns. One could thus similarly think of risk averse countries of ideally allocating their resources so as to produce an export mix that takes into consideration the covariability of goods' prices on the world market. As a matter of fact, Brainard and Cooper (1968) in their seminal paper advocated exactly this approach to deal with the likely uncertainty in trade. Nevertheless there is to date no comprehensive empirical study in this regard.

In the current paper we thus follow in the original spirit of Brainard and Cooper (1968) and explicitly estimate the trade-off between the export earnings and its variability due to world market prices given a country's export structure. In this regard, we use a large cross-country panel data set of developing countries' disaggregated exporting activity and construct corresponding world market prices. We find that there are considerable welfare gains from moving towards a more 'optimal' export structure on the mean-variance efficient frontier, although the extent of this differs widely across countries. We also examine how greater trade openness has affected countries export structure within the return-variability tradeoff sphere. Our econometric results indicate that while expected export earnings may rise as countries become more open, there will also be greater variability. Whether there will be a change in expected welfare crucially depends on the degree of risk aversion.

The remainder of the paper is organized as follows. In the subsequent section we outline the use of portfolio theory within our context. Section III describes our data and provides summary statistics. Our empirical analysis is contained in Section IV. Concluding remarks are provided in the final section.

SECTION II: THE PORTFOLIO OPTIMISATION PROBLEM IN AN EXPORT DIVERSIFICATION CONTEXT

Our main task is to apply the principles of portfolio theory to the analysis of countries' export diversification problem in terms of the tradeoff between risk and returns of exporting activity. In this regard let *Pi* be the price of one unit of good *i* on the world market of a set of products of *i* = *1,…N*. A country's given export structure, *A*, is described by a set of weights, wi, reflecting a product's share of total exports. The mean expected export earnings from this export configuration *A* is then described by:

$$E(P^A) = E(\sum_{i=1}^{N} w_i P_i) \qquad (1)$$

where *E* denotes the expectations operator. It follows that the variance of export earnings of export configuration *A*, σ_A^2, is:

$$\sigma_A^2 = \sum_{i=1}^{N} w_i^2 \sigma_i^2 + \sum_{i}^{N} \sum_{\substack{j=1 \\ j \neq i}} w_i w_j \sigma_{ij} \tag{2}$$

where σ_i^2 is the variance of the price of product i and σ_{ij} is the covariance between any products i and j. The second term in (2) introduces the possibility that exports that as long as products' prices are not perfectly positively correlated, then producing several products can form a 'hedge' that reduces the variance of the overall expected return of a given export structure of a country.

Within this context an efficient set of possible export configurations that yield the highest rate of export earnings for a given variance, or, alternatively, that result in the lowest variance for a given level of earnings, can be obtained by solving the following optimization problem:

Minimise
$$\sum_{i=1}^{N} w_i^2 \sigma_i^2 + \sum_{i}^{N} \sum_{\substack{j=1 \\ j \neq i}} w_i w_j \sigma_{ij} \tag{3}$$

s.t.
$$E(\sum_{i=1}^{N} w_i P_i) = E(P^A)$$

$$\sum_{i=1}^{N} w_i = 1$$

$$w_i \geq 0, \qquad i = 1,\ldots N$$

This is similar to the standard Markowitz quadratic programming problem of portfolio theory with no riskless asset and no short sales permitted; see, e.g., Elton and Gruber (1995). In terms of comparing the problem above to that typical in the finance literature there are two important distinctions however.

Specifically, in standard portfolio optimisation weights w_i are usually defined in terms of relative (to the total) amount invested in a particular asset. In contrast, standard export data, as is available to us, only provides total export earnings of products and thus arguably the equivalent of amount received from investment in an asset relative to the total. Moreover, and related to the previous point, the (expected) rate of return of an asset within standard portfolio analysis is generally defined as the difference between the amount received and the amount invested, relative to the amount invested. Again, a conceptually equivalent measure of this within our context would require (the not available) information on the costs of producing one unit of each product, whereas we can only calculate proxies of the (expected) amount a product receives on the world market and thus the gross return.[4]

SECTION III: DATA

Importantly our empirical analysis requires information regarding export activity across developing countries and world market prices they face across time by product. Export values across countries are readily available at a fairly disaggregated product level (SITC Rev. 1) over the period 1962-2002 from the COMTRADE database collected by the United Nations. While a higher level of disaggregation of export activity is available from the database, use of such

[4] One possibility to deal with this problem may be to acquire information on the costs of and levels employed of factors of production for all products products exported. Not surprisingly, no such data is available.

would have meant covering a shorter time period and/or would not have allowed the identification of units exported (rather than just values) and thus would have restricted our construction of world market prices. As it stands, even within the selected disaggregation level for many countries there is not complete coverage across the period and hence in terms of per product exporting activity in each country our data set consists of an unbalanced panel. We used the World Bank classification system to separate developed (high income) countries from those considered to be developing (all others).

Unfortunately no consistent time series of world market prices across all product categories is readily available. While the IMF does publish some long time series, these cover only relatively few primary commodity products and thus would not allow our portfolio analysis to span the complete range of products exported by countries. Thus in order to obtain indicators of world market prices across product categories we took advantage of the fact that the COMTRADE database provides both values and units of trading activity across product categories. In particular, one is able to calculate proxies of prices from the the per unit values of products of these trade flows. In this regard ideally one would have liked to have a complete and consistent series of export values and units across developing countries over the entire period to thus be able to calculate average export price movements over time faced by the developing world. Given that for very few developing countries' such information was complete across years, we instead resorted to using import values and units across product categories for all countries (including developed ones) for which complete time series (1962-2002) were available to calculate a per product price series.[5] In this regard we used a simple average of the derived per unit import price across countries to arrive at an aggregate per product price series. Even in using data on importing activity there were a few product categories at the three digit SITC Rev. 1 level for which we were unable to obtain at least one consistent time series of prices. Rather than completely excluding these categories from our analysis we either redefined the sectoral classification in our analysis by including these in the most related neighboring category or, where available, used the price series available from the IMF data. Finally, the set of constructed series of prices was appropriately deflated and normalized to its 1962 value. [6]

In order to ensure that our constructed series were 'reasonable' proxies of world market prices we compared these to the few commodity price series available (and which we did not use to fill in any missing categories) from the IMF data set. Reassuringly, our constructed price series tended on average to be highly correlated with the IMF data.[7] Nevertheless, a number of caveats regarding our constructed price series are noteworthy. First of all, one should note that by using common price series for all countries we are not allowing for price differences due to quality discrepancies of exported products across developing countries. Secondly, and related to this, by using import data to

[5] Data on imports are much more complete than for exports in the COMTRADE database.
[6] Data on values are reported in current US dollar values in the COMTRADE database.
[7] Detailed results available from the authors.

construct prices we are not distinguishing between prices faced by developed and developing countries – a factor that could arguably be particularly important for manufacturing products. Thus, importantly, we are assuming that differences in prices due to product differentiation is negligible in the world market for developing countries and/or that even though their may be differences across countries in similarly classified products, prices across these differences are nevertheless highly correlated.

Overall the construction of cross-country exporting activity and consistent series of world market prices resulted in data for 128 developing countries and 168 product categories – details of these are given in Appendix A. While we use the complete set of years to construct expected returns and variance of product prices, and hence to calculate our mean-variance efficient frontier, one should note that in terms of calculating out the mean returns and variance of individual countries' export structure and for our econometric analysis we restrict the use of data to the 1970-2000 period. This is mainly due to the restricted time dimension of some of the explanatory variables used. We plot the mean value (normalized at the 1962 value) of the price level and its standard deviation for our product categories in Figure . As can be seen, both prices and standard deviation differ widely across categories. More importantly, visual inspection provides strong tentative evidence of a positive relationship between mean prices and their variance.

We also calculated out the average (over time) Herfindahl Index of export shares in order to gain some preliminary insight into the degree of diversification of countries in our sample – where the lower the value is, the greater the degree of diversification. The results for the top and bottom 15 are shown in Table 1. As can be seen, there is a large range of values across countries and country groups. Notably in this regard is that for nine of the top fifteen least diversified nations petroleum is the most exported commodity. Again there is a large variety of countries within the top and bottom group. Looking at the individual country groups one finds that the Middle East and North Africa have the least, and Central Asia the most diversified export structures on average.

SECTIOIN III: EMPIRICAL RESULTS

A. The Mean-Variance Efficient Frontier and Countries' Export 'Portfolio'

In order to use our data to calculate the mean-variance efficient frontier from (3) and the mean return and standard deviation of individual countries' export structure we need an estimate of the `expected return' and its variance of a product on the world market. We assume this to be just the average price over the entire period for which data was available (1962-2002). Using these proxies for all 168 product categories we then implemented the M-V Optimizer developed by Wagner Math Finance to estimate the frontier along the return/standard deviation dimension of export structures. These expected returns and variability in conjunction with the actual structure of coutnries' exports also then allowed us to calculate countries' actual export structure's expected return and standard deviation.

The mean-variance efficient frontier along with the average (across time) returns and standard deviations of countries export diversification are plotted in Figure 2. With regard to the frontier a number of preliminary reminders from portfolio theory are worth pointing out. First, the feasible set of export structures must necessarily lie to right of the frontier. Secondly, the lowest depicted point of the frontier constitutes the minimum variance point of this mean-variance set. Finally, as would be expected, moving to a higher return structure along this front necessarily also entails accepting higher variance in returns, hence producing a positively sloped frontier above the minimum variance point.

In terms of the actual location of the export structures of our developing country group, one should note that, while in all cases there is a clear visual distance between countries actual structure and the mean-variance efficient frontier, countries' individual export structures result in widely different locations within the return-standard deviation set of possible values. For example, while most are relativelyt near the minimum variance point, and a number even below, there are some clear of outliers , particularly those with structures characterized by high expected returns and high variability. In order to investigate differences across country groups, we replot of the data for sub-Saharan, Latin American and Caribbean, and all others countries separately along with their isocodes in Figures 2, ,3 and 4, respectively. Examining the sub-

Saharan group first, one finds that the two outliers with high standard deviation but low expected return were Liberia (LBR) and Mauritania (MRT). Also, a number of countries, like Niger (NER), Nigeria (NGA), and Gabon (GAB), amongst others, have considerably higher standard deviation but also higher expected export earnings than others. In contrast, the Latin American and Caribbean group appears much more homogenous , except for Venezuela (VEN) and Trinidad and Tobago (TTO) which, as is well known, are large exporters of petroleum. In this regard, it is not surprising that one discovers from Figure 4, that similarly other oil exporters, like Saudi Arabia (SAU) and Yemen (YEM), also have diversfication structures that produce high export earnings but also high variability.

B. Welfare Analysis

While clearly all countries visually are some distance from the efficient frontier, it is difficult to judge which would have most to gain from changing their export structure. Moreover, it is not clear, that even if a country could move closer to the mean-variance efficient frontier, which point on this curve would be the most desirable. This dilemma is intrinsic to the nature of the optimization problem in that there is a trade-off between risk and expected return, so that ultimately the optimum point along the frontier or the comparisons between to points to the right of frontier will depend on how countries will evaluate this trade-off. The standard approach to measuring such gains from risk sharing has been to specify a utility function to compare welfare gains across the set of possible portfolios; see, for example, Levy and Sarnat (1970), Cole and Obstfeld (1991), Tesar (1995), Wincoop (1994), Lewis (2001), Roland and Tesar (2004). In this regard, we follow standard practice[8], but put in an export earnings context, and assume that export earnings X_t are log-normally distributed:

$$x_{t+1} = x_t + \mu - \frac{1}{2}\sigma^2 + \varepsilon_t \quad \text{where} \quad \varepsilon_t \sim N(0,\sigma^2) \tag{4}$$

where x is the logged value of X, μ is the mean value of x, and σ^2 is its variance. The welfare gain δ of moving from an export structure that generates X_t to the optimum structure that generates X_t^* is then defined by:

$$U(X_t(1+\partial),\mu,\sigma) = U(X_t^*,\mu^*,\sigma^*) \tag{5}$$

In terms of specifying the function in (5) traditional practise had been to use the constant-relative risk aversion utility function. However, this utility function assumes that risk aversion is just the inverse of the intertemporal elasticity of substitution. In this regard, Obstfeld (1994) has demonstrated that risk aversion and the inverse of intertemporal substitutability have opposite effects on welfare gains and thus that it is important to specify a function that does not impose this constraint. We follow Obstfeld (1994) and utilize the Epstein and Zin (1989) utility function:

$$U_t = \{X_t^{1-\theta} + \beta[E_t(U_{t+1}^{1-\gamma})]^{(1-\theta)/(1-\gamma)}\}^{1/(1-\theta)} \tag{6}$$

[8] See for instance, Lewis (2000), for a review.

where θ is the inverse of the intertemporal elasticity of substitution and γ is the parameter of risk aversion. When X_t is log-normally distributed, (6) becomes:

$$U_t = X_t(1-\beta\exp[(1-\theta)(\mu-\frac{1}{2}\gamma\sigma^2)])^{-(1/(1-\theta))} \tag{7}$$

In terms of implementing (7) on our data it should be noted that one needs to specify the four parameters β, γ, θ, μ, and σ. μ and σ can simply be calculated from the points on the frontier or the countries' individual export structure given prices. In terms of the other parameters we follow Lewis (2000) and assume β to be 0.98, but allow the measures of risk aversion and the inverse of the intertemporal elasticity of substitution to vary between 2 and 5. With these parameters on hand one can then calculate the optimum portfolio among the set along the mean-variance efficient frontier, i.e., the one that generates the greatest utility. If we assume that the initial export earnings are the same under the current and the optimum export structure, then the welfare gain of a country from changing its export structure to this point is just:

$$\partial = \frac{U(\mu^*,\sigma^*)}{U(\mu,\sigma)} - 1 \tag{8}$$

Using (2) we first calculated the expected utility of each point along the mean-variance efficient frontier and then found the point at which its value was highest. These points assuming that θ is 2 for various measures of the parameters of risk aversion are shown in Figure. As can be seen, the chosen measure of risk aversion can have a substantial influence on where the optimum export structure lies. Particularly, if one assumes a very low level then most countries lie well below the optimum point. We also experimented with changing θ but holding the risk aversion parameter constant, but this produced virtually identical optimum points, thus suggesting that the intertemporal elasticity of substitution, at least within our chosen range, is not very important in terms of the location no optimum export structure.

As a next step calculate welfare gains for countries export structures using (8) for various measures of γ. Notably, again the choice of risk aversion parameter produces large difference. For example, assuming θ to be 2, the raw correlation between welfare gains from γ=2 and γ=5 was only 0.10. Nevertheless, when ranked countries according to their welfare gain, the raw correlation between the rankings of when γ=2 compared to when we let γ=5 was 0.89. We thus only provide discuss the welfare gains of using γ=2. In this regard, we have specified the top and bottom ranked fifteen countries according to their average (across time) gain in Table 2. One should note first of all that using using our chosen admissiable ranges of γ and θ we were unable to define (7) for Liberia and Mauritania given the very high standard deviation of their export structure and these are thus included from our welfare analysis. From the remaining nations there is clearly a large variety across countries. For example, the country most to gain (Tuvalu) from moving to the optimum export structure has a value over 19 times that of the one least to gain (Namibia). Examining the average mean return and variance to their export structure one finds, not surprisingly, that the top gainers are usually also ranked high in terms of the variance and low in terms of their expected return of their structure. One may also note that a simple test for individual countries' time series in all cases rejected the hypothesis that the welfare gain was zero.

In terms of seeking patterns across country groupings one should note that both top and low ranked categories notably span countries across all continents. However, on average, the Middle East & North Africa group are characterized by the highest gains, while Latin American and Caribbean nations lie closest to their optimum structure.

C. Opennes and Welfare

As noted in the introduction, a number of theoretical models that have incorporated uncertainty have shown that in certain cases the traditional conclusions of trade theory may no longer hold so that countries may choose to diversify their production as they become more open and, potentially, experiences losses in welfare. In order to gain some insight into whether such cases are relevant we now proceed to examine the effect of trade openness on the tradeoff between expected return and variability of a country's export structure. In this regard, we estimate the following equation:

$$Y_{it} = \alpha + \beta_1 OPEN_{it} + \beta_2 GDPC_{it} + \phi_t + \eta_i + \varepsilon_{it} \quad (9)$$

where Y is alternatively, expected return, expected variability, and expected utility of a country's export structure. OPEN is a measure of a country's openness to world markets, defined as the total value of trade flows relative to GDP, GDPC is the GDP per capita intended to capture the effect of level of development of countries, ϕ are year specific effects, η are unobserved country specific time invariant effects possibly correlated with OPEN, and ε is an error term. We construct our dependent variables Y using the actual export structure of countries and the available price data, as in the previous section, and used the measure of openness and real GDP per capita series available from the World Penn Tables.

A number of aspects should be noted with regard to estimating (9). First of all, one can easily make the argument that OPEN is likely to be endogenous in that higher expected return or lower variability from a more open economy could cause countries to become more open.[9] Moreover, there may be other uncontrolled for factors not included in (9) that might affect expected returns and variability of exporting activity and OPEN, and thus could bias our estimate of β_1. One possibility to ensure unbiased estimates would be to use a fixed effects estimator to purge the effects of ϕ and an appropriately instrument for OPEN. However, unfortunately we have no readily available instrument that arguably affects OPEN but not the portfolio aspects and expected welfare of exporting activity. We thus instead first differenced (9) and employed a GMM estimator using appropriately lagged levels of our variables as instruments for OPEN and

[9] A similar argument of endogeneity could also be made in terms of GDP.

GDPC; see Arellano and Bond (1991).[10] One should note that the use of this estimator, which requires a minimum of three continuous observations for each country, and the lack of complete availability of our measures of openness and real GDP per capita meant that our estimated sample size was reduced to 63 countries covering 1233 observations.

The results of estimating (9) using OPEN as openness indicator are given in Table. 3 As can be seen from the first column, more open economies also export products that as a whole have greater expected return, suggesting that countries do indeed benefit from comparative advantage in production. However, results from using the exports structure variability as the dependent variable shows that at the same time greater returns are coupled with greater variability of export earnings, thus potentially reducing expected welfare if countries are risk averse.

To examine the overall impact of the countervailing forces of greater expected returns and export earnings variability due to greater openness, we calculated countries' expected utility and used this as the dependent variable in (9). As a frst step we assumed relatively low risk aversion and high intertemporal substitutabililty by setting both γ and θ equal to 2. The results from the estimated coefficient on OPEN depicted in the third column of Table 3 show that greater exposure to world markets, despite greater variability in

[10] This is essentially the well-known Arellano and Bond (1991) without use of the lagged dependent variable. We also experimented with including a lagged dependent in our estimation equation but this never proved to be significant.

export earnings, causes an increase in expected welfare. This holds even if we increase the risk aversion parameter to 3, as shown in the subsequent column. However, positive expected welfare effects disappear once one allows for greater degrees of risk aversion than 3. More precisely, while setting λ equal to 4 purges positive effects, using a risk aversion parameter as high as 5 causes all positive utility gains from increasing returns due to greater openness to be outweighed by losses due to greater variability. We also experimented with a lower degree of intertemporal substitutability, by increasing to 5. However, for both very high and very low risk aversion there is little change in the results, except for slightly decreasing the positive impact at low levels of risk aversion.

We also explored estimating (9) using an alternative measure of openness, namely the now well known Sachs-Warner trade liberalization index, here indicated as SW. This variables is a zero-one dummy variable that pinpoints the exact time points at which countries liberalized trade based on relatively subjective criteria; see . The results of re-estimating our specification in Table 3 with this alternative proxy are given in Table 4. Accordingly, in contrast to using OPEN, we find that there is no immediate effect of trade liberalization on the expected return of a country's export structure. This may, in part, be due to the fact that this index would by nature only allow for an immediate impact of trade liberalization, but that perhaps export structures need time to adjust. Moreover, as noted earlier it is based on a subjective assessment of when liberalization occurred. We do find, however, as before, that trade liberalization is immediately associated with greater expected export earnings variability of a country on the world market. This greater variability, when considered at a very low level of risk aversion, namely when λ is set to 2, is not sufficient to cause a fall in expected utility. Nevertheless, once one allows for greater degrees of risk aversion, the overall impact on expected welfare becomes negative. Again, these results are robust to allowing for greater values in θ.

SECTION V: CONCLUSION

In this paper we investigated the trade-off between the expected earnings and variability of countries' export structure within a modern portfolio theory framework. To this end we make use of a large cross-country panel data set on disaggregated exporting activities and construct a set of world market product prices. Our results show that there are considerable welfare gains from moving towards a more 'optimal' export structure on the mean-variance efficient frontier, although the extent of this differs widely across countries. In relating the trade-off between expected earnings and their variability of a country's exporting activity to the level of trade openness econometrically, we find that while expected export earnings may rise as countries become more open, there will also be greater variability. Whether there will be a change in expected welfare crucially depends on the degree of risk aversion.

There are a number of issues that we have not addressed in this study. First of all we have exclusively focused on export product price uncertainty.

Clearly, however, production shocks are also likely to be an important component of the stochastic nature of exporting. Moreover, due to data restrictions we were not able to take account of what role differences in costs across products play and hence the impact of net returns on the choice of exporting activity. Finally, our analysis ignores the role of world financial markets on the portfolio view of a country's export structure, an aspect which has been an important focus of theoretical developments. While arguably particularly developing countries for most of the period under consideration have not had access or participated in anything near complete insurance markets, greater financial integration has undoubtedly taken place and this may have had an impact on countries' exporting activity by allowing to diversify risk 'away'. Clearly all of these issues leave much scope for future research.

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Figure 1: Price Mean and Standard Deviation Relationship

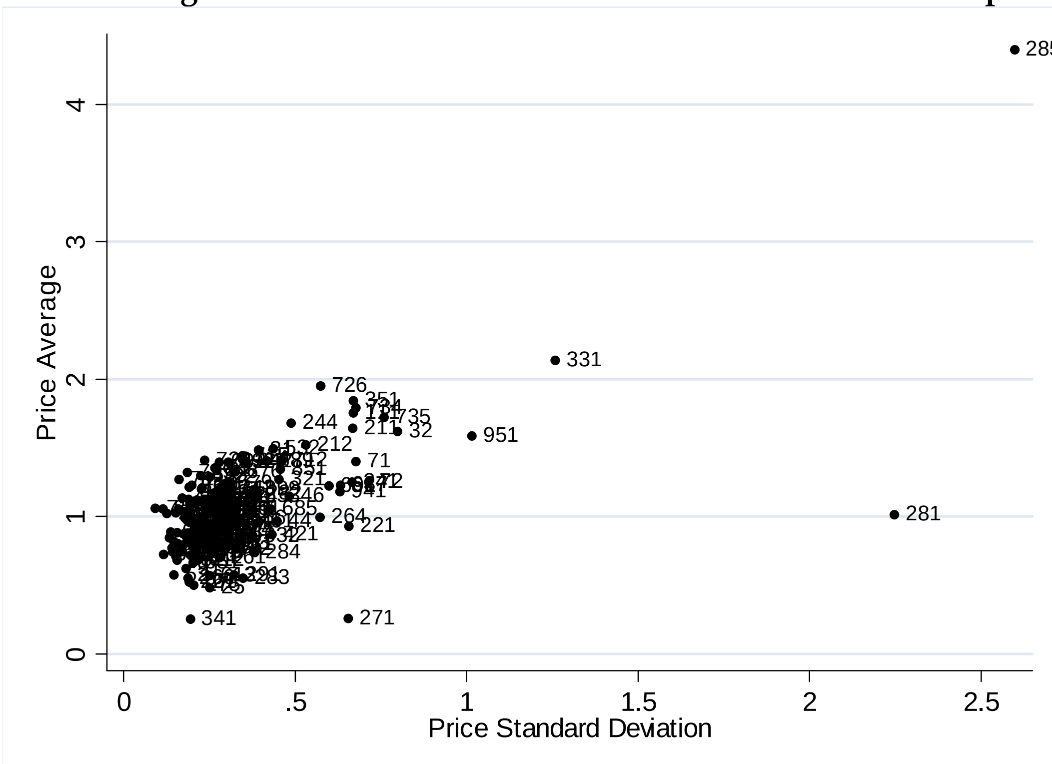

Figure 2: Efficient Frontier and Actual Structures

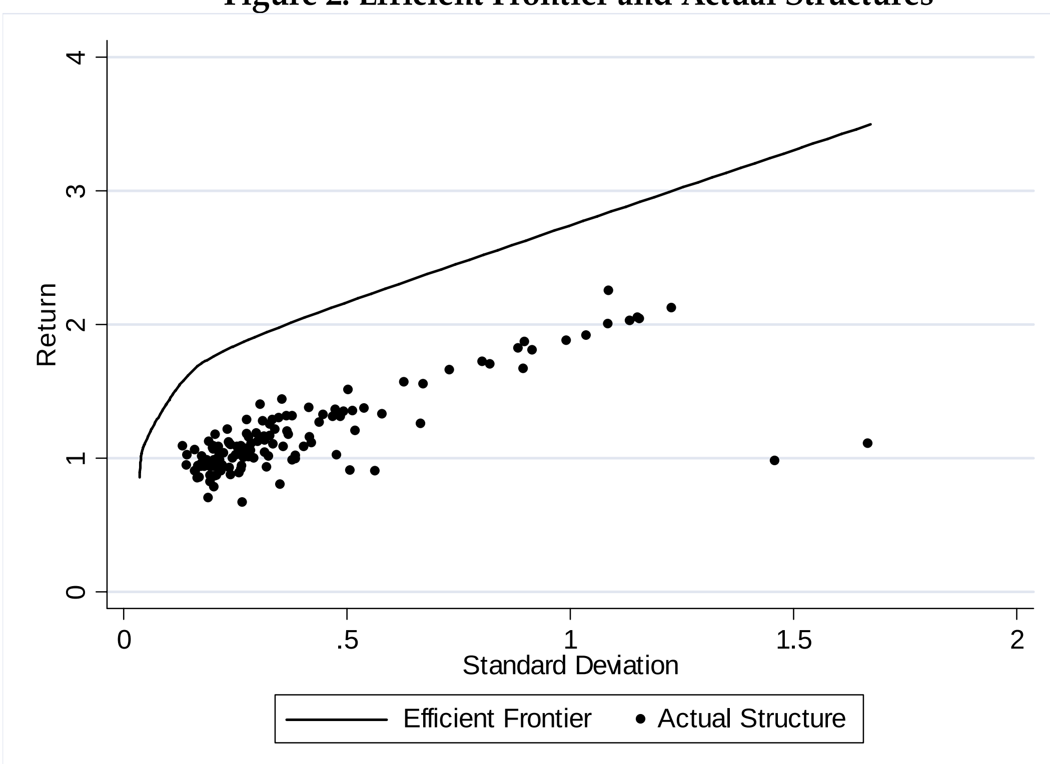

Figure 3: Subsaharan Africa

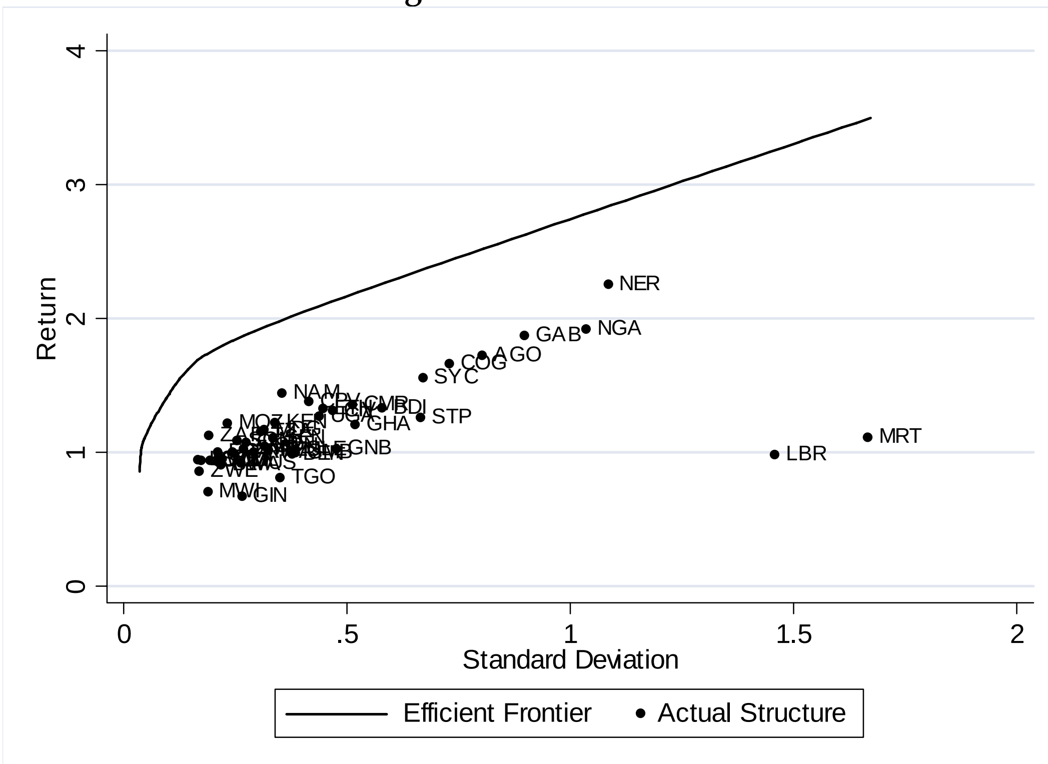

Figure 4: Latin America and Carribean

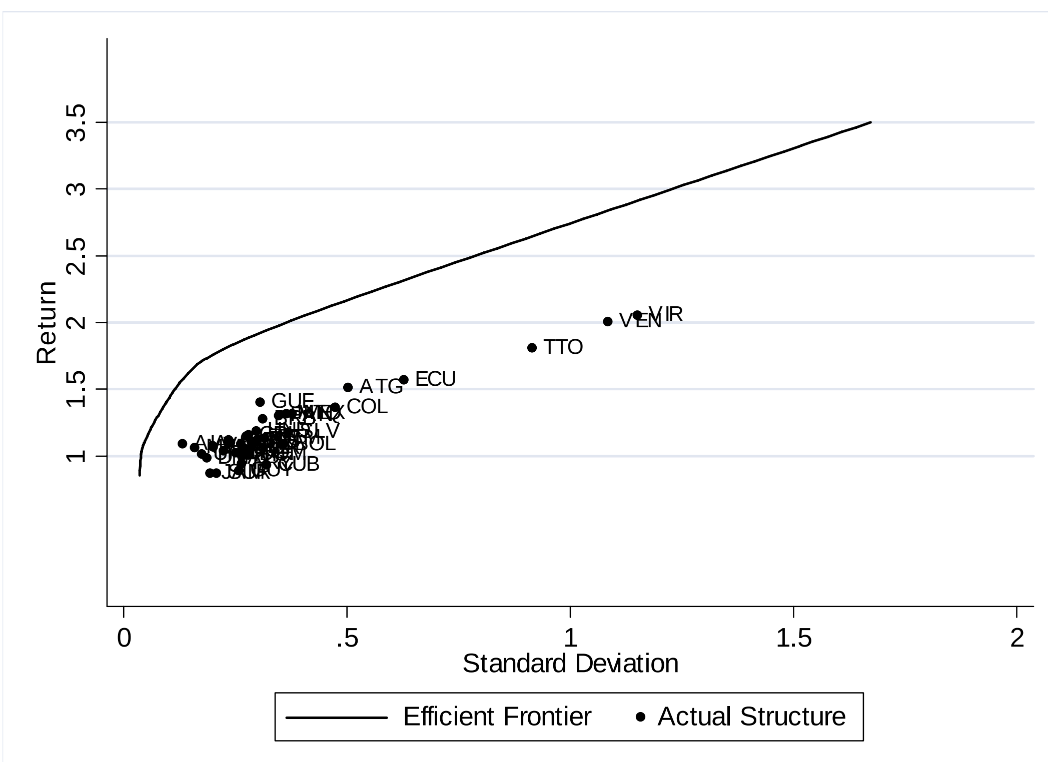

Figure 5: Other Developing Countries

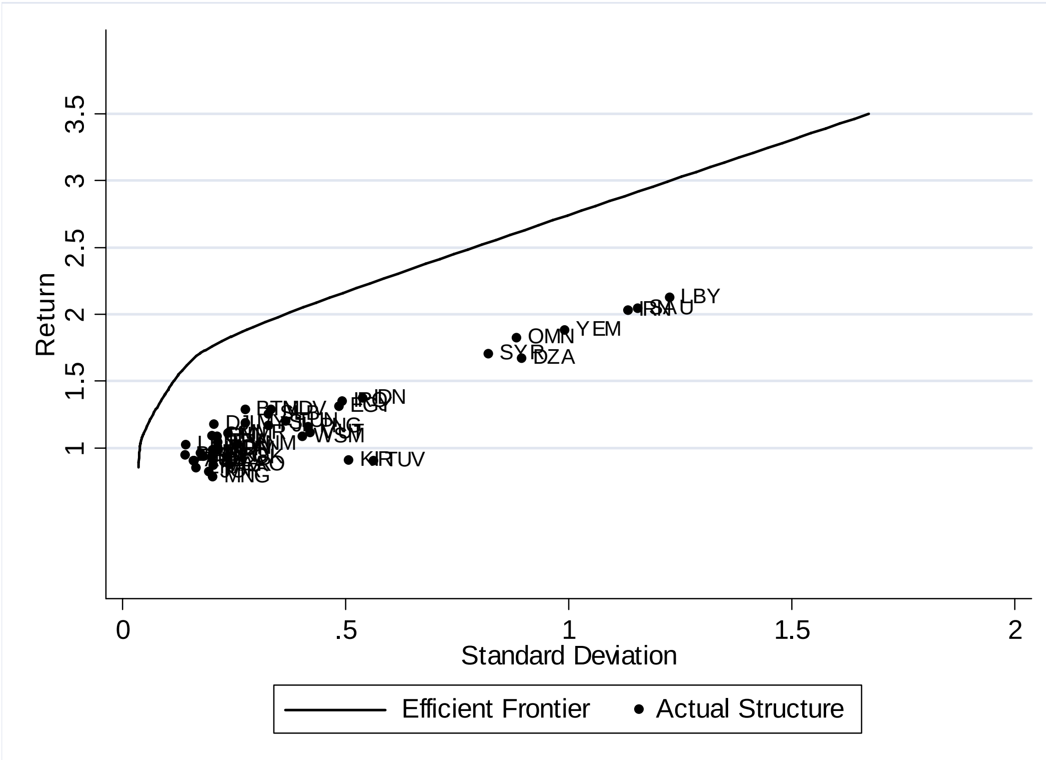

Figure 6: Efficient Frontier, Optimum Points, and Actual Structures

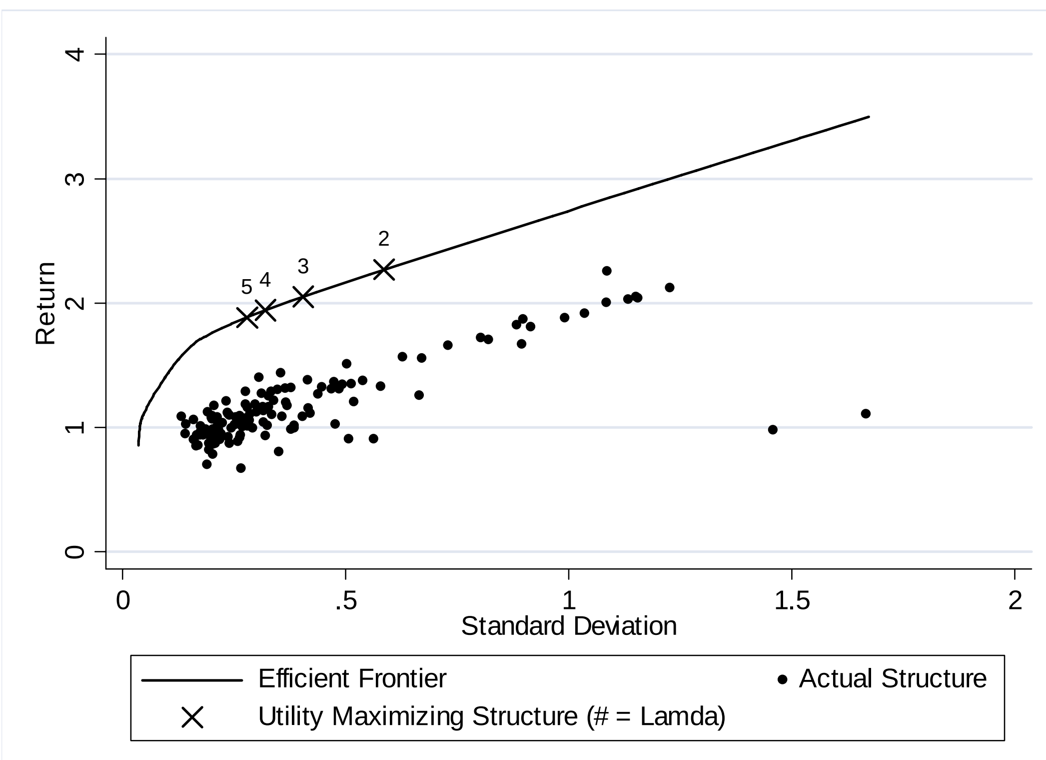

Table 1: Diversification

Country	Herfindahl	Highest Export(%)	Commodity
Lybia	0.94	96.9	Petroleum
Nigeria	0.66	92.3	Petroleum
US Virgin Isds	0.83	91.3	Petroleum
Saudi Arabia	0.83	90.8	Petroleum
Cook Isds	0.83	90.9	Glassware
Iran	0.81	90.0	Petroleum
Sao Tome & Principe	0.81	89.9	Cocoa
Venezuela	0.74	85.4	Petroleum
Tuvalu	0.72	82.2	Oil seeds, nuts
Burundi	0.71	82.9	Coffee
Botswana	0.69	83.1	Glassware
Yemen	0.69	75.2	Petroleum
Zambia	0.65	78.3	Copper
Gabon	0.65	78.2	Petroleum
Oman	0.63	67.2	Petroleum
Zimbabwe	0.12	28.8	Tobacco
Peru	0.11	15.9	Ores
Philippines	0.11	13.0	Electrical M.
Jordan	0.11	25.3	Fertilizers
Malaysia	0.11	12.7	Petroleum
Pakistan	0.10	13.3	Textiles
Uruguay	0.10	18.7	Meat
Turkey	0.08	15.6	Clothing
China	0.07	13.5	Clothing
Thailand	0.06	10.4	Rice
Argentina	0.06	8.2	Feed
India	0.05	11.5	Glassware
Brazil	0.05	11.2	Coffee
South Africa	0.04	11.9	Glassware
Lebanon	0.04	6.3	Manuf. nes
	Mean	**St.Dev.**	
Sub-Saharan Africa	0.17	0.24	
Lat. Am. & Carrib.	0.18	0.19	
East Asia & Pacific	0.13	0.19	
Central Asia	0.06	0.06	
South Asia	0.10	0.12	
Middle East & N. Africa	0.28	0.32	
Total	0.17	0.23	

Table 2: Welfare Gains

Country	Welfare Gain	Return (Rank)	St.Dev. (Rank)
Tuvalu	2.56	15	107
Guinea	2.41	1	52
Libya	2.20	125	125
Kiribati	1.94	16	102
Malawi	1.90	2	16
Togo	1.80	4	82
Nigeria	1.80	124	124
Saudi Arabia	1.49	121	122
US Virgin Isds	1.43	123	123
Iran	1.39	122	121
Mongolia	1.33	3	27
Jordan	1.07	5	17
Guinea-Bissau	1.07	45	100
Sao Tome and Principe	1.00	91	109
Guyana	0.96	11	47
Djibouti	0.27	81	30
Colombia	0.26	101	98
Solomon Isds	0.26	90	77
Mozambique	0.24	85	42
Panama	0.24	93	72
Maldives	0.23	95	79
Ecuador	0.23	112	111
Barbados	0.22	94	70
Martinique	0.21	100	90
Cape Verde	0.20	105	93
Mexico	0.20	104	92
Bhutan	0.20	96	58
Antigua and Barbuda	0.16	109	101
French Guiana	0.13	106	64
Namibia	0.13	108	84
	Mean	**St.Dev.**	
Sub-Saharan Africa	0.68	0.47	
Lat. Am. & Carrib.	0.49	0.28	
East Asia & Pacific	0.69	0.61	
Central Asia	0.76	0.03	
South Asia	0.58	0.25	
Middle East & N. Africa	0.80	0.57	
Total	0.61	0.46	

Note: Welfare gain is reported as δ times 100.

Table 3: GMM Estimates using as (Exports + Imports)/GDP as Proxy for Openness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. Var.:	**Return**	**St. Dev.**	**E(U)**	**E(U)**	**E(U)**	**E(U)**	**E(U)**	**E(U)**
Risk. Av.:	---	---	$\lambda = 2$	$\lambda = 3$	$\lambda = 4$	$\lambda = 5$	$\lambda = 2$	$\lambda = 5$
Int. Subst.:	---	---	$\theta = 2$	$\theta = 2$	$\theta = 2$	$\theta = 2$	$\theta = 5$	$\theta = 5$
OPEN	1.923***	0.649***	0.050***	0.050***	0.019	-0.150***	0.465***	0.185
	(0.380)	(0.214)	(0.008)	(0.008)	(0.014)	(0.031)	(0.111)	(0.229)
GDPC	-0.040***	-0.022***	-0.001***	-0.001***	-0.001***	-0.003***	-0.005	0.000
	(0.007)	(0.007)	(0.000)	(0.000)	(0.000)	(0.001)	(0.004)	(0.006)
Obs.	1233	1233	1233	1233	1233	1233	1233	1233
Countries	63	63	63	63	63	63	63	63
F-b	20501***	582***	549***	1015***	206***	6467***	147***	122***
Sargan	37.55	29.70	24.74	35.41	35.11	36.39	27.66	27.04

Table 4 : GMM Estimates using as Sachs-Warner Trade Liberalisation Index as Proxy for Openness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. Var.:	**Return**	**St. Dev.**	**E(U)**	**E(U)**	**E(U)**	**E(U)**	**E(U)**	**E(U)**
Risk. Av.:	---	---	$\lambda = 2$	$\lambda = 3$	$\lambda = 4$	$\lambda = 5$	$\lambda = 2$	$\lambda = 5$
Int. Subst.:	---	---	$\theta = 2$	$\theta = 2$	$\theta = 2$	$\theta = 2$	$\theta = 5$	$\theta = 5$
OPEN	0.023	0.044***	-0.000	-0.001**	-0.002***	-0.004**	-0.004	-0.028***
	(0.014)	(0.010)	(0.000)	(0.000)	(0.001)	(0.002)	(0.003)	(0.007)
GDPC	-0.015	-0.009	0.000*	0.000	0.001*	0.009**	0.006*	0.015**
	(0.009)	(0.009)	(0.000)	(0.000)	(0.001)	(0.004)	(0.003)	(0.006)
Obs.	1233	1233	1233	1233	1233	1233	1233	1233
Countries	63	63	63	63	63	63	63	63
F-b	1681***	10352***	84***	922***	6243***	368***	482***	2506***
Sargan	27.03	26.65	19.54	22.24	25.66	22.20	23.32	22.86