Openness, Volatility and the Risk Content of Exports*

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Abstract

It has been observed that more open countries experience higher output growth volatility. This paper uses an industry-level panel dataset of manufacturing production and trade to analyze the mechanisms through which trade can affect the volatility of production. We find that sectors with higher trade are more volatile and that trade leads to increased specialization. These two forces act to increase overall volatility. We also find that sectors which are more open to trade are less correlated with the rest of the economy, an effect that acts to reduce aggregate volatility. The point estimates indicate that each of the three effects has an appreciable impact on aggregate volatility. Added together they imply that a one standard deviation change in trade openness is associated with an increase in aggregate volatility of about 15% of the mean volatility observed in the data. The results are also used to provide estimates of the welfare cost of increased volatility under several sets of assumptions. We then propose a summary measure of the riskiness of a country's pattern of export specialization, and analyze its features across countries and over time. There is a great deal of variation in countries' risk content of exports, but it does not have a simple relationship to the level of income or other country characteristics.

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1 Introduction

World international trade has experienced exponential growth over the past two decades. The benefits and costs of increased integration remain the subject of a hotly contested debate. In particular, it has often been suggested that greater trade openness increases uncertainty because it exposes a country to external shocks (Rodrik 1997, ILO 2004). In a cross-country framework, Easterly, Islam and Stiglitz (2001) and Kose, Prasad and Terrones (2003) have found that higher de facto trade openness increases the volatility of output growth.[1] Moreover, Rodrik (1998) provides evidence that higher income and consumption volatility is strongly associated with exposure to external risk, proxied by the interaction of overall trade openness and terms of trade volatility.

Existing cross-country studies leave open the question of what are the mechanisms behind the openness-volatility link. For example, does trade affect volatility primarily by exposing industries to external shocks? Or because it changes the comovement properties of the trading sectors with the rest of the economy? Or does trade perhaps affect production patterns, resulting in a less diversified economy or specialization in more risky sectors?[2] This paper answers these questions by examining the relationship between trade openness and volatility using industry-level data on production and trade.

We begin by testing three hypotheses. The first is that volatility is higher in sectors that are more open to trade. It has been suggested that in an economy open to international trade, an industry is more vulnerable to world supply and demand shocks (Newbery and Stiglitz 1984). Furthermore, if trade opening increases the elasticity of labor demand, then not only output, but also wages and employment are more volatile in the presence of shocks (Rodrik 1997). The second hypothesis is that trade affects aggregate volatility by changing comovement between the sectors. For instance, when a sector is very open, it may depend more on global shocks to the industry, and less on the domestic cycle (Kraay and Ventura 2001). This channel has not, to our knowledge, been investigated empirically in the literature. The third hypothesis is that trade raises overall volatility because it leads to specialization and thus a less diversified production structure. We go beyond testing for the existence of the three effects, and quantify their relative importance for aggregate volatility using our estimates.

We then investigate another reallocation effect, which is that some countries specialize systematically in more or less risky sectors. We provide a classification of countries according to their *risk content of exports*, which is a summary measure intended to capture the riskiness of a country's export patterns.

[1] Furthermore, Kose et al. (2003) and Bekaert, Harvey and Lundblad (2004) find that greater trade openness also increases the volatility of consumption growth, suggesting that the increase in output volatility due to trade is not fully insured away.

[2] Koren and Tenreyro (2005) emphasize that aggregate volatility can arise from volatility of individual sectors, patterns of specialization, and the covariance properties of sectors with the aggregate shocks.

This paper uses data on production, value added, employment, and wages for the manufacturing sector from United Nations Industrial Development Organization (2005), and combines them with the World Trade Database (Feenstra et al. 2005) for the period 1970–99. The resulting dataset is a three-dimensional unbalanced panel of 59 countries, 28 manufacturing sectors, and 30 years.[3] Our approach has several advantages over the more traditional country-level analysis. First, an extra dimension in our panel allows us to include a much richer array of fixed effects in order to control for many possible unobservables, such as time-varying sector or country characteristics, or characteristics of individual country-sector pairs. Second, there is no natural tendency for exports to equal imports at sector level, making it possible to distinguish between the consequences of greater exports and those of greater import penetration. Third, besides looking at the volatility of GDP per capita (the standard measure used in previous studies), we are also able to look at other outcome variables, such as employment, wage, and price volatility at the industry level.

The main results can be summarized as follows. First, trade openness is positively correlated with volatility at the industry level. This result is remarkably robust for all volatility measures considered, over different sized panels, and to the inclusion of a plethora of fixed effects. Interestingly, once we look at exports and imports separately, it appears that importing in a sector increases volatility more than exporting. Second, more trade in a sector results in a lower correlation between growth in that sector and aggregate growth, an effect that leads to a reduction in aggregate volatility, all else equal. Third, trade is associated with greater specialization, which works as a channel for creating increased volatility.[4]

The point estimates can be used to calculate how important are the three effects quantitatively when it comes to their impact on aggregate volatility. It turns out that an increase in sector-level volatility that comes from a one standard deviation change in trade raises aggregate volatility by about 16.1% of the average aggregate variance observed in the data, all else held equal. The reduction in comovement due to increased trade leads to a *fall* in aggregate volatility roughly equivalent to 8.3% of its average. Increased specialization in turn implies an increase in aggregate variance of 7.5%. Adding up the three effects, our estimates imply that a one standard deviation increase in trade openness raises aggregate volatility by about 15% of the average aggregate variance observed in the data.

We then calculate the welfare impact of increased volatility following the methodology of Lucas (1987) under two sets of assumptions. In the first exercise, we assume there is no risk sharing

[3]The UNIDO database does not contain information on non-manufacturing sectors. Unfortunately, this limitation most probably leads to an understatement of the impact of openness on volatility for those countries which rely heavily on commodity exports, and are thus more vulnerable to global price shocks (Kose 2001). On the other hand, by examining the manufacturing sector alone we are able to focus on a sector that is generally considered key to a country's development process.

[4]An important caveat is in order to interpret our results. In this paper, we measure trade openness by actual trade in a sector, rather than by trade barriers.

across sectors and thus each agent faces income volatility typical of an individual sector.[5] Second, we assume perfect risk sharing across sectors, and calculate the welfare impact of trade due to its overall effect on aggregate volatility discussed above. We view the two exercises as providing an upper and a lower bound for welfare impact, respectively. The assumption of zero risk sharing is clearly extreme. However, micro evidence shows that risk sharing across individuals is far from complete even in the most developed countries (Attanasio and Davis 1996, Hayashi, Altonji and Kotlikoff 1996). Under the assumption of perfect risk sharing across sectors, our calculations show that trade-induced increases in aggregate volatility lead to a welfare loss of between 0.05% and 0.5% of consumption, depending on risk aversion. However, the welfare loss calculated based on volatility at the sector level is an order of magnitude higher, ranging from 0.4% to 4.3% of consumption.

To summarize, all three channels – sector-level volatility, comovement, and specialization – have a sizeable impact on aggregate volatility. Furthermore, the welfare-cost estimates imply that the volatility consequences of trade are potentially quite significant, especially when there is little within-country risk sharing.

While it is informative to analyze each of the three effects separately, there could be important interactions between them. In particular, if some sectors are inherently more risky than others, countries' exposure to external risk will vary with their patterns of specialization. In order to assess whether countries differ in the riskiness of their export structure, we construct a measure of the risk content of exports for each country and over time. In order to do so, we first estimate a variance-covariance matrix for our set of sectors using a methodology similar to Koren and Tenreyro (2005). We then use information on countries' export shares in each sector to construct an index of a country's risk content of exports. A country's export structure is more risky when its exports are highly undiversified, or when it exports in riskier sectors. Looking at the patterns of the risk content of exports yields some striking conclusions. The countries with the safest export structures are actually some of the poorest and least diversified countries in our sample. Their risk content of exports is low because they specialize in the safest sectors. Advanced countries are in the middle and bottom half of the riskiness distribution. Their exports are typically fairly diversified. The most risky countries in our sample are middle-income countries, whose exports are highly concentrated in volatile industries such as Petroleum and Metals. We also illustrate that the risk content of exports is positively correlated with standard measures of volatility, such as the variance of the terms-of-trade or of output growth.

The paper is organized as follows. Section 2 describes the data and empirical strategy. Section 3 describes the regression results, as well as the magnitudes of the estimated effects and the welfare

[5]This is in the spirit of Krebs, Krishna and Mahoney (2005), who examine the impact of trade on labor-income volatility using household-level data in Mexico, and use their estimates to calculate the welfare impact of trade liberalization.

implications. Section 4 constructs and analyzes a measure of the risk content of exports for the countries in our sample. Section 5 concludes.

2 Data and Empirical Strategy

Data on industry-level production, value added, employment, and wages at the sector level come from the 2005 UNIDO Industrial Statistics Database. We use the version that reports data according to the 3-digit ISIC Revision 2 classification for the period 1963–2002 in the best cases. There are 28 manufacturing sectors in total, plus the information on total manufacturing. We use data reported in current U.S. dollars, and convert them into constant international dollars using the Penn World Tables (Heston, Summers and Aten 2002).[6] We also correct inconsistencies between the UNIDO data reported in U.S. dollars and domestic currency. We dropped observations which did not conform to the standard 3-digit ISIC classification, or took on implausible values, such as a growth rate of more than 100% year to year. We also removed countries for which the production data and the trade data were not conformable. The resulting dataset is an unbalanced panel of 59 countries, but we insure that for each country-year we have a minimum of 10 sectors, and that for each country, there are at least 10 years of data.

We combine information on sectoral production with information on international trade flows from the World Trade Database (Feenstra et al. (2005)). This database contains bilateral trade flows between some 150 countries, accounting for 98% of world trade. Trade flows are reported using the 4-digit SITC Revision 2 classification. We aggregate bilateral flows across countries to obtain total imports and exports in each country and manufacturing sector. We then convert the trade flows from SITC to ISIC classification and merge them with production data.[7] The final sample is for the period 1970–99, giving us three full decades.

Appendix Table A1 reports the list of countries in our sample, along with some basic descriptive statistics on the average growth rate of output per worker in the manufacturing sector, its standard deviation, its import penetration, and the share of output that is exported. There is some dispersion in the average growth rates of the manufacturing output per worker, with Tanzania at the bottom with a growth rate of −3.2% per year over this period, and Pakistan at the top with 5.8% per year. There are also differences in volatility, with the United States having the least volatile manufacturing sector, and Senegal the most. Import penetration and the share of total manufacturing production that gets exported vary a great deal across countries. Appendix Table A2 lists the sectors we use in the analysis, along with the similar descriptive statistics. Growth

[6] Using the variable name conventions from the Penn World Tables, this deflation procedure involves multiplying the nominal U.S. dollar value by $(100/P) * (RGDPL/CGDP)$ to obtain the constant international dollar value.

[7] The merge is based on the concordance found on the International Trade Resources website maintained by Jon D. Haveman: `http://www.haveman.org`.

rates of output per worker across sectors are remarkably similar, ranging from roughly 1% per year for leather products to 4% for industrial chemicals. We can see that individual sectors have much higher volatility than manufacturing as a whole, and differ among themselves as well. The least volatile sector, food products, has an average standard deviation of 11%. The most volatile sector is petroleum refineries, with a standard deviation of 23%.

Using our data, we can calculate the variance of the growth rate of total manufacturing output per worker, and compare it with the variance of per capita GDP growth from Penn World Tables. The scatterplot of that comparison, in logs, is presented in Figure 1, along with a linear regression line. We can see that there is a close relationship between the two, with the correlation coefficient of around 0.7. The volatility of manufacturing output growth from the UNIDO dataset is considerably higher than the volatility of per capita GDP growth from Penn World Tables. This is sensible, because manufacturing output is a subset of GDP.

Figure 2 reports a scatterplot of trade openness and volatility of the manufacturing sector for the countries in the sample, along with a regression line. While the relationship is not extremely strong (the R^2 of this bivariate regression is around 0.1), there does seem to be a positive relationship between trade openness and volatility in our sample. We now move on to an in depth analysis of this relationship at the sector level.

2.1 Empirical Strategy

In an economy comprised of $\mathcal{I}$ sectors, the volatility of aggregate output growth σ_A^2 can be written as follows:

$$\sigma_A^2 = \sum_{i=1}^{\mathcal{I}} a_i^2 \sigma_i^2 + \sum_{i=1}^{\mathcal{I}} \sum_{\substack{j=1 \\ j \neq i}}^{\mathcal{I}} a_i a_j \sigma_{ij}, \tag{1}$$

where a_i is the share of sector i in total output, σ_i^2 is the variance of output growth in sector i, and σ_{ij} is the covariance between sectors i and j. Trade can change overall volatility through changing the variance of each sector separately (σ_i^2), through changing the covariance properties between the sectors (σ_{ij}), or through changing the production structure of the economy (a_i). This paper analyzes each of these mechanisms in turn.

We run ordinary least square (OLS) regressions using data for the period 1970–99. We estimate both cross-sectional and panel specifications. The advantage of the cross-sectional specifications is that they allow us to calculate our left-hand side variables — variances and covariances — over a long time series, reducing measurement error. The advantage of the panel specifications is that they make it possible to control for a much richer array of fixed effects. We estimate both five-year and ten-year panel specifications. As the conclusions are remarkably similar across specifications, we report only the cross-sectional and ten-year panel results to conserve space.[8]

3 Results

3.1 Trade and Volatility within a Sector

We first analyze the effects of trade on the volatility of output within a sector (σ_i^2 in equation (1)). The main specification is:

$$\text{Volatility}_{ict} = \alpha_0 + \alpha_1 \text{Output}_{ict} + \beta \text{Trade}_{ict} + \mathbf{u}_{ict} + \varepsilon_{ict}, \quad (2)$$

where i denotes sector, c denotes country, and t denotes time. The left-hand side, Volatility_{ict}, is the log variance of the annual growth rate of output per worker. In the cross-sectional specifications, the variance is computed over the entire sample period, 1970–99. In panel specifications, the volatility is computed over non-overlapping ten year periods: 1970–79, 1980–89, 1990–99. The trade measures are (i) total trade/output, (ii) exports/output and imports/ouput in each sector. The openness measures are averages for the same time periods over which the left-hand side variables are computed, and are always in logs. We proxy for sector-specific, time-varying productivity by including the log of the average output per worker, Output_{ict}, over the relevant period as one of the regressors.

We experiment with various configurations of fixed effects $\mathbf{u}_{ict}$. The cross-sectional specifications include both country and sector fixed effects. The panel specifications include country×sector fixed effects, country×time fixed effects, and sector×time fixed effects in alternative specifications. We view the ability to control for various fixed effects as a major strength of our empirical approach. In a three-dimensional panel, we can use fixed effects to take out country-specific time trends, global sector-specific trends, and non-time-varying effects of each sector in each country. Taken together, our specifications allow us to address a wide range of omitted variables concerns. In all panel specifications, the error term ε_{ict}, is clustered at the country×industry level.[9]

Table 1 presents the cross-sectional results for the volatility output per worker growth. Panel A considers total trade, whereas Panel B presents results for imports and exports separately. The first column reports the results of the most basic regression, while columns (2) through (4) add progressively more fixed effects. Overall trade openness, measured as the share of exports plus imports to total output in a sector, is always positively correlated with volatility. This result is robust to the inclusion of any fixed effect and is very statistically significant, with t-statistics in the range of 8–10. The point estimates are also quite stable across specifications.

[8] This work does not address potential issues of endogeneity, though, arguably, this concern is smaller when examining the link between volatility and openness than when considering the impact of openness on growth.

[9] This is the most conservative clustering of errors, which also helps to deal with autocorrelation as shown by Bertrand, Duflo and Mullainathan (2004).

Panel B of Table 1 looks at the impact of imports and exports separately. Imports are robustly positively correlated with volatility across all specifications. This result may reflect the impact of competition at the domestic level from foreign production. In particular, sectors that are more open to imports will experience more pressure to adjust to changes in global conditions. Theoretically, this adjustment need not be through production, but rather through profits or wages. It is clear from these results, however, that import competition affects the volatility of production, rather than being absorbed by changes in wages or profits.

The impact of exports on volatility is somewhat more ambiguous. In the specification without fixed effects, or with sector fixed effects only (columns (1) and (2)), exporting more has a negative and significant effect on volatility, of about half the impact of imports in absolute value. However, when country effects are included, the sign reverses: exports appear to have a positive effect on volatility. The fact that the sign on exports changes with the inclusion of country fixed effects may indicate that the most open countries also specialize in the least volatile sectors. We investigate this possibility further in later sections. Alternatively, the country effects may also pick up the fact that richer countries, which tend to be less volatile overall, are also more open on the export side on average.

As an aside, it is also interesting to note that coefficient on sector productivity is negative and significant when country fixed effects are not included (but when sector fixed effects are). This result is reminiscent of the negative growth-volatility relationship that has been observed at the country level. However, including country fixed effects actually reverses this finding at the industry level. This apparent difference between country-level and sector-level growth-volatility relationship corroborates the findings of Imbs (2004).

Table 2 reports estimation results for the 10-year panel regressions. We include specifications with no fixed effects, country, sector, time effects separately and together, and then interacted with each other. The most stringent specification, in terms of degrees of freedom, includes country×sector and time fixed effects. Panel A reports the results for overall trade. The coefficients on trade openness are actually remarkably stable across specifications, being noticeably lower only in column (7), which includes country×sector fixed effects. Nonetheless, the results are statistically significant at the one percent level in each case. Panel B separates the effects of exports and imports. The results confirm what we find in the cross-section: imports are robustly positively correlated with volatility. Exports, on the other hand, show a negative and significant correlation when no country effects are included, and a positive and significant correlation with country effects. Point estimates show the effect of exports being about one half to one third as strong as the effect of imports. Overall, the cross-sectional and panel results yield remarkably similar conclusions.

The effect of trade on volatility, while highly significant, is not implausibly large quantitatively. In particular, a one standard deviation increase in our right-hand side trade variable, the log of exports plus imports to GDP, results in an increase in the log variance of output per worker growth of between 0.1 and 0.25 standard deviations, depending on the coefficient estimate used. Examining exports and imports separately, it appears that about two thirds of that effect is due to imports.

3.1.1 Trade and Volatility of Other Variables

Given the strong effect of trade on the volatility of output per worker, it is worth investigating further. In particular, we would like to know whether higher trade openness increases the volatility of prices or quantities, and how it impacts labor outcomes. We present these two sets of results in turn.

The data on sector-specific price levels can be obtained from the UNIDO database. Along with information on the nominal value of output, the UNIDO database reports sector-level indices of production, which can be thought of as proxies for quantity. Using these two variables, we construct the growth rate of the sector-specific price level, and then its volatility.[10]

Part I of Table 3 reports the results of estimating the cross-sectional version of equation (2), using the log volatility of prices instead of output on the left-hand side. It is clear that higher price variability is an important channel through which trade raises volatility. The effect of total trade is significant at the one percent level in each specification, and the coefficient is quite stable. From Panel I.B, which includes exports and imports separately, it is clear that imports are primarily responsible for this effect, just as it was in the output volatility specifications. In fact, if one does not include country fixed effects, exports have a modest negative effect on price volatility.

As an alternative to constructing price volatility, we also use the variables in the UNIDO database to construct a proxy for markups. Following Braun and Raddatz (2005), we define the price-cost margin as:

$$\text{PCM}_{ict} = \frac{\text{Value of Sales}_{ict} - \text{Payroll}_{ict} - \text{Cost of Materials}_{ict}}{\text{Value of Sales}_{ict}}$$

This measure represents a different approach to assessing the volatility of prices. On the one hand it is less general, and presupposes that the volatility of prices is directly related to markups. On the other, it is constructed from arguably higher-quality underlying data, and has previously been used in the literature. Part II of Table 3 presents the cross-sectional results. It is clear that the volatility of markups increases with trade, similar to the price results. One important difference is that the effect of exports on the volatility of markups is as important as the effect of imports, once country and industry fixed effects are included. Panel regression estimates for the volatilities of prices and price-cost margins can be found in Appendix Table A3. We do not discuss them separately here, as the results only confirm what we see in the cross-section.

[10]Namely, if OUTPUT_{ict} is nominal output, and INDPROD_{ict} is the index number of industrial production, then the sector-specific growth rate of prices is $\text{GrowthP}_{ict} = \log((\text{OUTPUT}_{ict}/\text{OUTPUT}_{ic(t-1)})/(\text{INDPROD}_{ict}/\text{INDPROD}_{ic(t-1)}))$.

As discussed in the introduction, one of the possible costs of greater integration is increased insecurity for workers, which could manifest itself in uncertainty over both employment prospects and earnings (for micro evidence on this, see also Krebs et al. 2005). We next examine the effect of trade on the volatility of employment and wages.

Part I of Table 4 presents the cross-sectional results of estimating equation (2) using the log volatility of employment as the dependent variable. As with output volatility, total trade raises the volatility of employment in a sector. When imports and exports are included separately on the right-hand side, import penetration accounts for most of the overall effect. As a side note, the effect of sector productivity is always negative and significant, regardless of the fixed effects included — a difference from the output volatility specification.These results can be interpreted as complementary to those on price volatility. We find that not only do prices become more volatile, but, perhaps as a result, real activity responds as well.

Part II of Table 4 presents the cross-sectional results for the volatility of wages. We estimate equation (2) with log variance of wage growth on the left-hand side. The effect of trade openness on wage volatility is comparatively weaker. At times the coefficients are not statistically significant, and in some specifications the effect of trade on wage volatility is negative. The bottom line is that the impact of trade on output and employment volatility is more easily established in the data. This finding is sensible, given the conventional wisdom that wages are sticky. Panel regression estimates of the effect of trade on volatilities of employment and wages can be found in the Appendix Table A4, and are virtually identical to the cross-sectional results.

3.2 Trade and Sector Comovement

We now analyze the second channel through which trade can affect aggregate volatility. Referring back to equation (1), we look at how trade in a sector affects that sector's comovement with the rest of the economy. To operationalize this, we can rewrite equation (1) as:

$$\sigma_A^2 = \sum_{i=1}^{\mathcal{I}} a_i^2 \sigma_i^2 + \sum_{i=1}^{\mathcal{I}} a_i (1 - a_{A-i}) \rho_{i,A-i} \sigma_i \sigma_{A-i}, \tag{3}$$

where the subscript $A - i$ is used to denote the sum of all the sectors in the economy except i. Thus, $\rho_{i,A-i}$ is the correlation coefficient of sector i with the rest of the economy, and σ_{A-i} is the standard deviation of the aggregate output growth excluding sector i. This way, rather than writing the aggregate variance as a double sum of all the covariances of individual sector pairs, equation (3) rewrites it as the sum of covariances of each sector i with the rest of the economy.

Based on this expression, we estimate the following relationship in the cross-section and in 10-year panels:

$$\text{Correlation}_{ict} = \alpha_0 + \alpha_1 \text{Output}_{ict} + \beta \text{Trade}_{ict} + \mathbf{u}_{ict} + \varepsilon_{ict}, \tag{4}$$

The right-hand side variables are the same as in the volatility specifications (Section 3.1). We analyze both the effect of total trade openness and the role of imports and exports separately. The left-hand side variable is the correlation between output per worker growth in sector i with the overall manufacturing excluding that sector. In the cross-sectional specifications, these correlations are computed over thirty years. In the panel, we compute correlations over non-overlapping 10-year periods. In contrast to the volatility estimation in the previous section, the left-hand side is in levels rather than in logs because correlation coefficients can be negative. Note also that we use correlation rather than covariance. This is because the correlation coefficient is a pure measure of comovement, whereas changes the covariance are influenced by changes in the sector-level variance, which will themselves affected by trade, as shown above.

Table 5 presents the cross-sectional results. Panel A considers overall trade as a share of output. Intriguingly, more trade in a sector reduces the correlation of that sector with the rest of the economy. This negative effect is quite robust across specifications, although the significance level is typically not as high as in the volatility regressions, and the magnitude of coefficients not as stable. It is clear that increased exposure to the world cycle for a sector decouples it from the domestic economy. This covariance effect acts to reduce the overall variance in the economy, ceteris paribus. When we move to distinguish the effect of exports and imports in Panel B, it is clear that imports are responsible for the overall effect; in fact exports are not significant in the cross-sectional regressions. Thus, just as a sector that imports more becomes more vulnerable to external competition and thus more volatile, these same external conditions make it less correlated with the domestic cycle.

Table 6 presents results for the 10-year panel estimation. The results are broadly in line with those of the cross-section. Overall trade, and imports in particular, significantly reduce a sector's correlation with the rest of the economy. In contrast to the cross-sectional results, exports are significant in some specifications, but this effect is by no means robust.

The effect of trade on comovement is economically significant, but plausible in magnitude. A one standard deviation increase in the overall trade results in a decrease in correlation of between 0.05 and 0.25 standard deviations, depending on the coefficient estimate used.

3.3 Trade and Specialization

We next analyze whether trade leads to increased specialization in a small number of sectors. Going back to equation (1), we see that aside from its effect on σ_i^2's and σ_{ij}'s, trade openness can affect overall volatility through changing the configuration of a_i's. This could happen in two ways. First, trade can induce a reallocation of production shares from less volatile to more volatile sectors, or vice versa. Second, trade can result in a less diversified production structure. The former effect is the subject of the second half of this paper. We analyze the latter effect here. In particular, making the (heroic) simplifying assumption that all sectors have the same σ^2, we can rewrite equation (1) as:

$$\sigma_A^2 = h\sigma^2 + \sum_{i=1}^{\mathcal{I}} \sum_{\substack{j=1 \\ j \neq i}}^{\mathcal{I}} a_i a_j \sigma_{ij}, \tag{5}$$

where h is the Herfindahl index of production shares in the economy. A higher value of h represents a less diversified economy, and thus, at a given level of σ^2, leads to a higher aggregate volatility.

We thus compute indices of diversification directly at the country level, and relate them to trade openness. We estimate the following equation:

$$\text{Diversification}_c = \alpha_0 + \alpha_1 \mathbf{X}_c + \beta \text{Openness}_c + \varepsilon_c. \tag{6}$$

Here, c indexes a country, and the left-hand side variable is the log of the Herfindahl index of production shares of sectors in total manufacturing output. Openness_c is the log of total manufacturing trade divided by total manufacturing output in our data. $\mathbf{X}_c$ are controls such as per capita GDP. Table 7 reports estimation results for the year 1990.[11] Column (1) is the bivariate OLS regression of trade openness on the Herfindahl index, while column (2) controls for log per capita PPP-adjusted GDP from Penn World Tables. The coefficient on trade is significant at the one percent level. Since trade openness is likely endogenous to the diversification, columns (3) and (4) repeat the exercise instrumenting for trade using natural openness from Frankel and Romer (1999). Results are unchanged, while the magnitude of the coefficient increases. Breaking up the sample into OECD and non-OECD countries, as is in columns (5) and (6), we see that the phenomenon is especially prevalent in the non-OECD countries. Column (7) checks whether our results are driven by outliers. Dropping outliers actually improves the fit of the regression, and the results remain significant. Finally, columns (8) and (9) check if the results are robust to an alternative measure of trade openness. We use total trade openness as a share of GDP from the Penn World Tables instead of total manufacturing trade as a share of manufacturing output from our data. It is clear that the main result is not driven by our particular measure of trade openness. We illustrate these results in Figure 3, which presents partial correlations between trade openness and the Herfindahl index of sector shares for the available countries, once per capita income has been netted out. It is clear that there is a positive relationship between trade and the lack of diversification.

In order to probe further into this finding, we also analyze more directly how the export patterns are related to industrial specialization. We construct the Herfindahl index of export shares in a manner identical to our index of production concentration. The results are presented in Table 8. The first column replicates column (2) of the previous Table, while the second column includes the specialization regressor. The coefficient on trade openness decreases by about one third, but it

[11] We choose 1990 to maximize coverage. Re-estimating this equation for every other year in our sample yields virtually identical results.

remains significant at the one percent level. The coefficient on the Herfindahl of export shares is highly significant as well. When we split the sample into OECD and non-OECD countries, the export specialization variable is highly significant in the OECD sample, but trade on its own becomes significant as well. For non-OECD countries, both the overall trade and the export concentration are highly significant.

The effect of trade openness and export concentration on the specialization of production is sizeable. A one standard deviation change in log trade openness is associated with a change in the log Herfindahl of production equivalent to about 0.4 of a standard deviation. A one standard deviation change in export specialization is associated with a change in the log Herfindahl of production of roughly 0.65 standard deviations.

3.4 Discussion

In the preceding sections we estimated the effect of trade on the variance of individual sectors (σ_i^2), the correlation coefficient between an individual sector and the rest of the economy ($\rho_{i,A-i}$), and the Herfindahl index of sectoral concentration of production shares (h). From the regressions, we calculated the changes in these three variables that are brought about by a one standard deviation change in trade openness. In this section we perform two more exercises. First, we ask whether, according to our estimates, each of our three effects can generate a quantitatively important effect of trade on aggregate volatility. Second, we consider how changes in sector-level and aggregate volatility affect welfare.

3.4.1 Impact on Aggregate Volatility

The aggregate variance, σ_A^2, can be written as a function of σ_i^2 and $\rho_{i,A-i}$ as in equation (3), which we reproduce here:

$$\sigma_A^2 = \sum_{i=1}^{\mathcal{I}} a_i^2 \sigma_i^2 + \sum_{i=1}^{\mathcal{I}} a_i (1 - a_{A-i}) \rho_{i,A-i} \sigma_i \sigma_{A-i}. \tag{7}$$

In order to evaluate the estimated effect of trade-induced changes in σ_i^2, $\rho_{i,A-i}$, and h, we assume for simplicity that for all sectors, the variances and correlations are equal: $\sigma_i^2 = \sigma^2$, $\rho_{i,A-i} = \rho$, and $\sigma_{A-i} = \sigma_{A-}$ for all i. This allows us to write equation (7) in terms of σ^2, ρ, and h as:

$$\sigma_A^2 = h\sigma^2 + (1-h)\rho\sigma\sigma_{A-}, \tag{8}$$

Using a Taylor approximation, the effect of those changes ($\Delta\sigma^2$, $\Delta\rho$, and Δh) on the aggregate volatility is:

$$\Delta\sigma_A^2 \approx \frac{\partial \sigma_A^2}{\partial \sigma^2}\Delta\sigma^2 + \frac{\partial \sigma_A^2}{\partial \rho}\Delta\rho + \frac{\partial \sigma_A^2}{\partial h}\Delta h. \tag{9}$$

We can compute the partial derivatives using equation (8):

$$\Delta\sigma_A^2 \approx \underbrace{\left(h + (1-h)\rho\frac{\sigma_{A-}}{2\sigma}\right)\Delta\sigma^2}_{\text{[1] Sector Volatility Effect}} + \underbrace{(1-\ h)\sigma\sigma_{A-}\Delta\rho}_{\text{[2] Comovement Effect}} + \underbrace{(\sigma^2 -\ \ \rho\sigma\sigma_{A-})\Delta h}_{\text{[3] Specialization Effect}}. \qquad (10)$$

Each of the three terms represents the partial effect of the three channels we estimated on the aggregate volatility. We evaluate each of them in turn. To do so, we use the average values of the variables found in our sample. The average Herfindahl index in our sample is $h = 0.1$. The average comovement of a sector with the aggregate, $\rho = 0.34$. The average variance of a sector, $\sigma^2 = 0.03$. For the variance of the entire economy minus one sector, σ^2_{A-}, we simply use the average aggregate volatility in our sample of countries, which is 0.008. This is a sensible approximation of the volatility of all the sectors except one, since the mean share of an individual sector in total manufacturing is just under 0.04 in our sample, and thus on average, subtracting an individual sector from the aggregate will not make much difference. We obtain the values of $\Delta\sigma^2$, $\Delta\rho$, and Δh as a function of changes in openness from our estimation equations as follows:

$$\Delta\sigma^2 = \widehat{\beta}_\sigma\sigma^2\Delta\text{Log(Openness)} \qquad (11)$$

$$\Delta\rho = \widehat{\beta}_\rho\Delta\text{Log(Openness)} \qquad (12)$$

$$\Delta h = \widehat{\beta}_h h\Delta\text{Log(Openness)}, \qquad (13)$$

where $\widehat{\beta}_\sigma$ is the coefficient on the trade openness variable in equation (2), $\widehat{\beta}_\rho$ is the coefficient on trade openness obtained from estimating equation (4), and $\widehat{\beta}_h$ comes from estimating our specialization equation (6).[12]

Based on our regression results, we calculate that a one standard deviation change in sector-level trade leads to a change in sector-level variance of $\Delta\sigma^2 = 0.0068$. Using equation (10), we calculate that this increase in sector-level volatility raises aggregate volatility by 0.0013, which is of course considerably smaller than the sector-level increase, due to diversification among sectors. This change is sizeable, however, relative to the magnitudes of aggregate volatility we observe. In particular, this increase is equivalent to about 16.1% of the average aggregate variance found in our data.

Moving on to the effect of decreased comovement, our regression estimates indicate that a one standard deviation increase in trade results in a reduction of correlation between the sector and the aggregate equal to $\Delta\rho = 0.047$. Plugging this into equation (10) and evaluating the partial derivative, we obtain a reduction in the aggregate variance due to decreased comovement equal to -0.00066. This is about half the magnitude of the sectoral volatility effect. Nonetheless, it amounts to a reduction equivalent to 8.3% of the mean aggregate variance observed in our data.

[12] Note that in the estimation equations (2) and (6) the left-hand-side variable is in logs. Hence, in order to get the change in its level in equations (11) and (13), we must multiply the estimated coefficients by the average level of the variable.

Finally, according to our estimates, a one standard deviation change in overall trade openness leads to a change in the Herfindahl index of $\Delta h = 0.023$. The resulting change in aggregate volatility from this increased specialization is $\Delta\sigma_A^2 = 0.0006$. Thus, increased specialization raises aggregate volatility by about 7.5% of its mean.

Thus, our regression estimates imply changes in aggregate volatility resulting from trade that are relatively modest and plausible in magnitude. Two of the effects imply increased volatility, while the other leads to a reduction. Adding up the three effects, we obtain the overall change in aggregate volatility as implied by equation (9) of:

$$\Delta\sigma_A^2 \approx 0.0012,$$

or about 15% of average variance of the manufacturing sector observed in our data over the sample period, 1970–99.

3.4.2 Welfare

Armed with point estimates of how trade openness changes sector-level and aggregate volatility, we now evaluate the impact of increased volatility on welfare, following Lucas (1987). Specifically, we calculate the percentage increase in average consumption that leaves an agent indifferent from a trade-induced increase in consumption volatility. We perform this exercise in two ways. First, we posit that consumption volatility increases by the same amount as the sector-level volatility we estimated. This is the welfare effect in a world in which each agent derives all her income from a single sector, and does not diversify income risk across the different sectors at all. We view this calculation as an upper bound for the welfare impact, because some income risk sharing surely does exist, though it is highly incomplete even in the most developed economies (Attanasio and Davis 1996, Hayashi et al. 1996). Second, we instead assume perfect risk sharing across sectors, and evaluate the welfare impact of increased trade on the aggregate volatility calculated in Section 3.4.1 above. We view this as the lower bound for the welfare impact on the average agent. An important difference between our calculations and Lucas's is that we equate consumption volatility with income volatility — the object we can estimate with our data.[13]

Following Lucas (1987), we assume that an infinitely-lived consumer has a CRRA utility function with a relative risk aversion coefficient γ, and discount factor ϕ:

$$U(\{c_t\}) = \mathrm{E}\left\{\sum_{t=0}^{\infty}\left(\frac{1}{1-\phi}\right)^t \frac{c_t^{1-\gamma}}{1-\gamma}\right\}. \tag{14}$$

[13] This is a shortcoming because it rules out intertemporal self-insurance. In a similar exercise to ours, Krebs et al. (2005) justify this by assuming a model economy with borrowing constraints, no initial period assets, and a market-clearing interest rate.

Consumption, in turn, follows:

$$c_t = (1+\lambda)(1+\mu)^t e^{-\frac{1}{2}\omega^2}\eta_t, \tag{15}$$

where η_t is a log-normally distributed shock with mean zero and variance ω^2. We are interested in calculating a compensating variation in λ required to keep the consumer indifferent compared to her utility before the volatility increase. Specifically, let $U(\lambda, \mu, \omega^2)$ be the indirect utility from a consumption stream characterized by λ, μ, and ω^2. Suppose that volatility of consumption growth increases as a result of greater trade openness, going from ω^2_{OLD} to ω^2_{NEW}. We calculate the value of λ which solves the following equality:

$$U(\lambda, \mu, \omega^2_{NEW}) = U(0, \mu, \omega^2_{OLD}). \tag{16}$$

Lucas (1987) shows that under these functional form assumptions, this λ is given by:

$$\lambda \approx \frac{1}{2}\gamma\Delta\omega^2, \tag{17}$$

where $\Delta\omega^2 = \omega^2_{NEW} - \omega^2_{OLD}$.

To obtain the upper bound on the welfare effect of increased volatility due to trade, we set $\Delta\omega^2$ to be the increase in sector-level volatility, $\Delta\sigma^2$, given by equation (11). Plugging (11) into (17), we compute the welfare costs for a range of γ's and ΔLog(Openness)'s. The results are presented in Table 9, under rows labeled "Sector-Level". The values of λ are reported in percentage points. For a change in sector-level trade openness equivalent to moving from the 25th to the 75th percentiles observed in our data, the welfare loss ranges from 0.43% to 4.32%, for coefficients of relative risk aversion ranging from 1 to 10. Smaller movements in trade openness deliver correspondingly smaller welfare losses. Part (a) of Figure 4 depicts the welfare change graphically for a grid of γ's and ΔLog(Openness)'s.

We then perform the second type of exercise, and compute the welfare impact of the change in aggregate volatility instead: $\Delta\omega^2 = \Delta\sigma^2_A$. In order to obtain an estimate of $\Delta\sigma^2_A$, we use equation (10), and evaluate it using expressions (11)–(13) for $\Delta\sigma^2$, $\Delta\rho$, and Δh. We present the results at the bottom of Table 9, under rows labeled "Aggregate". The welfare costs from a trade-induced increase in aggregate volatility are an order of magnutude smaller than individual sector-based estimates. This is to be expected, since the second exercise allows for diversification of income shocks across sectors, and takes into account the effect of greater trade openness on reducing comovement between sectors, further helping diversification. Moving from the 25th to the 75th percentile of aggregate trade openness found in our data, the associated welfare cost ranges from 0.05% to 0.5%, as we increase the coefficient of relative risk aversion from 1 to 10. We also present results graphically in panel (b) of Figure 4, for a range of changes in trade openness and risk aversion. We interpret these results as lower bounds for the welfare effects of trade-induced volatility in the context of our exercise, since the assumption of perfect sharing of income risk across sectors is probably unrealistic.

We can compare our welfare results with previous estimates in the literature. First, our smallest estimate, given by the aggregate volatility exercise with $\gamma = 1$ (log utility), 0.05%, corresponds to the value obtained by Lucas (1987) for eliminating the business cycle in the United States. This is a small number, but the sector-level upper bound of 0.43% for $\gamma = 1$ is more than eight times larger, thereby indicating a much larger potential effect if risk sharing across sectors is incomplete. It is also interesting to compare our results with those of Pallage and Robe (2003), who consider welfare costs of the business cycle for developing countries using the Lucas model. They find that for developing countries with a moderate level of risk aversion ($\gamma = 2.5$), the cost exceeds 0.5% of permanent consumption. This value falls between our sector-level and aggregate-level bounds, though it is much closer to the sector-level values. In sum, the welfare effects that we find in our simple framework line up with the literature, and also show that the welfare impact can be quite large when breaking away from the representative agent framework and using sector-level data, a result similar to Krebs et al. (2005).

Clearly, a number of caveats that apply to this exercise. As already mentioned, we equate consumption volatility to income volatility when performing this exercise, ruling out self-insurance by saving, or international risk sharing.[14] As a related point, we make no attempt at a distinction between permanent and transitory shocks, using simply the variance of output growth. We also use the simplest possible framework, taken from the original Lucas (1987) contribution. As surveyed by Lucas (2003) and Reis (2005), the literature has since then produced a number of important extensions. While this is true, we actually perceive this to be an advantage of our estimates. All of the extensions were motivated by the desire to find larger welfare effects of volatility. The fact that we are using the basic framework actually implies that our estimates are on the conservative side. It is also worth mentioning that, though we speak of aggregate volatility, our data is for the manufacturing sector only. Finally, perhaps the most important caveat is that we are calculating the first-round welfare effect of trade through increased volatility. Thus, our approach is silent on direct effects of trade on trend growth. It is also silent on the possible second-round effects, if for instance the trade-driven increase in volatility in turn affects the growth rate, negatively (as in Ramey and Ramey 1995), or positively at sector level (as in Imbs 2004).

[14] When it comes to sharing risks internationally, evidence suggests that even in developed countries consumption behaves in ways not consistent with complete output risk sharing (Backus, Kehoe and Kydland 1992, Kehoe and Perri 2002). For developing countries, the problem is likely to be even more severe, as these countries typically experience current account behavior that on the face of it is inconsistent with consumption smoothing (Kaminsky, Reinhart and Végh 2005). Thus, evidence suggests that countries do not, to a first approximation, use international markets to insure their output risks.

4 The Risk Content of Exports

The preceding analysis could not tell us anything about the interactions of the three effects on volatility that we highlighted. In particular, while we could analyze the changes in a_i's, σ_i's, and σ_{ij}'s from equation (1) individually, the regressions would not capture any systematic pattern in whether some countries specialize in more or less risky sectors, or perhaps in sectors that exhibit especially high or low covariances. If there exist significant differences in σ_i's across sectors, and trade opening induces changes in the production structure of countries towards, or away from, the most risky sectors, it can have important effects on output volatility. We now attempt to address this issue by constructing a summary measure of risk content of exports designed to take this explicitly into account. This section is thus complementary to the regression approach above. Whereas, the previous section treated all sectors the same and focused on changes in a_i's, σ_i's, and σ_{ij}'s that come as a result of trade, this section focuses explicitly on inherent differences in σ_i's, and σ_{ij}'s across sectors, ignoring instead how trade might affect them on the margin in an average country-sector.

We first use the production data to construct a covariance matrix for the sectors; that is, we estimate σ_i^2's and σ_{ij}'s for all sectors and sector combinations using a method similar to Koren and Tenreyro (2005). This method obtains estimates of sector variances and covariances that are purged of the influences of specific countries. The result is a sector-level covariance matrix that is common across countries and years. We then use manufacturing export shares for each available country and time period to construct a summary measure of riskiness of a country's export structure. We describe the patterns of the risk content of exports and its relationship with various country characteristics. We also attempt to disentangle pure diversification effects from the average riskiness of the export sector. Because it is built using information on sector riskiness and export shares, the risk content of exports will be high both because a country's exports are undiversified, and/or because it specializes in risky sectors. The main conclusions of this exercise can be summarized as follows. Developed countries generally have low risk content of exports because they are well-diversified. However, among non-advanced countries, differences in diversification cannot account for the great dispersion in the risk content of exports. In that group, therefore, differences in the average riskiness of exports drive most of the variation in the total risk content. That is, among non-advanced countries, the safest ones are also often the least diversified: they are safe because they overwhelmingly specialize in safe sectors.

4.1 Construction of Sector Variance-Covariance Matrix

Using annual data on industry-level output per worker growth over 1970–99 for $\mathcal{C}$ countries and $\mathcal{I}$ sectors, we construct a cross-sectoral variance-covariance matrix using the following procedure. Let

y_{ict} be the output per worker growth in country c, sector i, between time $t-1$ and time t. First, in order to control for long-run differences in output growth across countries in each sector, we demean y_{ict} using the mean growth rate for each country and sector over the entire time period:[15]

$$\widetilde{y}_{ict} = y_{ict} - \frac{1}{T}\sum_{t=1}^{T} y_{ict}.$$

Second, for each year and each sector, we compute the cross-country average of output per worker growth:

$$Y_{it} = \frac{1}{\mathcal{C}}\sum_{c=1}^{\mathcal{C}} \widetilde{y}_{ict}.$$

The outcome, Y_{it}, is a time series of the average growth for each sector, and can be thought of as a global sector-specific shock. Using these time series, we calculate the sample variance for each sector, and the sample covariance for each combination of sectors along the time dimension. The sample variance of sector i is:[16]

$$\sigma_i^2 = \frac{1}{T-1}\sum_{t=1}^{T}(Y_{it} - \overline{Y_i})^2,$$

and the covariance of any two sectors i and j is:

$$\sigma_{ic} = \frac{1}{T-1}\sum_{t=1}^{T}(Y_{it} - \overline{Y_i})(Y_{jt} - \overline{Y_j}).$$

This procedure results in a 28×28 variance-covariance matrix of sectors, which we call Σ. By virtue of its construction, we think of it as a matrix of inherent variances and covariances of sectors, and it is clearly time- and country-invariant. The panel data used to compute Σ is the same sample as was used in the regression analysis above, and comprises of 59 countries. We report the results in Table 10. Since presenting the full 28×28 covariance matrix is cumbersome, the Table reports its diagonal: the variance of each sector, σ_i^2. The Petroleum Refineries sector is the most risky while Food Products and Electric Machinery sectors are among the least risky.

How robust is this procedure? While this risk measure has been purged of country×sector specific effects, it is nonetheless very highly correlated with the simple variance reported in Appendix Table A2, in which all the observations across countries and years have been pooled. The simple correlation coefficient between the two is 0.79, and the Spearman rank correlation is 0.77. We also

[15] This is equivalent to regressing the pooled sample of output per worker growth on country×sector dummies and retaining the residual.

[16] In a perfectly balanced panel of countries, sectors, and years, $\overline{Y_i} = \frac{1}{T}\sum_{t=1}^{T} Y_{it} = 0$ by construction. In our unbalanced panel, this is strictly speaking not the case when computing the sample mean, though it makes virtually no difference for the resulting variance and covariance estimates.

attempt to see whether our estimates are sensitive to the particular sample used, by constructing estimates of Σ in several subsamples. First, we break our country sample into OECD and non-OECD countries, and construct Σ for each of these. The resulting matrices are quite similar: the correlation between sector-specific variances estimated on the two subsamples is 0.84, and the Spearman rank correlation is 0.79. Thus, applying Σ to the entire sample of countries is unlikely to appreciably affect our results. Another concern is that countries differ significantly in their sectoral specialization. Thus, by pooling across countries, we are not making any distinction based on whether a country is a net importer or exporter in a given industry. In order to see whether these differences are important, we construct Σ on the subsamples of net exporters and net importers in each sector. This way, in a given country, some of the sectors will end up in the net exporters sample, while others will be in the net importers sample. It turns out that the estimates of Σ from these subsamples are quite similar, with the correlation of 0.87 and the Spearman rank correlation of 0.75. Notably, the most volatile sector, Petroleum Refineries, is actually slightly less volatile in the net exporters sample. Finally, we also break up the sample into two subperiods, 1970–84 and 1985–99. The results are once again very similar, with the correlation between the two subperiods of 0.96 and Spearman rank correlation of 0.78. Overall, the latter period seems to be somewhat less volatile.

How does our estimate of sector-specific volatility compare to other sector characteristics? It does not seem to be highly correlated with average sector growth, with a rank correlation of 0.14. Surprisingly, the Spearman rank correlation between our sector risk measure and the external dependence from Rajan and Zingales (1998) is low and negative, −0.12. The same is true for the measures of liquidity needs used by Raddatz (2005). Depending on which variant of the Raddatz measure we use, the correlation is either zero or mildly negative. The correlations between sector riskiness and measures of reliance on institutions from Cowan and Neut (2002) are also not very strong.[17] Sector riskiness does seem to be somewhat correlated with capital intensity, reported in Cowan and Neut. The simple correlation is 0.6, while the Spearman rank correlation is 0.38.

4.2 Construction of the Risk Content of Exports

For each country and year, we construct shares of each sector in total manufacturing exports, a^X_{ict}. Using the sectoral variance-covariance matrix Σ, and the industry shares of exports for each country and each year, we define the risk content of exports as:

$$RX_{ct} = \mathbf{a^X_{ct}}'\Sigma\mathbf{a^X_{ct}},$$

[17] These authors use measures of product complexity — the number of intermediate goods used and the Herfindahl index of intermediate good shares — to proxy for reliance on contracting institutions. Our sector riskiness measure is actually somewhat positively correlated with the former, but negatively with the latter.

where $\mathbf{a_{ct}^X}$ is the 28×1 vector of a_{ict}^X. The resulting measure is simply the aggregate variance of the entire manufacturing export sector of the economy. We used production data to construct Σ. However, the construction of the risk content of exports measures does not rely on production data. Thus, we can build measures of risk content of exports for the entire sample in the World Trade Database, or about 135 countries.

Appendix Table A5 reports the risk content of exports in our sample of countries for 1995, along with information on the top two export sectors, the share of the top two export sectors in total manufacturing exports, and the simple Herfindahl index of manufacturing export shares. The latter is meant as a measure of export diversification that does not take into account riskiness differences among sectors.

Differences in the risk content of exports are large. Estimated variance of the manufacturing export sector ranges from 0.0002 to 0.01, which is equivalent to a 63-fold difference in variance, or about an 8-fold difference in standard deviation. Countries with the highest risk content of exports are mainly those with a high export share of Petroleum Refineries (Algeria, Kuwait, Saudi Arabia), followed by exporters of Non-Ferrous Metals, the second most volatile sector in our sample (Zambia, Chile). What is surprising is that among the countries with the lowest risk content of exports are also some of the poorest and least diversified. Thus, it seems that for these countries, a low risk content of exports reflects mostly a high export concentration in the least risky industries, mainly Food Products, Textiles, and Clothing. In the center of the distribution, we find most of the advanced economies, with a high share of exports in medium risk industries such as Transportation Equipment and Machinery, and a diversified export base. Those characteristics are shared by a few emerging economies such as Korea, Mexico and Indonesia.

The risk content of exports does not exhibit a strong relationship with the usual country outcomes, such as per capita income, institutions, or financial development. Figure 5 plots for 1995 the log risk content of exports against the log level of PPP-adjusted income per capita, along with the least squares regression line. While there does seem to be a negative relationship, it is not very pronounced. In particular, even some of the poorest countries in our sample (Tanzania, Ethiopia, Burundi) have the same level of risk content of exports as some of the richest ones (Finland, Norway, Australia). It seems that differences in the risk content of exports are not driven primarily by differences in income. The relationship between the quality of institutions (taken from Kaufmann, Kraay and Mastruzzi 2005) and financial development, measured as the ratio of private credit to GDP, is similarly weakly negative. Figure 6 reports the scatterplot of the 1995 log risk content of exports and log overall trade openness, measured as imports plus exports as a share of GDP and taken from Penn World Tables. It is clear from this picture that there is absolutely no relationship between aggregate trade openness and the patterns of trade that determine the risk content of exports. There does seem to be a relationship between the risk content of exports and terms of trade volatility, pictured in Figure 7, as would be expected. Finally, Figure 8 reports the scatterplot of per capita GDP growth volatility against the risk content of exports, except this time the latter is on the horizontal axis. Clearly there is a relationship between the riskiness of a country's exports and the overall growth volatility, though of course this scatterplot says nothing about causality.

Having described the features of the risk content of exports, we now would like to examine what drives it. In particular, a higher risk-content of exports can reflect a higher allocation of exports in risky sectors, or a high degree of specialization. We now attempt to illustrate whether variation in the risk content of exports is driven primarily by simple diversification of export shares (a^X_{ict}'s), or by countries' specialization in risky sectors (σ_i^2's). To do so, we construct two sub-measures intended to separate these two effects. The first is a measure of simple diversification that ignores riskiness differences across sectors:

$$\text{Herfindahl}^X_{ct} = \sum_{i=1}^{\mathcal{I}} (a^X_{ict})^2,$$

which is simply the Herfindahl index of manufacturing export shares. If all of the σ_i^2's were the same, then differences in the risk content of exports would be driven entirely by differences in Herfindahl^X_{ct} between countries. Second, we construct the average variance of a country's exports:

$$\text{MeanRisk}_{ct} = \sum_{i=1}^{\mathcal{I}} a^X_{ict}\sigma_i^2.$$

This is intended to be a "diversification-free" measure, in the sense that two countries with the identical Herfindahl of exports can nonetheless have very different values of MeanRisk_{ct}, if in one of the countries the largest export sectors are riskier.

Figure 9 plots the log of risk content of exports against the log of Herfindahl index of export concentration.[18] It is clear that the risk content of exports is not primarily driven by diversification. The relationship between export diversification and the risk content of exports is negative as expected. However, at low levels of diversification, there is a great deal of variation in the risk content of exports. That is, while the riskiest economies in our sample are also the least diversified (e.g., Algeria, Yemen, and Kuwait), there are also many undiversified economies that are among the safest (e.g., most of the West African countries, but also some Central American ones that are a bit more diversified). At a similar level of diversification (0.39 vs. 0.35), we can find the seventh most volatile country in our sample (Saudi Arabia) and the third safest (Guatemala). As expected, there is less dispersion in the risk content of exports among the well-diversified economies (e.g., OECD countries).

[18]The Herfindahl index takes on higher values for less diversified economies. Thus, in generating the graph, we reverse the x-axis, so that more diversified economies are further to the right.

It appears, therefore, that diversification, while clearly important, cannot account for a large portion of the variation in the risk content of exports. The differences in the average riskiness play an important role. We confirm this result in Figure 10. It plots, in logs, the risk content of exports against the average riskiness of the export sector, MeanRisk_{ct}, along with a linear regression line. The relationship is much closer. This figure makes it clear why the countries at the top of the risk content of exports distribution are there: it is because they specialize in the risky sectors, not simply because they are undiversified.

It is clear from this discussion that developing countries are not necessarily the most exposed to external risk. Indeed, a more complex picture emerges, at least when we look at manufacturing trade. Some of the least risky export structures are observed in the poorest and least diversified countries in our sample because they specialize in the least risky sectors. Advanced economies tend to have an intermediate level of export risk, and achieve it mainly through diversification of export structure rather than specializing in safe sectors. The countries with the highest export risk are the middle-income countries, which are highly specialized in risky industries, predominantly Petroleum Refineries.

4.3 A Snapshot of the Risk Content of Exports over Time

How have the patterns of risk content of exports changed over time? Before describing some individual country experiences, in Figure 11 we plot the evolution of risk content of exports along with Herfindahl^X_{ct} and MeanRisk_{ct} for the world and three broad country groupings: advanced, emerging market, and developing countries.[19] All the series are presented in 5-year moving averages, in order to smooth short-term volatility in export shares. The first panel reports the results based on exports in all 28 sectors. Given that Petroleum products are the most volatile sector in our sample, it seems that the hump shape for the developing countries may be driven by the oil shocks of the late 1970's. We confirm this in the bottom panel of Figure 11, which reports results excluding the Petroleum sector.

Overall, the risk content of world trade had decreased somewhat over the past 30 years, going from about 0.0004 to 0.00025. This is sizeable given that it is computed from exports of the entire world. This change is slightly larger than moving from the 25th to the 50th percentile of the individual-country risk content of exports distribution in our data. Breaking down by country group, advanced countries have experienced a more modest reduction in the risk content of exports. It is interesting that exports from the advanced countries as a whole have become progressively less

[19] Advanced countries are defined as in the IMFs *World Economic Outlook*, except for Korea which for the purpose of the empirical analysis is classified as emerging rather than advanced to capture the experience of its 1997-98 crisis; emerging market countries are countries included in either the (stock market based) International Financial Corporations Major Index (2005) or JP Morgans EMBI Global Index (2005) (which includes countries that issue bonds on international markets), excluding countries classified as advanced by the WEO; remaining countries are classified as developing.

diversified starting in the early 1980's, while MeanRisk has been decreasing throughout the sample period. Emerging markets started the period with the highest risk content of exports among the three groups of countries.[20] However, they also experienced the most dramatic reduction over the period. This reduction seems to have been driven by both diversification and moving to less risky sectors until about 1990, at which point diversification stopped.

The picture for developing countries depends strongly on whether or not we include oil exports. With oil, there is a strong hump shape with the peak in the early 1980's: all three of our measures showed a sharp increase, then a sharp decrease, ending up in 1999 roughly where they were in 1970. Without oil, the picture looks considerably more interesting. The overall risk content of exports remained broadly unchanged until 1990, even increasing slightly. Over that period, however, there was also a sharp diversification. After 1990, diversification stopped, while the riskiness of exports actually declined sharply.

The worldwide and country group trends are interesting, but they mask a great deal of heterogeneity across countries. In Appendix Figure A1, we plot the evolution of risk content of exports, as well as Herfindahl^X_{ct} and MeanRisk_{ct}, for every country in our sample over 1970–99. From this Figure, it is possible to get a sense of how the risk content of exports has changed for each country, and which channel — diversification or average risk — is mainly responsible for the change. The main observation is that there is a great deal of heterogeneity across countries in both the time pattern of overall risk content of exports and its components. Country patterns can be grouped into three main categories: (i) countries whose change in the risk content of exports is mainly driven by change in the average risk; (ii) countries whose change in risk content of exports is mainly driven by change in export concentration; and (iii) countries that experience a similar pattern in all three measures.

The first group is the most common. It includes, for example, many developed countries, such as Spain, France, or Italy, whose risk content of exports has broadly declined, driven entirely by the average risk. In fact, for many of these countries, diversification has decreased in the last two decades. Typically, these countries are moving away from heavy and risky industries (e.g., Iron and Steel) and are increasing specialization in less risky sectors such as Transportation and Machinery. The opposite can be observed, for instance, in Egypt. While it diversified its export structure, the risk content of exports increased. In Egypt's case, the shift is due to a sharp increase in the share of Petroleum Refineries in its manufacturing exports.

The second group, which consists of countries that experienced a diversification-led change in the risk content of exports is less common. In it, we find countries such as India, Mauritius, Fiji, and Philippines, which did not change the average risk of exports, but diversified substantially. There are also some examples of the opposite: Honduras and El Salvador experienced increases in

[20] This is the case when we exclude Petroleum exports from the sample.

the risk content of exports after about 1990 that are driven entirely by increased specialization. In fact, mean risk of exports has actually fallen in these two countries over the same period. Interestingly, Honduras initially diversified away from Food and Wood Products (1970–85) before strongly specializing into Textile and Wearing Apparel.

The third group comprises of countries in which changes in average risk and diversification move together to reinforce each other. In this category, the typical example is Chile, which diversified away from Non-Ferrous Metals (reducing its share of exports from 80% to 40%). This pattern is fairly common for commodity exporting countries, but, unlike Chile, is not necessarily associated with robust growth. In fact, the pictures for Bolivia and Peru are quite similar to Chile's after 1980. The same pattern could be observed in the main oil-exporting countries, such as Saudi Arabia and Venezuela. On the other end of the spectrum, there are countries in which diversification and average risk moved together to increase the overall risk content of exports. In this group, we can find some of the best growth success stories, such as Ireland, Korea, and Taiwan, P.O.C., which over about the last 15 years become more specialized and moved into more risky sectors.

5 Conclusion

Whether increased trade openness has contributed to rising uncertainty and exposed countries to external shocks remains a much debated topic. In this paper, we use industry-level data to document several aspects of the relationship between openness and volatility. Our main conclusions can be summarized as follows. First, higher trade in a sector raises its volatility. Second, more trade also implies that the sector is less correlated with the rest of the economy. Third, higher overall trade openness increases specialization in the economy. The sum of these effects implies that a one standard deviation increase in trade openness raises volatility of the aggregate manufacturing by about 15% of the average aggregate variance observed in our sample. We also use the methodology of Lucas (1987) to provide a range of estimates for the welfare effect of increased volatility coming from trade openness.

We then explore one particular interaction of these effects. We construct a measure of riskiness of a country's exports, and relate it to a variety of country characteristics. The main conclusion is that the poorest countries, while least diversified, are also among the least exposed to external risk, when looking exclusively at manufacturing exports.[21] Advanced countries, by contrast, have low external exposure because their exports are highly diversified. The analysis of the risk content of exports we presented here has not moved much beyond descriptive. We established that the usual country outcomes, such as per capita income, trade openness, institutional quality, or financial

[21] For countries that specialize in agricultural exports which are more volatile than the manufacturing sector, we would be understating the true risk content of exports.

development do not exhibit a very close association to the risk content of exports. There does seem to be a positive correlation between the risk content of exports and macroeconomic volatility, however. Thus, a closer characterization of the risk content of exports, its determinants, and its consequences remains on the research agenda.

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Table 1. Volatility of Annual Output Growth per Worker: Cross-Sectional Results

	(1)	(2)	(3)	(4)
		(A) Total Trade		
Log(Trade/Output)	0.248**	0.232**	0.213**	0.173**
	(0.024)	(0.028)	(0.017)	(0.024)
Log(Output per Worker)	0.006	-0.668**	0.389**	0.163**
	(0.037)	(0.053)	(0.030)	(0.056)
Observations	1518	1518	1518	1518
R^2	0.07	0.28	0.67	0.74
		(B) Exports and Imports		
Log(Exports/Output)	-0.109**	-0.099**	0.092**	0.071**
	(0.022)	(0.022)	(0.017)	(0.020)
Log(Imports/Output)	0.231**	0.190**	0.131**	0.112**
	(0.021)	(0.022)	(0.014)	(0.018)
Log(Output per Worker)	-0.022	-0.670**	0.391**	0.166**
	(0.037)	(0.053)	(0.031)	(0.059)
Observations	1514	1514	1514	1514
R^2	0.09	0.29	0.66	0.74
μ_c	no	no	yes	yes
μ_i	no	yes	no	yes

Notes: Robust standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. The sample period is 1970–99. The dependent variable is the log variance of the growth rate of output per worker, 1970–99, and all regressors are period averages. μ_c denotes the country fixed effects. μ_i denotes the sector fixed effects. All specifications are estimated using OLS.

Table 2. Volatility of Annual Output Growth per Worker: Panel Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			(A) Total Trade				
Log(Trade/Output)	0.189**	0.185**	0.160**	0.152**	0.193**	0.143**	0.092**
	(0.018)	(0.020)	(0.013)	(0.018)	(0.019)	(0.017)	(0.026)
Log(Output per Worker)	-0.040	-0.603**	0.322**	0.133**	0.147**	0.184**	0.009
	(0.036)	(0.046)	(0.029)	(0.045)	(0.046)	(0.045)	(0.080)
Observations	4287	4287	4287	4287	4287	4287	4287
R^2	0.05	0.18	0.45	0.50	0.51	0.60	0.68
			(B) Exports and Imports				
Log(Exports/Output)	-0.106**	-0.102**	0.068**	0.061**	0.064**	0.059**	0.051+
	(0.018)	(0.018)	(0.014)	(0.015)	(0.015)	(0.015)	(0.027)
Log(Imports/Output)	0.209**	0.184**	0.128**	0.126**	0.131**	0.124**	0.143**
	(0.018)	(0.018)	(0.013)	(0.015)	(0.016)	(0.015)	(0.032)
Log(Output per Worker)	-0.046	-0.591**	0.350**	0.165**	0.166**	0.221**	0.033
	(0.036)	(0.047)	(0.029)	(0.047)	(0.048)	(0.047)	(0.086)
Observations	4181	4181	4181	4181	4181	4181	4181
R^2	0.07	0.19	0.45	0.51	0.51	0.60	0.69
μ_t	yes	yes	yes	yes	no	no	yes
μ_c	no	no	yes	yes	yes	no	no
μ_i	no	yes	no	yes	no	yes	no
$\mu_c \times \mu_i$	no	no	no	no	no	no	yes
$\mu_c \times \mu_t$	no	no	no	no	no	yes	no
$\mu_i \times \mu_t$	no	no	no	no	yes	no	no

Notes: Robust standard errors clustered at country×sector level are in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. The sample period is 1970–99. The dependent variable is the log variance of the growth rate of output per worker over 10-year periods: 1970–79, 1980–89, 1990–99. Regressors are averages over the 10-year periods. μ_c denotes the country fixed effects, μ_i the sector fixed effects, and μ_t the time fixed effects. All specifications are estimated using OLS.

Table 3. Volatility of Annual Price and Price-Cost Margin Growth: Cross-Sectional Results

	(1)	(2)	(3)	(4)
I. Price Volatility				
(I.A) Total Trade				
Log(Trade/Output)	0.173**	0.166**	0.175**	0.171**
	(0.022)	(0.026)	(0.017)	(0.028)
Log(Output per Worker)	-0.142**	-0.541**	0.107**	0.054
	(0.038)	(0.056)	(0.030)	(0.051)
Observations	1342	1342	1342	1342
R^2	0.08	0.22	0.58	0.65
(I.B) Exports and Imports				
Log(Exports/Output)	-0.066**	-0.067**	0.053**	0.037+
	(0.020)	(0.021)	(0.018)	(0.020)
Log(Imports/Output)	0.155**	0.130**	0.111**	0.105**
	(0.018)	(0.020)	(0.013)	(0.018)
Log(Output per Worker)	-0.168**	-0.551**	0.101**	0.042
	(0.038)	(0.055)	(0.029)	(0.051)
Observations	1341	1341	1341	1341
R^2	0.09	0.22	0.57	0.64
II. Price-Cost Margin Volatility				
(II.A) Total Trade				
Log(Trade/Output)	0.321**	0.283**	0.265**	0.150**
	(0.027)	(0.032)	(0.023)	(0.031)
Log(Output per Worker)	-0.138**	-0.805**	0.172**	-0.232**
	(0.045)	(0.067)	(0.040)	(0.077)
Observations	1536	1536	1536	1536
R^2	0.11	0.29	0.55	0.65
(II.B) Exports and Imports				
Log(Exports/Output)	-0.022	-0.023	0.137**	0.072**
	(0.025)	(0.026)	(0.022)	(0.024)
Log(Imports/Output)	0.238**	0.195**	0.138**	0.079**
	(0.024)	(0.025)	(0.019)	(0.023)
Log(Output per Worker)	-0.169**	-0.829**	0.178**	-0.234**
	(0.046)	(0.069)	(0.040)	(0.076)
Observations	1531	1531	1531	1531
R^2	0.09	0.28	0.55	0.65
μ_c	no	no	yes	yes
μ_i	no	yes	no	yes

Notes: Robust standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. The sample period is 1970–99. The dependent variable is the log variance of the growth rate of prices or of the price-cost margin, 1970–99, and all regressors are period averages. μ_c denotes the country fixed effects. μ_i denotes the sector fixed effects. All specifications are estimated using OLS.

Table 4. Volatility of Annual Employment and Wage Growth: Cross-Sectional Results

	(1)	(2)	(3)	(4)
I. Employment Volatility				
(I.A) Total Trade				
Log(Trade/Output)	0.169**	0.097**	0.184**	0.143**
	(0.024)	(0.034)	(0.022)	(0.036)
Log(Output per Worker)	-0.296**	-0.321**	-0.234**	-0.164**
	(0.014)	(0.017)	(0.020)	(0.032)
Observations	1540	1540	1540	1540
R^2	0.33	0.38	0.63	0.68
(I.B) Exports and Imports				
Log(Exports/Output)	0.039+	-0.008	0.107**	0.053*
	(0.021)	(0.023)	(0.019)	(0.024)
Log(Imports/Output)	0.090**	0.034	0.094**	0.100**
	(0.021)	(0.027)	(0.017)	(0.026)
Log(Output per Worker)	-0.306**	-0.335**	-0.242**	-0.154**
	(0.014)	(0.018)	(0.021)	(0.036)
Observations	1535	1535	1535	1535
R^2	0.32	0.38	0.63	0.68
II. Wage Volatility				
(II.A) Total Trade				
Log(Trade/Output)	0.007	-0.186**	0.118**	0.052*
	(0.020)	(0.027)	(0.015)	(0.025)
Log(Output per Worker)	-0.341**	-0.409**	-0.197**	-0.167**
	(0.012)	(0.013)	(0.015)	(0.026)
Observations	1516	1516	1516	1516
R^2	0.42	0.47	0.76	0.79
(II.B) Exports and Imports				
Log(Exports/Output)	-0.026	-0.077**	0.054**	0.012
	(0.018)	(0.019)	(0.014)	(0.016)
Log(Imports/Output)	0.003	-0.134**	0.077**	0.059**
	(0.017)	(0.020)	(0.013)	(0.020)
Log(Output per Worker)	-0.342**	-0.408**	-0.197**	-0.145**
	(0.012)	(0.013)	(0.015)	(0.028)
Observations	1512	1512	1512	1512
R^2	0.42	0.48	0.76	0.79
μ_c	no	no	yes	yes
μ_i	no	yes	no	yes

Notes: Robust standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. The sample period is 1970–99. The dependent variable is the log variance of the growth rate of employment or of wages, 1970–99, and all regressors are period averages. μ_c denotes the country fixed effects. μ_i denotes the sector fixed effects. All specifications are estimated using OLS.

Table 5. Correlation of Annual Output Growth per Worker with the Rest of the Manufacturing Sector: Cross-Section Results

	(1)	(2)	(3)	(4)
	(A) Total Trade			
Log(Trade/Output)	-0.034**	-0.064**	-0.012+	-0.037**
	(0.007)	(0.008)	(0.007)	(0.010)
Log(Output/Worker)	-0.007	-0.011	-0.032**	-0.088**
	(0.010)	(0.016)	(0.010)	(0.021)
Observations	1561	1561	1561	1561
R^2	0.02	0.10	0.31	0.37
	(B) Exports and Imports			
Log(Exports/Output)	0.014*	0.008	0.004	-0.003
	(0.006)	(0.006)	(0.006)	(0.007)
Log(Imports/Output)	-0.032**	-0.050**	-0.011*	-0.032**
	(0.005)	(0.006)	(0.005)	(0.007)
Log(Output/Worker)	-0.003	-0.008	-0.029**	-0.088**
	(0.010)	(0.016)	(0.010)	(0.021)
Observations	1557	1557	1557	1557
R^2	0.02	0.10	0.31	0.37
μ_c	no	no	yes	yes
μ_i	no	yes	no	yes

Notes: Robust standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. The sample period is 1970–99. The dependent variable is the correlation of the growth rate of output per worker, 1970–99, and all regressors are period averages. μ_c denotes the country fixed effects. μ_i denotes the sector fixed effects. All specifications are estimated using OLS.

Table 6. Correlation of Annual Output Growth per Worker with the Rest of the Manufacturing Sector: Panel Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			(A) Total Trade				
Log(Trade/Output)	-0.032**	-0.050**	-0.023**	-0.045**	-0.034**	-0.058**	-0.042**
	(0.005)	(0.006)	(0.005)	(0.007)	(0.007)	(0.008)	(0.013)
Log(Output/Worker)	-0.009	0.011	-0.040**	-0.066**	-0.058**	-0.072**	-0.008
	(0.009)	(0.014)	(0.009)	(0.018)	(0.019)	(0.018)	(0.045)
Observations	4272	4272	4272	4272	4272	4272	4272
R^2	0.01	0.05	0.14	0.17	0.27	0.18	0.47
			(B) Exports and Imports				
Log(Exports/Output)	0.009+	0.006	-0.006	-0.014*	-0.009	-0.018**	-0.008
	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.014)
Log(Imports/Output)	-0.029**	-0.045**	-0.017**	-0.041**	-0.031**	-0.045**	-0.071**
	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.016)
Log(Output/Worker)	-0.004	0.011	-0.039**	-0.074**	-0.063**	-0.078**	-0.053
	(0.010)	(0.015)	(0.010)	(0.019)	(0.019)	(0.019)	(0.047)
Observations	4166	4166	4166	4166	4166	4166	4166
R^2	0.01	0.05	0.14	0.17	0.28	0.18	0.48
μ_t	yes	yes	yes	yes	no	no	yes
μ_c	no	no	yes	yes	no	yes	no
μ_i	no	yes	no	yes	yes	no	no
$\mu_c \times \mu_i$	no	no	no	no	no	no	yes
$\mu_c \times \mu_t$	no	no	no	no	yes	no	no
$\mu_i \times \mu_t$	no	no	no	no	no	yes	no

Notes: Robust standard errors clustered at country×sector level are in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. The sample period is 1970–99. The dependent variable is the correlation of the growth rate of output per worker over 10-year periods: 1970–79, 1980–89, 1990–99. Regressors are averages over the 10-year periods. μ_c denotes the country fixed effects, μ_i the sector fixed effects, and μ_t the time fixed effects. All specifications are estimated using OLS.

Table 7. Specialization and Trade Openness at the Country Level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log(Manuf. Trade/Output)	0.382**	0.324**	0.424**	0.383**	0.351	0.369**	0.195**		
	(0.100)	(0.087)	(0.143)	(0.126)	(0.207)	(0.114)	(0.050)		
Log(Total Trade/GDP)								0.275**	0.318**
								(0.068)	(0.102)
Log(GDP per Capita)		-0.126*		-0.126*	0.461	-0.175+	-0.119**	-0.154*	-0.158**
		(0.061)		(0.063)	(0.452)	(0.102)	(0.039)	(0.058)	(0.058)
Constant	-2.115**	-1.048+	-2.095**	-1.018+	-6.785	-0.624	-1.223**	-0.810	-0.747
	(0.088)	(0.555)	(0.111)	(0.571)	(4.312)	(0.906)	(0.365)	(0.537)	(0.539)
Sample	full	full	full	full	OECD	non-OECD	no outliers	full	full
Estimation	OLS	OLS	IV	IV	OLS	OLS	OLS	OLS	IV
Observations	57	54	56	54	19	35	49	54	54
R^2	0.19	0.23	–	–	0.18	0.26	0.32	0.20	–

Notes: Robust standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. The values are for 1990. The dependent variable is the log Herfindahl index of manufacturing production shares, and regressors are period averages. In the instrumental variables regressions, the instrument for trade openness is the natural openness from Frankel and Romer (1999).

Table 8. Specialization, Trade Openness, and Trade Concentration at the Country Level

	(1)	(2)	(3)	(4)	(5)
Log(Manuf. Trade/Output)	0.324**	0.214**	0.342**	0.186*	0.177**
	(0.087)	(0.060)	(0.104)	(0.085)	(0.049)
Log(Herfindahl of Exports)		0.588**	0.627**	0.574**	0.251**
		(0.104)	(0.090)	(0.166)	(0.074)
Log(GDP per Capita)	-0.126*	0.038	0.212	0.006	-0.049
	(0.061)	(0.050)	(0.228)	(0.079)	(0.042)
Constant	-1.048+	-1.535**	-3.070	-1.313*	-1.404**
	(0.555)	(0.371)	(2.279)	(0.588)	(0.329)
Sample	full	full	OECD	non-OECD	no outliers
Estimation	OLS	OLS	OLS	OLS	OLS
Observations	54	54	19	35	49
R^2	0.23	0.61	0.79	0.53	0.42

Notes: Robust standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. The values are for 1990. The dependent variable is the log Herfindahl index of manufacturing production shares, and regressors are period averages. The Herfindahl of Exports is the Herfindahl index of export shares in total manufacturing exports.

Table 9. Welfare Cost of a Change in Trade Openness at the Sector Level and at the Aggregate Level of the Manufacturing Sector

			Cost (in percent)			
	Δ(Log Openness)	$\Delta\omega^2$	$\gamma = 1$	$\gamma = 2.5$	$\gamma = 5$	$\gamma = 10$
Sector-Level	25^{th} to 50^{th} pctile	0.0045	0.23	0.57	1.14	2.27
	25^{th} to 75^{th} pctile	0.0086	0.43	1.08	2.16	4.32
Aggregate	25^{th} to 50^{th} pctile	0.0006	0.03	0.07	0.14	0.28
	25^{th} to 75^{th} pctile	0.0010	0.05	0.13	0.26	0.52

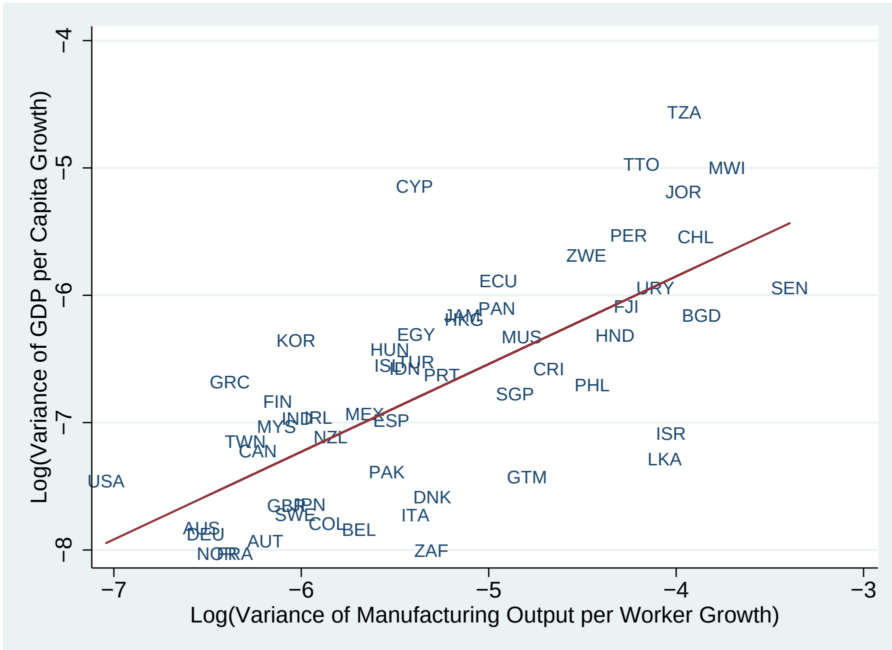
Notes: "Cost" refers to the compensating variation in consumption that an agent must receive in order to remain indifferent in moving from an initial consumption volatility to a new one ($\Delta\omega^2$). Openness refers to the total trade to output ratio. The initial volatility is such that the sector or aggregate economy is located in the twenty-fifth percentile of trade openness, and then moves to either the fiftieth or seventy-fifth percentile. The parameter γ is the coefficient of relative risk aversion. See Section 3.4 for the underlying model and methodology used in these calculations.

Table 10. Sector-Specific Volatility

ISIC	Sector Name	Sector Volatility
311	Food products	0.0005
313	Beverages	0.0004
314	Tobacco	0.0014
321	Textiles	0.0008
322	Wearing apparel, except footwear	0.0002
323	Leather products	0.0024
324	Footwear, except rubber or plastic	0.0007
331	Wood products, except furniture	0.0012
332	Furniture, except metal	0.0006
341	Paper and products	0.0026
342	Printing and publishing	0.0005
351	Industrial chemicals	0.0026
352	Other chemicals	0.0006
353	Petroleum refineries	0.0126
354	Misc. petroleum and coal products	0.0040
355	Rubber products	0.0010
356	Plastic products	0.0015
361	Pottery, china, earthenware	0.0008
362	Glass and products	0.0008
369	Other non-metallic mineral products	0.0007
371	Iron and steel	0.0031
372	Non-ferrous metals	0.0055
381	Fabricated metal products	0.0005
382	Machinery, except electrical	0.0007
383	Machinery, electric	0.0005
384	Transport equipment	0.0009
385	Professional & scientific equipment	0.0011
390	Other manufactured products	0.0008

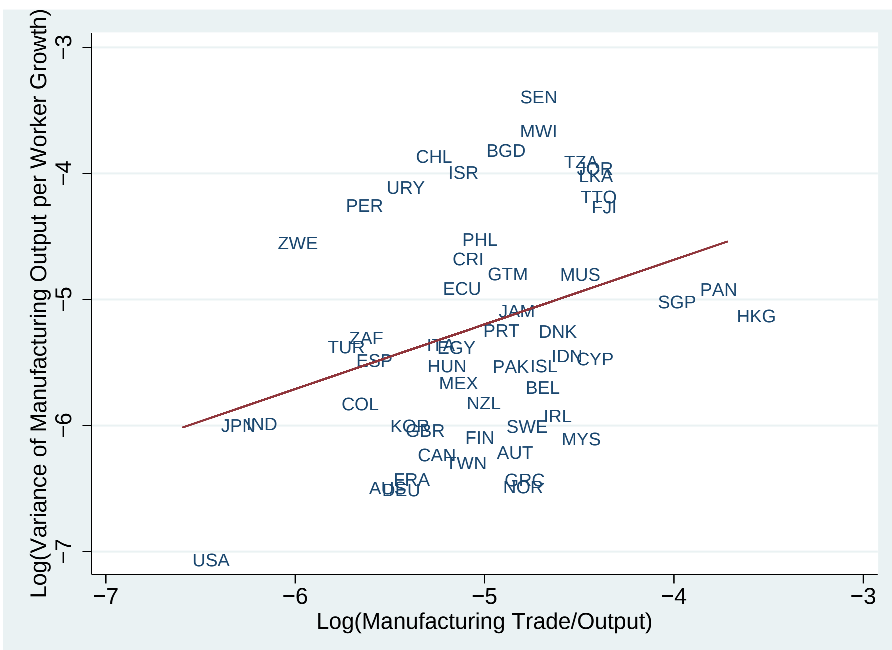
Notes: This table reports the sector-specific variance of the growth rate of output per worker, i.e. the diagonal of the Σ matrix constructed as described in Section 4.1.

Figure 1. Comparison of Manufacturing and Aggregate Volatility



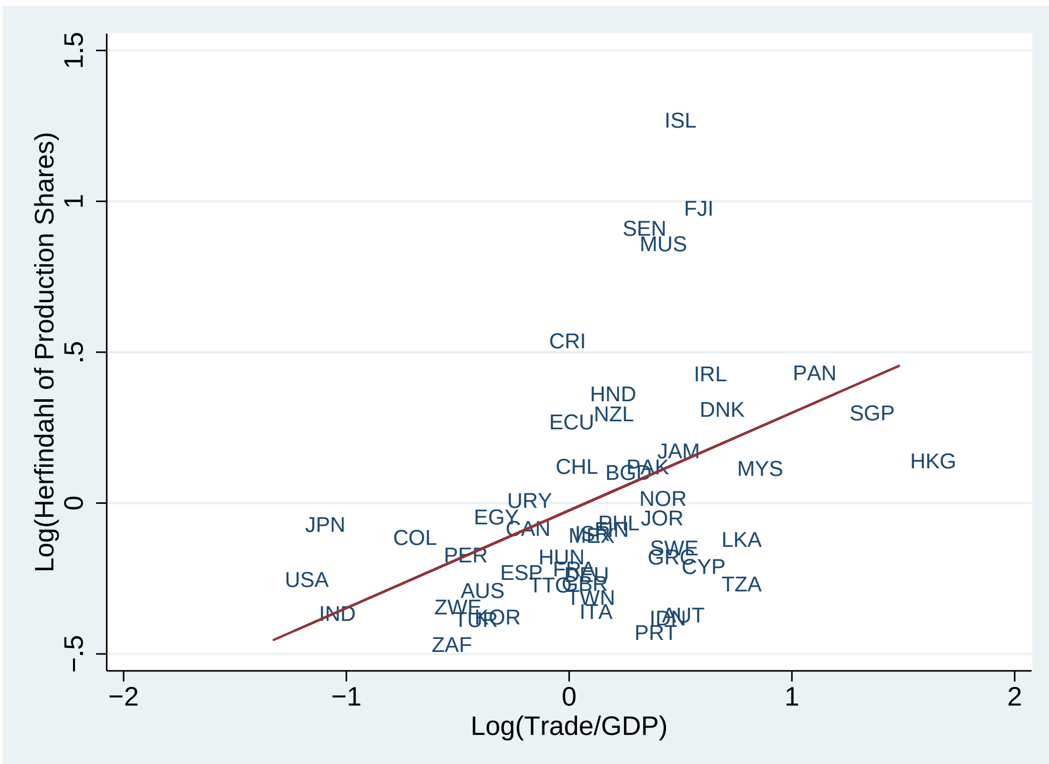
Notes: Volatility is calculated using annual growth rates over 1970–99 for manufacturing output per worker and per-capita GDP from the Penn World Tables, respectively.

Figure 2. Manufacturing Output Volatility and Openness



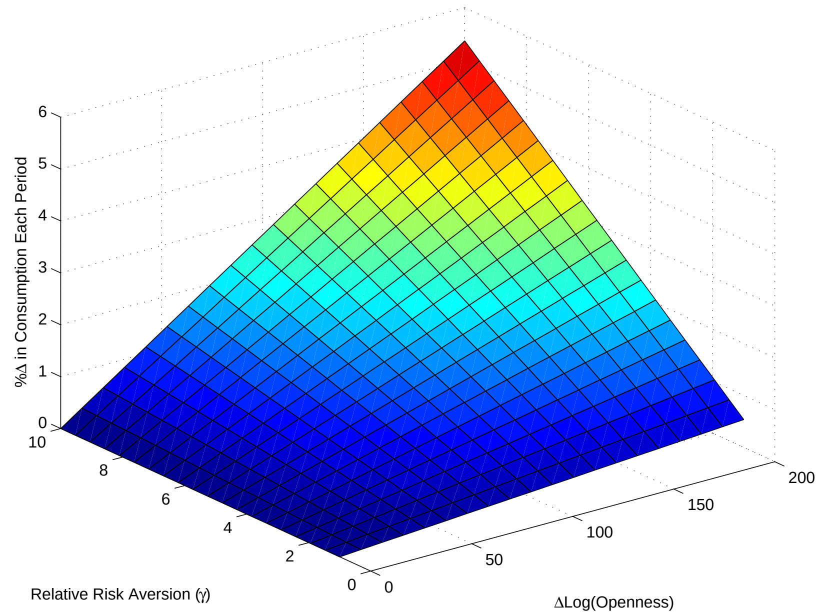
Notes: Manufacturing output volatility is calculated using annual growth rates over 1970–99, and the manufacturing trade-to-output ratio is an average over 1970–99.

Figure 3. Trade and Specialization

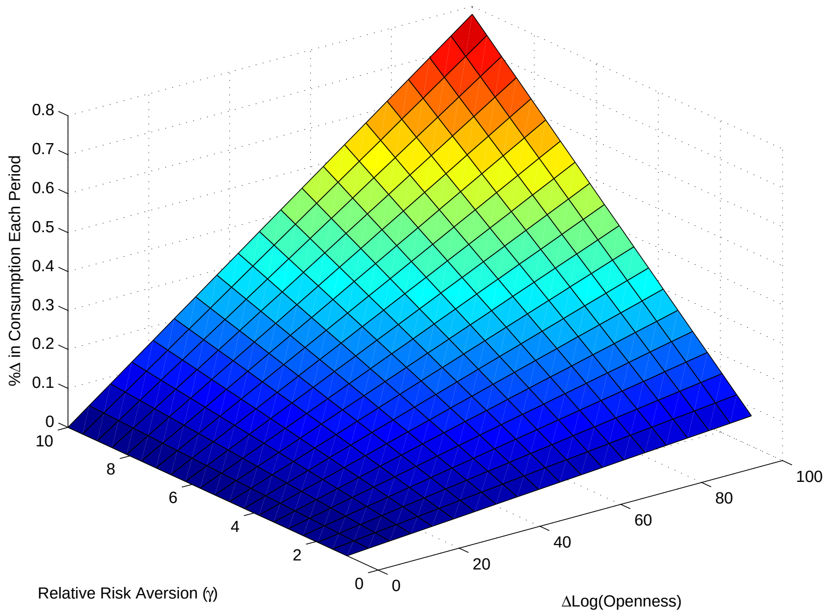


Notes: The Herfindahl of production shares and the manufacturing trade-to-output measures ratio are for the year 1990. The graph reports partial correlations with GDP per capita netted out.

Figure 4. Welfare Impact due to a Change in Trade Openness: Sector-Level and Aggregate Manufacturing Sector-Level Results



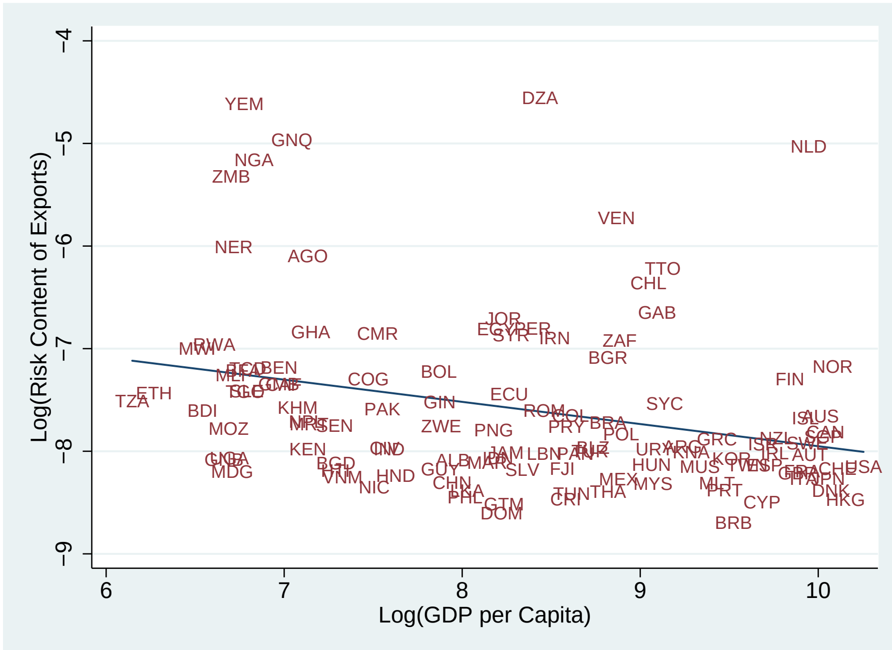
(a) Sector Level



(b) Aggregate Manufacturing Sector

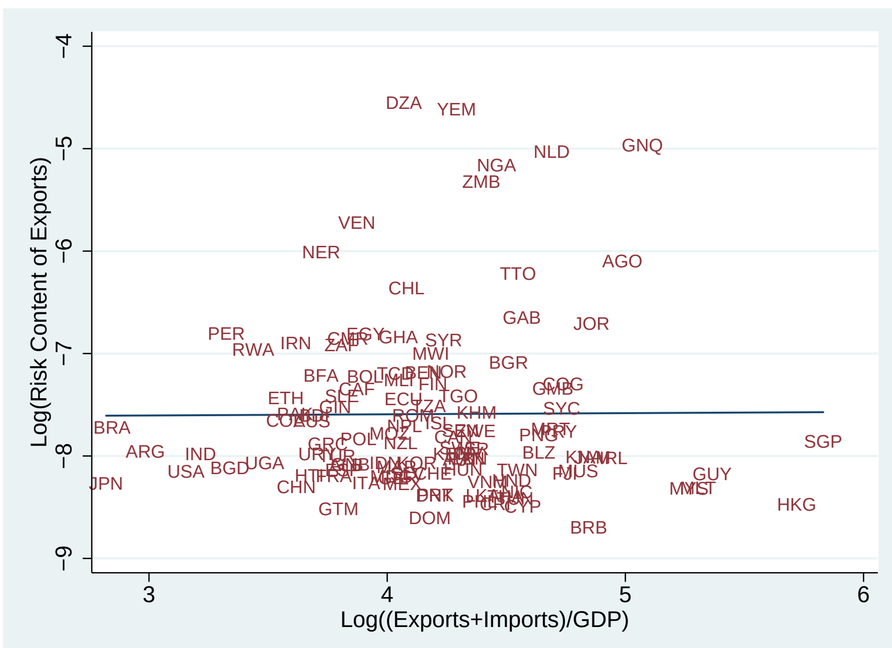
Notes: These plots are based on the methodology described in Section 3.4. The x-axis range corresponds to a change in Log(Openness) (in percent) and includes the difference between the 25^{th} and 75^{th} percentiles of the distribution of the data used in the sector-level and aggregate-level volatility regressions, respectively. The y-axis is the coefficient of relative risk aversion. The z-axis is the percentage increase in average consumption required to make an agent indifferent from a trade-induced increase in consumption volatility.

Figure 5. Risk Content of Exports and Per-Capita Income



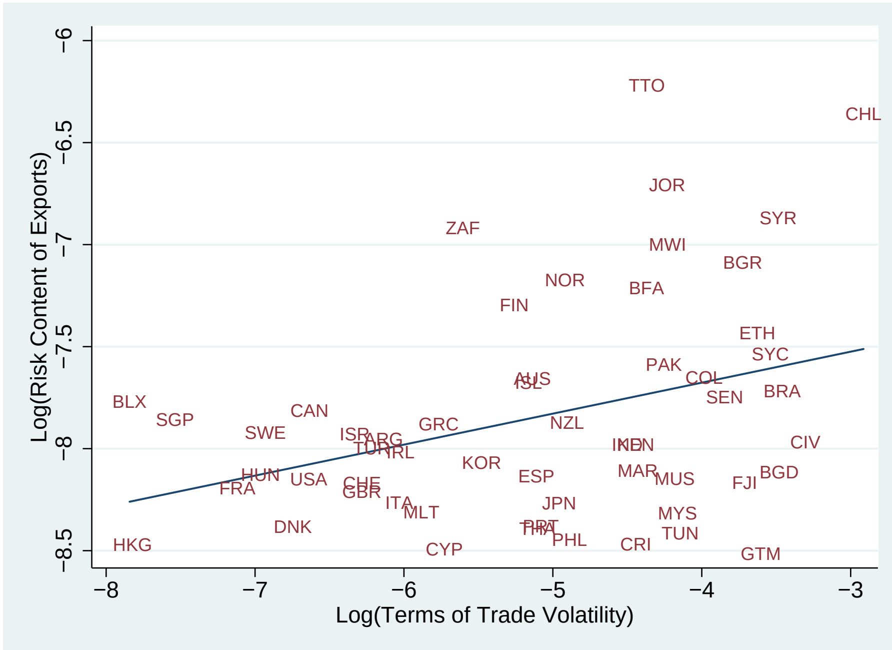
Notes: The risk content of exports and the per-capita GDP are for 1995.

Figure 6. Risk Content of Exports and Overall Trade Openness



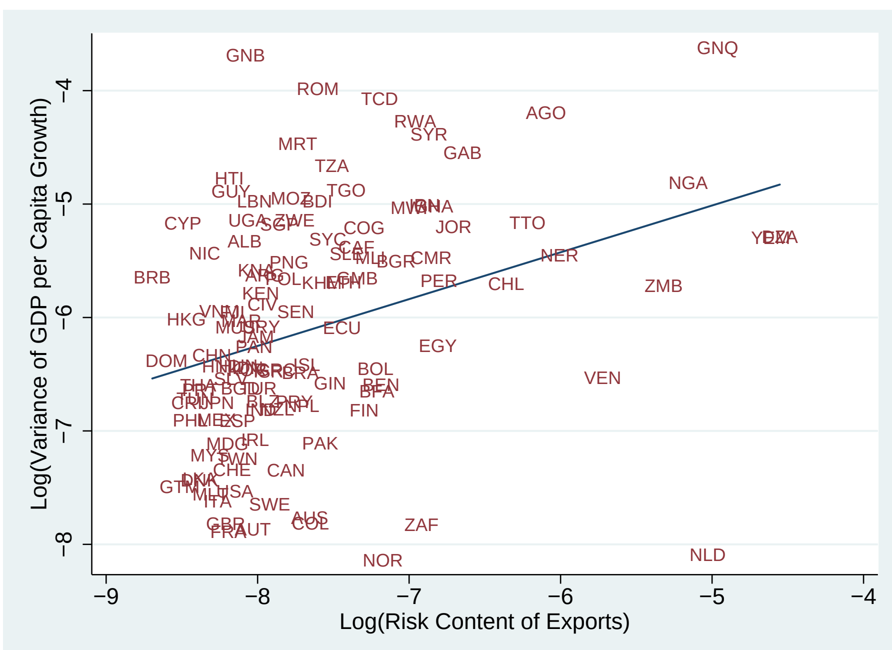
Notes: The risk content of exports and the overall trade openness are for 1995.

Figure 7. Risk Content of Exports and Terms of Trade Volatility



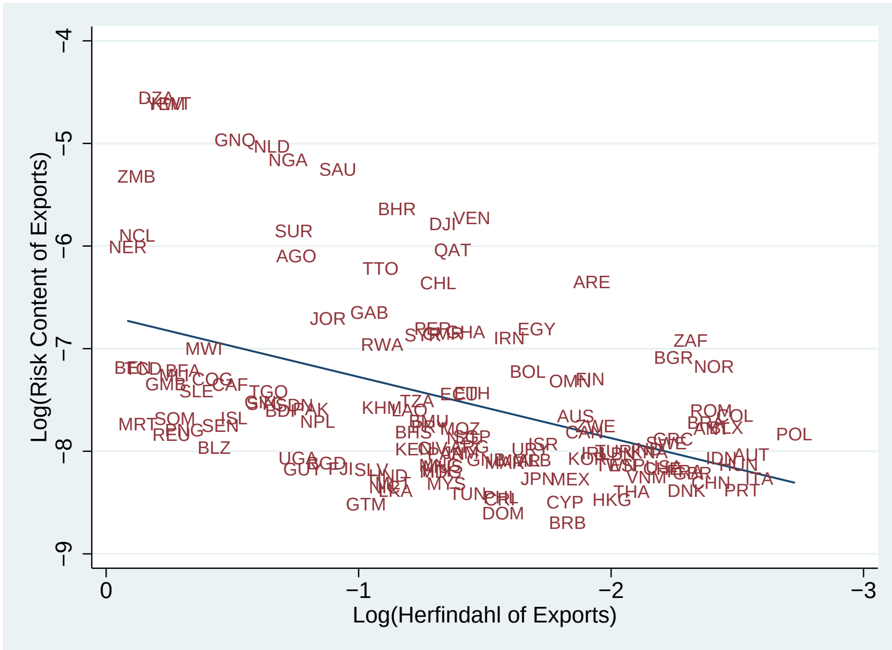
Notes: Risk content of exports is measured at 1995, and terms of trade volatility is calculated using annual growth rates over 1970–99, using terms of trade data from the International Financial Statistics.

Figure 8. Per-Capita Income Volatility and Risk Content of Exports



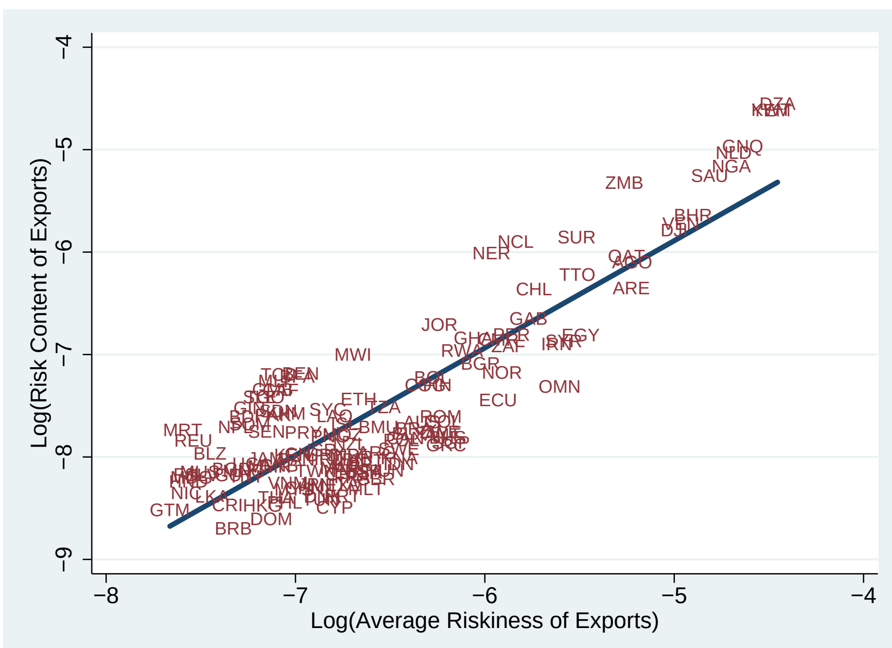
Notes: Per-capita income volatility is calculated using annual growth rates over 1970–99, and the risk content of exports is measured at 1995.

Figure 9. Risk Content of Exports and Diversification



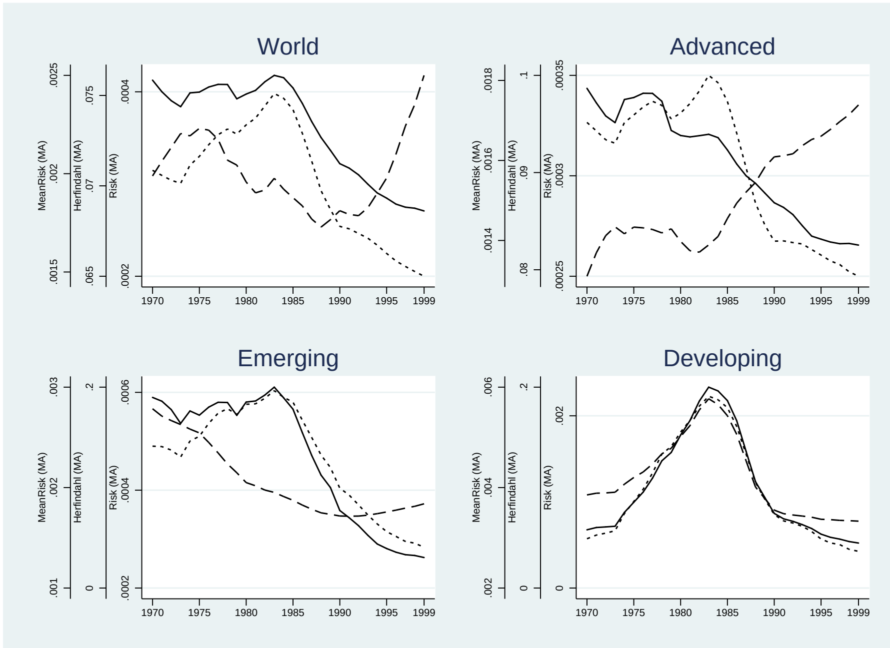
Notes: The risk content of exports and the Herfindahl index of export shares are measured at 1995.

Figure 10. Risk Content of Exports and Average Risk

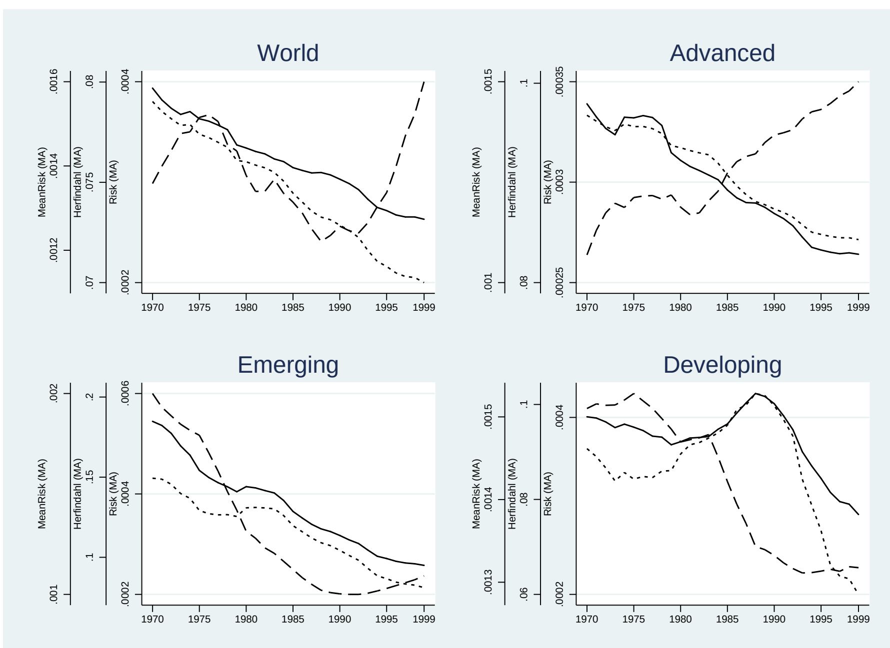


Notes: The risk content of exports and the average risk are measured at 1995.

Figure 11. Risk Content of Exports Over Time: The World and by Income Group



(a) All Sectors Included



(b) Excluding Petroleum Refineries Sector

Notes: Figure plots five-year moving averages of the log of (i) the Risk Content of Exports (—), (ii) the Herfindahl Index of Exports (– –), and (iii) Mean Risk (- - -). See Appendix Table A5 for the breakdown of country groups between Advanced, Emerging and Developing.

Table A1. Country Summary Statistics: 1970–99

	Growth		Imports/	Exports/		Growth		Imports/	Exports/
Country	Avg.	St. Dev.	Output	Output	Country	Avg.	St. Dev.	Output	Output
Australia	0.028	0.038	0.172	0.161	Korea	0.055	0.049	0.178	0.186
Austria	0.027	0.045	0.319	0.293	Malawi	0.057	0.155	0.713	0.329
Bangladesh	-0.008	0.145	0.405	0.191	Malaysia	0.032	0.047	0.471	0.506
Belgium	0.042	0.058	0.339	0.384	Malta	0.054	0.074	0.989	0.388
Canada	0.024	0.044	0.136	0.263	Mauritius	-0.008	0.090	0.437	0.628
Chile	0.041	0.143	0.197	0.226	Mexico	0.017	0.059	0.146	0.473
China,P.R.:Hong Kong	0.050	0.077	1.837	0.784	New Zealand	0.011	0.054	0.250	0.327
Colombia	0.022	0.053	0.198	0.079	Norway	0.026	0.040	0.363	0.284
Costa Rica	-0.026	0.096	0.373	0.184	Pakistan	0.058	0.063	0.358	0.294
Cyprus	0.020	0.067	0.875	0.202	Panama	0.013	0.084	2.071	0.504
Denmark	0.012	0.071	0.414	0.397	Peru	-0.027	0.119	0.154	0.154
Ecuador	0.027	0.084	0.409	0.099	Philippines	0.013	0.108	0.296	0.261
Egypt	0.017	0.068	0.340	0.149	Poland	0.044	0.082	0.229	0.184
Fiji	-0.007	0.118	0.656	0.471	Portugal	0.021	0.072	0.344	0.260
Finland	0.032	0.047	0.218	0.317	Senegal	-0.022	0.183	0.532	0.241
France	0.038	0.042	0.170	0.187	Singapore	0.037	0.088	0.851	0.646
Germany	0.028	0.039	0.139	0.204	South Africa	0.009	0.070	0.177	0.144
Greece	0.026	0.041	0.465	0.197	Spain	0.030	0.063	0.154	0.134
Guatemala	0.006	0.091	0.450	0.255	Sri Lanka	0.011	0.131	0.767	0.364
Honduras	-0.013	0.115	0.526	0.259	Sweden	0.025	0.049	0.279	0.367
Hungary	0.038	0.063	0.231	0.217	Syrian Arab Republic	0.033	0.166	0.372	0.162
Iceland	0.030	0.063	0.406	0.395	Taiwan, P.O.C.	0.036	0.043	0.179	0.352
India	0.043	0.049	0.092	0.094	Tanzania	-0.032	0.138	0.725	0.282
Indonesia	0.049	0.066	0.532	0.306	Trinidad and Tobago	0.042	0.123	0.447	0.679
Ireland	0.043	0.052	0.390	0.419	Turkey	0.037	0.068	0.159	0.101
Israel	0.030	0.133	0.353	0.276	United Kingdom	0.029	0.048	0.207	0.196
Italy	0.036	0.067	0.198	0.245	United States	0.021	0.030	0.086	0.034
Jamaica	0.017	0.076	0.454	0.236	Uruguay	0.022	0.128	0.173	0.206
Japan	0.035	0.051	0.039	0.101	Zimbabwe	0.056	0.107	0.097	0.111
Jordan	0.028	0.138	0.866	0.138					

Notes: 'Growth' is the real manufacturing output per worker growth rate computed annually over 1970–99. Imports and exports to output are averages of total manufacturing imports and exports divided by total manufacturing output. These summary statistics are calculated based on the sample used in the cross-sectional regressions of Table 1.

Table A2. Sector Summary Statistics: 1970–99

ISIC	Sector Name	Growth Avg.	Growth St. Dev.	Imports/ Output	Exports/ Output
311	Food products	0.015	0.108	0.107	0.124
313	Beverages	0.029	0.129	0.062	0.036
314	Tobacco	0.034	0.166	0.030	0.021
321	Textiles	0.021	0.120	0.238	0.214
322	Wearing apparel, except footwear	0.018	0.113	0.108	0.236
323	Leather products	0.013	0.163	0.288	0.291
324	Footwear, except rubber or plastic	0.021	0.150	0.179	0.178
331	Wood products, except furniture	0.021	0.159	0.145	0.124
332	Furniture, except metal	0.022	0.149	0.148	0.116
341	Paper and products	0.028	0.143	0.328	0.089
342	Printing and publishing	0.031	0.124	0.103	0.036
351	Industrial chemicals	0.040	0.181	0.617	0.198
352	Other chemicals	0.028	0.124	0.353	0.089
353	Petroleum refineries	0.037	0.230	0.155	0.075
354	Misc. petroleum and coal products	0.026	0.225	0.094	0.041
355	Rubber products	0.017	0.149	0.179	0.056
356	Plastic products	0.023	0.131	0.131	0.041
361	Pottery, china, earthenware	0.031	0.162	0.240	0.113
362	Glass and products	0.033	0.142	0.282	0.117
369	Other non-metallic mineral products	0.035	0.128	0.087	0.048
371	Iron and steel	0.028	0.175	0.408	0.142
372	Non-ferrous metals	0.022	0.199	0.450	0.299
381	Fabricated metal products	0.023	0.135	0.283	0.087
382	Machinery, except electrical	0.029	0.158	1.022	0.178
383	Machinery, electric	0.032	0.141	0.352	0.075
384	Transport equipment	0.033	0.172	0.813	0.154
385	Professional & scientific equipment	0.025	0.178	1.676	0.457
390	Other manufactured products	0.020	0.166	0.637	0.367

Notes: 'Growth' is the real manufacturing output per worker growth rate computed annually over 1970–99. Imports and exports to output are averages of total manufacturing imports and exports divided by total manufacturing output. These summary statistics are calculated based on the sample used in the cross-sectional regressions of Table 1.

Table A3. Volatility of Annual Price and Price-Cost Margin Growth: Panel Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
I. Price Volatility							
(I.A) Total Trade							
Log(Trade/Output)	0.128**	0.126**	0.131**	0.148**	0.185**	0.131**	0.111**
	(0.017)	(0.019)	(0.013)	(0.018)	(0.021)	(0.018)	(0.031)
Log(Output per Worker)	-0.160**	-0.507**	0.080**	0.057	0.062	0.063	0.089
	(0.035)	(0.047)	(0.028)	(0.045)	(0.046)	(0.048)	(0.103)
Observations	3798	3798	3798	3798	3798	3798	3798
R^2	0.06	0.14	0.41	0.46	0.47	0.58	0.66
(I.B) Exports and Imports							
Log(Exports/Output)	-0.071**	-0.078**	0.043**	0.036*	0.040**	0.026+	0.037
	(0.017)	(0.018)	(0.013)	(0.015)	(0.015)	(0.015)	(0.035)
Log(Imports/Output)	0.145**	0.125**	0.114**	0.122**	0.124**	0.107**	0.147**
	(0.016)	(0.017)	(0.012)	(0.016)	(0.016)	(0.016)	(0.035)
Log(Output per Worker)	-0.168**	-0.507**	0.093**	0.060	0.053	0.061	0.125
	(0.036)	(0.048)	(0.028)	(0.045)	(0.046)	(0.048)	(0.106)
Observations	3714	3714	3714	3714	3714	3714	3714
R^2	0.07	0.15	0.42	0.46	0.47	0.58	0.67
II. Price-Cost Margin Volatility							
(II.A) Total Trade							
Log(Trade/Output)	0.256**	0.208**	0.233**	0.157**	0.202**	0.145**	0.107*
	(0.022)	(0.025)	(0.018)	(0.023)	(0.027)	(0.022)	(0.043)
Log(Output per Worker)	-0.221**	-0.847**	0.088+	-0.298**	-0.285**	-0.275**	-0.469**
	(0.049)	(0.065)	(0.045)	(0.069)	(0.071)	(0.069)	(0.152)
Observations	4228	4228	4228	4228	4228	4228	4228
R^2	0.07	0.19	0.36	0.43	0.44	0.57	0.63
(II.B) Exports and Imports							
Log(Exports/Output)	-0.040+	-0.056*	0.121**	0.071**	0.080**	0.066**	0.068
	(0.023)	(0.023)	(0.020)	(0.020)	(0.022)	(0.020)	(0.042)
Log(Imports/Output)	0.229**	0.193**	0.154**	0.124**	0.131**	0.111**	0.181**
	(0.021)	(0.022)	(0.017)	(0.020)	(0.021)	(0.021)	(0.052)
Log(Output per Worker)	-0.245**	-0.868**	0.110*	-0.282**	-0.279**	-0.251**	-0.479**
	(0.051)	(0.066)	(0.046)	(0.069)	(0.071)	(0.071)	(0.138)
Observations	4126	4126	4126	4126	4126	4126	4126
R^2	0.07	0.19	0.36	0.43	0.44	0.57	0.64
μ_t	yes	yes	yes	yes	no	no	yes
μ_c	no	no	yes	yes	yes	no	no
μ_i	no	yes	no	yes	no	yes	no
$\mu_c \times \mu_i$	no	no	no	no	no	no	yes
$\mu_c \times \mu_t$	no	no	no	no	no	yes	no
$\mu_i \times \mu_t$	no	no	no	no	yes	no	no

Notes: Robust standard errors clustered at country×sector level are in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. The sample period is 1970–99. The dependent variable is the log variance of the growth rate of prices or of the price-cost margin over 10-year periods: 1970–79, 1980–89, 1990–99. Regressors are averages over the 10-year periods. μ_c denotes the country fixed effects, μ_i the sector fixed effects, and μ_t the time fixed effects. All specifications are estimated using OLS.

Table A4. Volatility of Annual Employment and Wage Growth: Panel Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				I. Employment Volatility			
				(I.A) Total Trade			
Log(Trade/Output)	0.110**	0.062**	0.138**	0.119**	0.170**	0.087**	0.115**
	(0.017)	(0.022)	(0.015)	(0.021)	(0.026)	(0.019)	(0.029)
Log(Output per Worker)	-0.337**	-0.361**	-0.302**	-0.298**	-0.266**	-0.271**	-0.492**
	(0.013)	(0.015)	(0.016)	(0.025)	(0.027)	(0.024)	(0.059)
Observations	4335	4335	4335	4335	4335	4335	4335
R^2	0.23	0.26	0.43	0.46	0.47	0.64	0.62
				(I.B) Exports and Imports			
Log(Exports/Output)	0.005	-0.030	0.086**	0.061**	0.069**	0.032*	0.086*
	(0.019)	(0.019)	(0.015)	(0.017)	(0.018)	(0.015)	(0.035)
Log(Imports/Output)	0.081**	0.030	0.096**	0.097**	0.111**	0.087**	0.134**
	(0.020)	(0.022)	(0.015)	(0.022)	(0.022)	(0.019)	(0.043)
Log(Output per Worker)	-0.338**	-0.370**	-0.298**	-0.276**	-0.260**	-0.239**	-0.451**
	(0.014)	(0.016)	(0.017)	(0.031)	(0.032)	(0.029)	(0.062)
Observations	4226	4226	4226	4226	4226	4226	4226
R^2	0.22	0.26	0.44	0.47	0.48	0.65	0.63
				II. Wage Volatility			
				(II.A) Total Trade			
Log(Trade/Output)	0.006	-0.102**	0.081**	0.045**	0.075**	0.029+	0.063*
	(0.015)	(0.019)	(0.012)	(0.017)	(0.020)	(0.016)	(0.025)
Log(Output per Worker)	-0.360**	-0.407**	-0.233**	-0.227**	-0.208**	-0.213**	-0.320**
	(0.010)	(0.011)	(0.013)	(0.021)	(0.021)	(0.020)	(0.043)
Observations	4321	4321	4321	4321	4321	4321	4321
R^2	0.33	0.36	0.55	0.57	0.57	0.68	0.70
				(II.B) Exports and Imports			
Log(Exports/Output)	-0.034*	-0.057**	0.042**	0.026*	0.033*	0.002	0.084**
	(0.015)	(0.015)	(0.011)	(0.013)	(0.013)	(0.012)	(0.025)
Log(Imports/Output)	0.005	-0.103**	0.069**	0.042**	0.057**	0.046**	0.035
	(0.015)	(0.017)	(0.011)	(0.016)	(0.017)	(0.016)	(0.030)
Log(Output per Worker)	-0.362**	-0.420**	-0.226**	-0.216**	-0.201**	-0.189**	-0.322**
	(0.011)	(0.011)	(0.013)	(0.023)	(0.023)	(0.024)	(0.046)
Observations	4215	4215	4215	4215	4215	4215	4215
R^2	0.33	0.37	0.55	0.57	0.57	0.68	0.71
μ_t	yes	yes	yes	yes	no	no	yes
μ_c	no	no	yes	yes	yes	no	no
μ_i	no	yes	no	yes	no	yes	no
$\mu_c \times \mu_i$	no	no	no	no	no	no	yes
$\mu_c \times \mu_t$	no	no	no	no	no	yes	no
$\mu_i \times \mu_t$	no	no	no	no	yes	no	no

Notes: Robust standard errors clustered at country×sector level are in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. The sample period is 1970–99. The dependent variable is the log variance of the growth rate of employment or of wages over 10-year periods: 1970–79, 1980–89, 1990–99. Regressors are averages over the 10-year periods. μ_c denotes the country fixed effects, μ_i the sector fixed effects, and μ_t the time fixed effects. All specifications are estimated using OLS.

Table A5. Risk Content of Exports Across Countries for 1995

Country	Risk Content of Exports	Largest export sector	Second Largest Export Sector	Share of Top 2 Export Sectors	Herf
Algeria[1]	0.0105	Petroleum refineries	Industrial chemicals	0.9330	0.8195
Kuwait[1]	0.0100	Petroleum refineries	Industrial chemicals	0.9201	0.7726
Yemen, Republic of[1]	0.0099	Petroleum refineries	Food products	0.9496	0.7896
Equatorial Guinea[1]	0.0070	Petroleum refineries	Wood products, except furniture	0.9482	0.6003
Netherlands[3]	0.0066	Petroleum refineries	Food products	0.8066	0.5187
Nigeria[2]	0.0058	Petroleum refineries	Leather products	0.7981	0.4864
Saudi Arabia[2]	0.0052	Petroleum refineries	Industrial chemicals	0.8358	0.3993
Zambia[1]	0.0049	Non-ferrous metals	Textiles	0.9729	0.8863
Bahrain, Kingdom of[1]	0.0036	Petroleum refineries	Non-ferrous metals	0.7870	0.3160
Venezuela, Rep. Bol.[2]	0.0033	Petroleum refineries	Non-ferrous metals	0.5659	0.2349
Djibouti[1]	0.0031	Petroleum refineries	Food products	0.6312	0.2637
Suriname[1]	0.0029	Non-ferrous metals	Food products	0.8231	0.4753
Niger[1]	0.0025	Industrial chemicals	Food products	0.9720	0.9173
Qatar[1]	0.0024	Industrial chemicals	Petroleum refineries	0.6434	0.2535
Angola[1]	0.0023	Other manufactured products	Petroleum refineries	0.9548	0.4708
Trinidad and Tobago[1]	0.0020	Industrial chemicals	Iron and steel	0.6924	0.3371
United Arab Emirates[1]	0.0017	Petroleum refineries	Non-ferrous metals	0.4484	0.1460
Chile[2]	0.0017	Non-ferrous metals	Food products	0.6555	0.2683
Gabon[1]	0.0013	Industrial chemicals	Wood products, except furniture	0.7622	0.3526
Jordan[2]	0.0012	Industrial chemicals	Other chemicals	0.7206	0.4152
Peru[2]	0.0011	Food products	Non-ferrous metals	0.7176	0.2742
Egypt[2]	0.0011	Textiles	Petroleum refineries	0.5607	0.1817
Ghana[1]	0.0011	Non-ferrous metals	Wood products, except furniture	0.5506	0.2408
Cameroon[1]	0.0011	Wood products, except furniture	Non-ferrous metals	0.6134	0.2634
Syrian Arab Republic[1]	0.0010	Textiles	Petroleum refineries	0.6953	0.2851
Iran, I.R. of[1]	0.0010	Textiles	Petroleum refineries	0.5410	0.2025
South Africa[2]	0.0010	Non-ferrous metals	Iron and steel	0.3595	0.0988
Rwanda[1]	0.0009	Food products	Non-ferrous metals	0.7609	0.3352
Malawi[1]	0.0009	Tobacco	Textiles	0.9155	0.6788
Bulgaria[2]	0.0008	Industrial chemicals	Iron and steel	0.3489	0.1056
Norway[3]	0.0008	Non-ferrous metals	Industrial chemicals	0.2671	0.0900
Benin[1]	0.0008	Textiles	Other manufactured products	0.9673	0.8994
Chad[1]	0.0008	Textiles	Transport equipment	0.9839	0.8631
Burkina Faso[1]	0.0007	Textiles	Leather products	0.9329	0.7375

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Country	Risk Content of Exports	Largest export sector	Second Largest Export Sector	Share of Top 2 Export Sectors	Herf
Bolivia[1]	0.0007	Food products	Non-ferrous metals	0.4881	0.1882
Mali[1]	0.0007	Textiles	Other manufactured products	0.9342	0.7635
Finland[3]	0.0007	Paper and products	Machinery, electric	0.4472	0.1470
Congo, Republic of[1]	0.0007	Other manufactured products	Petroleum refineries	0.8851	0.6559
Oman[2]	0.0007	Transport equipment	Petroleum refineries	0.5101	0.1591
Gambia, The[1]	0.0006	Other manufactured products	Food products	0.9690	0.7893
Central African Rep.[1]	0.0006	Other manufactured products	Textiles	0.8962	0.6120
Sierra Leone[1]	0.0006	Other manufactured products	Food products	0.9399	0.6989
Togo[1]	0.0006	Textiles	Other manufactured products	0.9088	0.5255
Ethiopia[1]	0.0006	Leather products	Food products	0.6118	0.2346
Ecuador[2]	0.0006	Food products	Petroleum refineries	0.6162	0.2471
Tanzania[1]	0.0005	Textiles	Food products	0.6601	0.2918
Guinea[1]	0.0005	Other manufactured products	Food products	0.8865	0.5425
Seychelles[1]	0.0005	Food products	Paper and products	0.9529	0.5327
Sudan[1]	0.0005	Textiles	Food products	0.9072	0.4744
Cambodia[1]	0.0005	Wood products, except furniture	Textiles	0.7111	0.3354
Pakistan[2]	0.0005	Textiles	Wearing apparel, except footwear	0.7907	0.4444
Lao People's Dem.Rep[1]	0.0005	Wood products, except furniture	Wearing apparel, except footwear	0.7259	0.3007
Romania[1]	0.0005	Wearing apparel, except footwear	Iron and steel	0.3219	0.0910
Burundi[1]	0.0005	Textiles	Food products	0.9733	0.5017
Colombia[2]	0.0005	Industrial chemicals	Food products	0.2988	0.0829
Australia[3]	0.0005	Food products	Non-ferrous metals	0.4835	0.1557
Iceland[3]	0.0005	Food products	Non-ferrous metals	0.8808	0.6024
Somalia[1]	0.0005	Food products	Iron and steel	0.9599	0.7616
Bermuda[3]	0.0004	Transport equipment	Textiles	0.6752	0.2786
Nepal[1]	0.0004	Textiles	Wearing apparel, except footwear	0.8858	0.4324
Brazil[2]	0.0004	Food products	Iron and steel	0.3216	0.0930
Mauritania[1]	0.0004	Food products	Transport equipment	0.9537	0.8818
Senegal[1]	0.0004	Food products	Textiles	0.8671	0.6356
Zimbabwe[2]	0.0004	Tobacco	Iron and steel	0.4416	0.1439
Paraguay[1]	0.0004	Textiles	Food products	0.7050	0.2777
Belgium-Luxembourg[3]	0.0004	Transport equipment	Industrial chemicals	0.3175	0.0858
Netherlands Antilles[1]	0.0004	Industrial chemicals	Machinery, except electrical	0.2937	0.0909
Mozambique[1]	0.0004	Food products	Textiles	0.6826	0.2460
Papua New Guinea[1]	0.0004	Food products	Transport equipment	0.8961	0.7331
Bahamas, The[1]	0.0004	Transport equipment	Industrial chemicals	0.6321	0.2960
Canada[3]	0.0004	Transport equipment	Paper and products	0.4526	0.1504

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Country	Risk Content of Exports	Largest export sector	Second Largest Export Sector	Share of Top 2 Export Sectors	Herf
Poland[2]	0.0004	Wearing apparel, except footwear	Transport equipment	0.2038	0.0655
Singapore[3]	0.0004	Machinery, except electrical	Machinery, electric	0.6602	0.2348
New Zealand[3]	0.0004	Food products	Paper and products	0.5403	0.2426
Greece[3]	0.0004	Textiles	Food products	0.3897	0.1058
Sweden[3]	0.0004	Transport equipment	Paper and products	0.3313	0.1087
Israel[3]	0.0004	Other manufactured products	Machinery, electric	0.4911	0.1771
Argentina[2]	0.0004	Food products	Transport equipment	0.5530	0.2369
Belize[1]	0.0003	Food products	Wearing apparel, except footwear	0.8983	0.6516
Côte d'Ivoire[2]	0.0003	Food products	Wood products, except furniture	0.6932	0.2744
Uruguay[2]	0.0003	Food products	Textiles	0.5197	0.1862
India[2]	0.0003	Other manufactured products	Textiles	0.3902	0.1175
Kenya[1]	0.0003	Food products	Wearing apparel, except footwear	0.6290	0.2958
Turkey[2]	0.0003	Textiles	Wearing apparel, except footwear	0.4491	0.1341
St. Kitts and Nevis[3]	0.0003	Transport equipment	Food products	0.3630	0.1164
Jamaica[1]	0.0003	Textiles	Wearing apparel, except footwear	0.5991	0.2455
Ireland[3]	0.0003	Machinery, except electrical	Industrial chemicals	0.4280	0.1440
Lebanon[1]	0.0003	Other manufactured products	Industrial chemicals	0.4046	0.1315
Panama[2]	0.0003	Transport equipment	Food products	0.5807	0.2602
Austria[3]	0.0003	Machinery, except electrical	Transport equipment	0.2779	0.0776
Uganda[1]	0.0003	Food products	Tobacco	0.8189	0.4675
Indonesia[2]	0.0003	Wood products, except furniture	Textiles	0.2937	0.0874
Korea[2]	0.0003	Machinery, electric	Machinery, except electrical	0.4279	0.1485
Guinea-Bissau[1]	0.0003	Food products	Footwear, except rubber or plastic	0.6147	0.2220
Albania[1]	0.0003	Wearing apparel, except footwear	Footwear, except rubber or plastic	0.5549	0.1834
Myanmar[1]	0.0003	Wood products, except furniture	Food products	0.4846	0.1947
Morocco[2]	0.0003	Wearing apparel, except footwear	Industrial chemicals	0.5618	0.2061
Bangladesh[1]	0.0003	Wearing apparel, except footwear	Textiles	0.8548	0.4174
Hungary[2]	0.0003	Machinery, electric	Transport equipment	0.2942	0.0816
Spain[3]	0.0003	Transport equipment	Machinery, except electrical	0.3883	0.1270
Mongolia[1]	0.0003	Food products	Wearing apparel, except footwear	0.6272	0.2665
Taiwan, P.O.C.[2]	0.0003	Machinery, except electrical	Machinery, electric	0.4606	0.1328
Mauritius[1]	0.0003	Textiles	Food products	0.6028	0.2633
United States[3]	0.0003	Machinery, except electrical	Machinery, electric	0.3681	0.1098
Fiji[1]	0.0003	Food products	Wearing apparel, except footwear	0.7697	0.3946
Switzerland[3]	0.0003	Machinery, except electrical	Professional & scientific equipment	0.3290	0.1106
Guyana[1]	0.0003	Food products	Wood products, except furniture	0.8172	0.4586
El Salvador[2]	0.0003	Wearing apparel, except footwear	Textiles	0.8156	0.3498

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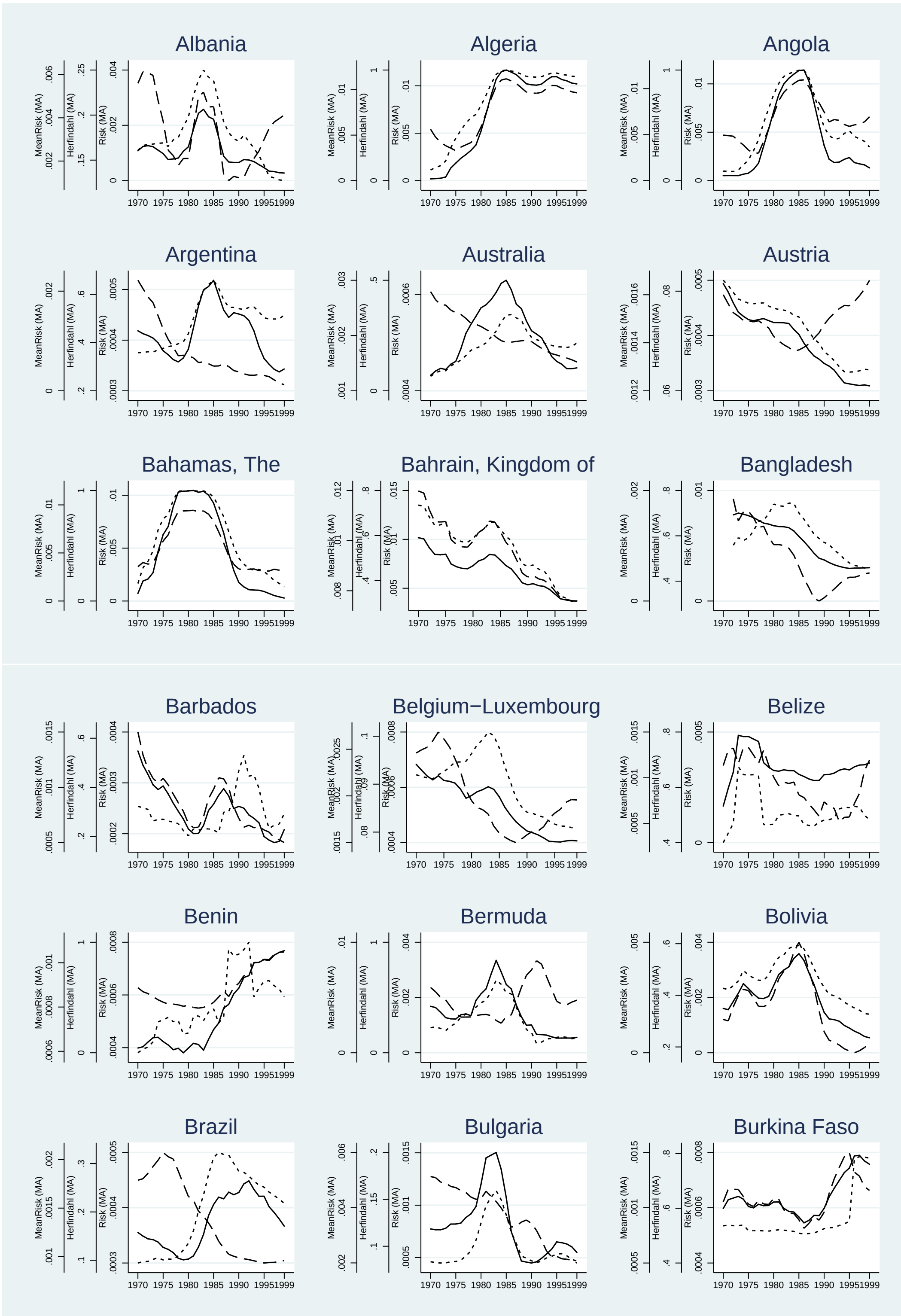
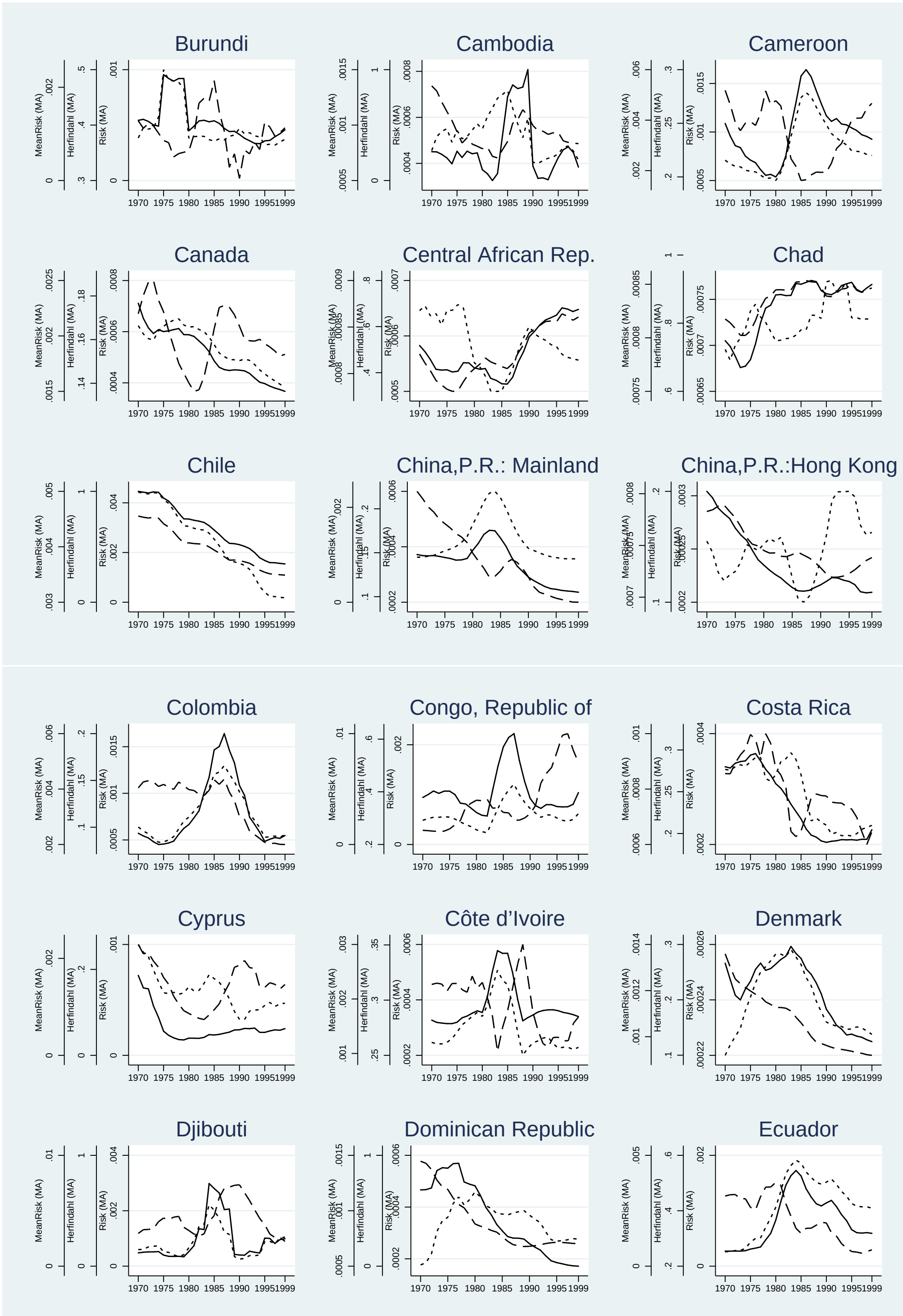
Country	Risk Content of Exports	Largest export sector	Second Largest Export Sector	Share of Top 2 Export Sectors	Herf
Haiti[1]	0.0003	Wearing apparel, except footwear	Textiles	0.7020	0.2701
France[3]	0.0003	Transport equipment	Machinery, except electrical	0.3362	0.1010
Madagascar[1]	0.0003	Wearing apparel, except footwear	Food products	0.6271	0.2657
United Kingdom[3]	0.0003	Transport equipment	Machinery, except electrical	0.3415	0.0981
Honduras[1]	0.0003	Wearing apparel, except footwear	Textiles	0.7736	0.3270
Vietnam[1]	0.0003	Wearing apparel, except footwear	Footwear, except rubber or plastic	0.3587	0.1176
Italy[3]	0.0003	Machinery, except electrical	Transport equipment	0.2857	0.0753
Japan[3]	0.0003	Machinery, electric	Machinery, except electrical	0.4907	0.1810
Mexico[2]	0.0003	Machinery, electric	Transport equipment	0.5282	0.1590
China,P.R.: Mainland[2]	0.0002	Machinery, electric	Wearing apparel, except footwear	0.3031	0.0911
Malta[1]	0.0002	Machinery, electric	Wearing apparel, except footwear	0.6359	0.3207
Malaysia[2]	0.0002	Machinery, electric	Machinery, except electrical	0.6268	0.2598
Nicaragua[1]	0.0002	Food products	Wearing apparel, except footwear	0.7849	0.3320
Portugal[3]	0.0002	Textiles	Machinery, electric	0.2629	0.0805
Sri Lanka[2]	0.0002	Wearing apparel, except footwear	Textiles	0.6825	0.3178
Denmark[3]	0.0002	Food products	Machinery, except electrical	0.3596	0.1004
Thailand[2]	0.0002	Machinery, electric	Machinery, except electrical	0.4220	0.1248
Tunisia[2]	0.0002	Wearing apparel, except footwear	Industrial chemicals	0.5689	0.2387
Philippines[2]	0.0002	Machinery, electric	Machinery, except electrical	0.5257	0.2095
Costa Rica[1]	0.0002	Wearing apparel, except footwear	Food products	0.5448	0.2102
China,P.R.: Hong Kong[3]	0.0002	Machinery, electric	Wearing apparel, except footwear	0.3994	0.1348
Cyprus[3]	0.0002	Transport equipment	Wearing apparel, except footwear	0.5261	0.1624
Guatemala[1]	0.0002	Wearing apparel, except footwear	Food products	0.7964	0.3571
Dominican Republic[2]	0.0002	Wearing apparel, except footwear	Textiles	0.5208	0.2074
Barbados[1]	0.0002	Food products	Machinery, electric	0.5033	0.1608

Notes: This table reports the risk content of exports, RX_{ct}, as defined in the text, along with the top export sectors and their share in total manufacturing exports. "Herf" is the Herfindahl index of the manufacturing export shares. All figures are for 1995. Country codes: 1=Developing, 2=Emerging, 3=Advanced. Advanced countries are defined as in the IMFs *World Economic Outlook*, except for Korea which for the purpose of the empirical analysis is classified as emerging rather than advanced to capture the experience of its 1997-98 crisis; emerging market countries are countries included in either the (stock market based) International Financial Corporations Major Index (2005) or JP Morgans EMBI Global Index (2005) (which includes countries that issue bonds on international markets), excluding countries classified as advanced by the WEO; remaining countries are classified as developing.

Figure A1. Risk Content of Exports Over Time, by Country



Legend: — Risk, – – Herf, - - - Mean Risk



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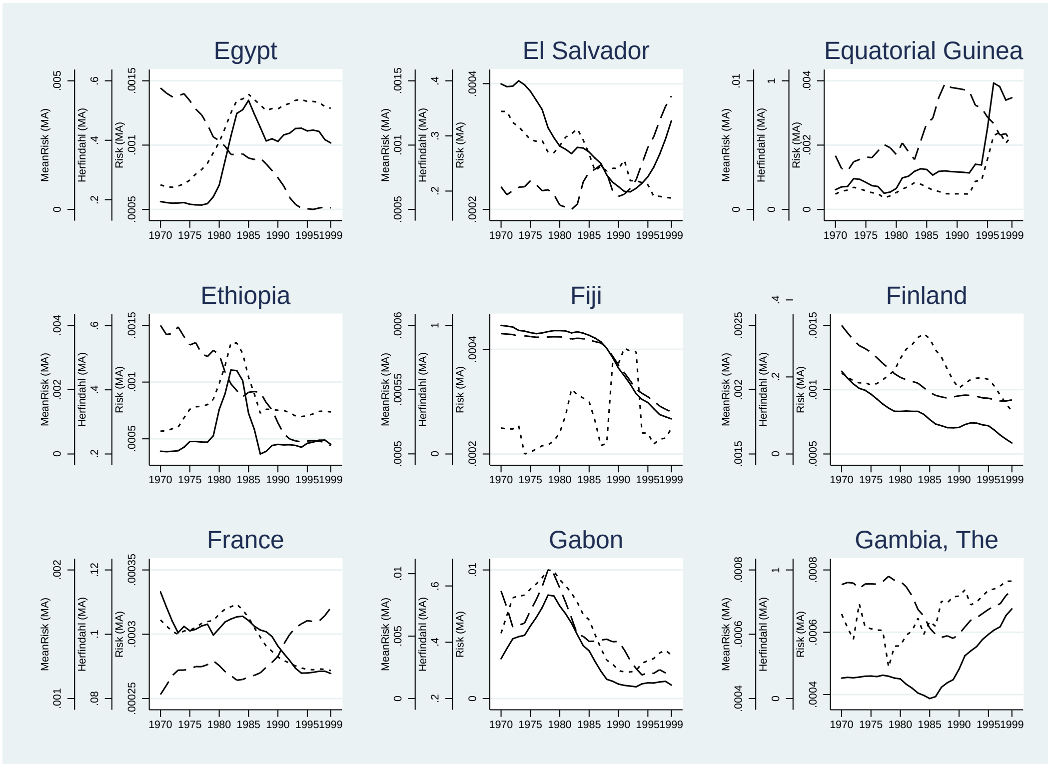
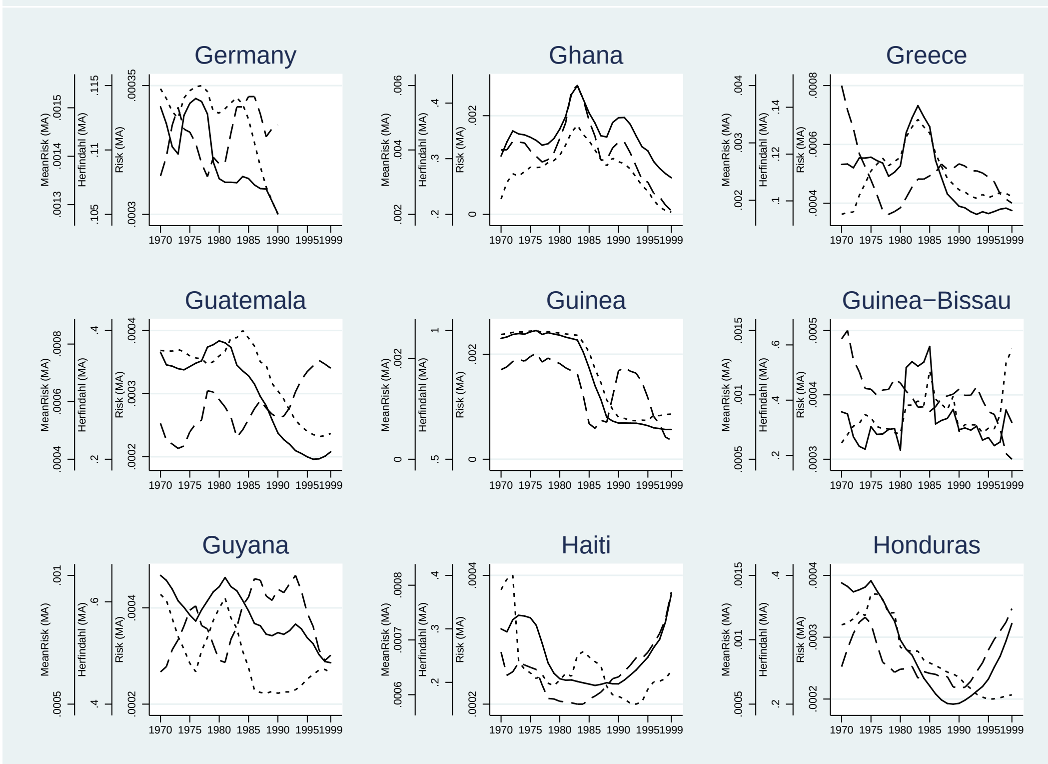
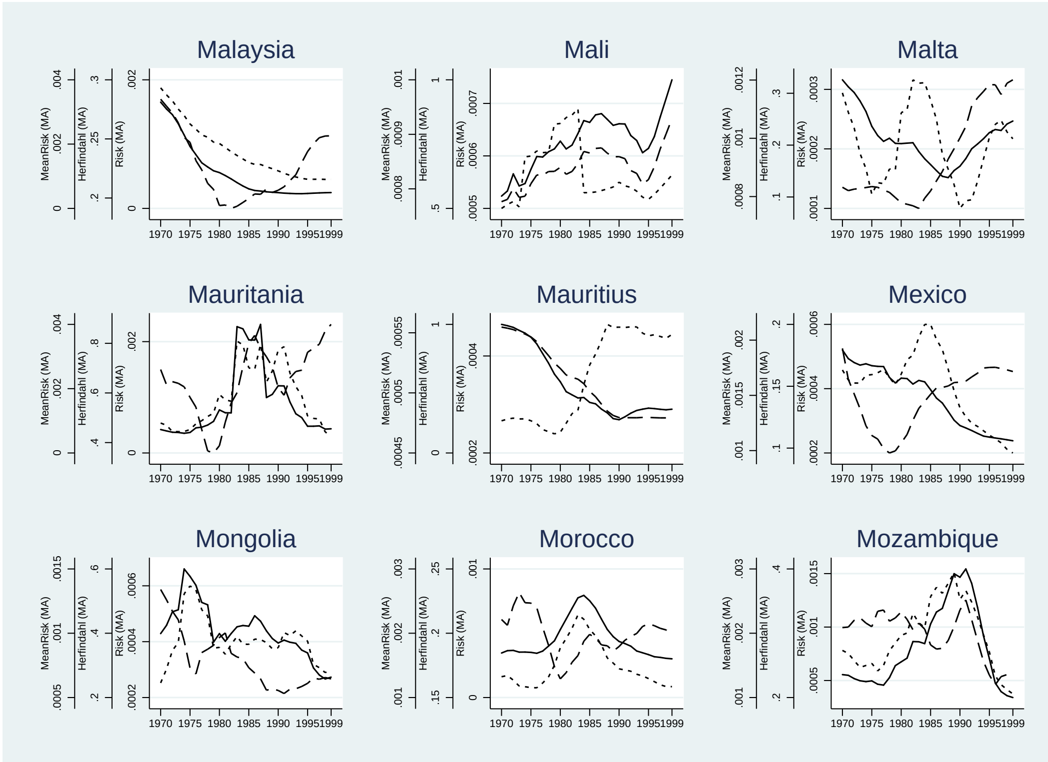
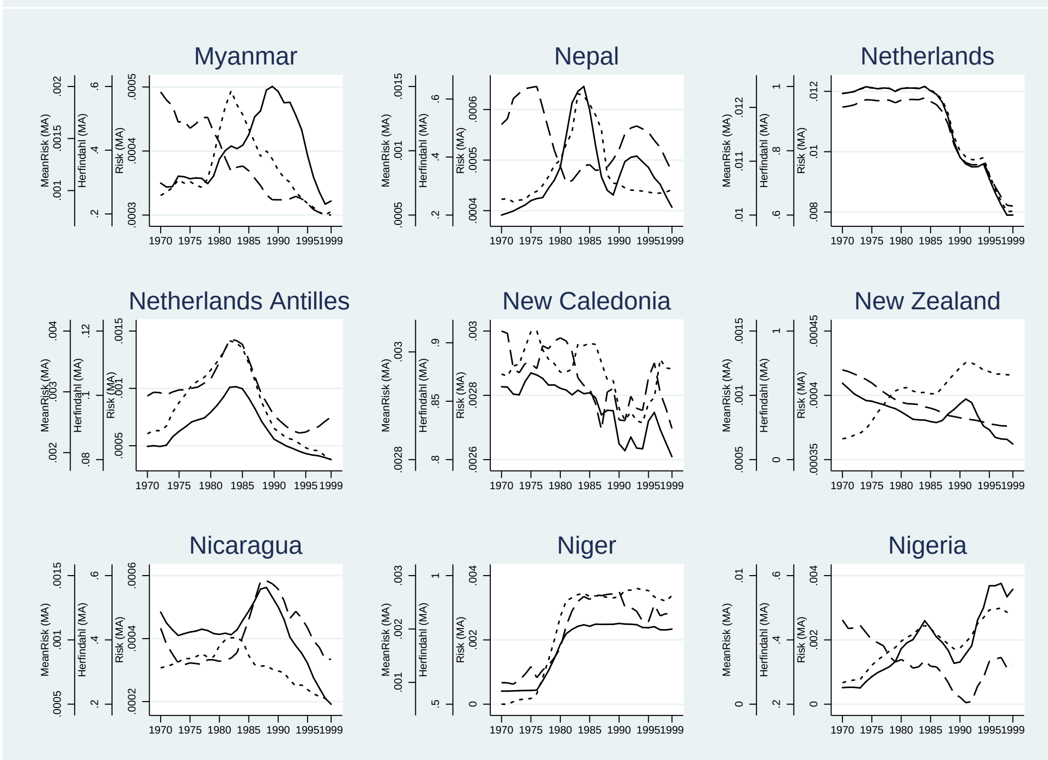




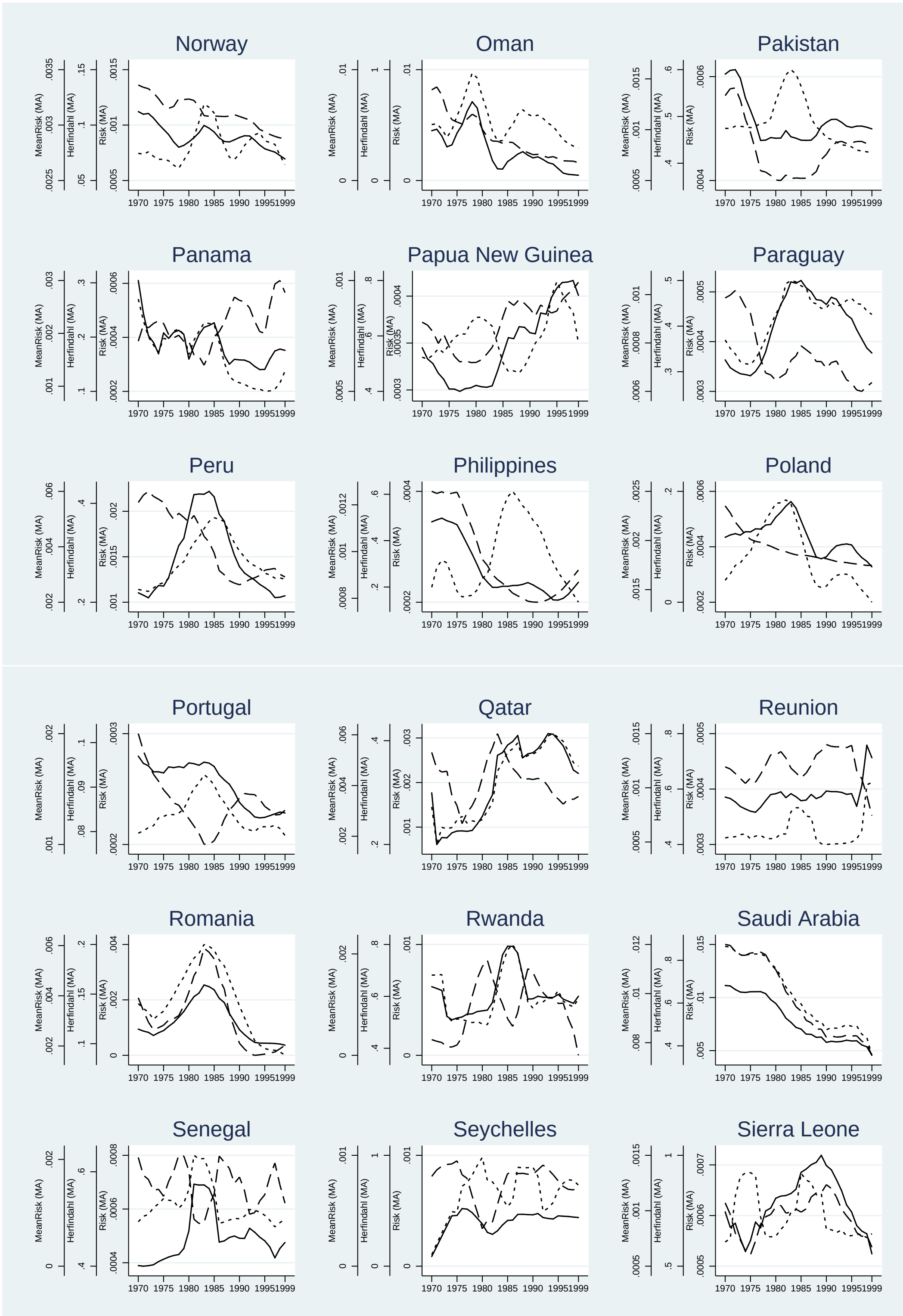
Legend: — Risk, – – Herf, - - - Mean Risk

Legend: — Risk, – – Herf, - - - Mean Risk

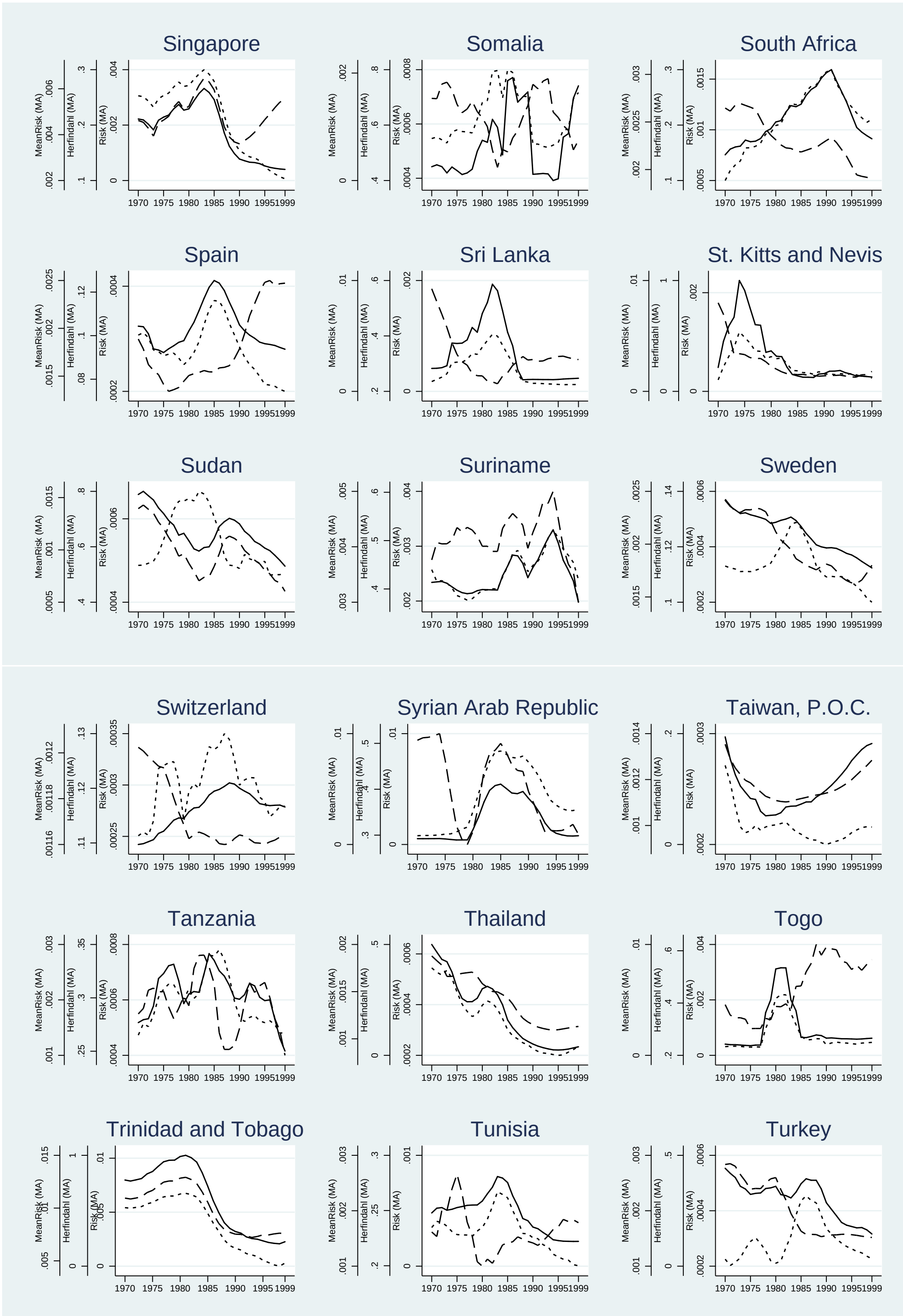




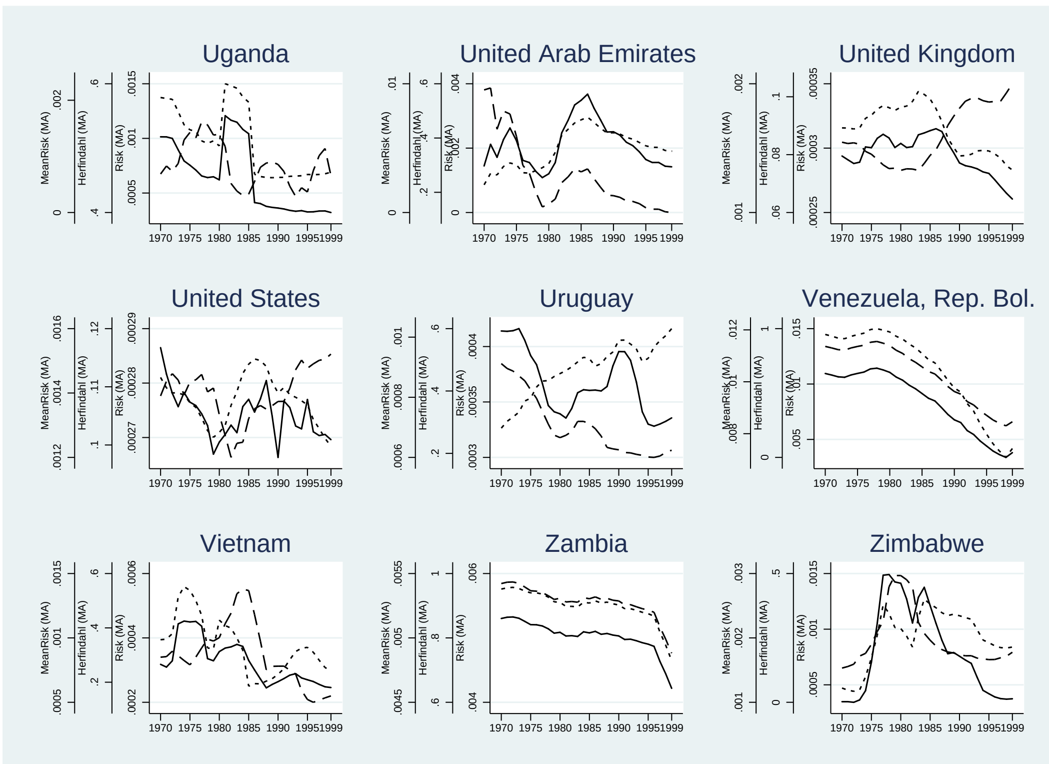
Legend: — Risk, – – Herf, - - - Mean Risk



Legend: — Risk, – – Herf, - - - Mean Risk



Legend: — Risk, – – Herf, - - - Mean Risk



Legend: — Risk, – – Herf, - - - Mean Risk