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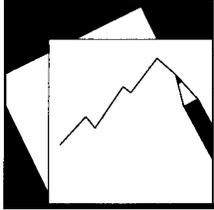
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# IMF Working Paper

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## The Cost of Economic Specialization: Evidence from Earthquakes

*Rodney Ramcharan*

**IMF Working Paper**

Research

**The Cost of Specialization: Evidence from Earthquakes**

Prepared by Rodney Ramcharan<sup>1</sup>

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**Abstract**

Economic specialization can be costly when insurance is unavailable. Concerns over these costs have risen along with increased trade and the predicted rise in specialization. However, there is little systematic evidence quantifying the relationship between economic specialization and the costs of shocks. This paper exploits the exogeneity and randomness of earthquakes to estimate the impact of economic specialization on the consumption cost of shocks. There is robust evidence that more specialized economies experience larger declines in consumption when earthquakes occur, and consistent with the insurance channel, the size of this negative impact is smaller in more financially developed economies.

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## I. INTRODUCTION

When returns across economic sectors are imperfectly correlated and insurance is unavailable, diversification can reduce the economic impact of shocks. Thus, despite the well known efficiency benefits from specialization, the risks of too little diversification have long been widely acknowledged [Brainard and Cooper (1968), Kemp and Livatan (1973), Ruffin (1974)]. Indeed, concerns over these risks have risen with the expansion of trade and the predicted rise in specialization [Krugman (1979) and Helpman (1981) and the survey in Findlay (1995)]. Moreover, the tradeoff between diversification and efficiency is often viewed as a fundamental determinant of economic development [Obstfeld (1994), Saint-Paul (1992), Acemoglu and Zilibotti (1997)]. However, there has been little systematic empirical evidence quantifying the relationship between economic specialization and the economic costs of shocks.

This paper uses the exogeneity and randomness of earthquake events to help estimate the impact of economic specialization on the costs of shocks. Earthquakes are geophysical hazards that are commonly precipitated by movements in the earth's tectonic plates<sup>2</sup>, and the resulting surface level shaking can cause substantial damage to human and physical capital. Aside from the celebrated 1975 Haicheng Earthquake in China, where based on abnormal animal behavior an earthquake was correctly predicted sufficiently in advance to reduce casualties, earthquakes remain unpredictable events, commonly regarded as random shocks of mostly low probability<sup>3</sup>. The unpredictability of earthquakes, the idiosyncratic nature of the damage across sectors and the fact that their incidence is largely unrelated to human activity provide several advantages in identifying how economic specialization can influence the cost of shocks.

First, since the incidence of earthquakes are not determined by the pattern of specialization, they can help identify the role of specialization in shaping the economic cost of shocks from the related but distinct role that specialization plays in determining the pattern of shocks. For example, two economies may have the same degree of specialization, but in very different sectors, e.g. agriculture and manufacturing, and thus subject to different types and frequencies of shocks, making systematic cross country inferences about the links between specialization and the costs of shocks difficult. Second, because the precise timing of earthquakes usually cannot be predicted accurately, the anticipation of a particular earthquake would not be expected to influence the degree of specialization. Of course, a country's general susceptibility to earthquakes may influence its specialization patterns. However, earthquake susceptibility is usually determined using a broadly agreed upon set of country observables that can be taken into account when estimating the impact of specialization on the economic cost of an earthquake.

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<sup>2</sup> See Earthquakes [2002] for a survey of the current literature on the causes of earthquakes.

<sup>3</sup> Indeed, eighteen months later there was no formal prediction when an earthquake of a similar magnitude occurred in Tangshan, killing a quarter of a million people. See Fradkin [1999].

Third, earthquakes idiosyncratically affect economic sectors. While some sectors may be devastated, others may remain unaffected or benefit. And predicting the impact across sectors is difficult, for in addition to the well known damage to the building stock, earthquakes can also destroy transportation systems and pipelines, potentially impacting not only manufacturing, but agriculture, fisheries and other sectors [ see Brookshire et. al (1997) for a discussion of the 1994 Kobe earthquake]. For example, detailed case study evidence from the 1999 Turkish earthquake indicates that while employment immediately declined in agriculture, manufacturing, and construction it rose in services [World Bank (2003)]. Therefore, by inducing imperfect correlation in returns across sectors, earthquakes can help identify the extent to which economic diversification affect the cost of shocks.

Using a panel of 39 countries over the period 1971-2002, the evidence suggests that economic specialization greatly magnifies the consumption costs of earthquakes. A one standard deviation increase in labor specialization is associated with an additional 2 percentage point decline in household expenditures in the year of an earthquake; a similar impact is observed using final consumption expenditures. In contrast, there is no significant relationship between specialization patterns and changes in consumption in non earthquake years. These results are robust across a variety of labor specialization measures, specifications and methodologies. However, these results do not extend to specialization measures based on value added contribution to GDP, or export concentration, suggesting that the diversification of labor income across sectors influences how an economy responds to shocks.

The analysis also suggests that the impact of specialization is closely related to the level of financial development. For an economy at the median level of financial development—proxied using the ratio of broad money to GDP—the impact of a one standard deviation increase in specialization on the change in household expenditures in the year of an earthquake is about -0.45 percentage points. A similar increase in specialization for an economy at the 10<sup>th</sup> percentile level of financial development is associated with a 3.29 percentage point decline in household expenditures. The significant interaction between specialization and financial development is consistent with the idea that insurance opportunities determine whether the pattern of labor specialization affects consumption when negative shocks occur.

This paper is related to the larger empirical literature that examines the causes and consequences of economic specialization [(Kalemli-Ozcan et. al (2004), (2001)) and Imbs and Wacziarg (2003)], and less directly to the substantial literature on risk sharing [Bekaert (2004), and Van Wincoop (1999)]. It of course also builds on earlier work that uses weather events as part of an identification strategy [see for example Brunner (2002), Caselli et. al (2004), Miguel et. al (2004) and Paxson (1992)]. The paper is organized as follows. Section II provides an overview of the data, and discusses both the incidence and economic impact of earthquakes. Section III reports the empirical results, while Section IV concludes.

## II. DATA

This section briefly provides an overview of the data and its sources—more detail is provided in the Appendix--and documents both the incidence and economic impact of earthquakes.

### A. Overview of the Data

The data on earthquakes is taken from the Center for the Research on the Epidemiology of Disasters (CRED), with global coverage from 1900-2003. This database records an earthquake event based on the following conditions: 10 or more reported killed; 100 people reported affected; a call for international assistance; a declaration of a state of emergency. Other data sources include the World Bank (WB), the International Labor Office (ILO, 2003) and the United Nations Industrial Development Organization (UNIDO, 2003). Coverage varies across the three databases, and the most inclusive specification relies on a panel of 39 countries from 1971-2001.

The distribution of labor across economic sectors<sup>4</sup> is conceptually the most attractive source for measures of specialization. Thus as the primary source of specialization measures we use the International Labor Office (ILO, 2003) data on employment shares across sectors, covering all economic activities at the 1-digit International Standard Industrial Classification (ISIC) level. With little reason to emphasize a particular distribution measure, the analyses uses four common measures: the Gini coefficient, the log mean deviation, the coefficient of variation and the Theil index. From the World Bank data, the fraction of the labor force employed in agriculture ( $AEM$ ), the value added from agriculture as a percent of GDP ( $AVL$ ), and the value of agricultural raw material as a percent of exports ( $AEX$ ) are also used as albeit narrower measures of economic concentration. As a robustness exercise we also construct dispersion measures derived from the United Nations Industrial Development Organization (UNIDO, 2003). But the data are a less comprehensive measure of cross sector diversification since it covers the distribution of economic activity only within the manufacturing sector, at the 3-digit ISIC code, rather than across sectors. Table 2 summarizes the various measures of economic concentration and Table 3 examines the correlation across some of these measures, revealing that employment and value added concentration in the agricultural sector are more highly correlated with the broader ILO derived specialization measure (Gini) than those based solely on the manufacturing sector data (UNIDO).

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<sup>4</sup> Using employment shares as a measure of sectoral concentration is common in the literature. See Imbs and Wacziarg (2003), Krugman (1991) and Sukkoo Kim (1995) for examples.

## B. The Incidence and Impact of Earthquakes

This section documents the incidence of earthquakes and their impact on consumption. As Table 4 indicates, there were 272 earthquakes for the 39 countries in the sample over the period 1971-2001. Geology and geography make some countries more earthquake prone than others, and Table 4 also lists the frequency of earthquakes over this period, with Japan, Turkey and the United States most frequently subject to earthquakes. Intuitively, Table 5 reveals a large positive correlation between the probability of an earthquake and a country's size, as countries with larger surface areas are more likely to have tectonic fault lines—a major cause of earthquakes--within their borders.

Table 6 details the impact of earthquakes on consumption levels using two widely available measures: final consumption expenditures (*CON*) and household final expenditures (*HCN*), both measured as a percent of GDP. In the pooled sample the mean level of *CON* in years with earthquakes is about 3 percentage points ( $p$ -value=0.00) below the mean level for non earthquake years; there is little difference in the standard deviation of *CON* across years with compared to those years without earthquakes; a simple non parametric rank sum test rejects the hypothesis ( $p$ -value=0.00) that *CON* in earthquake versus non earthquake country years are drawn from the same distribution. In the case of household expenditures (*HCN*), the mean level in earthquake years is about a percentage point less than those years without earthquakes ( $p$ -value=0.05), and there is a marginally significant difference in volatility across earthquake years ( $p$ -value=0.08).

Table 7 examines the impact of earthquakes on the change in the consumption measures; e.g. the change in final consumption expenditures,  $\Delta CON_{it}$ , for country  $i$  in year  $t$  is defined as  $\Delta CON_{it} = CON_{it} - CON_{it-1}$ . The mean change in final consumption expenditures in non earthquake years is about 0.13 percentage points higher, but this difference is not significant at conventional values. Similarly,  $\Delta HCN_{it}$  is about 0.18 percentage points higher in non earthquake years, but the difference is also not statistically significant. The negative impact of earthquakes on aggregate consumption data is consistent with the micro level evidence. According to household surveys conducted after the 1999 Turkish earthquake, nearly three quarters of rural households reported a reduction in food consumption, and 26 percent reported an end to spending on non food consumption; 59 percent of urban households indicated that they cut down on non food items, while 15 percent eliminated spending on non food items [World Bank, (2003)].

## III. EMPIRICAL FRAMEWORK AND RESULTS

It is well established theoretically that when risks are uninsurable, economic diversification across sectors whose returns are imperfectly correlated can mitigate the impact of shocks. Thus, our rendition of this idea is quite minimal, and is focused mainly on motivating the role of earthquakes in the empirics. To this end, we assume that there are two sectors,  $A$  and  $B$ , that produce an identical good, labor is the sole input, and wages are  $w^A$  and  $w^B$  respectively. We assume that  $w^A > w^B$ , so that without uninsurable risks, production would be specialized in sector  $A$ . However, an earthquake occurs with probability  $p$  and to

capture the idea of imperfectly correlated sectoral returns across states of nature, we assume earthquakes shut down production in sector  $A$ ,  $w^A = 0$ , while sector  $B$  remains unaffected. Because of the idiosyncratic risk, the optimal fraction of labor in sector  $A$ ,  $\lambda$ , reflects the tradeoff between the gains from specialization in that sector versus the benefits of diversifying income in the less risky sector  $B$ . And in the case of log utility:

$$\lambda = \left[ w^A (1 - p) - w^B \right] \left[ (w^A - w^B) \right]^{-1} \quad (1.1)$$

it is readily apparent that the sectoral allocation of labor can shape the impact of an adverse uninsured shock on consumption;  $-\lambda w^A$  is the difference in consumption between earthquake and non earthquake states.

Turning to the data we investigate how the variation in the sectoral distribution of labor can affect the consumption cost of earthquakes. For country  $i$  we consider the sub sample of years with earthquakes, letting  $y_{it}$  denote the impact of an earthquake on country  $i$ 's consumption in year  $t$ , defined as the change in consumption:  $y_{it} = CON_{it} - CON_{it-1}$ , where  $CON_{it-1}$  is the consumption level in the last non earthquake year. To understand the role of pre-existing country characteristics,  $X_{it-1}$ , and the degree of specialization,  $SPC_{it-1}$ , in determining the economic cost of the current shock, we use their values in the year before the earthquake in period <sup>5</sup>. The estimating equation is thus:

$$y_{it} = \beta_0 + \beta_1 SPC_{it-1} + \beta X_{it-1} + c_i + u_{it} \quad (1.2)$$

where  $\beta_j$  are parameters to be estimated;  $c_i$  are country specific time invariant factors such as geology, topography and size that determine the magnitude and frequency of earthquakes;  $u_{it}$  is a residual term that is allowed to be correlated across years for the same country in all regressions.

A key challenge to consistent estimation is that the probability of earthquakes,  $p$ , determined by geography and other country specific time invariant factors<sup>6</sup>,  $c_i$  can affect

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<sup>5</sup> Variables observed in the same year may reflect the effects of the of the shock, rather than the variables' impact on the economic cost of the shock. Consider for example the case of an earthquake that disrupts agriculture, forcing labor to migrate into the manufacturing sector. The labor reallocation may both lead to increased specialization in the year of the shock, and a decline in consumption. This however is different from asking whether the consumption cost of the shock was larger because of the existing high degree of specialization in agriculture before the shock.

<sup>6</sup> Movements in tectonic plates—the principal factor behind earthquakes—occur over hundreds of thousands of years, making it plausible to treat a country's geological characteristics as constant over the last three decades.

both specialization patterns and the consumption cost of earthquakes, rendering it likely that  $SPC_{it-1}$ , and  $c_i$  are correlated. Intuitively, from equation (1.1) the optimal degree of diversification would be slight in countries where  $p$  is small; as a result, those countries would suffer large consumption costs,  $-\lambda w^A$ , when earthquakes do occur. Other geophysical characteristics such as topography can also affect both specialization patterns and the consumption cost of earthquakes. Mountainous countries with large transportation costs between regions may not become highly specialized. But high transportation costs may make it difficult to provide relief when earthquakes occur, magnifying the consumption costs of earthquakes.

Therefore, the analyses emphasize the within country variation in the data to mitigate these sources of omitted variable bias, and derive consistent estimates of  $\beta_1$ . Also, throughout the analyses we use an unbalanced panel. However, because earthquake events—the criteria that “selects” or determines the frequency of country  $i$  in the sample—are random natural shocks and thus independent of the unobserved component of the consumption cost,  $u_{it}$ , conditional on the country’s geographic and socioeconomic characteristics,  $c_i$  and  $X_{it-1}$ , fixed effects on the unbalanced panel remains consistent<sup>7</sup>.

## A. Results

### A.1 Cross--Sector Labor Concentration (ILO):

Before estimating equation (1.2), Figures 1-2 depict the bivariate relationship in the pooled sample between the Gini measure of specialization in the year before an earthquake, and the impact of earthquakes on the two consumption measures: household final expenditures ( $\Delta HCN$ ) and total final expenditures on consumption ( $\Delta CON$ ). In both cases there is a large negative and significant relationship, as an increase in the sectoral concentration of labor is associated with a greater decline in consumption relative to its value in the last non earthquake year. The non-parametric tests (Table 8) for independence between specialization measures in the year before an earthquake and the subsequent change in consumption are rejected in 6 out of the 8 cases at the 1 percent level; the remaining two cases are rejected at the 5 percent level.

Using the within country variation in the data column 3 of Table 9 reports the relationship between the Gini measure of labor specialization and the impact of earthquakes on household final expenditures ( $\Delta HCN$ ). Consistent with Figure 1, this relationship is negative, but its magnitude is about 2.5 times larger than the corresponding OLS estimate (column 2), though it is less precisely estimated (p-value=0.07). A one standard deviation increase in specialization since the last earthquake is associated with a decline in household expenditures ( $HCN$ ) of about 1.9 percentage points in the year of the current earthquake.

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<sup>7</sup> The appendix discusses this issue more formally.

While these results summarize general tendencies within the data, the Venezuelan experience is also illustrative. An earthquake of magnitude 5.0 in 1980 saw a small increase in household expenditures of about 0.2 percentage points compared to its value in 1979. A second earthquake of similar magnitude—5.4—occurred in 1989, but  $H_{CN}$  declined by 3.75 percentage points relative to the 1988 level; in the period in between earthquakes Venezuela underwent roughly a one standard deviation increase in labor specialization. The point estimate in column 3 suggests that the increase in labor specialization over the period accounts for about 1.9 percentage points of the 3.95 difference in impact across the two events.

Column 4 includes the set of control variables—observed the year before the earthquake—that are potentially correlated with economic specialization and are likely to determine the consumption impact of earthquakes. Insurance opportunities in more developed countries, proxied for by GDP per capita ( $GPC_{it-1}$ ), may be more widely available, and governments in those economies may be able to respond more effectively once earthquakes occur. At the same time, specialization patterns have been shown to be closely related to income levels [Imbs and Wacziarg (2003)]. Some theories [Krugman (1991)] also predict that specialization patterns may be linked to population density ( $PDN_{it-1}$ ) and population size ( $LPO_{it-1}$ ), but these variables are also likely to influence the consumption cost of earthquakes, although the direction of their impact is a priori difficult to predict. Earthquakes that strike densely populated countries may cause more damage, leading to larger declines in consumption. But population centers may evolve in those areas least subject to earthquakes, minimizing the impact of earthquakes<sup>8</sup>. Including per capital income, the log of population levels and population density does little to change the  $SPC$  point estimate. The point estimates of the control variables are intuitive, as a one standard deviation increase in per capita income is associated with a 1.7 percentage point increase in  $\Delta H_{CN}$ , but these additional covariates are all individually and jointly insignificant.

Columns 5-7 include the alternative specialization measures: the mean log deviation (Column 5); Theil Index (Column 6); and the coefficient of variation (Column 7). These estimates are uniformly negative, large and significant. Moreover, the implied impact is similar across all four measures. A one standard deviation increase in the mean log deviation is associated with a 1.72 percentage point decline in  $\Delta H_{CN}$ ; similar increases in the Theil Index and the coefficient of variation are associated with a 2.14 and 2.37 percentage point decline in  $\Delta H_{CN}$ , respectively. And as with the Gini specification, the control variables remain individually and jointly insignificant.

Table 10 repeats the above exercise using the change in final consumption expenditures, measured as a percent of GDP ( $\Delta CON_{it}$ ) as the dependant variable. Column 3

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<sup>8</sup> That said, a cursory look at the population densities of Los Angeles, San Francisco, Tokyo, and other earthquake prone zones would suggest little attempt to move away from these areas.

reports a negative association between the Gini measure of labor specialization and  $\Delta CON_{it}$ , implying that a one standard deviation increase in  $SPC_{it-1}$  implies a 1.6 percentage point decline in  $\Delta CON_{it}$ . In the full specification (Column 4), there is little change in the  $SPC_{it-1}$  point estimate, but it remains insignificant at conventional levels (p-value=0.12). Columns 5-7 consider the alternative measures of labor concentration. These point estimates are uniformly negative, and the implied impact is similar across specialization measures, as well as when compared with the household expenditures' point estimates in Table 9. One standard deviation increases in the mean log deviation, the Theil Index and the coefficient of variation are associated with 1.54 (p-value=0.00), 1.72 (p-value=0.09) and 1.85 (p-value=0.15) percentage points decline in  $\Delta CON_{it}$ , respectively.

### A.2 Cross--Sector Specialization (Agriculture):

This section uses various indicators of concentration in the agricultural sector as alternative measures of specialization. While these measures are narrower, they help to gauge the robustness of the previous results to alternative measures of cross sector specialization and data sources, and to ascertain whether these results were driven by countries with large agricultural sectors. Column 2 of Table 11 suggests a negative relationship between the percent of the labor force employed in the agricultural sector ( $AEM_{it-1}$ ) and impact of an earthquake on household expenditures ( $\Delta HCN_{it}$ ). Introducing the control variables (Column 3) affects a slight increase in the  $AEM_{it-1}$  point estimate, implying that a one standard deviation increase in  $AEM_{it-1}$  is associated with a 2.29 percentage point decline in  $\Delta HCN_{it}$  - a magnitude similar to that estimated in Tables 9 and 10, but the point estimate remains relatively imprecise (p-value=0.15). Columns 4 and 5 use  $\Delta CON_{it}$  as the dependant variable. While the relationship is again negative, the estimated impact is much smaller and not significant (p-value=0.44), as a one standard deviation increase in  $AEM_{it-1}$  implies only a 0.23 percentage point decrease in  $\Delta CON_{it}$ .

How does the concentration of labor in agriculture,  $AEM_{it-1}$ , magnify the consumption cost of earthquakes? From Table 3,  $AEM_{it-1}$  and the percent of agricultural products in merchandise exports ( $AEX$ ) are positively correlated. And instead of reflecting a lack of labor income diversification *per se*, the negative results obtained using  $AEM_{it-1}$  might be due to disruptions in agricultural exports. To understand better the mechanism through which labor concentration might impact the consumption cost of earthquakes the analysis includes alternative measures of agricultural specialization such as the value added share of agricultural products in GDP ( $AVL_{it-1}$ ) and  $AEX_{it-1}$ . These results are in columns 6 and 7 of Table 11. Labor specialization remains negative (p-value=0.23) with little change in its point estimate when the other covariates are included, but it continues to be imprecisely estimated (p-value=0.23); the other specialization measures are positive but poorly estimated. That the  $AEM_{it-1}$  point estimate appears little changed from the inclusion of other measures of agricultural specialization suggests that rather than reflecting indirect channels

such as the disruption of export earnings, labor income diversification itself may determine the consumption cost of earthquakes.

Tables 12A and 12B consider whether the earlier findings using the ILO labor shares data (Tables 9 and 10) might have been driven by economies heavily specialized in agriculture. Because of the limited overlap between the ILO and WB data, Table 12A is based on a sample that is 25 percent smaller than used previously, and omits entirely the decade 1971 through 1980. Thus, results based on this smaller sample for the earlier ILO derived specification are also reported (Columns 2-5)<sup>9</sup>; the estimates when  $AEM_{it-1}$  is included are reported in Columns 6-9. Compared to the larger sample in Table 9, the ILO specialization point estimates in the top row of Table 12A are noticeably smaller and poorly estimated. Including  $AEM_{it-1}$  affects on average a 30 percent decline in the ILO point estimates, but they continue to be imprecisely estimated. The  $AEM_{it-1}$  point estimate itself remains similar in magnitude to the values obtained in Table 11, but they are also imprecise, with an average p-value of 0.12 across the four measures. The results in 12B using final consumption expenditures are qualitatively similar.

Taken together, there is some evidence that labor concentration in agriculture can account for some of the negative correlation between the ILO specialization measures and the consumption cost of earthquakes. But this is of course intuitive since the ILO specialization measures are in part derived from the labor share in agriculture. That said, although imprecisely estimated in the smaller sample, the persistent negative relationship of the labor distribution measures after including  $AEM_{it-1}$  suggests that the distribution of labor allocation in the economy, rather than just in agriculture negatively impacts the consumption cost of earthquakes. However, the limited sample size and the mechanical multicollinearity between  $SPC_{it-1}$  and  $AEM_{it-1}$  make conclusions tentative.

### A.3 Financial Development:

The theoretical tradeoff between diversification and specialization hinges on the inability of agents to insure against shocks. Therefore, if the estimated negative impact of specialization on the cost of earthquakes reflects this theoretical tradeoff, then in instances where insurance and other financial instruments are widely available, the estimated impact of specialization should be smaller, as agents would have used the available financial instruments to insure income. Financial development can also directly influence the degree of specialization. For example, the scarcity of credit may prevent agents from investing in new sectors, leading to a concentration of economic activity. At the same time, financial underdevelopment may also worsen the impact of the shock, since agents may be less able to smooth consumption.

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<sup>9</sup> for economy, the control variables' coefficients are suppressed.

This subsection uses the ratio of broad money (M2) to GDP ( $BMG$ )—a widely available proxy of financial depth<sup>10</sup>—to examine whether indeed the negative impact of specialization on the cost of earthquakes is moderated by this particular proxy of financial development. To this end, the specification interacts  $BMG$  with the various measures of specialization ( $SPC$ ). In addition, the specification allows  $BMG$  to enter into the specification linearly in order to control for possible omitted variable bias as financial development may both influence the degree of specialization, as well as the ability to smooth consumption. These results are presented in Tables 12A and 12B, where because of the limited availability of  $BMG$  a smaller sample than used in Tables 9 and 10 is used. For comparison purposes, estimates are also presented from the specification in Tables 9 and 10 using this smaller sample.

For the case of household expenditures in Table 13A, the various specialization measures' point estimates are almost identical to those derived earlier (Table 9). And including the ratio of broad money to GDP ( $BMG$ ) induces a qualitatively similar pattern across all four specialization measures, as their point estimates become substantially larger and more precisely estimated; the interaction terms are consistently positive; and  $BMG$  enters with a negative sign, though it is not significantly different from zero.

For example, the coefficient of variation measure is nearly identical across the two samples (Table 9 column 7 and Table 13A), but the inclusion of  $BMG$  nearly doubles the magnitude of the point estimate, and it is now significant at the one percent level. Moreover, the interaction term is also significant, implying that the negative impact of specialization is more muted in economies with greater financial depth. For an economy at the median level of  $BMG_{it-1}$ , a one standard deviation increase in the coefficient of variation measure of labor specialization implies a decline in household expenditures of about 0.45 percentage points. An identical increase in specialization for an economy at the 10 percentile of  $BMG_{it-1}$  is associated with a 3.29 percentage points decrease in household expenditures.

A similar pattern emerges in Table 13B, where the dependant variable is the change in final consumption expenditures. The specialization point estimates are analogous to those derived in Table 10, but they increase considerably in magnitude and precision once the financial development proxy is included. In addition, the implied impact of specialization on  $\Delta CON$  is similar across specialization measures, as well as to  $\Delta HCN$  in Table 13B. These results are consistent with the idea that the benefits of specialization depend on the degree to which shocks can be insured.

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<sup>10</sup> See for example the survey by Levine (2004) on the various proxies for financial development.

## B. Robustness

This section assesses the robustness of the negative relationship between economic specialization and the consumption cost of earthquakes. In particular, the results in Tables 9 and 10 may not be limited to earthquake years, but may reflect a systematic pattern between specialization and changes in consumption that holds true for all years, including non earthquake years. In that case, using earthquakes to identify the impact of specialization on the consumption cost of shocks would be invalid.

To examine the relationship between *SPC* and consumption changes in non earthquake years Table 14 replicates the non-parametric independence tests reported earlier in Table 8. But unlike Table 8, the hypothesis that the previous year's specialization pattern and the current change in consumption are independent series is not rejected in 5 out of the eight cases; the remaining three cases reject this hypothesis at the 10 percent level. Employing parametric methods for the same specification and sample of countries as in Tables 9 and 10, Tables 15A and 15B examine the relationship between specialization and consumption in non earthquake years.

The estimates in Tables 15A and 15B reveal no statistically significant relationship between any of the specialization measures and the two measures of consumption in non earthquake years; moreover, the point estimates are sometimes positive and much smaller in magnitude than those estimated in earthquake years, and the hypothesis that the point estimates are identical across earthquake and non earthquake years is rejected. For example, from Table 15A, a one standard deviation increase in the Gini measure of specialization ( $p$ -value=0.32) implies a 0.32 percentage point decline in the household expenditures; recall that the estimated relationship in earthquake years is about six times as large (Table 9). Thus, both the parametric and non parametric evidence indicate that preexisting specialization patterns are unrelated to consumption changes in non earthquake years.

The estimation strategy has relied on the within country variation in the data to reduce the biases that might arise from the potential correlation between omitted geographical factors that determine the magnitude of earthquakes, the resulting consumption cost, and the pattern of specialization. But fixed effects may only partially mitigate this possible bias. For example, the consumption cost from an earthquake with a large Richter scale measure is likely to be different from a less severe earthquake. At the same time, an economy that experiences severe earthquakes may also have a different labor specialization pattern. Thus, earthquake severity may be an important omitted variable. Tables 16A and 16B replicate the specification in Tables 9 and 10, including the Richter (*MAG*) scale measure of earthquake intensity—available for a subset observations. For comparison purposes, the estimates excluding *MAG* are reported for the smaller sample. The magnitude of the specialization coefficients are uniformly larger and more precisely estimated when *MAG* is included, suggesting that the earlier results in Tables 9 and 10 might be taken as lower bound estimates.

Throughout, the analyses has emphasized the timing of the regressors, arguing that variables observed in the year of the earthquake may reflect the underlying mechanism through which earthquakes disrupt economic activity and consumption, rather than the role of pre-existing characteristics in shaping the cost of earthquakes. That is, an earthquake that disrupts agriculture, may force labor to migrate into the manufacturing sector, and lead both to increased specialization in the year of the shock, and a decline in consumption. While this traces the mechanism of the shock, it is fundamentally different from investigating whether the consumption cost of the shock was larger because of the existing high degree of specialization in agriculture before the shock.

To understand better the mechanism of the shock, as well as to determine the sensitivity of the results to the timing of the regressors, Tables 17A and 17B reconsider the specification in Tables 7 and 8, using regressors observed in the same year as the earthquake. The estimated impact of specialization on the consumption cost of earthquakes is on average about 40 percent larger than those obtained when using measures observed the year prior to the event (Tables 9 and 10). Thus, while pre-existing labor income diversification can reduce the cost of shocks, the larger estimates in Tables 17A and 17B suggest, perhaps not surprisingly, that the dislocation and idling of labor, which would generate increased labor concentration, are associated with larger declines in consumption. For example, detailed case study evidence after the 1999 Turkish earthquake [World Bank (2003)] indicated that the log mean deviation of labor allocation increased by 5 percent, as labor increased in the services, but declined in other sectors.

Does the negative relationship between cross sector specialization and the cost of earthquakes extend to specialization within the manufacturing sectors? Tables 18-20 (available upon request) explore this question using measures of specialization within the manufacturing sector at the three digit ISIC code based on the distribution of labor and the distribution of value added (UNIDO, 2003). Because the data measures specialization within the manufacturing sector, a country highly specialized within that sector may also have a large manufacturing sector, making it difficult to interpret the specialization coefficient. Thus, we use the agricultural concentration measures to control for the relative size of other sectors. Furthermore, compared to the ILO data, the UNIDO data covers both more years and countries. There is however no statistically significant relationship between any of the manufacturing sector specialization measures, and consumption. This finding is robust to various sub samples and specifications

#### IV. CONCLUSION

Exploiting the exogeneity and unpredictability of earthquakes, this paper has used the timing of earthquakes to estimate the relationship between economic specialization and the consumption cost of shocks. The evidence suggests that economic specialization greatly magnifies the consumption cost of earthquakes. A one standard deviation increase in specialization is associated with an additional 2 percentage point decline in household expenditures in the year of an earthquake. And this negative impact of specialization on the cost of earthquakes is observed using both household expenditures and final consumption expenditures, across a variety of specialization measures, as well as various specifications

and methodologies. In contrast, there is no significant relationship between specialization patterns and changes in consumption in non earthquake years.

The evidence also suggests that the impact of specialization is closely related to the level of financial development. For an economy at the median level of financial development—proxied using the ratio of broad money to GDP—the impact of a one standard deviation increase in specialization on the change in household expenditures in the year of an earthquake is about -0.45 percentage points. A similar increase in specialization for an economy at the 10<sup>th</sup> percentile level of financial development is associated with a 3.29 percentage point decline in household expenditures. Taken together, these results are consistent with the idea that the benefits of specialization depend on the degree to which financial markets are able to smooth consumption during bad times.

While these results are intriguing, several questions remain open. First, the analysis has focused mainly on the short term relationship between specialization and the consumption cost of earthquakes. Thus, further work is needed in order to understand whether this negative relationship extends into the longer term. Is it the case for example that more specialized economies take a longer time to recover from earthquakes? Or is it that while consumption declines more precipitously in those economies, it also rebounds faster in the medium term?

Second, the proxy for financial dept, the ratio of broad money to GDP (*BMG*), used to establish a link between the cost of earthquakes, specialization and financial development is only one element of financial development, and adding measures such as liquidity, bank credit and other proxies may provide additional insight. To this end, including other types of natural disasters such as hurricanes may allow a larger sample of countries, and more data availability. Third, governments often play a large role in implicitly insuring against natural risks. Understanding how this implicit role might affect our results is also an opportunity for further research.

## V. APPENDIX

### A. Figures and Tables

**Table 1. Variables: Definitions and Sources.**

Variable	Definition	Source
<i>AEM</i>	Employment in Agriculture, (% of total Employment)	World Bank, (2003).
<i>AEX</i>	Agricultural Raw Materials Exports, (% of merchandise exports)	World Bank, (2003).
<i>AVL</i>	Agriculture, Value Added (% of GDP)	World Bank, (2003).
<i>BMG</i>	Money and Quasi Money (% of GDP)	World Bank, (2003).
<i>CON</i>	Final Consumption Expenditures, (% of GDP)	World Bank, (2003).
<i>GPC</i>	Ratio of Real GDP in \$US to Population	World Bank, (2003).
<i>HCN</i>	Household Final Expenditures, (% of GDP)	World Bank, (2003).
<i>LPO</i>	Log of Population	World Bank, (2003).
<i>MAG</i>	Richter Scale Measure of Earthquake Intensity	CRED, (2003)
<i>PDN</i>	Population Density: People per Square Kilometer.	World Bank, (2003).

**Table 2. Specialization Measures: Summary Statistics**

	ILO	ILO	UNIDO (EP)	UNIDO (EP)	UNIDO (VA)	UNIDO (VA)	WB	WB
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Gini	.544	0.083	0.536	0.070	0.529	0.074		
Log Mean Deviation	0.911	0.333	0.619	0.191	0.637	0.218		
Coefficient of Variation	0.559	0.190	0.536	0.202	0.508	0.180		
Theil Index	0.660	0.350	0.791	0.601	0.676	0.405		
% Labor Employed in Agriculture	---	---	---	---	---	---	25.608	19.631
Agriculture Value Added, % GDP	---	---	---	---	---	---	15.642	9.730
Agricultural Raw Materials, % of Merchandise Exports	---	---	---	---	---	---	4.985	5.414

**Table 3. Correlation Among Specialization Measures**

	Gini (ILO)	Gini (UNIDO(EP))	Gini (UNIDO (VA))	AEM	AVL	AEX
Gini (ILO)	1.0000					
Gini (UNIDO(EP))	0.3369	1.0000				
Gini (UNIDO (VA))	0.1450	0.6439	1.0000			
AEM	0.7088	0.3703	-0.0008	1.0000		
AVL	0.6755	0.4918	0.2306	0.7800	1.0000	
AEX	0.1940	0.5013	0.3206	0.2030	0.3749	1.0000

**ILO: Labor allocation data from International Labor Office (2003); UNIDO (EP): Employment data (Manufacturing Only) from UNIDO (2002) ; UNIDO (VA): Value added data (Manufacturing Only) from UNIDO (2002); WB: Data from World Development Indicators, World Bank, 2003.**

**Table 4. Countries in Sample and Average Incidence of Earthquakes, 1971-2001**

<b>Country</b>	<b>Percent of Years with Reported Earthquakes</b>	<b>Country</b>	<b>Percent of Years with Reported Earthquakes</b>
Australia	4.8	Iran, I.R. of	37.5
Azerbaijan	2.8	Iceland	1.9
Belgium	1.9	Italy	19.2
Bangladesh	4.8	Japan	27.8
Bulgaria	3.8	Kyrgyz Republic	1.9
Bolivia	2.8	Mexico	18.2
Brazil	0.9	Nicaragua	7.6
Chile	19.2	Netherlands	0.9
China,P.R.: Mainland	38.4	New Zealand	4.8
Colombia	14.4	Pakistan	13.4
Costa Rica	5.7	Peru	26.9
Cyprus	1.9	Philippines	17.3
Germany	0.96	Russia	3.8
Ecuador	12.5	El Salvador	5.7
Egypt	4.8	Slovenia	0.9
Spain	1.9	Trinidad and Tobago	0.9
United Kingdom	0.9	Turkey	36.5
Greece	23.0	United States	25.9
Honduras	2.8	Venezuela, Rep. Bol.	6.7
Indonesia	32.6		

**Source: Center for Research on the Epidemiology of Disasters (CRED, 2003).**

**Table 5. The Correlation Between Economic Characteristics and the Frequency of Earthquakes**

	<b>Frequency of Earthquakes</b>	<b>GDP per capita</b>	<b>Population</b>	<b>Size</b>	<b>Population Density</b>
<b>Frequency of Earthquakes</b>	1.000				
<b>GDP per capita</b>	0.225	1.000			
<b>Population</b>	-0.135	0.012	1.000		
<b>Size</b>	0.4744	0.5728	-0.0732	1.0000	
<b>Population Density</b>	-0.1480	-0.2479	0.2301	0.0425	1.0000

**Table 6: The Impact of Earthquakes on Consumption Levels**

	Final Consumption Expenditures, % of GDP		Household Final Expenditures, % of GDP	
	Mean	Standard Deviation	Mean	Standard Deviation
Earthquake Year	77.07	8.49	63.74	9.27
Non-Earthquake Year	80.03	8.86	64.86	9.94
Earthquake Year=Non-Earthquake Year (p-value)	0.00	0.40	0.10	0.15
Earthquake Year>Non-Earthquake Year (p-value)	1.00	0.19	0.95	0.92
Earthquake Year<Non-Earthquake Year (p-value)	0.00	0.81	0.05	0.08
Rank Sum Test (p-value)	0.001	---	0.34	---

**Table 7: The Impact of Earthquakes on the Change in Consumption**

	$\Delta$ Final Consumption Expenditures, % of GDP		$\Delta$ Household Final Expenditures, % of GDP	
	Mean	Standard Deviation	Mean	Standard Deviation
Earthquake Year	0.00	3.42	-0.07	3.51
Non-Earthquake Year	0.13	3.81	0.10	3.73
Earthquake Year=Non-Earthquake Year (p-value)	0.61	0.03	0.52	0.23
Earthquake Year>Non-Earthquake Year (p-value)	0.70	0.98	0.74	0.88
Earthquake Year<Non-Earthquake Year (p-value)	0.30	0.02	0.26	0.12
Rank Sum Test (p-value)	0.68	---	0.78	---

Figure 1: The Change in Household Expenditures and Labor Specialization (Gini Coefficient--ILO Data), 1971-2001.

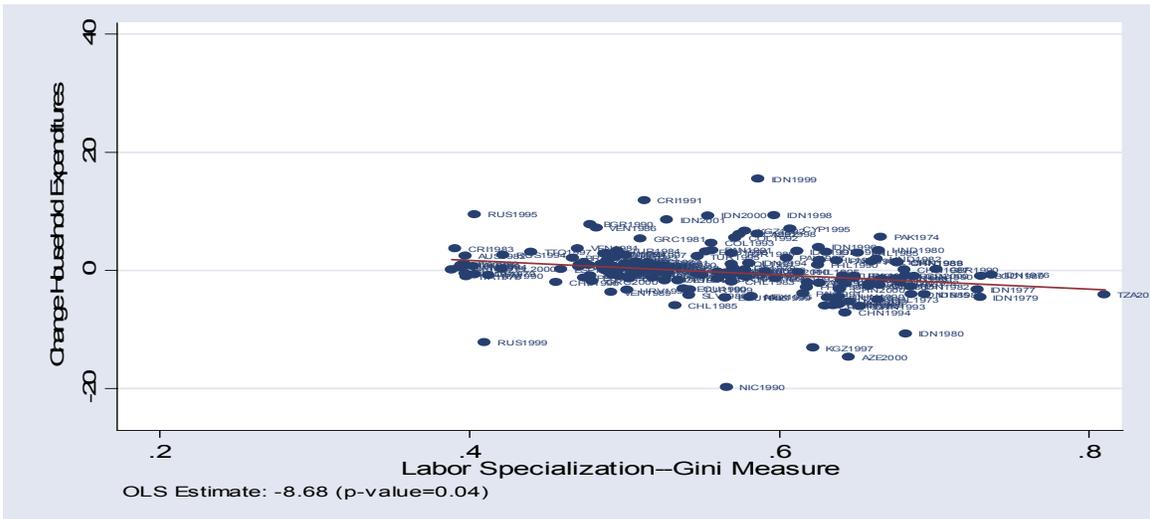


Figure 2: The Change in Final Consumption Expenditures and Labor Specialization (Gini Coefficient--ILO Data), 1971-2001.



**Table 8. Earthquake Years and Chi-Squared Tests for Independence: Labor Specialization (ILO, 2003) and the Impact of Earthquakes on Household Final Expenditures ( $\Delta HCN$ ) and Final Consumption Expenditures ( $\Delta CON$ ) 1971-2001**

	Gini	Mean Log Deviation	Theil Index	Coefficient of Variation
$\Delta HCN$	0.000	0.035	0.000	0.000
$\Delta CON$	0.000	0.026	0.000	0.000

P-values in rows indicate the probability of rejecting the null hypothesis of independence.

**Table 9**  
**Labor Specialization (ILO, 2003) and the Impact of Earthquakes on Household Final Expenditures, 1971-2001**  
*Dependant Variable: The Change in Household Consumption ( $\Delta HCN$ )*

	Gini	Gini	Gini	Mean Log Deviation	Theil Index	Coefficient of Variation
	(2)	(3)	(4)	(5)	(6)	(7)
$SPC_{it-1}$	-9.475** (5.204)	-20.219* (11.874)	-20.462* (11.511)	-5.123*** (1.523)	-11.289** (5.252)	-6.794* (3.670)
$GPC_{it-1}$	---	---	0.154 (0.395)	0.256 (0.360)	0.211 (0.371)	0.227 (0.362)
$LPO_{it-1}$	---	---	7.836 (16.002)	11.207 (15.927)	8.876 (15.583)	8.231 (15.596)
$PDN_{it-1}$	---	---	-0.018 (0.069)	-0.005 (0.065)	-0.023 (0.065)	-0.029 (0.062)
Year Dummies?	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects?	No	Yes	Yes	Yes	Yes	Yes
Adjusted $R^2$	0.13	0.09	0.073	0.11	0.10	0.116
NOB	178	178	178	178	178	178

Huber -White robust standard errors in parenthesis. Regression residual terms are clustered at the country level. \*, \*\*, \*\*\* indicates significance at the 10, 5 and 1 percent levels respectively.  $SPC_{it-1}$  indicates the specialization measure used in the specification; for example columns 4 and 5 use the Gini and log deviation specialization measures respectively.  $GPC_{it-1}$  is per capita income\* 1000. See Table 1 for definition and sources of variables.

**Table 10**  
**Labor Specialization (ILO, 2003) and the Impact of Earthquakes on Final Consumption Expenditures, 1971-2001 .**      *Dependant Variable: The Change in Final Consumption Expenditures ( $\Delta CON$ )*

	Gini	Gini	Gini	Mean Log Deviation	Theil Index	Coefficient of Variation
	(2)	(3)	(4)	(5)	(6)	(7)
$SPC_{it-1}$	-13.378** (6.772)	-16.761 (12.387)	-16.872 (10.624)	-4.561*** (1.474)	-9.073* (5.422)	-5.290 (3.600)
$GPC_{it-1}$	---	---	0.249 (0.204)	0.340 (0.196)	0.271 (0.179)	0.281 (0.177)
$LPO_{it-1}$	---	---	12.377 (12.377)	15.469 (11.922)	13.174 (11.803)	12.623 (11.969)
$PDN_{it-1}$	---	---	-0.040 (0.055)	-0.034 (0.050)	-0.043 (0.056)	-0.047 (0.040)
Year Dummies?	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects?	No	Yes	Yes	Yes	Yes	Yes
$R^2$	0.16	0.28	0.28	0.31	0.29	0.30
NOB	178	178	178	178	178	178

Huber -White robust standard errors in parenthesis. Regression residual terms are clustered at the country level. \*, \*\*, \*\*\* indicates significance at the 10, 5 and 1 percent levels respectively.  $SPC_{it-1}$  indicates the specialization measure used in the specification; for example columns 4 and 5 use the Gini and log deviation specialization measures respectively.  $GPC_{it-1}$  is per capita income\* 1000. See Table 1 for definition and sources of variables.

**Table 11**  
**Specialization in Agriculture and the Impact of Earthquakes on Consumption, 1981-2001**

Dependant Variable	$\Delta HCN$	$\Delta HCN$	$\Delta CON$	$\Delta CON$	$\Delta HCN$	$\Delta CON$
	(Household Expenditures)	(Household Expenditures)	(Final Consumption Expenditures)	(Final Consumption Expenditures)	(Household Expenditures)	(Final Consumption Expenditures)
	(2)	(3)	(4)	(5)	(6)	(7)
$AEM_{it-1}$	-0.095 (0.092)	-0.112 (0.077)	0.009 (0.077)	-0.052 (0.067)	-0.128 (0.106)	-0.052 (0.092)
$GPC_{it-1}$	---	0.708* (0.415)	---	0.755** (0.313)	0.300* (0.178)	0.405** (0.154)
$LPO_{it-1}$	---	32.207* (18.782)	---	34.797** (14.876)	17.015 (10.967)	22.864** (9.959)
$PDN_{it-1}$	---	-0.092 (0.065)		-0.115** (0.056)	-0.071 (0.102)	-0.070 (0.095)
$AVL_{it-1}$	---	---	---		0.154 (0.229)	0.243 (0.248)
$AEX_{it-1}$	---	---	---		-0.084 (0.362)	0.069 (0.345)
Year Dummies?	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects?	Yes	Yes	Yes	Yes	Yes	Yes
$R^2$	0.482	0.51	0.56	0.36	0.37	0.69
NOB	161	161	161	161	148	148

Huber -White robust standard errors in parenthesis. Regression residual terms are clustered at the country level. \*, \*\*, \*\*\* indicates significance at the 10, 5 and 1 percent levels respectively.  $GPC_{it-1}$  is per capita income\* 1000. See Table 1 for definition and sources of variables.

**Table 12.A. Labor Specialization (ILO, 2003) and Specialization in Agriculture, The Change in Household Expenditures, 1981-2001.**

	The Change in Household Expenditures, (Truncated Sample)				The Change in Household Expenditures, (Truncated Sample)			
$Gini_{it-1}$	-7.434 (11.586)	---	---	---	-3.137 (11.246)	---	---	---
$Mean\ Log\ Deviation_{it-1}$	---	-1.693 (2.292)	---	---	---	-1.298 (2.168)	---	---
$Theil\ Index_{it-1}$	---	---	-4.878 (6.224)	---	---	---	-2.691 (6.167)	---
$Coeff\ Variation_{i,t-1}$	---	---	---	-3.623 (4.626)	---	---	---	-2.119 (4.820)
$AEM_{it-1}$	---	---	---	---	-0.112 (0.073)	-0.114 (0.074)	-0.106 (0.068)	-0.096 (0.065)
$R^2$	0.48	0.48	0.49	0.49	0.50	0.50	0.50	0.50
NOB	145	145	145	145	145	145	145	145

**Table 12.B Labor Specialization and Specialization in Agriculture, The Change in Final Consumption Expenditures, 1981-2001**

	The Change in Final Consumption Expenditures, (Truncated Sample)				The Change in Final Consumption Expenditures, (Truncated Sample)			
$Gini_{it-1}$	-7.406 (12.536)	---	---	---	-5.644 (12.459)	---	---	---
$Mean\ Log\ Deviation_{it-1}$	---	-1.820 (2.539)	---	---	---	-1.643 (2.444)	---	---
$Theil\ Index_{it-1}$	---	---	-3.893 (6.694)	---	---	---	-3.005 (6.745)	---
$Coeff\ Variation_{i,t-1}$	---	---	---	-2.658 (4.675)	---	---	---	-2.114 (4.981)
$AEM_{it-1}$	---	---	---	---	-0.046 (0.063)	-0.051 (0.062)	-0.043 (0.060)	-0.035 (0.061)
$R^2$	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
NOB	145	145	145	145	145	145	145	145

Huber -White robust standard errors in parenthesis. Regression residual terms are clustered at the country level. \*, \*\*, \*\*\* indicates significance at the 10, 5 and 1 percent levels respectively. Control variables include per capita income, population density, the log of population size; year and country specific effects are also included.

**Table 13A Financial Development and Specialization (ILO, 2003): The Impact on the Change in Household Expenditures, 1971-2001**

	Gini		Log Mean Deviation		Theil Index		Coefficient of Variation		Percent of Employment in Agriculture	
	(Table 8)	(BMG)	(Table 8)	(BMG)	(Table 8)	(BMG)	(Table 8)	(BMG)	(Table 8)	(BMG)
$SPC_{it-1}$	-21.178** (10.011)	-35.237** (18.176)	-5.488** (1.979)	-12.160*** (3.387)	-12.024** (4.647)	-23.073*** (7.052)	-7.544** (2.867)	-15.358*** (3.569)	-0.127* (0.071)	-0.197 (0.142)
$BMG_{it-1}$	---	-0.339 (0.230)	---	-0.278* (0.162)	---	-0.314 (0.231)	---	-0.264 (0.200)	---	-0.112 (0.172)
$SPC_{it-1} * BMG_{it-1}$	---	0.625 (0.416)	---	0.330*** (0.115)	---	0.520* (0.225)	---	0.363** (0.164)	---	0.003 (0.004)
$R^2$	0.60	0.48	0.50	0.54	0.49	0.51	0.50	0.54	0.52	0.53
NOB	150	150	150	150	150	150	150	150	150	150

**Table 13.B Financial Development and Specialization: The Impact on the Change in Final Consumption Expenditures, 1971-2001.**

	Gini		Log Mean Deviation		Theil Index		Coefficient of Variation		Percent of Employment in Agriculture	
	(Table 9)	(BMG)	(Table 9)	(BMG)	(Table 9)	(BMG)	(Table 9)	(BMG)	(Table 9)	(BMG)
$SPC_{it-1}$	-16.720 (11.447)	-29.548 (22.395)	-4.797** (1.800)	-10.237** (3.689)	-9.056* (5.044)	-20.583** (9.005)	-5.579* (3.062)	-14.181*** (4.582)	-0.061 (0.061)	-0.134 (0.126)
$BMG_{it-1}$	---	-0.328 (0.373)	---	-0.242 (0.160)	---	-0.346 (0.259)	---	-0.303 (0.200)	---	-0.156 (0.165)
$SPC_{it-1} * BMG_{it-1}$	---	0.567 (0.553)	---	0.268** (0.128)	---	0.534* (0.295)	---	0.393** (0.184)	---	0.003 (0.003)
$R^2$	0.596	0.602	0.619	0.645	0.605	0.628	0.610	0.650	0.623	0.631
NOB	150	150	150	150	150	150	150	150	150	150

Huber -White robust standard errors in parenthesis. Regression residual terms are clustered at the country level. \*, \*\*, \*\*\* indicates significance at the 10, 5 and 1 percent levels respectively. All regressions include per capita income, population density, the log of population size as control variables; year and country specific effects are also included. Columns labeled Table 8 refer to estimating the specification in Table 8 using the current sample; similarly for Table 9. Note that the Percent of Employment in Agriculture specification uses data from 1980-2001.

**Table 14 . Non Earthquake Years in Chi-Squared Tests for Independence: Household Final Expenditures ( $\Delta HCN$ ) and Final Consumption Expenditures ( $\Delta CON$ ) 1971-2001**

	Gini	Mean Log Deviation	Theil Index	Coefficient of Variation	Percent of Employment in Agriculture
$\Delta HCN$	0.112	0.493	0.075	0.056	0.862
$\Delta CON$	0.199	0.886	0.172	0.099	0.324
Number of Observations	446	446	446	446	329

P-values in rows indicate the probability of rejecting the null hypothesis of independence.

**Table 15A. Non Earthquake Years: Labor Specialization and Household Consumption, 1971-2001**  
*Dependant Variable: The Change in Household Consumption ( $\Delta HCN$ )*

	Gini	Mean Log Deviation	Theil Index	Coefficient of Variation	Percent of Employment in Agriculture
	(2)	(3)	(4)	(5)	(6)
$SPC_{it-1}$	-3.827 (2.531)	0.491 (1.587)	-2.427 (1.640)	-1.575 (1.095)	0.046 (0.035)
$GPC_{it-1}$	0.396 (0.648)	0.060 (0.069)	0.040 (0.006)	0.003 (0.006)	0.003 (0.002)
$PDN_{it-1}$	0.007 (0.009)	0.006 (0.009)	0.007 (0.008)	0.007 (0.008)	-0.016 (0.017)
$LPO_{it-1}$	1.841 (1.745)	2.446 (1.824)	1.550 (1.832)	1.037 (1.840)	9.050* (4.938)
Year Dummies?	Yes	Yes	Yes	Yes	Yes
Fixed Effects?	Yes	Yes	Yes	Yes	Yes
$R^2$	0.18	0.18	0.19	0.19	0.24
NOB	438	438	438	438	321

Huber -White robust standard errors in parenthesis. Regression residual terms are clustered at the country level.

\*, \*\*, \*\*\* indicates significance at the 10, 5 and 1 percent levels respectively.  $GPC_{it-1}$  is per capita income\* 1000. Note that column 6 uses data from 1981-2001. See Table 1 for definition and sources of variables.

**Table 15B. Non Earthquake Years: Labor Specialization and Final Consumption Expenditures, 1971-2001** *Dependant Variable: The Change in Final Consumption Expenditures ( $\Delta CON$ )*

	Gini	Mean Log Deviation	Theil Index	Coefficient of Variation	Percent of Employment in Agriculture
	(2)	(3)	(4)	(5)	(6)
$SPC_{it-1}$	-2.739 (2.688)	0.544 (1.251)	-2.026 (1.608)	-1.498* (0.998)	0.040 (0.028)
$GPC_{it-1}$	0.114 (0.008)	0.129 (0.086)	0.113 (0.081)	0.107 (0.080)	0.370 (0.254)
$PDN_{it-1}$	0.001 (0.011)	0.0006 (0.012)	0.0007 (0.010)	0.001 (0.010)	-0.022 (0.019)
$LPO_{it-1}$	4.111** (2.130)	4.580** (2.146)	3.807* (2.222)	3.226 (2.237)	10.826* (5.707)
Year Dummies?	Yes	Yes	Yes	Yes	Yes
Fixed Effects?	Yes	Yes	Yes	Yes	Yes
$R^2$	0.19	0.19	0.19	0.19	0.23
NOB	438	438	438	438	321

Huber -White robust standard errors in parenthesis. Regression residual terms are clustered at the country level.

\*, \*\*, \*\*\* indicates significance at the 10, 5 and 1 percent levels respectively.  $GPC_{it-1}$  is per capita income\* 1000. Note that column 6 uses data from 1980-2001. See Table 1 for definition and sources of variables.

**Table 16A Earthquake Magnitude and Specialization (ILO, 2003): The Impact on the Change in Household Expenditures, 1971-2001**

	Gini		Log Mean Deviation		Theil Index		Coefficient of Variation		Percent of Employment in Agriculture	
	(Table 8)	(MAG)	(Table 8)	(MAG)	(Table 8)	(MAG)	(Table 8)	(MAG)	(Table 8)	(MAG)
$SPC_{it-1}$	-19.538 (12.821)	-22.064* (12.630)	-5.537*** (1.716)	-5.903*** (1.781)	-11.582** (5.809)	-12.832** (5.792)	-7.309 (3.992)	-8.104** (4.062)	-0.108 (0.083)	-0.124 (0.078)
$MAG$	---	1.341 (1.013)	---	1.353 (0.984)	---	1.421 (0.984)	---	1.485 (0.961)	---	1.567 (1.015)
$R^2$	0.44	0.46	0.47	0.493	0.46	0.49	0.579	0.50	0.52	0.54
NOB	162	162	162	162	162	162	162	162	154	154

**Table 16.B Earthquake Magnitude and Specialization: The Impact on the Change in Final Consumption Expenditures, 1971-2001.**

	Gini		Log Mean Deviation		Theil Index		Coefficient of Variation		Percent of Employment in Agriculture	
	(Table 9)	(MAG)	(Table 9)	(MAG)	(Table 9)	(MAG)	(Table 9)	(MAG)	(Table 9)	(MAG)
$SPC_{it-1}$	-17.053 (13.446)	-19.310 (13.029)	-5.053** (1.888)	-5.358*** (1.888)	-9.715 (6.133)	-10.740* (6.053)	-6.021 (3.981)	-6.671* (4.041)	-0.048 (0.071)	-0.066 (0.063)
$MAG$	---	1.105 (0.858)	---	1.123 (0.841)	---	1.164 (0.834)	---	1.213 (0.810)	---	1.451 (0.877)
$R^2$	0.564	0.58	0.590	0.601	0.576	0.564	0.583	0.60	0.62	0.64
NOB	162	162	162	162	162	162	162	162	154	154

Huber -White robust standard errors in parenthesis. Regression residual terms are clustered at the country level. \*, \*\*, \*\*\* indicates significance at the 10, 5 and 1 percent levels respectively. All regressions include per capita income, population density, the log of population size as control variables; year and country specific effects are also included. Columns labeled Table 8 refer to estimating the specification in Table 8 using the current sample; similarly for Table 9. Note that the Percent of Employment in Agriculture specification uses data from 1980-2001.

**Table 17A. Timing: Labor Specialization and the Impact of Earthquakes on Household Consumption, 1971-2001** *Dependant Variable: The Change in Household Consumption ( $\Delta HCN$ )*

	Gini	Mean Log Deviation	Theil Index	Coefficient of Variation	Percent of Employment in Agriculture
	(2)	(3)	(4)	(5)	(6)
$SPC_{it}$	-31.064** (15.518)	-6.686*** (1.499)	-14.880** (6.321)	-7.390* (4.006)	-0.137 (0.107)
$GPC_{it}$	0.145 (0.205)	0.285 (0.256)	0.215 (0.253)	0.203 (0.247)	0.577* (0.308)
$PDN_{it}$	-0.021 (0.023)	-0.023 (0.017)	-0.022 (0.022)	-0.021 (0.024)	-0.080 (0.056)
$LPO_{it}$	8.535 (10.460)	12.761 (10.997)	9.454 (10.335)	8.358 (9.761)	30.545** (15.346)
Year Dummies?	Yes	Yes	Yes	Yes	Yes
Fixed Effects?	Yes	Yes	Yes	Yes	Yes
$R^2$	0.40	0.407	0.411	0.407	0.500
NOB	183	183	183	183	169

Huber -White robust standard errors in parenthesis. Regression residual terms are clustered at the country level.

\*, \*\*, \*\*\* indicates significance at the 10, 5 and 1 percent levels respectively.  $GPC_{it-1}$  is per capita income\* 1000. Note that column 6 uses data from 1980-2001. See Table 1 for definition and sources of variables.

**Table 17B. Timing: Labor Specialization and the Impact of Earthquakes on Final Consumption Expenditures, 1971-2001** *Dependant Variable: The Change in Final Consumption Expenditures ( $\Delta CON$ )*

	Gini	Mean Log Deviation	Theil Index	Coefficient of Variation	Percent of Employment in Agriculture
	(2)	(3)	(4)	(5)	(6)
$SPC_{it-1}$	-23.783* (12.662)	-5.650*** (1.258)	-10.928* (5.819)	-5.190 (3.801)	-0.079 (0.102)
$GPC_{it-1}$	0.259 (0.228)	0.381* (0.216)	0.310 (0.214)	0.298 (0.215)	0.680** (0.279)
$PDN_{it-1}$	-0.034* (0.019)	-0.036** (0.014)	-0.035* (0.019)	-0.034* (0.020)	-0.091* (0.048)
$LPO_{it-1}$	13.80* (7.829)	17.302** (8.312)	14.503* (7.803)	13.732* (7.547)	31.696** (13.301)
Year Dummies?	Yes	Yes	Yes	Yes	Yes
Fixed Effects?	Yes	Yes	Yes	Yes	Yes
$R^2$	0.50	0.52	0.51	0.50	0.62
NOB	183	183	183	183	169

Huber -White robust standard errors in parenthesis. Regression residual terms are clustered at the country level. \*, \*\*, \*\*\* indicates significance at the 10, 5 and 1 percent levels respectively.  $GPC_{it-1}$  is per capita income\* 1000. Note that column 6 uses data from 1980-2001. See Table 1 for definition and sources of variables.

### B. “Selection” into the Panel

To investigate how specialization affects the impact of earthquakes on consumption, the methodology selected only those years from 1971-2001 in which an earthquake occurred for the panel of 39 countries. This led to an unbalanced panel because some countries are more earthquake prone than others and appear more frequently based on the earthquake selection criteria. This subsection shows that under reasonable assumptions the fixed effects estimator remains consistent despite the unbalanced panel.

Let  $s_{it}$  take on the value of one if an earthquake occurs in country  $i$  on year  $t$ , and zero otherwise. Since  $s_{it}$  is the selection criteria for the panel, we observe  $(X_{it-1}, y_{it}, SPC_{it-1})$  if and only if  $s_{it} = 1$ . Letting  $z_{it}$  denote the regressors, the fixed effects estimator is thus:

$$\begin{aligned}\hat{\beta} &= \left( N^{-1} \sum_{i=1}^N \sum_{t=1}^T s_{it} \widetilde{z}_{it} \widetilde{z}_{it}' \right)^{-1} \left( N^{-1} \sum_{i=1}^N \sum_{t=1}^T s_{it} \widetilde{z}_{it} \widetilde{y}_{it} \right) \\ &= \beta + \left( N^{-1} \sum_{i=1}^N \sum_{t=1}^T s_{it} \widetilde{z}_{it} \widetilde{z}_{it}' \right)^{-1} \left( N^{-1} \sum_{i=1}^N \sum_{t=1}^T s_{it} \widetilde{z}_{it} \widetilde{u}_{it} \right)\end{aligned}\tag{1.3}$$

where  $\widetilde{\cdot}$  denotes the usual within transformation:  $\widetilde{z}_{it} = z_{it} - T^{-1} \sum_{r=1}^T s_{ir} z_{ir}$ . Standard

assumptions ensure that consistent estimates:  $E(u_{it} | x_i, s_i, c_i) = 0$  and  $\sum_{t=1}^T E(s_{it}, \widetilde{z}_{it}' \widetilde{z}_{it})$  is non singular. Obviously selection in the to panel is correlated with  $c_i$  --a country's geophysical characteristics. However, it seems reasonable to assume that after controlling for  $c_i$ , the incidence of earthquakes,  $s_{it}$ , is mean independent of  $u_{it}$  --the unobserved factors that determine consumption costs-- conditioned on  $(z_i, c_i)$ . This assumption can fail however if the earthquake database, CRED, disproportionately included earthquakes from more developed countries because of their wider media coverage, or if because improvements in data gathering technologies, recent earthquakes are more likely to be included. But conditioning on per capita income, and including year effects reduces this possible bias.

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