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Human Capital, Trade Liberalization and Income Risk [1]

Tom Krebs
Mannheim University

Pravin Krishna
Johns Hopkins University and NBER

William Maloney
World Bank

Abstract

Using data from Mexico, this paper studies empirically the link between trade policy and individual income risk and the extent to which this varies across workers of different human capital (education) levels. Longitudinal income data on workers are used to estimate time-varying individual income risk parameters in different manufacturing sectors in Mexico between 1987 and 1998, a period in which the Mexican economy experienced substantial changes in trade policy. In a second step, the variations in trade policy – across different sectors and over time – are used to estimate the linkage between trade policy and income risk for workers of varying education levels. Our findings are as follows. The level of openness of an economy is not found to be related to income risk for workers of any type. Furthermore, changes in trade policy (i.e., trade policy reforms) are not found to have any effect on the risk to income faced by workers with either low or high levels of human capital. However, workers with intermediate levels of human capital are found to experience a statistically and economically significant increase in income risk immediately following liberalization of trade. Our findings thus point to an interesting non-monotonicity in the interaction between human capital, income risk and trade policy changes.

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I. Introduction

In recent years, the impact of the increased "openness" of countries on factor markets has been actively debated in the theoretical and empirical literature in international trade.[2] This literature has focused primarily on how greater openness to trade might differentially impact the *level* of the returns earned by different factors of production. More specifically, guided by the logic of the well-known Stolper-Samuelson theorem, which predicts an increase in returns to abundant factors with trade, analysts have sought to examine how trade may have impacted workers of different levels of human capital (education) – looking, for example, to see whether wage inequality between skilled and unskilled workers has increased in countries with a relative abundance of skilled workers (developed countries) in the manner predicted by the theory.[3]

Recently, however, the literature has also begun discussing the important question of how openness may impact income *volatility* at the aggregate (see, for instance, Rodrik (1997)) as well as at the individual level (see Krebs, Krishna and Maloney (2005)). Various channels through which trade reform might affect individual income risk have been articulated. For example, lowering trade barriers leads to an increase in foreign competition in the import-competing sectors and is likely to induce a reallocation of capital and labor across firms and sectors. In the short run, the resulting turbulence may raise individual labor income risk.[4] Rodrik (1997), going beyond the short-term re-allocational effects of trade reform on income risk, has additionally argued that increased foreign competition following trade reform will increase the elasticity of the goods and the derived labor demand functions. If higher demand elasticity translates any given shock into larger variations in wages and employment, lower trade barriers may lead to increased individual income risk.[5] On the other hand, it has also been suggested that the world economy is likely to be less

[2]For a general discussion of the debate, see for instance, Bhagwati (2001) and Rodrik (1997).

[3]Early papers in this area include Lawrence and Slaughter (1993) and Borjas, Freeman and Katz (1992). See Richardson (1995) for a survey discussion.

[4]See, for instance, the analysis of policy change by Fernandez and Rodrik (1991), in which ex-ante identical workers experience ex-post different outcomes since some workers retain their jobs while others are forced to move to other firms.

[5]While Rodrik (1997) appears to have in mind mostly aggregate volatility, it can be seen that with heterogeneous impact of such a change on firms (and thus individuals) in the economy, individual income volatility will be raised as well. See, for instance, the analysis of Melitz (2003) for an example of an aggregate policy shock affecting an entire sector leading to heterogeneous outcomes for

volatile than the economy of any single country, which leads to goods prices that are more stable worldwide than in any single autarkic economy. This opens up the possibility that greater openness may reduce the variance in individual incomes. Thus, overall, the relationship between openness and individual income risk is theoretically ambiguous, requiring empirical analysis for its resolution. In a recent paper, Krebs, Krishna and Maloney (2005), we have investigated this trade-income risk question empirically and have reported economically significant impacts of trade policy (changes) on the volatility of worker incomes.[6]

The possibility that trade policy may affect income risk in labor markets raises additional questions. Is the effect uniform across workers? Or, for instance, are workers with higher human capital better able to insulate themselves against trade policy changes? Evaluating empirically the interaction between human capital, trade policy and income risk is important for a number of reasons. First, this helps us evaluate the merits of particular theoretical arguments that assume differential effects of openness on variables such as labor turnover for workers of different human capital levels. For instance, the well-known argument by Bhagwati and Dehejia (1994) regarding "kaleidoscopic comparative advantage" argues that the observed trend of increased inequality in wages between workers of high and low levels of education may be explained by the differences in the way that openness impacts labor turnover rates (a component of income risk) for these two groups. Second, from a public policy perspective, it is important to know how policy changes impact different segments of the population; public opposition to "globalization" is driven at least in part by concerns that openness affects most adversely the poorest workers. Finally, such an analysis will deepen our understanding of the trends in the supply of human capital in the labor market.

In this paper, we study *empirically* the effects of trade policy on individual income risk for workers of different levels of human capital using the following approach. For each industry (sector), we use longitudinal data on individual earnings for different types of workers to estimate time-varying parameters of individual income risk using

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individual firms within that sector.

[6] In this paper, we draw substantially on this earlier paper by us, specifically in presenting the main issues and in describing the methodological approach (Sections I-III).

an approach similar to Carroll and Samwick (1997), Meghir and Pistaferri (2004), and Storesletten, Telmer, and Yaron (2004). More specifically, we focus on the variance of (unpredictable) changes of individual income as a measure of income risk, and carefully distinguish between transitory and persistent income shocks. The distinction between transitory and persistent income shock is important since workers can effectively self-insure against transitory shocks through own savings, which implies that the effect of these types of shocks on workers' consumption and welfare are quite small (Aiyagari (1994) Heaton and Lucas (1996), Levine and Zame (2002)). In contrast, highly persistent or permanent income shocks have a substantial effect on the present value of future earnings, and therefore lead to significant changes in consumption even if workers have own savings. Thus, from a welfare point of view, persistent income shocks matter the most, and we therefore focus on the relationship between trade policy and the persistent component of income risk. More specifically, after obtaining the estimates of the persistent component of income risk for each industry and each year, we use these estimates in conjunction with tariff data (as a proxy for trade policy) to study empirically the effect of trade policy on income risk.

Our previous discussion highlights the need for longitudinal information on incomes at a disaggregated level (individual or household)[7] in countries that have undergone discernable (and, ideally substantial) changes in their external regime. Unfortunately, countries that maintain detailed longitudinal records on individual incomes have rarely undertaken major trade reforms and countries that have undertaken extensive trade policy reforms have rarely collected data on individuals of requisite scope and quality. In this paper, however, we focus on one country that satisfies both criteria, namely Mexico. As is well known, the Mexican economy experienced substantial changes in trade policy in the late 1980s and in the later half of the 1990s.[8] Moreover, as we discuss in detail later in this paper, the Mexican government, since the mid-1980's, has conducted quarterly longitudinal income surveys that comprehensively surveyed workers in all manufacturing sectors of the economy – providing the unique data source that we use in our study.

[7]It should be clear that our need for longitudinal data follows from our desire to study how trade policy impacts the magnitude and frequency of individual income shocks (changes). This is a quite distinct task from that of measuring the impact of trade policy on the distribution of income levels.

[8]In an early wave of trade reforms in the late 1980s, tariffs were cut from an average of about 40 percent to about 15 percent.

Our empirical results for the Mexican case can be summarized as follows. The level of openness of an economy is not found to be related to income risk for workers of any type. Furthermore, changes in trade policy (i.e., trade policy reforms) are not found to have any affect on the risk to income faced by workers with either low or high levels of human capital. However, workers with intermediate levels of human capital are found to experience a statistically and economically significant increase in income risk immediately following liberalization of trade. Our findings thus point to an interesting non-monotonicity in the interaction between human capital, income risk and trade policy changes. Finally, the welfare costs of the increased income risk following trade policy reforms are substantial – amounting to reduction of between one and two percent of permanent income.[9]

The rest of the paper proceeds as follows. Section II describes the estimation procedure and data that we use to estimate individual income risk. Section III discusses the empirical methodology we use in a second stage to find estimates of the relationship between income risk and trade policy. Section IV describes the theoretical framework that will be used to translate changes in income risk into changes in welfare. Section V presents our results. Section VI concludes.

II. Income Risk

The first stage of our analysis concerns the estimation of individual income risk. Our estimation strategy follows earlier approaches taken in the literature estimating US labor income risk (Carroll and Samwick (1997) Meghir and Pistaferri (2004) and Storesletten, Telmer, and Yaron (2004)) with some important differences which we discuss in detail below. As in these papers, we define income risk as the variance of (unpredictable) changes in individual income, and carefully distinguish between transitory and persistent income shocks. This separation is essential from a welfare point of view since self-insurance through saving works well for transitory income

[9]At this stage, it is worth pointing out that our welfare analysis focuses *exclusively* on the link between trade policy and individual income risk, and that other possible channels through which trade policy may affect the economy are not studied here. More specifically, we would expect trade reform to have positive effects on the efficiency of resource allocation and economic growth, and these effects are important factors that should be taken into account when evaluating the total costs and benefits of trade

shocks, but not for persistent ones (Aiyagari (1994), Heaton and Lucas (1996), and Levine and Zame (2002)). For this and other reasons (to be discussed in detail below), we eventually focus on persistent shocks and their relation to trade policy.

II.1. Data

In Mexico, the National Urban Employment Survey (ENEU) conducts extensive *quarterly* household interviews in the 16 major metropolitan areas and is available from the mid-1980s (we use data from 1987-1998 in our study). The sample is selected to be geographically and socio-economically representative. The survey questionnaire is extensive in scope and covers all standard elements such as participation in the labor market, earnings etc. The ENEU is structured so as to track a fifth of each sample across a five quarter period. To construct the panels, workers were matched by position in an identified household, level of education, age and sex to ensure against generating spurious transitions. Taken together, we have 44 complete panels of 5 periods (i.e., quarters) each, spanning a total of 12 years (48 quarters). The number of individuals surveyed in any given calendar year is approximately 100,000. Table I presents a summary description of the workers surveyed by the ENEU. Data on sectoral (i.e., industry) trade barriers and other sectoral and macroeconomic variables were obtained from the World Bank.

II.2. Specification

Our survey data provide us with earnings (wage rate times number of hours worked) of individuals. As in previous empirical work, we assume that the log of this labor income of individual i employed in industry j in period t, $log\ y_{ijt}$, is given by:

$$log\ y_{ijt} = \alpha_{jt} + \beta_t \cdot x_{ijt} + u_{ijt}\ . \tag{1}$$

In (1) α_{jt} and β_t denote time-varying coefficients, x_{ijt} is a vector of observable characteristics (such as age and education), and u_{it} is the stochastic component of earnings. The stochastic component u_{ijt} represents individual income changes that are

reform.

not due to changes in the return to observable worker characteristics. For example, income changes that are caused by an increase in the skill (education) premium are not contained in u_{ijt} In this sense, u_{ijt} measures the unpredictable part of changes in individual income. Notice that we allow the fixed effects α_{jt} to vary across sectors, but that the coefficient β_t is restricted to be equal across sectors. The latter assumption is made in order to ensure that the number of observations is large compared to the number of parameters to be estimated.

We assume that the stochastic term is the sum of two (unobserved) components, a permanent component ω_{ijt} and a transitory component η_{ijt}:

$$u_{ijt} = \omega_{ijt} + \eta_{ijt} \ . \tag{2}$$

Permanent shocks to income are fully persistent in the sense that the permanent component follows a random walk:

$$\omega_{ij,t+1} = \omega_{ijt} + \varepsilon_{ij,t+1} \ , \tag{3}$$

where the innovation terms, $\{\varepsilon_{ijt}\}$, are independently distributed over time and identically distributed across individuals. Notice that we allow the parameters to depend on time t and industry j, but not on individual i. We further assume that $\varepsilon_{ijt+1} \sim N(0, \sigma^2_{\varepsilon jt+1})$. Transitory shocks have no persistence, that is, the random variables η_{ijt} are independently distributed over time. Clearly, η_{ijt} captures both temporary income shocks and measurement error. We assume that they are normally distributed with zero mean and a variance that is independent of i, but may depend on time or industry: $\eta_{ijt} \sim N(0, \sigma^2_{\eta jt})$.

Our specification for the labor income process is in accordance with the empirical work on US labor income risk. For most part, however, the previous literature has confined attention to the special case of time-independent variances (homoscedastic case). As we discuss in II.3, the introduction of time-variation in the parameters $\sigma^2_{\varepsilon jt}$ and $\sigma^2_{\eta jt}$ makes the estimation of these parameters more challenging. Finally, we should note that, in principle, both $\sigma^2_{\varepsilon jt}$ and $\sigma^2_{\eta jt}$ represent measures of individual income risk. In this paper, we will focus on $\sigma_{\varepsilon jt}$ and its relationship to trade policy.

This choice is motivated by the following two considerations. First, as mentioned before, transitory income shocks are unlikely to generate consumption volatility since self-insurance through own-saving is highly effective, and the welfare effects of these shocks are therefore small (Aiyagari (1994) Heaton and Lucas (1996) and Levine and Zame (2002)). Second, the term $\sigma^2_{\eta jt}$ will absorb the measurement error in income, and therefore overstate the degree of transitory income risk (and this is indeed reflected in our data, as we discuss in Section V).

II.3. Estimation

Consider the change in the residual of income of individual i between period t and $t+n$:

$$\begin{aligned} \Delta_n u_{ijt} &= u_{ij,t+n} - u_{ijt} \\ &= \varepsilon_{ij,t+1} + \ldots + \varepsilon_{ij,t+n} + \eta_{ij,t+n} - \eta_{ijt} \ . \end{aligned} \tag{4}$$

Thus, we have the following expression for the variance of income changes:

$$var[\Delta_n u_{ijt}] = \sigma^2_{\varepsilon j,t+1} + \ldots \sigma^2_{\varepsilon j,t+n} + \sigma^2_{\eta jt} + \sigma^2_{\eta j,t+n} \ . \tag{5}$$

We use the moment restrictions (5) to estimate the parameters $\sigma^2_{\varepsilon jt}$ and $\sigma^2_{\eta jt}$ using GMM,[10] where the sample analogs to the moment conditions are formed by using the estimates of u_{ijt} obtained as residuals from regressions of labor income on observable characteristics as specified in (1) − an approach also used by Meghir and Pistaferri (2004), Storesletten et al. (2004) and Gourinchas and Parker (2002). Specifically, the estimator is obtained by minimizing:

$$\sum_{t,n} \left(var[\Delta_n u_{ijt}] - \left(\sigma^2_{\varepsilon j,t+1} + \ldots \sigma^2_{\varepsilon j,t+n} + \sigma^2_{\eta jt} + \sigma^2_{\eta j,t+n} \right) \right)^2 \tag{6}$$

[10]More specifically, we follow the bulk of the literature and use the equally weighted minimum distance (EWMD) estimator. Altonji and Segal (1996) suggests that the EWMD estimator (identity weighting matrix) is superior to the two-stage GMM estimator (optimal weighting matrix) once small-sample bias is taken into account.

The first order conditions corresponding to the parameters $\sigma^2_{\varepsilon j,t}$ and $\sigma^2_{\eta j,t}$ are given by:

$$\forall t: \frac{\partial \sum}{\partial \sigma^2_{\varepsilon j,t}} = 0 \tag{7}$$

$$\forall t: \frac{\partial \sum}{\partial \sigma^2_{\eta j,t}} = 0$$

Notice that in general there are many more moment conditions (5) than there are parameters to be estimated. More precisely, for each time period t and each industry j, there are two parameters ($\sigma^2_{\varepsilon jt}$ and $\sigma^2_{\eta jt}$), but n moment conditions given by (5).

Notice also that the objective function (6) is quadratic, which implies that the first-order conditions associated with the corresponding minimum-distance problem are linear in $\sigma^2_{\varepsilon jt}$ and $\sigma^2_{\eta jt}$ – a feature that facilitates the estimation substantially. Specifically, the first order conditions can be organized into a linear equation system

$$\mathbf{A} \cdot \sigma = \mathbf{B} \tag{8}$$

where $\varepsilon = (\sigma^2_{\varepsilon,2} .... \sigma^2_{\varepsilon,t} ... \sigma^2_{\varepsilon,T}, \sigma^2_{\eta,2} .. \sigma^2_{\varepsilon,t} .. \sigma^2_{\eta,T})'$ is a 2(T-1)-dimensional vector of income parameters (T being the total number of time periods). Estimates of these income parameters can then easily be obtained through matrix inversion: $\sigma = \mathbf{A}^{-1}\mathbf{B}$.

Some intuition for the way in which our approach separates transitory from permanent income shocks can be obtained from the following simple example. Suppose that risk is time-invariant, $\sigma^2_{\varepsilon jt} = \sigma^2_{\varepsilon j}$ and $\sigma^2_{\eta jt} = \sigma^2_{\eta j}$, an assumption that has been made by most of the previous empirical literature on income risk. In this case, the moment restrictions (5) become the following:

$$var[\Delta_n u_{ijt}] = 2\sigma^2_{\eta j} + n\,\sigma^2_{\varepsilon j} \tag{9}$$

Thus, the variance of observed n-period income changes is a linear function of n, where the slope coefficient is equal to $\sigma^2_{\varepsilon j}$. The insight that the random walk component in income implies a linearly increasing income dispersion over time is the basis of the estimation method used by several authors. For example, Carroll and Samwick (1997) estimate σ^2_{ε} by performing OLS regressions of the left-hand-side of (9) on n. While the preceding example, with time-invariant parameters, serves to illustrate the intuition underlying the estimation procedure, it should be clear that our exercise is more general in the sense that it allows for arbitrary time-variation in the income risk parameters.

II.4. Estimation using ENEU data

The preceding section provided a detailed description of a general econometric methodology that may be used to estimate time-variant income risk parameters given longitudinal data on individual incomes. We note here some additional issues that arise in applying this methodology to our data, with particular emphasis on the type of income risk accounted for by our estimation procedure.

In forming the sample analogs to the moment conditions (5), we can only use information on individuals who are present in a given manufacturing industry in both time periods t and $t+n$. In doing so, we pick up shocks to workers who retain their jobs but experience income changes due to changes in their wage rates or the number of hours worked. Moreover, we also account for changes in income experienced by displaced workers who are re-employed in the same industry. In contrast, displaced workers who are reallocated to a different manufacturing industry are not taken into account.[11] However, the exclusion of such workers should not be expected to cause too great an under-estimation of our income risk parameters as the fraction of displaced manufacturing workers who make transition from one manufacturing sector to another is very small. In our data, on average less than 10 percent of displaced

[11]This allows us to circumvent the extremely difficult problem of assigning industries (and thus trade policy) to individuals who transit to different industries. Including individuals who make transitions to the service (non-tradables) sector by using the procedure of counting them as belonging to the manufacturing sector in which they are first observed does not result in any qualitative difference in our reported results.

workers undergo such a transition. This is consistent with observations from the United States that most job creation and destruction takes place within industries.

It is worth noting that there are very few labor force participants in our survey who do no work and receive zero wages in any given quarter, which is mainly a consequence of the lack of any government-provided unemployment insurance in Mexico and the very active informal labor market. More importantly, the proportion of workers who are unemployed for longer than the five quarter-periods is extremely small (implying that forming the moment conditions as we do above does not cause problems in the consistent estimation of persistent income shocks faced by workers).

Finally, we should mention that the variability in income experienced by workers in our data set derives from differential changes in the number of hours worked and also from both upward and downward changes in their real wages. Thus, despite the often cited downward rigidity of wages, our sample includes large numbers of workers whose real wages declined. Specifically, Mexico experienced very high inflation rates during our sample period with annual declines in *aggregate* real wage as high as 25 percent during this time (see, for instance, Hanson (2003)), implying that the wage rates of some individual workers declined by an even larger amount.

III. Trade Reform and Income Risk

The procedure outlined in the previous section provides us with estimates of individual income risk, $\sigma^2_{\varepsilon jt}$, for each industry (i. e., manufacturing sector) j and time period, i.e., quarter, t. These time-varying, industry-specific estimates in conjunction with observations on trade policy, τ_{jt}, allow us to estimate the relationship between income risk, $\sigma^2_{\varepsilon jt}$, and openness, τ_{jt}. Consider the following linear specification allowing for industry fixed-effects and aggregate time effects:

$$\sigma^2_{\varepsilon jt} = \alpha_0 + \alpha_{1j} + \alpha_{2t} + \alpha_\tau \tau_{jt} + \alpha_\delta \Delta\tau_{jt} + \nu_{jt} \ . \tag{10}$$

In (10) the coefficients α_{1j} capture the industry fixed-effects, the α_{2t}'s pick up

aggregate trends, the coefficient α_τ measures the effect of openness on income risk and α_δ captures the effects of changes(in the preceding year, say) in trade policy, $\Delta\tau_{jt}$. The inclusion of industry dummies in the specification above allows us to control for any fixed industry-specific factors that may affect the level of riskiness of income in that industry. Moreover, the inclusion of time dummies controls for any changes in macroeconomic conditions that affect the level of income risk. While this ensures that our estimation results are not driven by changes in *macroeconomic* conditions (business cycle effects and/or long-run structural changes) unrelated to trade policy, it also means that identification of the relationship between $\sigma^2_{\varepsilon jt}$ and τ_{jt} will have to be based on the differential rate of change in trade barriers across sectors over time (or the vector of observations on tariffs in the panel corresponding to (10) will be perfectly collinear with the time-dummy vector). This, however, does not pose problems for our estimation since trade barriers in Mexico and their changes over time do in fact do exhibit substantial cross-sectional variation.[12]

Several econometric issues arise in the estimation of equations (10) above. One concern is that the left hand side variable, income risk, is estimated and not observed. This is not a substantial problem by itself as it is well known that while "measurement error" in the dependent variable does reduce precision, it does not bias our estimates. A concern arises, however, from the fact that the estimates of $\sigma^2_{\varepsilon jt}$ have different standard errors across industries, that is, the specification we have described above suffers from a heteroscedasticity problem. Further, since the industries all belong to the same macroeconomic environment, there is a possibility of contemporaneous correlation in their σ's even after controlling for observable macroeconomic factors as in (10'), i.e., $Cov(\nu_{jt}\nu_{j't}) \neq 0$. Finally, serial correlation in income volatility within an industry is a possibility, i.e., $Cov(\nu_{jt}\nu_{jt'}) \neq 0$. Given the possible presence of heteroscedasticity, spatial correlation and serial dependence, consistent estimates of the standard errors associated with the coefficient estimates in (10) above are obtained by using robust estimation techniques.

[12]For instance, in Mexico, tariffs varied between 80 and 20 percent prior to the trade reforms of 1987 and ranged between 20 and 10 percent by 1994 - implying a variation in tariff changes across sectors that is quite substantial.

IV. Income Risk and Welfare

The preceding discussion has outlined our approach to estimating the relationship between trade policy and income risk. We now turn to the analysis of the link between income risk and welfare, which is provided by a simple dynamic model with incomplete markets along the lines of Constantinides and Duffie (1996) and Krebs (2004). The model extends the basic insights of the large literature on the permanent income hypothesis to a general-equilibrium setting with iso-elastic preferences and incomplete markets. It remains tractable enough to permit closed-form solutions for equilibrium consumption and welfare which are simple and transparent. Clearly, our goal here is not to provide a complete assessment of the effects of income risk on welfare taking into account all possible channels, but rather to articulate a simple framework that allows us to obtain *indicative* estimates of welfare change through the *income risk* channel. The model structure and assumptions underlying our approach and the limitations of our methodology are discussed below in detail.

The model features long-lived households (workers) that make consumption/saving choices in the face of uninsurable income shocks. These income shocks are permanent, which implies that self-insurance is an ineffective means to smooth out income fluctuations. In other words, the effect of permanent income shocks on consumption is substantial. In accordance with Constantinides and Duffie (1996) and Krebs (2004), we consider an exchange economy and do not model the labor-leisure choice. In this section, we briefly discuss the basic assumptions of the model and state the main welfare results.

IV.1. Model

Time is discrete and open ended. Income of household i employed in industry j in period t is denoted by y_{ijt}. Income is random and defined by an initial level $\tilde{y}_{ij0}$ and the law of motion

$$\tilde{y}_{ij,t+1} = (1+\mu_{j,t+1})(1+\theta_{ij,t+1})\,\tilde{y}_{it}\,, \tag{11}$$

where $\mu_{j,t+1}$ is a mean growth-rate effect common across workers in the sector and $\theta_{ij,t+1}$ is an individual-specific shock to the growth rate of income. We assume that $log(1+\theta_{ij,t+1})$ is normally distributed with time- and industry-dependent variance σ_{jt}^2.

Although the distribution of individual-specific shocks may change over time, the shocks are unpredictable in the sense that current and future shocks are uncorrelated. To ensure that workers are ex-ante identical, we also assume that the distribution of shocks is identical across workers. Each household begins life with no initial financial wealth. Households have the opportunity to save, but not borrow, at the common risk-free rate r_t. Hence, the sequential budget constraint of worker i reads

$$a_{ij,t+1} = (1+r_t)a_{ijt} + y_{ijt} - c_{ijt} \tag{12}$$
$$a_{ijt} \geq 0 \ , \ a_{ij0} = 0 .$$

Here c_{ijt} denotes consumption of household i in period t and a_{ijt} his asset holdings at the beginning of period t (excluding interest payment in this period). Notice that by assuming the non-negativity of a_{ijt}, we have automatically ruled out Ponzi schemes.

Households have identical preferences that allow for a time-additive expected utility representation:

$$U(\{c_{ijt}\}) = E\left[\sum_{t=0}^{\infty} \beta^t u(c_{ijt})\right]. \tag{13}$$

Moreover, we assume that the one-period utility function, u, is given by $u(c) = \frac{c^{1-\gamma}}{1-\gamma}, \gamma \neq 1$, or $u(c) = log\, c$, that is, preferences exhibit constant degree of relative risk aversion γ.

IV.2. Welfare

We can derive an explicit formula for equilibrium welfare that depends on the preference parameters β and γ and the income parameters μ_{jt} and σ_{jt}^2, where σ_{jt}^2 is the variance of the log-normally distributed income shocks η. We also show that the

variance σ_{jt}^2 of the income process (11) can be identified with the variance $\sigma_{\varepsilon jt}^2$ of the permanent component of our empirical specification (1). This provides a tight link between the empirical results obtained in section II and the welfare analysis conducted in this section. We now briefly outline and discuss the main welfare results.

For simplicity, assume that the income parameters are time-independent: $\mu_{jt} = \mu_j$ and $\sigma_{\varepsilon jt}^2 = \sigma_{\varepsilon j}^2$. Suppose now that trade reform changes the tariff rate in a particular industry j from τ to $(1+a_\tau)\tau$ permanently. Suppose also that the change in the tariff rate leads to a corresponding permanent change in income risk from σ_ε^2 to $(1+\Delta_\sigma)\sigma_\varepsilon^2$. Clearly, this change in income risk induced by trade reform corresponds to the long-run effect that is associated with the level term, τ_{jt}, on the right-hand-side of our regression equation (10). We can find the welfare effect of the change in risk, Δ_σ, by calculating the compensating variation in lifetime consumption, Δ_c. That is, we can ask by how much we have to change consumption in each period and state of the world to compensate the household for the change in income risk. We can show that this compensating differential, expressed as percent of lifetime consumption, is given by

$$\Delta_c = \left(\frac{1-\beta(1+\mu)^{1-\gamma} exp\left(.5\left((1-\gamma)^2-(1-\gamma)\right)(1+\Delta_\sigma)\sigma_\varepsilon^2\right)}{1-\beta(1+\mu)^{1-\gamma} exp\left(.5\left((1-\gamma)^2-(1-\gamma)\right)\sigma_\varepsilon^2\right)} \right)^{\frac{1}{1-\gamma}} - 1 \quad if\ \gamma \neq 1$$

$$\Delta_c = exp\left(\frac{\beta}{(1-\beta)^2} \frac{\sigma_\varepsilon^2 \Delta_\sigma}{2} \right) - 1 \quad if\ \gamma = 1. \tag{14}$$

Equation (14) shows how to translate long-run changes in labor income risk, Δ_σ, into equivalent changes in lifetime consumption, Δ_c. It provides the answer to the following question: how much lifetime consumption are risk averse workers willing to give up in return for not having to experience the increase in income risk that is caused by a change in trade policy. Notice that (14) is the result of an ex-ante welfare calculation under rational expectations. More specifically, (14) assumes that workers

do not know who will lose and who will gain from trade reform, but they know to what extent trade reform creates winners and losers (the effect of trade reform on the income risk parameters is known ex-ante).

The welfare expression (14) assumes that the change in σ_ε^2 is permanent. However, we are also interested in the welfare effect of an increase in income risk from σ_ε^2 to $(1+\Delta_\sigma)\sigma_\varepsilon^2$ for n periods. In this case, the welfare effect is given by

$$\Delta_c = \left[\left(\frac{1-x}{1-x'}\right)\left(1-x'^{n+1}\right)+xx'^{n}\right]^{\frac{1}{\gamma-1}}-1 \quad if\ \gamma \neq 1 \tag{15}$$

$$\Delta_c = exp\left(\frac{\beta(1-\beta^n)}{2(1-\beta)^2}\sigma_\varepsilon^2\,\Delta_\sigma\right)-1 \quad otherwise$$

where we introduced the following notation:

$$x = \beta(1+\mu)^{1-\gamma} exp\left(.5\left((1-\gamma)^2-(1-\gamma)\right)\sigma_\varepsilon^2\right)$$

$$x' = \beta(1+\mu)^{1-\gamma} exp\left(.5\left((1-\gamma)^2-(1-\gamma)\right)(1+\Delta_\sigma)\sigma_\varepsilon^2\right).$$

The welfare expressions (14) and (15) have some intuitive properties. First, the welfare effect of a change in income risk is a nonlinear and increasing function of the initial level of income risk. Put differently, if workers are already exposed to a large amount of income risk, then increasing income risk hurts a lot. Second, the welfare effects are increasing in the risk-aversion parameter γ: the more risk-averse the workers are, the stronger is the welfare effect of a change in income risk. Finally, the welfare effects are the same for all workers regardless of their wealth. This property is the result of the joint assumption of homothetic preferences and an income process defined as in (11).

The welfare expressions (14) and (15) form the basis for our quantitative welfare analysis of trade reform. In order to conduct such an analysis, we need information about the income parameters μ, σ_ε^2, and Δ_σ and the preferences parameters β and

γ. Our empirical analysis provides estimates of the income parameters. For the preference parameters, we choose an annual discount factor of $\beta = .96$ and allow the degree of risk aversion γ to (separately) take values 1 and 2. These values for the preference parameters are in line with the values used in the macroeconomic literature (Cooley (1995)).

V. Results

In the first step of our analysis, we use data on individual income changes from workers in different manufacturing sectors in Mexico and the methodology outlined in section II to estimate quarterly income risk parameters in each of these sectors during the time period 1987-1998. Tables II and III provide the average estimate of σ_ε^2 and σ_η^2 for each year (averaged across industries) and for each industry (averaged over time) respectively. The mean value (across industries and over time) of the quarterly variance of the persistent shock, σ_ε^2, is estimated to be 0.0065, or 0.026 in annual variance. As expected, given the extent of measurement error in the income data (see our discussion in Section II), the estimated variances of transitory shocks are much larger in magnitude.

Human Capital Categories

We separate workers into three human capital (education) categories. In the first group, we have workers with zero to six years of education. The second group consists of those workers with more than six years of education but who haven't graduated high school. Finally, the third group consists of workers who are all high school graduates. As indicated in Table IV, In our data set, the first group comprises approximately 36 percent of the workforce, the second group comprises 46 percent and workers in the highest human capital category the remaining seventeen percent of the workforce. Table II also presents estimates (averaging over industries and time) of the quarterly variance for the different human capital categories. An indicated there, on average, workers with intermediate levels of human capital face the highest level of income risk in our data. The quarterly variance of the persistent shocks to income that they face is 0.0075. In comparison, the quarterly variance is estimated to be

0.0045 for workers in the low human capital category and 0.006 for workers in the high human capital category.

A similar regression analysis (not reported here) was conducted for transitory income-shock parameters, σ_{η}^{2}, but we did not find any statistically significant relationship between transitory shocks to income and trade policy. One explanation of this negative finding is that our estimates of transitory income shocks are contaminated by measurement error in income.

As indicated earlier, to relate trade policy to idiosyncratic income risk, the specification we use is:

$$\sigma_{\varepsilon jt}^{2} = \alpha + \alpha_{j} + \alpha_{t} + \alpha_{\tau}\,\tau_{jt} + \alpha_{\delta}\,\Delta\tau_{jt} + \nu_{jt} \tag{10}$$

In (10) we have included on the right hand side the following variables: τ – the ad-valorem sectoral tariff rate, $\Delta\tau$ – the change in the tariff over the preceding year, α_{j} – an industry fixed- effect, and α_{t} – a time dummy that captures general macroeconomic events in the economy. The effect of the tariff level on income risk is given by the coefficient α_{τ} and the effect of tariff changes on income risk is given by the coefficient α_{δ}.

Regression results are presented in Table V.[13] We note first that the estimate of α_{τ} is insignificant for all the human capital categories and we are therefore unable to reject that the *mean* effect of the tariff level on income risk is zero for all three groups. However, trade policy *changes* have statistically and economically significant short run effect on income risk for individuals with intermediate levels of human capital ($\hat{\alpha}_{\delta}$ = -0.219, with an estimated standard error of 0.102). This estimate indicates that, on average, lowering the tariff rate by five percent would, for a year, raise σ_{ε} from a mean level of 0.0065 to 0.013 – a substantial increase in the risk to income faced by individuals. It is worth emphasizing that the effect of trade policy changes on risk to

[13] See Krebs, Krishna and Maloney (2005) for a detailed qualitative discussion of why policy endogeneity and the possible self-selection of workers into sectors is only a minimal concern in this context.

income faced by very low income workers is highly insignificant. Individuals in the top human capital category see only marginally (statistically) significant effects.

Welfare Analysis

Using the theoretical results derived in section IV and the empirical estimates obtained from the estimation of (10), we can estimate the welfare costs of trade policy changes due to any changes in income risk faced by workers. For the preference parameters we choose an annual discount factor of $\beta = .96$ and a degree of risk aversion of $\gamma = 1$ or $\gamma = 2$. As mentioned before, these values for the preference parameters are in line with the values used in the macroeconomic literature (Cooley (1995)). Consider a tariff reform which involves a lowering of the tariff level by five percent. Given our empirical estimates, this would raise σ_ε^2 in the short run (i.e., for one year following the reform) from a mean level of 0.065to 0.013. The corresponding welfare cost of this change is calculated to be 0.98 percent of permanent consumption if the co-efficient of risk aversion $\gamma = 1$ and is calculated to be 1.96 percent of lifetime consumption if the $\gamma = 2$ instead (always using an annual discount factor of $\beta = .96$).

Our findings can be summarized as follows. The level of openness of an economy is not found to be related to income risk for workers of any type. Furthermore, changes in trade policy (i.e., trade policy reforms) are not found to have any affect on the risk to income faced by workers with either low or high levels of human capital. However, workers with intermediate levels of human capital are found to experience a statistically and economically significant increase in income risk immediately following liberalization of trade. Our findings thus point to an interesting non-monotonicity in the interaction between human capital, income risk and trade policy changes. Finally, the welfare costs associated with the estimated increases in income risk, for workers with intermediate levels of human capital are substantial.

VI. Conclusions

This paper studies empirically the relationship between trade policy and *individual*

income risk. The analysis proceeds in three steps. First, longitudinal data are used to estimate individual income risk of manufacturing workers in various human capital categories. Second, the variation in income risk and trade barriers – both over time and across sectors – is used to arrive at estimates of the relationship between trade policy and individual income risk for these different workers. Finally, using the estimates of this relationship between trade policy and income risk, a simple dynamic general equilibrium model with incomplete markets is used to obtain estimates of the welfare costs of the effects of trade policy on income risk.

Our findings can be summarized as follows. The level of openness of an economy is not found to be related to income risk for workers of any type. Furthermore, changes in trade policy (i.e., trade policy reforms) are not found to have any affect on the risk to income faced by workers with either low or high levels of human capital. However, workers with intermediate levels of human capital are found to experience a statistically and economically significant increase in income risk immediately following liberalization of trade. Our findings thus point to an interesting non-monotonicity in the interaction between human capital, income risk and trade policy changes. Finally, the welfare costs associated with the estimated increases in income risk, for workers with intermediate levels of human capital are substantial. However, it is worth pointing out that our welfare analysis here focuses *exclusively* on the link between trade policy and individual income risk, and other possible channels through which trade policy may affect the economy are not studied here. More specifically, we would expect trade reform to have positive effects on the efficiency of resource allocation and economic growth, and such effects are important factors that ought to be taken into account when evaluating the total costs and benefits of trade reform. Additionally, our welfare calculations are based on a simple theoretical model whose limitations include its neglect of the effect of income risk on labor supply and capital accumulation. Moreover, our calculations do not take into account that the welfare cost of an increase in income risk might be partially offset by a rise in transfer payments from the government or firms.[14] Finally, while our estimates of income shocks were obtained using observations on individuals over a limited time period, our welfare analysis assumes that shocks that are highly persistent through our sample

[14]Being that such transfers are provided by entities within the economy, they should perhaps

period are equally persistent beyond this period. Thus, the welfare results presented in this paper have to be interpreted with caution keeping in mind our exclusive focus on the link between trade policy and income risk and the methodological limitations noted above.

nevertheless be counted as costs, even if the risk to workers is fully offset by these payments.

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Table I: ENEU Worker Survey - Summary

(1987-1998)

Variables	
Mean Age	32
Mean Years of Education	8
Fraction High School and Above	17
Fraction Wage Earners	65
Fraction Self Employed	25

Table II: Estimates of Persistent and Transitory Income Shocks[15]

Annual Averages (1987-1998)

Year	σ_{ε}^{2}	σ_{η}^{2}	Sample Size
87	0.011 (0.003)	0.096 (0.002)	19136
88	0.005 (0.003)	0.101 (0.002)	35397
89	0.004 (0.002)	0.103 (0.001)	28203
90	0.014 (0.002)	0.098 (0.001)	35167
91	0.001 (0.002)	0.103 (0.001)	37344
92	0.006 (0.001)	0.106 (0.001)	54022
93	0.007 (0.001)	0.112 (0.001)	78741
94	0.006 (0.001)	0.110 (0.001)	121716
95	0.014 (0.001)	0.118 (0.001)	164212
96	0.000 (0.001)	0.107 (0.001)	172766
97	0.006 (0.001)	0.104 (0.001)	172870
98	0.008 (0.001)	0.097 (0.001)	158707

[15]Figures shown are annual averages (across industries and quarters) of the point estimates of the persistent shock and the transitory shock. The figures in parentheses are the averages of the corresponding standard errors. Sample size denotes the numbers of workers surveyed in the respective year.

Table III: Estimates of Persistent and Transitory Income Shocks[16]

Industry Averages (1987-1998)

Industry	σ_ε^2	σ_η^2	**Industry**	σ_ε^2	σ_η^2
311	0.013 (0.0004)	0.131 (0.0003)	352	0.020 (0.0025)	0.111 (0.0019)
313	0.012 (0.0007)	0.088 (0.0005)	353	0.002 (0.0009)	0.081 (0.0007)
321	0.005 (0.0006)	0.097 (0.0005)	356	0.006 (0.0016)	0.079 (0.0011)
322	0.012 (0.0008)	0.124 (0.0006)	369	0.011 (0.0014)	0.113 (0.0011)
323	0.008 (0.0022)	0.107 (0.0015)	371	0.003 (0.0031)	0.110 (0.0025)
324	0.004 (0.0002)	0.088 (0.0001)	381	0.006 (0.0006)	0.125 (0.0004)
331	0.004 (0.0027)	0.120 (0.0020)	382	-0.002 (0.0015)	0.098 (0.0011)
332	0.019 (0.0017)	0.121 (0.0013)	383	0.008 (0.0002)	0.056 (0.0002)
341	0.004 (0.0016)	0.102 (0.0012)	384	0.004 (0.0002)	0.073 (0.0001)
342	0.011 (0.0016)	0.134 (0.0012)	390	0.005 (0.0062)	0.143 (0.0047)
351	0.012 (0.0029)	0.107 (0.0023)			

[16]Figures shown are averages over time of the point estimates of the persistent shock and the transitory shock for the respective industries. The figures in parentheses are the averages of the corresponding standard errors.

Table IV: Educational Categories – Summary Statistics
(1987-1998)

Educational Categories	**Percentage of Labor Force**	σ_{ε}^{2}
0 – 6 Years of Education	36	0.0045
6 – 12 Years of Education	46	0.0075
12 Years of Education and above	18	0.0060

Table V: Trade Policy and Income Risk - Panel Estimates [17]

Variables	Low HC	Intermediate HC	High HC
	σ_{ε}^{2} vs	σ_{ε}^{2} vs	σ_{ε}^{2} vs
τ	0.077	0.127	0.180
	(0.097)	(0.104)	(0.181)
$\Delta\tau$	-0.041	-0.119	-0.081
	(0.125)	(0.03)	-(0.056)
Time Effects	Included	Included	Included
Industry Effects	Included	Included	Included
N	450	450	450
R^2	0.18	0.25	0.2

[17]Figures in parentheses are robust standard error estimates obtained by allowing for heteroscedasticity, contemporaneous correlation of errors across industries and serial correlation within industries.