The Equilibrium Effects of Income Taxation on Formal and Informal Labor Markets*

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Abstract

Many developing countries face constrained tax capacity due to the presence of an informal sector. Informal workers often evade taxation, and governments may choose low tax rates in order to prevent workers from moving to the informal sector, further reducing tax revenue. The extent of distortionary effects on the allocation of labor across sectors depends on the extensive- and intensive-margin labor supply and wage responses to taxation. I estimate the equilibrium effects of taxation on sectoral choice, work hours and wages in Mexico, a developing country with a large informal sector. I exploit uniquely advantageous sources of variation in worker and firm incentives generated by the Mexican tax and trade policies in the 1990s to study these effects. I find that workers are sensitive to income taxation: the elasticity of formal sector participation with respect to relative after-tax income is 0.4 and the elasticity of hours with respect to the net-of-marginal tax rate is 0.08. On average, 25.1% of sectoral mobility, from 1988-2004, is explained by changes in the average tax rate. In addition, equilibrium wages respond to tax-induced changes in the relative supply of imperfectly substitutable labor inputs. A ten percentage point increase in the net-of-average tax rate causes an increase in formal participation of 2.5%, an effect two-thirds the size of that when labor demand is perfectly elastic and wages do not adjust. These wages responses limit the effectiveness of tax instruments designed to encourage formal sector employment, such as a formal sector tax credit.

JEL Codes: H2, J2, O17
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1 Introduction

Many developing countries face constrained tax capacity due to the presence of an informal sector. Informal workers often evade taxation, and governments may choose low tax rates in order to prevent workers from moving to the informal sector, further reducing tax revenue.[1] Therefore, in countries with a large informal sector where tax evasion is prevalent, governments may face a binding tradeoff between tax rates and the size of the tax base. The extent of distortionary effects on the allocation of labor across sectors is previously unexplored and depends on the extensive- and intensive-margin labor supply and wage responses to taxation. Understanding these behavioral responses is crucial to designing tax policies that increase fiscal capacity and foster economic growth. While there is a substantial literature that estimates the sensitivity of workers to taxation in rich countries, there is limited evidence in the context of developing countries.[2] The presence of an informal sector which offers returns to skill similar to that of the formal sector suggests that workers may be sensitive to income taxation. Yet, exploring the full extent of cross-sectoral mobility requires understanding both the demand for and supply of labor to sectors and the responses of wages to the inter-sectoral tax wedge. I estimate the equilibrium effects of taxation on sectoral choice, work hours and wages in Mexico, exploiting uniquely advantageous sources of variation in worker and firm incentives generated by Mexican tax and trade policies in the 1990s.

Mexico ranks among the lowest tax collectors in Latin America and has historically borne a low tax burden relative to its potential (Corbacho et al., 2013). Informal employment is substantial in Mexico, as it is throughout Latin America, and mobility between the sectors is high: 15% of workers transition between formal and informal employment annually, with substantial movements in both directions. Informal workers do not receive the benefits associated with formal work, such as health insurance; however, they evade income taxation almost completely. Informal work has traditionally been viewed as comprising the less-advantaged sector of a dualistic labor market where workers queue for preferred, formal jobs (Harris and Todaro, 1970; Chandra and Khan, 1993; Chandra, 1992; Loayza, 1994). However, recent descriptive research shows that, while some attractive formal sector jobs may be rationed, many workers optimally self-select into sectors based on relative after-tax income and preferences for formal benefits (Aroca and Maloney, 1998; Maloney, 2004; Levy, 2008; Busso et al., 2012). This is especially true in Mexico where, despite compelling accounts of the inflexibility and costliness of the labor code, the labor market is characterized as relatively flexible and the majority of informal employment is voluntary.

The nature and role of the informal sector in economic development generates lively

[1] Fuest and Riedel (2009) and Besley and Persson (2013) provide recent surveys of the literature on taxation and development.
[2] See Saez et al. (2012) for a recent survey of studies in the context of developed countries.

debate.[3] In the case of Mexico, recent work shows that the productivity losses associated with informality are substantial (Busso et al., 2012; Anton et al., 2012). For example, Busso et al. (2012) show that one peso of capital and labor allocated to the formal sector is 28-50% more productive than if allocated to the informal sector.[4] In 1993, the Mexican government introduced an employment tax credit, Credito al Salario, to encourage formal sector work. The credit is available to all formal workers and is given at a rate that declines with income. At low-to-modest levels of pre-tax income, the credit generates negative average tax rates and thus increases the after-tax wage in the formal sector relative to that in the informal sector, holding pre-tax relative wages constant. I show that the credit causes an increase in the formal sector participation rate and a decrease in the informal participation rate. However, these tax-induced changes in formal and informal labor supply drive pre-tax wages down in the formal sector and up in the informal sector, thus reducing the intended benefit to formal workers and providing an unintended transfer to informal workers. These equilibrium effects limit the extent to which the credit encourages formal sector employment. The impact on wages, and hence the indirect leakage, depends on two key labor demand parameters. First, the impact depends on the elasticity of substitution among the labor inputs of differently skilled workers, who are exposed to different tax-induced labor supply shocks. Second, the impact depends on the elasticity of substitution between formal and informal labor inputs: tax-induced changes in aggregate formal labor inputs affect informal wages indirectly via substitution of sectoral labor inputs in production.[5]

I develop a model of general equilibrium tax incidence to take account of the following complexities in the labor markets: workers are mobile between sectors and have heterogeneous sectoral preferences, informal workers evade taxation, tax rates are heterogeneous across pre-tax income, labor is imperfectly substitutable in production across skill and sectoral status, and labor supply choices combine discrete (sectoral participation) and continuous (hours supply) decisions. I use my model to derive estimating equations that measure the effect of changes in net-of-marginal and average tax rates on sectoral hours, participation and pre-tax wages and I simultaneously estimate the system of equations using Three-Stage Least Squares. I use the estimated elasticities to conduct incidence calculations and measure the efficiency cost of taxation.

To estimate the effects of taxation on sectoral choice, work hours and wages, I use uniquely advantageous variation in worker and firm incentives generated by the Mexican tax and trade

[3] For example, see Guha-Khasnobis et al. (2006), De Soto (2003), Fields (2007), Levy (2008), and Maloney (2004) for competing views of the role of the informal sector.

[4] La Porta and Shleifer (2014) generalize these findings to other developing countries. The barriers that prevent the reallocation of capital and labor toward the more productive sector include other dimensions of firm legality, for example, compliance with value added taxes, in addition to the labor tax wedge.

[5] The sectoral status of a worker is not representative of the sectoral status of their employer. The Mexican labor market is comprised of a continuum of firms that employ different combinations of formal and informal workers: many firms employ both formal and informal workers of similar skill and outsource work to the informal sector (Beltran, 2009; Anton et al., 2012).

policies in the 1990s. Identification of the labor supply parameters of interest - hours supply and sectoral participation elasticities - comes from variation in the tax schedules across the income distribution and across time. For example, upon implementation of Credito al Salario, average tax rates for low-skilled workers decreased by over 30%, compared to a decrease of 5% for high-skilled workers. To identify the equilibrium wage effects, I use geographic variation in aggregate and sectoral labor demand across metropolitan areas and across time. Mexico liberalized trade by joining GATT in 1986 and NAFTA in 1994. Trade liberalization induced new firms, often in the form of Maquiladoras, to open and manufacture export products. Existing research shows that trade liberalization generated substantial changes in labor demand that varied across geography and sectors.[6] These trade shocks further affected relative wages between the formal and informal sectors. Because tax rates are similar for all workers within a skill group regardless of their geography, I exploit the fact that a tax-induced increase in formal labor supply affects formal wages differently depending on whether local formal labor demand is simultaneously decreasing, increasing, or remains unchanged.

I find that labor supply is not perfectly inelastic nor is labor demand perfectly elastic: workers are sensitive to income taxation and wages adjust in response. The elasticity of hours supply with respect to the net-of-marginal tax rate is 0.082 and the elasticity of formal sector participation with respect to relative after-tax income is 0.401. While these findings indicate relatively inelastic labor supply, and less so on the extensive than the intensive margin, 25.1% of movement between the sectors is explained by changes in the average tax rate alone, over the period of study. In addition, I find that the wage incidence effects are important in practice: equilibrium wages are responsive to tax-induced changes in the relative supply of imperfectly substitutable labor inputs. The elasticities of substitution between differently skilled workers and between formal and informal labor inputs indicate that labor demand is not perfectly elastic, as is assumed in most studies of labor supply and taxation. The elasticity of substitution between education groups ranges from 1.47-1.73, comparable to existing estimates, and the elasticity of substitution between formal and informal labor inputs is approximately 1.7. As a result, a ten percentage point increase in the net-of-average tax rate causes an increase in formal participation of 2.5%, an effect two-thirds the size of that when labor demand is perfectly elastic. These wages responses limit the effectiveness of tax instruments designed to encourage formal sector employment, such as the formal sector tax credit.

This paper contributes to three strands of literature. First, it adds to the well-developed literature on the labor supply effects of income taxation. Two notable examples in this liter-

[6]For example, total employment in export manufacturing rose by over 200% between 1986 and 2000. See Aleman-Castilla (2006), Atkin (2009), and Atkin (2012).

ature use data from developing countries. In the first study to use administrative tax return data in a developing country context, Kleven and Waseem (2013) estimate intensive-margin responses to tax notches - points in the tax schedule where average tax rates change discontinuously - among high income earners in Pakistan. They find substantial bunching at tax notches among tax filers and estimated hours elasticities that imply intensive-margin labor supply responses to taxation comparable to what I find. I omit analysis of labor supply at the kinks of taxable labor income induced by the tax schedule in order to facilitate analysis of the sectoral choice and wage effects.[7] In a paper studying a later reform, Waseem (2013) finds that higher tax rates among firm owners induce substantial movement to the informal sector, under-reporting of taxable earnings and income shifting to tax-favored business forms. Because Pakistan has a high income exemption threshold, the methodology of those papers is not suited to uncover the behavioral responses of lower income workers who comprise the majority of employees in labor markets in most developing countries. In addition, the administrative tax data increasingly used to study behavioral responses to taxation inherently restrict analysis to *taxpayers*. In the absence of complementary survey data that measure informal labor and wages, administrative data alone cannot be used to study tax incidence. I use 17 years of rich labor survey data, which includes earnings and labor supply details for both formal and informal workers. To my knowledge, this paper represents the first effort at analyzing intensive- and extensive-margin labor supply and wage responses to taxation in a developing country context.

Second, this paper contributes to the smaller collection of studies on tax incidence. A goal of Credito al Salario is to increase formal labor supply. This is similar to the intended goal of employment tax credits in the developed world, such as the Earned Income Tax Credit (EITC) in the U.S., which is designed to increase labor supply among eligible workers. However, as the tax incidence literature emphasizes, taxes may affect the equilibrium price of the taxed good.[8] While much of the optimal income tax literature assumes that labor demand is perfectly elastic, the supply-side taxes may be partially passed through to demand via their effects on equilibrium prices. In one of the first studies to test this in the context of labor income taxation, Kubik (2004) analyzes the incidence associated with the U.S. Tax Reform Act of 1986. He finds that individuals in occupations that experienced large decreases in the median marginal tax rate received lower pre-tax wages after the reform because the hours worked in those professions increased. Rothstein (2008) finds that EITC-induced increases in labor supply decrease pre-tax wages, and Rothstein (2010) shows that neglecting wage effects leads to misleading estimates of the impact of taxes on labor supply and welfare. My model of labor supply is similar to Rothstein (2010); however, I distinguish between formal

[7] For the period under my consideration, there is no graphical evidence of bunching. I discuss this observation in more detail in Section 3.1.

[8] See Kotlikoff and Summers (1987) and Fullerton and Metcalf (2002) for detailed discussions of incidence.

and informal labor supply, where income from the former is subject to taxation, and my theory of labor demand is more closely related to that in the immigration literature. In an unpublished study that is most closely related to mine, Marrufo (2001) develops a Harberger model to study the payroll tax incidence associated with the 1997 social security reform which affected the formal sector in Mexico. She also finds incidence effects that suggest that labor demand is not perfectly elastic. However, she does not model or impute income taxes, which change over her period of analysis. In addition, because the tax changes she studies are the same across workers regardless of their income, her analysis does not differentiate workers by skill.[9]

Finally, this paper is related to a sizable literature that estimates labor demand elasticities. The tax changes I study vary across time and pre-tax income. Therefore, a labor demand model that allows for heterogeneous labor is necessary to study tax changes that affect skill groups differently. For example, a large tax-induced increase in the labor supply of low-skill workers may affect the labor demand of high-skill workers through substitution in production and changes in the relative cost of heterogeneous labor inputs. In the context of developed countries, many analyses estimate the elasticity of substitution between differently skilled labor inputs in the production process. This has received the most attention in studies of the effects of immigration on native and immigrant wages.[10] Surprisingly, few studies provide estimates in developing countries. An exception is Behar (2009) who, using a model of endogenous skill-biased technical change, estimates the elasticity of substitution between more and less educated workers using several cross-country datasets. Adopting the approach favored by immigration scholars, I define skill groups at the education and education-experience levels. I allow for imperfect substitution between heterogeneously skilled labor and aggregate formal and informal labor inputs. To my knowledge, this is the first paper to estimate the elasticity of substitution between formal and informal labor inputs.

2 Theoretical Model of the Labor Market

I develop a model of the formal and informal labor markets to study the sectoral participation, intensive labor supply and wage responses to changes in tax liability introduced by the formal sector tax schedule.[11] I assume that there are no labor force participation responses to taxation: workers respond to taxes by moving between the sectors but do not

[9] I do not include the 1997 reform as part of my analysis. Kumler et al. (2013) find that the reform did not affect sectoral mobility among workers, including those most likely to benefit.

[10] For example, see Welch (1979), Katz and Murphy (1992), Autor et al. (1998), Card and Lemieux (2001), Borjas (2003), Borjas and Katz (2007), and Ottaviano and Peri (2006). Ottaviano and Peri (2008) provide a recent discussion of the immigration literature.

[11] A fully general equilibrium model would consider the incidence of capital and goods prices as well.

exit the labor market completely. This would be a nontrivial assumption for developed countries, where labor force participation responses to taxation are large. However, in developing economies, the separation between labor force and informal participation is less distinct. In the absence of public transfers, non-working individuals rely on private social networks for consumption and may work in domestic production in exchange for such transfers. In these cases, any distinction between labor force and informal sector participation choices would be superficial.[12]

I conduct my analysis at the skill-group level to facilitate analysis of equilibrium wage effects. I use a labor demand model that allows for heterogeneous labor because the tax changes I study vary across pre-tax income. To model the determination of sector-skill-specific equilibrium wages, I allow for imperfect substitutability among heterogeneously skilled labor inputs and aggregate sectoral labor inputs.

2.1 Labor Supply

I assume that individuals work in one job and participate in one sector.[13] The income tax schedule applies to formal workers. I consider the effects of changes in average and marginal tax rates on sectoral participation and hours supply among labor market participants. Changes in marginal tax rates induce intensive-margin responses and changes in average tax rates cause sectoral participation responses.

Individuals have quasi-linear utility over a numeraire consumption good c and hours of work h, as shown by equation 1. This utility function is analytically and empirically convenient because it eliminates income effects and implies a constant wage elasticity of labor supply equal to σ. For these reasons, it is commonly used in the public finance literature (Saez et al., 2012).[14] The parameter α captures the disutility of labor supply. I assume that the parameters σ and α are the same across formal and informal workers. This is reasonable because there is high mobility between the sectors, most individuals work in both sectors at least once during their lifetime, and there is no reason to believe that these behavioral parameters change upon switching sectors.[15]

$$u(c,h) = c - \alpha^{\frac{1}{\sigma}} \frac{h^{1+\frac{1}{\sigma}}}{1+\frac{1}{\sigma}} \tag{1}$$

The economy has K imperfectly substitutable skill groups, $\{k_1, k_2, ...k_K\}$. Skill group k

[12]Empirically, I limit my sample to working-age men, who have a high and stable employment rate of 90%. I do not find any statistically significant or meaningful relationship between average tax rates and labor force participation.

[13]About 2% of workers in my sample have more than one job: however, the data do not contain the characteristics of the second job needed to determine the sector.

[14]Gruber and Saez (2002) estimate negligible income effects in the context of the U.S..

[15]In Section 5.3, I explore the sensitivity of my results to this assumption. While it is likely that the structural hours elasticity is the same among workers regardless of sector, workers may face different optimization frictions (e.g. adjustment costs) in the two sectors, which would affect the point estimate of the observed elasticity.

workers in the informal sector receive the same hourly wage w_{Ik}. Conditional upon informal sector participation, the informal hours supply function is:

$$h_{Ik} = \frac{1}{\alpha}(w_{Ik})^{\sigma} \tag{2}$$

Formal sector workers in skill group k receive hourly wage w_{Fk}. Total tax liability is a function of pre-tax labor income, $T(w_{Fk}h_{Fk})$, where h_{Fk} is formal hours worked in skill group k. If an individual works in the formal sector, his after-tax income is equal to pre-tax income $w_{Fk}h_{Fk}$ minus his tax liability and there is no opportunity for evasion because his employer withholds his tax liability. If an individual works in the informal sector, I assume he does not pay personal income taxes.[16] Conditional upon formal sector participation, a skill-group k workers' hours supply decision depends on the marginal tax rate on labor income, $MTR_k \equiv \partial T(w_{Fk}h_{Fk})/\partial(w_{Fk}h_{Fk})$. The formal hours supply function is:

$$h_{Fk} = \frac{1}{\alpha}((1 - MTR_k)w_{Fk})^{\sigma} \tag{3}$$

The formal hours supply function indicates that an increase in the net-of-marginal tax rate $1 - MTR_k$ increases the supply of hours, holding the equilibrium wage constant.[17] The elasticity of hours with respect to the net-of-marginal tax rate is:

$$\sigma = \frac{\partial h_F(w_F)}{\partial(1 - MTR)} \cdot \frac{(1 - MTR)}{h_F(w_F)} \tag{4}$$

Formal workers pay payroll taxes to finance a benefits package that includes health, disability and life insurance. The payroll tax is a flat percentage of pre-tax income and workers pay different amounts for the same benefits. Workers have heterogeneous valuations of payroll tax-financed benefits (Corbacho et al., 2013; Levy, 2008).[18] Aside from the payroll-tax financed benefits, participation in the formal sector entails a fixed utility gain q.[19] The fixed utility gain may arise from heterogeneous valuations of formal sector benefits, warm glow from formal participation, or the evasion costs associated with informal participation, to the extent that those costs are not a function of earnings.[20] A skill group k individual participates in the formal sector if his indirect utility from formal participation $V(w_{Fk}, ATR_k, MTR_k)+q$ is greater than that from informal participation $V(w_{Ik})$, as shown by the participation con-

[16] With the exception of a small fraction of self-employed individuals, informal sector workers evade taxation completely (Levy, 2008; Busso et al., 2012; Abramovsky et al., 2010).

[17] Both marginal and average tax rates depend on pre-tax earnings and are thus endogenous to formal hours supply. In my empirical work, I use simulated instruments to deal with this source of endogeneity. A separate issue is introduced by the non-linearity of tax schedules: I ignore hours supply bunching among formal workers in response to the tax schedule. There is no graphical evidence of bunching among formal workers, which I discuss in more detail in Section 3.1.

[18] The average worker values them at about two-thirds of the cost (Corbacho et al., 2013; Levy, 2008).

[19] The fixed utility gain associated with formal participation is analogous to fixed costs associated with labor market participation, for example due to hours constraints or commuting costs (Kleven et al., 2009; Brewer et al., 2010).

[20] If evasion costs are a function of informal earnings, then the optimal hours supply functions would differ across sectors because informal earnings would be a function of the tax schedule, not only through the participation response, but also through an evasion cost function (i.e. $q(w_{Ik}h_{Ik})$). For example, this assumption would be violated in a situation in which someone works in the informal sector and their informal hours are a function of the tax schedule because greater informal earnings yield a greater likelihood of a tax audit or greater penalties if caught evading. This is unlikely because the incidence of personal audits in Mexico is low (Levy, 2008; Busso et al., 2012; Corbacho et al., 2013).

straint in equation 5, where the average tax rate is $ATR_k \equiv T(w_{Fk}h_{Fk})/w_{Fk}h_{Fk}$.

$$q \geq V(w_{Ik}) - V(w_{Fk}, ATR_k, MTR_k) \equiv \bar{q}_k \tag{5}$$

I define $\bar{q}_k$ as the threshold cost of working in the formal sector exclusive of the fixed utility gain q. Defined at the skill group level, $\bar{q}_k$ has three components: the lost (gained) utility due to a positive (negative) tax liability in the formal sector, a disutility of work differential, and the difference in utility due to different formal and informal wages. The utility cost of tax liability is the same sign as the average tax rate. For example, it is positive when average tax rates are positive and thus is a cost associated with formal work. Alternatively, if average tax rates are negative, as they were after the implementation of the tax credit at most levels of pre-tax income, this component can be seen as a net benefit to working in the formal sector. The second component is the difference in disutility from work associated with the difference in optimal hours worked, h_{Fk} and h_{Ik}. This will be negative (a benefit) if, say, the optimal formal hours worked, given the wage and tax rates, are less than the optimal informal hours worked: $h_{Fk} < h_{Ik}$. The third component is the difference in utility due to different wage rates. For example, if the formal wage w_{Fk} is more than the informal wage w_{Ik}, this component of the term will be negative (a benefit).[21]

The threshold cost $\bar{q}_k$ is an implicit function of wages, the marginal tax rate, and the average tax rate. Skill group k workers with a low utility gain associated with the formal sector - those with a fixed formal utility gain q below the threshold $\bar{q}_k$ - are employed in the informal sector. Workers with a high utility gain, $q > \bar{q}_k$, are employed in the formal sector. I assume that q is distributed smoothly throughout the population within a skill group and represented by the distribution function $F(q)$. It is important to allow for heterogeneous preferences within a skill group because this generates an aggregate labor market equilibrium in which some individuals participate in each sector across the skill distribution, which is what I observe empirically.[22] The formal participation rate of group k can be represented by fraction $p_{Fk} \equiv 1 - F(\bar{q}_k)$. Similarly, the informal participation rate is $p_{Ik} = 1 - p_{Fk} = F(\bar{q}_k)$. The indirect utility functions imply that the net cost of working in the formal sector for group k is:

$$\bar{q}_k = \frac{1}{\alpha}\frac{1}{(1+\sigma)}\left(w_{Ik}^{1+\sigma} - w_{Fk}^{1+\sigma}(1 - MTR_k)^{\sigma}(1 + \sigma \cdot MTR_k - (1+\sigma) \cdot ATR_k)\right) \tag{6}$$

[21] I ignore possible time-varying links between taxes paid in the formal sector and the benefits that the taxes pay for. For example, if payroll-tax financed benefits increase, holding payroll taxes constant, this may shift the distribution of formal preferences. It is unlikely that this occurred because the largest change in the benefit system during the period of consideration, the 1997 pension reform, did not affect sectoral mobility among workers, including those most likely to benefit (Kumler et al., 2013). In addition, the Seguro Popular health insurance reform in the mid-2000s did not affect sectoral participation (Del Valle, 2013).

[22] While the formal participation rate increases with pre-tax income (skill), a substantial portion of individuals work in the informal sector even at the highest income (skill) level.

Equation 6 shows that an increase in the average tax rate ATR_k, an increase in the marginal tax rate MTR_k, a decrease in the formal wage w_{Fk} or an increase the informal wage w_{Ik} will cause an increase in $\bar{q}_k$, and thus a decrease in the formal participation rate. Changes in relative after-tax income, for example, due to changes in the average tax rate or sectoral wages, induce movement from the formal to the informal sector and can be captured by the formal and informal participation elasticities:

$$\eta_F \equiv \frac{\frac{\partial p_F}{p_F}}{\frac{\partial \frac{w_F(1-ATR)}{w_I}}{\frac{w_F(1-ATR)}{w_I}}}, \quad \eta_I \equiv \frac{\frac{\partial p_I}{p_I}}{\frac{\partial \frac{w_I}{w_F(1-ATR)}}{\frac{w_I}{w_F(1-ATR)}}} \tag{7}$$

The formal (informal) participation elasticity η_F (η_I) is the parameter of interest with regard to formal (informal) sector extensive responses and measures the percent change in the proportion of workers who work in the formal (informal) sector due to a percentage change in relative after-tax income. In equilibrium, the participation elasticities satisfy the following condition: $\eta_I = -\eta_F \cdot \frac{p_F}{p_I}$. That is, the percent change in the informal participation rate equals the negative of the percent change in the formal participation rate multiplied by the ratio of the previous period's participation rates.

In defining the participation elasticities shown in equation 7, I make an important simplifying assumption. The participation constraint shown in equation 6 indicates that extensive responses may be due to both changes in relative after-tax income and the difference in the disutility of work associated with working different hours in each sector. However, in equation 7, I define my participation elasticities with respect to relative after-tax income in order to gain tractability in my empirical specification. That is, I assume that the difference in disutility a worker gets from small differences in optimal hours in each sector – intensive responses – do not affect participation decisions. An implication that follows is that the marginal tax rate does not affect participation decisions, after controlling for the average tax rate. This assumption is consistent with the existing public finance literature, which treats extensive- and intensive-margin responses as separate in both estimation and optimal tax analysis.[23] Because the average hours in each sector are quite similar across skill groups and over time in my data set, the disutility of work hours differential is unlikely to drive participation responses. In Section 5.4, I show more comprehensively that allowing for intensive responses to affect participation is unlikely to be quantitatively important.

The total labor supplies of skill-group k at time t in the formal and informal sectors are functions of the total size of the participating labor force N_{kt}, the group-specific participation rates p_{Fkt} and p_{Ikt}, and the group-specific hours supplies h_{Fkt} and h_{Ikt}. The total labor

[23]If hours differences affect participation, the participation equations are highly nonlinear, which complicates estimation substantially. I discuss this in detail in Section 5.4.

supplies in the formal and informal sectors, respectively, are:

$$L_{Fkt}(w_{Fkt}) = N_{kt}p_{Fkt}h_{Fkt}(w_{Fkt}), \quad L_{Ikt}(w_{Ikt}) = N_{kt}p_{Ikt}h_{Ikt}(w_{Ikt}) \tag{8}$$

Tax changes affect the participation rates, p_{Fkt} and p_{Ikt}, and the hours supply functions, h_{Fkt} and h_{Ikt}. I assume that the total size of the participating labor force within a skill group, N_{kt}, is not affected by tax changes.[24] In the next section, I show how tax-induced changes in labor supply affect equilibrium wages, w_{Fkt} and w_{Ikt}.

2.2 Labor Demand

To model the determination of sector-skill equilibrium wages, I allow for imperfect substitution among labor inputs along two dimensions. First, I assume that workers within each sector-skill group are perfect substitutes and that workers across skill groups, within a sector, are imperfect substitutes. Second, I allow the aggregate labor input of formal workers to be an imperfect substitute for the aggregate labor input of informal workers. By allowing for imperfect substitution in labor inputs across skill and sector, the tax-induced changes in the formal labor supply of one skill group have indirect effects on the formal labor supply of all other skill groups and on the labor supply of all informal workers via the wage effects induced by substitution in labor demand.[25] Following Ottaviano and Peri (2008), I assume that aggregate production in the entire economy is a Cobb-Douglas aggregation of capital and labor:

$$Y_t = A_t L_t^{\alpha} K_t^{1-\alpha} \tag{9}$$

where Y_t is aggregate output at time t, A_t is exogenous total factor productivity, K_t is physical capital, and α is the income share of labor. This functional form has been widely used in the growth literature and is supported by the fact that the share of income going to labor, α, is constant across countries and over time (Kaldor, 1961; Gollin, 2002).

Total effective labor L_t is a Constant Elasticity of Substitution (CES) aggregate of labor supply across formal and informal labor and defined as:

$$L_t = \left(\theta_{Ft} L_{Ft}^{\frac{\rho_{IF}-1}{\rho_{IF}}} + \theta_{It} L_{It}^{\frac{\rho_{IF}-1}{\rho_{IF}}} \right)^{\frac{\rho_{IF}}{\rho_{IF}-1}} \tag{10}$$

[24]2SLS regressions of labor force participation on net-of-average tax rates, year fixed effects, skill group fixed effects, metropolitan area fixed effects and interactions of these do not reveal any statistically significant or meaningful relationship between tax rates and labor force participation.

[25]The sectoral status of a worker is not representative of the sectoral status of their employer. Beltran (2009) and Anton et al. (2012) characterize the Mexican labor market as comprised of a continuum of firms that employ different combinations of formal and informal workers. Their descriptive evidence suggests that many firms employ both formal and informal workers of similar skill and outsource work to the informal sector.

where L_{Ft} (L_{It}) is the total effective labor supplied by formal (informal) workers at time t. The elasticity of substitution between formal and informal labor inputs is $\rho_{IF} > 0$: this measures the percent change in the demand for formal (informal) aggregate labor given a percentage change in the price of informal (formal) labor. The terms θ_{Ft} and θ_{It} measure the relative productivity levels of formal and informal labor inputs. These are time varying and standardized within a year so that $(\theta_{Ft} + \theta_{It}) = 1$.[26]

Total effective formal and informal labor are CES aggregates of labor supply across skill groups k and defined as:

$$L_{Ft} = \left(\sum_k \beta_{Fkt} L_{Fkt}^{\frac{\rho_e - 1}{\rho_e}} \right)^{\frac{\rho_e}{\rho_e - 1}}, L_{It} = \left(\sum_k \beta_{Ikt} L_{Ikt}^{\frac{\rho_e - 1}{\rho_e}} \right)^{\frac{\rho_e}{\rho_e - 1}} \tag{11}$$

where L_{Ft} and L_{It} are aggregate measures of the total effective labor supplied by workers in the formal and informal sectors, respectively. The elasticity of substitution between skill groups is ρ_e: this measures the percent change in the demand for skill group m workers given a percentage change in the price of skill group n workers, among workers with the same sectoral status. The β_{Fkt} and β_{Ikt} terms are time-varying productivity levels specific to workers with skill k in the formal and informal sectors, respectively. Within each sector and year, these are standardized to sum up to one. This specification allows for skill-biased technical change (SBTC): that is, shifts in the production technology that favor one skill group over another. This is an important determinant of changes in the relative wages of skill groups during the period of trade liberalization in Mexico. Cragg and Epelbaum (1996) and Hanson (2003) find that Mexico became more skill-intensive and wages for high-skilled workers increased relative to lower skilled workers, a trend supported by the data used in this paper.[27] Empirically, it is important to control for SBTC because the wage effects of shifts in the relative labor supply of skill groups induced by differential tax changes could be confounded by SBTC.

My model of labor demand draws heavily from immigration studies that analyze the effects of immigration on wages. However, it is comparatively simple in that I include only two CES nests.[28] I define skill at either the education or education-age group levels. One

[26]Informal workers may have different abilities or be less skilled compared to formal workers, who are more difficult to fire due to labor market regulations. However, because a large proportion of individuals work as both an formal and informal worker at some point in their lives, it is unclear if informal labor inputs are differentiated enough to be imperfect substitutes for formal labor inputs. In specifications not presented in this paper, I reverse the CES nest order from that presented here and find that formal and informal workers of the same skill are imperfect substitutes, with an elasticity of substitution of approximately 1.5.

[27]More generally, there is evidence that developing countries experienced technical change that favored skilled workers and that increases in wage inequality are due to shifts in the relative demand for skilled labor because of trade liberalization (Bekman et al., 1998; Goldberg and Pavcnik, 2007).

[28]Many immigration studies use models with some combination of the following: a nest of high- and low-education labor, an education nest within each type of broad education category (for example, high-school dropout and high-school graduate in the low-education category), an experience nest within each of those finer education categories, and a nest within those experience nests of immigrants and natives. For example, see Welch (1979), Katz and Murphy (1992), Autor et al. (1998), Card and Lemieux (2001), Borjas (2003), Borjas and Katz (2007), and Ottaviano and Peri (2006).

limitation to this formulation is that restricting the elasticity across all education groups to be the same assumes that the education groups are "symmetric": it does not allow for workers with no education to be a less close substitute for workers with a high-school degree than high-school dropouts. This is a necessary simplification given the sources of exogenous variation I exploit for identification.

I use the production functions to calculate the labor demand functions and wages for each type of labor at a given point in time. In a competitive equilibrium, the (natural log of) the marginal productivity of skill group k workers in the formal sector equals (the natural log of) their pre-tax wage at time t, and similarly for their wage in the informal sector:

$$\begin{aligned} \ln w_{Fkt} = & \ln(\alpha A_t \kappa_t^{1-\alpha}) + \ln \theta_{Ft} + \frac{1}{\rho_{IF}}(\ln L_t) + \ln \beta_{Fkt} \\ & + \left(\frac{1}{\rho_e} - \frac{1}{\rho_{IF}}\right) \ln L_{Ft} - \frac{1}{\rho_e}(\ln L_{Fkt}) \end{aligned} \tag{12}$$

$$\begin{aligned} \ln w_{Ikt} = & \ln(\alpha A_t \kappa_t^{1-\alpha}) + \ln \theta_{It} + \frac{1}{\rho_{IF}}(\ln L_t) + \ln \beta_{Ikt} \\ & + \left(\frac{1}{\rho_e} - \frac{1}{\rho_{IF}}\right) \ln L_{It} - \frac{1}{\rho_e}(\ln L_{Ikt}) \end{aligned} \tag{13}$$

where κ_t is the capital-labor ratio, L_{Fkt} and L_{Ikt} are the total labor supplies of skill group k formal and informal labor as defined in equation 8, and w_{Fkt} and w_{Ikt} are the corresponding formal and informal average wages. I assume that the relative productivity parameters (the θ and β terms), total factor productivity (A), and the capital-labor ratio depend on technological factors and are independent of the supply of formal and informal workers.[29]

The overall wage effect of tax-induced changes in labor supply can be decomposed into four effects. First, there is a positive effect that works through capital adjustment, represented by κ. As labor supply increases, capital adjusts to maintain the capital-to-labor ratio. Second, there is an aggregate labor effect: there is a positive overall effect of labor supply increases on the productivity of workers in group k due to an increased supply of all types of labor. Intuitively, a worker benefits from the increase in aggregate sectoral labor supply because of the imperfect substitutability among differently skilled workers. This effect operates through $\frac{1}{\rho_{IF}} \ln L_t$ for all workers. The third effect is a sectoral aggregate labor effect: there is a positive effect of overall formal (informal) labor increases for formal (informal) workers. Intuitively, a formal worker benefits from the increase in aggregate formal labor supply due to the

[29] In Section 5.5, I present results using firm data to explore the sensitivity of my estimates to the assumption that there is full capital adjustment to tax- and trade-induced changes in labor. I find that controlling for these technological parameters is important but the way in which I control for them – explicit measures or fixed effects – does not affect estimates of the labor demand parameters.

imperfect substitutability among differently skilled formal workers. This effect operates through $\left(\frac{1}{\rho_e} - \frac{1}{\rho_{IF}}\right) \ln L_{Ft}$ for formal workers, and through $\left(\frac{1}{\rho_e} - \frac{1}{\rho_{IF}}\right) \ln L_{It}$ for informal workers. Finally, there is a direct "partial" effect, which can be thought of as measuring the wage impact, keeping constant the aggregate and sectoral aggregate supplies of labor. This is represented by the last term in each equation. Because all of the tax changes I consider affect many skill groups at the same time, it is important to include the aggregate cross-effect terms to account for the fact that the labor demand of one skill group shifts when the supplies of other imperfectly substitutable skill groups change.[30] My empirical estimates suggest that these cross-effect terms matter.

2.3 Tax Changes

I consider tax policies that generate changes in marginal tax rates MTR and average tax rates ATR across skill groups. Changes in the marginal and average tax rates induce both labor supply and wage responses. Using equations 2, 3 and 7, the labor supply responses are represented by the equations below, which show the percent change in formal hours, informal hours, the formal participation rate, and the informal participation rate for education group k between periods t and $t+1$.

$$\ln\left(\frac{h_{Fkt+1}}{h_{Fkt}}\right) = \sigma\left[\ln\left(\frac{w_{Fkt+1}}{w_{Fkt}}\right) + \ln\left(\frac{1 - MTR_{kt+1}}{1 - MTR_{kt}}\right)\right] \tag{14}$$

$$\ln\left(\frac{h_{Ikt+1}}{h_{Ikt}}\right) = \sigma \ln\left(\frac{w_{Ikt+1}}{w_{Ikt}}\right) \tag{15}$$

$$\ln\left(\frac{p_{Fkt+1}}{p_{Fkt}}\right) = \eta_F\left[\ln\left(\frac{w_{Fkt+1}}{w_{Fkt}}\right) - \ln\left(\frac{w_{Ikt+1}}{w_{Ikt}}\right) + \ln\left(\frac{1 - ATR_{kt+1}}{1 - ATR_{kt}}\right)\right] \tag{16}$$

$$\ln\left(\frac{p_{Ikt+1}}{p_{Ikt}}\right) = \eta_I\left[\ln\left(\frac{w_{Ikt+1}}{w_{Ikt}}\right) - \ln\left(\frac{w_{Fkt+1}}{w_{Fkt}}\right) - \ln\left(\frac{1 - ATR_{kt+1}}{1 - ATR_{kt}}\right)\right] \tag{17}$$

Equation 14 shows the percent change in formal hours worked: this depends on the percent changes in the formal pre-tax wage and the net-of-marginal tax rate. Similarly, equation 15 shows the percent change in informal hours worked, which depends on the percent change in the informal wage. Both hours supply equations show that as the wage increases, hours supply increases: a one percent increase in the wage causes a σ percentage increase in hours worked. Similarly, a one percent increase in the net-of-marginal tax rate causes a σ percentage increase in hours worked in the formal sector.[31]

[30] For example, consider the case when the marginal and average tax rates decrease for all skill groups in the formal sector, causing an increase in formal labor supply and a decrease in informal labor supply. The wages of formal workers in group k are affected by: a direct effect of workers in their same education group, a sectoral aggregate cross-effect produced by increases in total formal labor by other skill groups, an aggregate cross-effect produced by all workers, and a capital-adjustment term.

[31] The parameter σ is over-identified, provided the intensive-margin elasticity σ is the same in both sectors. While it is likely

Equations 16 and 17 show the percent changes in the formal and informal participation rates, respectively, which depend on: the percent changes in formal and informal wages and the percent change in the net-of-average tax rate. A one percent decrease in the net-of-average tax rate causes an η_F percentage decrease in the formal participation rate or, alternatively, an η_I percentage increase in the informal participation rate. An implicit assumption is that the change in the tax rates faced by formal workers captures the change in the labor supply incentives faced by informal workers.

The labor supply response equations depend on both changes in tax rates *and* changes in sectoral wages induced by general equilibrium effects. For this reason, I expect to see wage effects in the informal sector if tax changes induce participation responses. In a model without equilibrium wage effects, there would be no effect of a formal tax change on the informal wage. Also, there would not be wage effects if sectoral labor demand is perfectly elastic and, in the case of imperfectly substitutable labor inputs, a tax-induced change in the labor supply of one skill group does not affect the labor demand of another skill group. For any departure from these conditions, the equilibrium effects of tax policies on (pre-tax) sectoral wages depend on changes in the aggregate sectoral labor demands and the sectoral labor demand parameters.

Using equations 12 and 13, the wage responses due to changes in sectoral labor supply among group k workers between time periods t and $t+1$ in the formal and informal sectors, respectively, are:

$$\begin{aligned}\ln\left(\frac{w_{Fkt+1}}{w_{Fkt}}\right) &= \ln\left(\frac{A_{t+1}\kappa_{t+1}^{1-\alpha}}{A_t\kappa_t^{1-\alpha}}\right) + \ln\left(\frac{\theta_{Ft+1}}{\theta_{Ft}}\right) + \ln\left(\frac{\beta_{Fkt+1}}{\beta_{Fkt}}\right) \\ &+ \frac{1}{\rho_{IF}}\left[\ln\left(\frac{L_{t+1}}{L_t}\right)\right] + \left(\frac{1}{\rho_e} - \frac{1}{\rho_{IF}}\right)\ln\left(\frac{L_{Ft+1}}{L_{Ft}}\right) \\ &- \frac{1}{\rho_e}\left[\ln\left(\frac{p_{Fkt+1}}{p_{Fkt}}\right) + \ln\left(\frac{h_{Fkt+1}}{h_{Fkt}}\right)\right]\end{aligned} \tag{18}$$

$$\begin{aligned}\ln\left(\frac{w_{Ikt+1}}{w_{Ikt}}\right) &= \ln\left(\frac{A_{t+1}\kappa_{t+1}^{1-\alpha}}{A_t\kappa_t^{1-\alpha}}\right) + \ln\left(\frac{\theta_{It+1}}{\theta_{It}}\right) + \ln\left(\frac{\beta_{Ikt+1}}{\beta_{Ikt}}\right) \\ &+ \frac{1}{\rho_{IF}}\left[\ln\left(\frac{L_{t+1}}{L_t}\right)\right] + \left(\frac{1}{\rho_e} - \frac{1}{\rho_{IF}}\right)\ln\left(\frac{L_{It+1}}{L_{It}}\right) \\ &- \frac{1}{\rho_e}\left[\ln\left(\frac{p_{Ikt+1}}{p_{Ikt}}\right) + \ln\left(\frac{h_{Ikt+1}}{h_{Ikt}}\right)\right]\end{aligned} \tag{19}$$

that the structural elasticity is the same among workers in both sectors, it may be that workers face different optimization frictions in the two sectors. In this case, the estimated elasticity would be different across the two sectors. In Section 5.3, I show that σ is similar in both sectors after allowing for sector-specific optimization frictions.

The first term in each equation is the same and represents changes in total factor productivity and the capital-to-labor ratio.[32] The second and third terms in each equation capture changes in the relative productivity of sectoral and skill-group labor inputs. The fourth term in each equation captures the change in aggregate labor, as represented by equation 10 and the fifth terms capture the change in sectoral aggregate labor, as represented by equation 11. The wage responses depend not only on the labor supply responses, but also on the elasticity of substitution parameters, ρ_e and ρ_{IF}. For example, if the elasticity of substitution between skill groups, ρ_e, is large, then the percent change (decrease) in the wage for skill group k due to a percentage change (increase) in the labor supply of skill group k will be small and the incidence of the tax credit on workers will be small. The last term represents changes in the total labor supplies of formal and informal workers in skill-group k at time t. This can be decomposed into changes in the group-specific participation rates, p_{Fkt} and p_{Ikt}, and changes in the group-specific hours supplies, h_{Fkt} and h_{Ikt}.

The system of equations 14 - 19 show the effects of changes in the marginal and average tax rates, MTR and ATR, on labor supply and wages. In the following section, I describe how I simultaneously estimate this system of equations using exogenous variation in tax rates and trade-induced variation in aggregate labor.

3 Empirical Implementation

3.1 Data

I combine 2 sources of data to explore the labor market effects of tax policy. First, I use micro-data from the Survey of Urban Employment (ENEU), from 1988 to 2004. The ENEU is a quarterly rotating panel with approximately 120,000 households surveyed every quarter in the urban municipalities of Mexico. Households are interviewed for 5 consecutive quarters. The survey contains demographic characteristics for each household member, such as municipality and metropolitan area, gender, age, and education. Current and historical labor force participation and job-related details are collected for those 12 years of age and older. Specifically, I observe labor force participation, weekly (after-tax) earnings, and weekly labor supply. In addition to labor supply and earnings, I observe a workers' occupation, industry, and various benefits associated with their primary job. Using classifications consistent with studies of the informal sector in Mexico, I use detailed questions on receipt and source of health insurance to determine a workers' sectoral status.[33]

[32] A priori, it is unclear if capital adjusts in response to tax-induced changes in labor supply. I control for these variables in my main specification and present results that allow for different levels of capital adjustment using firm data in Section 5.5.

[33] All formal workers are registered with the Mexican Social Security Institute (IMSS), and private sector workers receive their payroll tax-financed benefits through IMSS. Public sector workers receive a similar package of benefits through the Institute for Social Security for State Workers (ISSSTE). The literature that studies formality in Mexico defines a workers' sectoral status based on receipt of these benefits (Marrufo, 2001; Aleman-Castilla, 2006; Levy, 2008; Beltran, 2009; Abramovsky et al., 2010;

Second, I gathered historical tax parameters from the Mexican tax code for 1988-2004. The personal income tax is required of all Mexican residents. While the tax base is comprised of income from wages, pensions, and financial capital, non-labor earnings are not available at the household or individual level. Therefore, unlike studies that use large administrative tax return data that report taxable income, such as Saez (2010), Chetty et al. (2011), and Kleven and Waseem (2013), my analysis is restricted to labor income. While this likely represents the large majority of total income for most workers, and especially for low-income workers who experience much of the tax policy variation, this is a limitation to using this data.[34] Taxes due on wage earnings are withheld and paid by the employer and workers with only one formal sector job are not required to file taxes. With the exception of a small fraction (less than .2%) of the self-employed, informal sector workers evade taxation completely (Levy, 2008; Busso et al., 2012; Abramovsky et al., 2010; Corbacho et al., 2013). Therefore, I assume that informal workers do not pay taxes. I use after-tax labor income and the tax schedule to impute pre-tax income and income and payroll tax rates.[35]

Income tax is applied from the first peso of taxable income using a progressive rate schedule.[36] Tax liability is determined at the individual level and does not depend on family or household composition. The income tax thresholds and rates change frequently during the period of consideration, 1988-2004. The refundable formal employment tax credit, Credito al Salario, was introduced in the fourth quarter of 1993. The tax credit is given at a rate that declines with income and generates negative average tax rates at low-to-modest levels of income. Figures 1 and 2 show the tax credit in levels and as a percent of pre-tax income across the income distribution annually. Figures 3 and 4 show the marginal and average tax rate schedules, respectively, during this period. These figures show that before the credit was introduced average tax rates were always positive. There is substantial variation in tax rates over time, and substantial variation in rates across income within a given year.[37]

I limit my sample to working-age men who are not enrolled in school. The primary reason I limit my analysis to men is that they are more attached to the labor force than women. Figures 5 and 6 show male and female employment rates by age and across time, respectively. Employment rates for men are high, around 90% in any year, and do not change

Del Valle, 2013; Kumler et al., 2013).

[34]However, the alternative – administrative tax return data – only contain information on formal workers and would not be sufficient to study sectoral participation responses and tax incidence in Mexico.

[35]I include the payroll tax rates and thresholds when I impute pre-tax income. However, I do not add the monetary amount of payroll tax-financed benefits back into wage income for formal workers. Because the payroll tax is a flat percentage of pre-tax income, workers pay different amounts for the same benefits. Corbacho et al. (2013) and Levy (2008) show that workers have heterogeneous valuations of payroll tax-financed benefits, with the average worker valuing them at about two-thirds of the cost.

[36]There are tax exemptions on social security benefits, pension benefits in some cases, profit-sharing and vacation allowances, and interest paid on savings deposits. There are also deductions for the following expenditures: voluntary contributions to individual pension accounts (AFORES) in some cases, charitable donations, funeral expenses, school bus transport, and medical expenditures. I do not observe these.

[37]Prior to 2005, states did not impose additional income taxes on labor income. However, many states have implemented a small income tax in recent years of 1-2%.

much over the period. This is important because I do not model labor market participation decisions. There is descriptive and empirical evidence that women's participation is changing during this time for reasons unrelated to tax policy (Atkin, 2009). In addition, women are disproportionately found in informal self-employment and likely have distinct sectoral preferences from those of men. Chant (1991) and Maloney (2004) suggest that this is because women are more easily able to balance their market work with household obligations if they are self-employed. Female employment rates are quite low compared to men - below 50% until the mid-2000s - and they increase over time. The increase begins before the tax credit and it is unlikely that the increase in female employment rates are due to decreasing average tax rates in the mid-1990s.[38]

I use a sample of working-age men – ages 22-55 – for two reasons. First, the majority of individuals have completed their education by age 22, including college-educated workers.[39] Second, formal workers reach the required minimum number of years of work to collect their pension at an average age of 53 (OECD, 2005). As shown in Figure 5, there is a steep decline in the employment rate of men after age 55. There are changes in the population size and average education of men over time. Figure 7 shows the total size of the urban population of men by birth year, as measured in 1988, 1995, and 2002. For example, in 1988 there were approximately 600,000 working-age men who were in born in 1962 and live in urban areas. Among this same age cohort, there is an increase in the number who reside in urban areas in later years. This phenomenon could be due to sampling variation or, likely, rural-to-urban migration. This trend is particularly evident among young cohorts and occurs across all regions in a similar magnitude for a given cohort.[40] The average education of men in urban areas increased over the period. Figure 8 shows the average education of men, ages 22-55, by birth cohort and as measured in 1988, 1995 and 2002. Average education for a given birth cohort is quite similar when measured in different years and suggests that endogenous skill upgrade is not an empirical problem.[41]

Of the sample of working-age men, I limit my sample to those individuals who worked in the previous week and have non-missing earnings, hours, education and benefits data.[42] I standardize all earnings data, after imputing tax rates, to 2004 pesos using price indices

[38]Women's labor force participation could affect wages because the labor inputs of men and women are likely substitutes. I include metropolitan area fixed effects, year fixed effects and skill group-year fixed effects in my wage equations. Therefore, as long as women's participation changes similarly across geographic areas over time, I control for it. Empirically, I find that this assumption is reasonable.

[39]I drop individuals who are still in school and working, about 7% of men aged 22-55.

[40]I discuss the empirical implications of changes in the skill group size that are heterogeneous across geographic areas in Section 5.1. I find that after controlling for metropolitan area fixed effects, year fixed effects and skill group fixed effects, there is little remaining variation in the total size of skill groups across metropolitan areas.

[41]For example, if average education measured in 1995 was very different from that measured in 2002 for the same birth cohort, I might worry that individuals increased their education because trade liberalization increased the returns for highly educated individuals relative to those with less education. As discussed in Section 5.2, this is unlikely to have occurred.

[42]Of 3.6 million observations, just under 4000 observations are dropped due to missing labor supply data. 7.5% of observations have missing earnings data. In any particular quarter, 3-4% of the employed do not work in the previous week, primarily because of planned time off (holidays).

published by the Bank of Mexico.[43] Panel A of Table 1 shows summary statistics for my sample. With 17 years of data, I have 3.5 million observations. Compared to national averages, the sample is slightly younger, with an average age of 35.6, and more educated, with an average of 10.67 years of schooling. The higher education levels are due to the fact that the survey is conducted in urban areas and average education is lower in rural areas. Fifty-four percent of the sample is formal. The average after-tax formal and informal wages are similar, at \$25.8 and \$24.25 pesos, respectively. However, the average pre-tax formal wage is \$30.57 pesos. This is indicative of a substantial wedge introduced by both income and payroll taxes. There is substantial variation in average and marginal tax rates, which is expected given the tax schedules shown in Figures 3 and 4. The average tax rate ranges from negative 371% to positive 44% and the marginal tax rate from 3% to 50%.[44]

The primary feature of skill in the model is that workers with the same skill are perfect substitutes in production. Therefore, to accurately estimate the elasticities of interest it is critical that in the empirical implementation, workers in different skill groups who compete for the same jobs have different productivity. If that were not the case, then the average change in labor supply in a particular group would not equal the labor supply shock to the average skill member's labor market. I create skill groups that are defined by the characteristics of education and age to limit skill group switching. These characteristics are commonly used to define skill groups, for example, in the immigration literature. While including occupation or industry characteristics may generate a richer set of skill groups, using these characteristics in my definition is problematic because changes in the differential returns to education and experience across these groups could drive occupation or industry switching, which I do not model.

To facilitate the incidence analysis, I use observations at the level of the skill group, metropolitan area and year. While a change in the labor supply of an individual is unlikely to affect their formal or informal wage, by defining wages at the skill-group level, the labor supply changes of individuals who experience similar tax changes and have similar productivity in production may affect equilibrium wages. I use two definitions of skill groups: education groups and education-experience groups. I use the more narrowly defined skill groups for two reasons. First, a large literature suggests that experience is an important determinant of wage and that workers within the same education group who have different levels of experience are not perfect substitutes. Second, using 30 groups exploits more of the identifying variation in tax rates. I define the following education groups: primary

[43] In 2004, one Mexican peso was worth about \$0.09 U.S. dollar.

[44] Men's labor supply decisions may include the option of migrating to the U.S., which may respond to both taxes and wages. Empirically, this would be an issue because the average change in labor supply of a particular group would not equal the labor supply shock to the average skill member's labor market. I include metropolitan area fixed effects, year fixed effects and skill group-year fixed effects in my wage equations. Therefore, as long as immigration changes similarly across geographic areas over time, I control for it. There is no data for the period of study to confirm this pattern.

school or less, some secondary school, completed secondary, some high school, completed high school, and more than high school.[45] I define age groups in roughly 6 year age groups, starting with age group 22-27 and ending with age group 49-55. I define labor markets at the metropolitan-area level and ignore domestic migration.[46]

Table 2 shows the composition of my sample across the education and education-age groups. I use the weighting factors (expansion factors) provided by the surveyors when I compute group-level averages so that the sample is representative of the local labor market. A worker with median education has 9 years of schooling and the median age is 35 years old. In Panels B and C of Table 1, I present group-level summary statistics for the sample under the two definitions of skill. All variables are averaged at the skill-metropolitan area-year level. The size of the groups are large under both definitions: when skill groups are defined at the education level, the average group size is 113,078 and when they are defined at the education-experience level, the average size is 22,697. The sectoral participation, hours supply, wage and tax rates averaged at the group level are similar to those at the individual level. However, when the skill groups are more broadly defined, there is less variation in the marginal and average tax rates.

The formal sector participation rate decreases over time across most education groups, as shown in Figure 9. The largest decreases are among the lowest education group, with a rate of 50% in 1988 that dropped to 37% by 2004. Among the most highly educated, the participation rate remains fairly stable around 60%, and increases by a small amount in later years. However, even within an education group, there is substantial variation in the evolution of formal participation across geographic regions. Figure 10 shows the evolution of formal participation for the median education group (finished secondary schooling) by geographic region. In the north, where trade liberalization-induced changes in labor demand were largest in early years, formal participation is relatively high at over 65% in most years. In other regions, there are much larger fluctuations over time and a general downward trend.

Figures 11 and 12 show the evolution of average formal and informal hours, respectively, by education group. Average hours in both sectors increased over time among all education groups with one exception: average formal hours among the most highly educated increased around the time of the signing of NAFTA (1994) and then decreased toward pre-liberalization levels. Figures 13 and 14 show the evolution of average after-tax, inflation-adjusted formal and informal wages by education group. Real wages increased moderately for all education groups from 1988-1994 and decreased, in both sectors and for all but the highest education group, following the Mexican peso crisis in late 1994. From 1996-2004, wage growth was small and generally positive across education groups. It is important to keep in mind that changes

[45] Compulsory education laws require schooling through secondary school, which corresponds to 9 years of education: my sample has an average education of slightly more than 10.7 years.

[46] I discuss the implications of this assumption in the following section.

in wages are substantial during the period of study, independent of tax-related equilibrium effects. They are important to control for and, as I discuss in the next section, the labor demand shifts associated with trade provide plausibly exogenous variation that allow me to separately identify the labor supply and wage effects of taxation.

3.2 Sources of Identification

As shown in Section 2, the impact of changes in the net-of-marginal and average tax rates, $1 - MTR$ and $1 - ATR$, on labor supply and wages can be measured by the following parameters: the elasticity of hours with respect to the marginal tax rate (or wages) σ, the sectoral participation elasticities η_F and η_I, the elasticity of substitution between different education groups, ρ_e, and the elasticity of substitution between formal and informal labor, ρ_{IF}. Equations 18 and 19 show that the effects of tax-induced changes in labor supply on wages depend on the evolution of the capital-to-labor ratio (κ), total factor productivity (A), total effective sectoral labor supply (L_F and L_I) and total effective labor supply (L), as discussed in Section 2.2. Heterogeneity in skill allows for identification of the sectoral participation and hours supply elasticities: with multiple years of tax changes, my estimate of the hours supply elasticity exploits within-skill, across-time variation in marginal tax rates. The participation elasticities are identified by within-skill, across-time variation in average tax rates. As Figures 3 and 4 show, there is considerable variation in marginal and average tax rates across time and across the income distribution.

Both marginal and average tax rates depend on pre-tax earnings and, therefore, changes in the tax rates for workers of skill k are endogenous to unobserved determinants of changes in either labor supply or wages. I use simulated instruments, a method commonly used to remove this source of endogeneity in the public finance literature.[47] An instrument is created from an exogenous component of a tax change by using only changes in rates due to changes in the tax schedule, holding hours and wages constant.[48]

Nonlinear tax schedules introduce additional complexities that I do not account for. I implicitly assume that small tax changes do not cause workers to jump from one segment of the tax schedule to another. An example of such behavior would be someone who reduces his hours, lowering total earnings from just above a tax kink to just below it, in order to have a lower marginal tax rate. While this assumption is necessary to obtain empirically tractable expressions of the incident effects, it is nontrivial. Standard utility functions usually do not yield labor supply functions that are linear in the wage and tax parameters. I offer two defenses for my approach. First, the evidence suggests that behavioral responses to nonlinearities in the tax schedule, at least in the U.S., are relatively small (Saez, 2002,

[47]For example, see Auten and Carroll (1999), Gruber and Saez (2002), Leigh (2010), or Rothstein (2008).

[48]To account for bracket creep, I inflate the baseline wages by the CPI before simulating the counterfactual schedule.

2010). In the Mexican context, most of the kinks are small, close together, and frequently changing. Second, the consequences of mis-measuring any individual's tax rate are minor because the key tax rates are averages within relatively large groups – these are likely to be reasonably accurately proxied by a no-bracket-switching simulation.

Visual inspection of the formal pre-tax income distribution does not indicate bunching at the tax kinks. For example, Figure 15 shows the pre-tax formal annual income distribution for a sample of years, 1996-1999, with the tax kinks.[49] The lack of bunching could be for several reasons. First, workers may not pay attention to their marginal tax rate or know exactly where they fall within a tax bracket. Inattention is plausible in this context because the tax brackets are close together, especially a low-to-modest levels of income, and they change nearly every year. An equally likely explanation for the lack of bunching is that there are adjustment costs associated with changing hours to a post-reform optimum. Intuitively, workers may face additional constraints such that choosing their optimal hours requires that they search for and obtain a new job. In the context of the U.S., graphical evidence of bunching is limited to the self-employed, a group that can adjust their labor supply frictionlessly, or to older workers.[50] Even among the self-employed, graphical evidence of bunching is found only at the first kink of the Earned Income Tax Credit schedule and not at other convex kinks in the tax schedule, for example those in the federal income tax schedule (Saez, 2010). A small but growing literature suggests that non-self-employed individuals face frictions in adjusting behavior to tax policy and that this is a likely explanation for the small estimated hours supply elasticity, which the profession has settled on as being close to zero (Chetty et al., 2009, 2011; Chetty, 2012; Kleven and Waseem, 2013; Gelber et al., 2013). I discuss the empirical implications of optimization frictions, particularly those that vary by sector, in Section 5.3.

To separately identify labor supply and equilibrium wage effects, I require an additional source of variation. The incidence model elucidates the importance of changes in aggregate labor used in production: I use an exogenous component of variation in aggregate labor due to trade liberalization. Mexico liberalized trade by joining GATT in 1986 and NAFTA in 1994. New firms opened to manufacture export products and existing research shows that trade generated significant changes in labor demand that varied across geography and sectors.[51] These trade shocks further affected relative wages between the sectors. I use metropolitan-area changes in sectoral aggregate labor to isolate the wage incidence and labor supply responses to taxation. I specify labor markets at the metropolitan level because my analysis requires well-defined labor markets. In the large urban areas of Mexico, such as Mexico

[49] I can supply additional years on request.

[50] Friedberg (2000) finds substantial bunching among Social Security beneficiaries and that the bunching shifts in response to changes in the earnings test kink.

[51] For example, total employment in export manufacturing rose by over 200% between 1986 and 2000. See Aleman-Castilla (2006), Atkin (2009), Atkin (2012).

City and Guadalajara, the labor market is sourced from the residents of many municipalities and therefore defining markets at the municipality level would be incorrect. In my primary specifications, I use the ENEU metropolitan area classifications: 221 municipalities comprise 48 metropolitan areas. Not all areas are observed in all years because new geographic areas were added over time as they became more urbanized.[52] Because tax rates are similar for workers within a skill group regardless of the metropolitan area in which they work, my estimation strategy exploits the fact that a tax-induced increase in formal labor supply affects formal wages differently depending on whether local formal aggregate labor demand is simultaneously decreasing, increasing, or remains unchanged.

There are two endogeneity concerns with regard to aggregate labor used in production. First, the evolution of total effective labor across metropolitan areas is endogenous to tax-induced changes in labor supply. The direction of bias for a particular skill group depends on the co-variation between the skill-group labor supply and aggregate labor supply. Second, there may be local demand shocks that affect both relative wages and alter the demand for local output. Because I do not allow for changes in the price level, I assume away the effects of taxes operating through the aggregate demand for labor. To isolate an exogenous component of aggregate demand associated with trade liberalization, I instrument for the aggregate and sectoral aggregate labor terms with the growth in export-intensive jobs per working-age population, as in Atkin (2012). For metropolitan area m at time $t+1$, the growth in export-intensive jobs over the previous year is:

$$export_{mt+1} = \frac{\triangle exportemployment_{mt+1}}{working - agepopulation_{mt+1}} \tag{20}$$

where $\triangle exportemployment_{mt+1}$ is the change in the number of export-oriented jobs in metropolitan area m between t and $t+1$. I use the export industry classifications in Atkin (2012) and the industry codes in ENUE to define an export-oriented job as one in the following industries: textiles; apparel; shoes; leather; wood and furniture; electrical, electronic, transport and scientific equipment; toys, clocks and ceramics. I focus on export industries whose demand derives from foreign consumers, instead of local consumers, in order to address the endogeneity of local labor demand shocks. My identifying assumption is that the growth in export jobs affects wages only via its effect on aggregate and sectoral aggregate demand. Figure 16 shows the trends in the growth of export jobs in metropolitan areas across major geographic regions over time.[53]

[52]One limitation of this classification is that, while it is consistent with what is considered a single labor market for the largest cities of Mexico, there are 2 metropolitan "areas" defined in such a way that they consist of entire states. For both Oaxaca and Tlaxcala, all urban municipalities are classified as a single labor market. In these cases, it seems unlikely that similarly skilled individuals on opposite sides of the states compete for the same jobs in a single market. I present results for the entire sample of metropolitan areas as classified by the ENEU surveyors; however, when I exclude Oaxaca and Tlaxcala my results are the same.

[53]There is no evidence that firms choose to locate new jobs in areas that have better workers or lower wages.

I assume that the total size of the participating labor force within a skill group is exogenous to wages: that is, individuals do not move between metropolitan areas in response to changes in wages. If endogenous migration is substantial, then within-skill group wage dispersion across geographic areas of the country would be low because workers would move to the area with the highest wage. However, existing research finds the opposite: within-skill group wage dispersion *increased* after trade liberalization (Cragg and Epelbaum, 1996; Hanson, 2003). For example, in the northern border states where trade-induced increases in labor demand were largest immediately following trade liberalization, wages increased and remained high relative to those in other areas for similarly skilled workers. I cannot completely rule out endogenous migration and the labor survey data does not lend itself to migration analysis. The implications for my estimates are the following: if the change in the size of the participating labor force is an omitted variable in equation 18 or 19, then estimates of $\frac{1}{\rho_e}$, the elasticity of substitution between heterogeneously skilled labor inputs, would exhibit downward bias and I would underestimate tax incidence. In the most plausible scenario, the size of the labor force would increase more in areas that have larger wage increases, which would put downward pressure on wages.

3.3 Empirical Specification

In Section 2, I derive the system of equations 14 - 19, which show the effects of changes in the net-of-marginal and average tax rates on labor supply and equilibrium wages. I proceed by defining labor markets at the metropolitan level in order to exploit variation in local labor demand. The following set of equations show the effects of changes in the net-of-marginal and average tax rates, $1 - MTR$ and $1 - ATR$, on the average formal hours of skill group k in metropolitan area m between the years t and $t+1$, h_{Fmkt}, the average informal hours h_{Imkt}, the formal and informal participation rates, p_{Fmkt} and p_{Imkt}, and the formal pre-tax and informal wages, w_{Fmkt} and w_{Imkt}.

$$\ln\left(\frac{h_{Fmkt+1}}{h_{Fmkt}}\right) = \sigma\left[\ln\left(\frac{w_{Fmkt+1}}{w_{Fmkt}}\right) + \ln\left(\frac{1-MTR_{mkt+1}}{1-MTR_{mkt}}\right)\right] + \epsilon_{1mkt+1} \tag{21}$$

$$\ln\left(\frac{h_{Imkt+1}}{h_{Imkt}}\right) = \sigma\ln\left(\frac{w_{Imkt+1}}{w_{Imkt}}\right) + \epsilon_{2mkt+1} \tag{22}$$

$$\ln\left(\frac{p_{Fmkt+1}}{p_{Fmkt}}\right) = \eta_F\left[\ln\left(\frac{w_{Fmkt+1}}{w_{Fmkt}}\right) - \ln\left(\frac{w_{Imkt+1}}{w_{Imkt}}\right) + \ln\left(\frac{1-ATR_{mkt+1}}{1-ATR_{mkt}}\right)\right] + \epsilon_{3mkt+1} \tag{23}$$

$$\ln\left(\frac{p_{Imkt+1}}{p_{Imkt}}\right) = \eta_I\left[\ln\left(\frac{w_{Imkt+1}}{w_{Imkt}}\right) - \ln\left(\frac{w_{Fmkt+1}}{w_{Fmkt}}\right) - \ln\left(\frac{1-ATR_{mkt+1}}{1-ATR_{mkt}}\right)\right] + \epsilon_{4mkt+1} \quad (24)$$

$$\begin{aligned}\ln\left(\frac{w_{Fmkt+1}}{w_{Fmkt}}\right) = &\ln\left(\frac{A_{mt+1}\kappa_{mt+1}^{1-\alpha}}{A_{mt}\kappa_{mt}^{1-\alpha}}\right) + \ln\left(\frac{\theta_{Ft+1}}{\theta_{Ft}}\right) + \ln\left(\frac{\beta_{Fkt+1}}{\beta_{Fkt}}\right) \\ &+ \frac{1}{\rho_{IF}}\left[\ln\left(\frac{L_{mt+1}}{L_{mt}}\right)\right] + \left(\frac{1}{\rho_e} - \frac{1}{\rho_{IF}}\right)\ln\left(\frac{L_{Fmt+1}}{L_{Fmt}}\right) \\ &- \frac{1}{\rho_e}\left[\ln\left(\frac{p_{Fmkt+1}}{p_{Fmkt}}\right) + \ln\left(\frac{h_{Fmkt+1}}{h_{Fmkt}}\right)\right] + \epsilon_{5mkt+1}\end{aligned} \quad (25)$$

$$\begin{aligned}\ln\left(\frac{w_{Imkt+1}}{w_{Imkt}}\right) = &\ln\left(\frac{A_{mt+1}\kappa_{mt+1}^{1-\alpha}}{A_{mt}\kappa_{mt}^{1-\alpha}}\right) + \ln\left(\frac{\theta_{It+1}}{\theta_{It}}\right) + \ln\left(\frac{\beta_{Ikt+1}}{\beta_{Ikt}}\right) \\ &+ \frac{1}{\rho_{IF}}\left[\ln\left(\frac{L_{mt+1}}{L_{tm}}\right)\right] + \left(\frac{1}{\rho_e} - \frac{1}{\rho_{IF}}\right)\ln\left(\frac{L_{Imt+1}}{L_{Imt}}\right) \\ &- \frac{1}{\rho_e}\left[\ln\left(\frac{p_{Imkt+1}}{p_{Imkt}}\right) + \ln\left(\frac{h_{Imkt+1}}{h_{Imkt}}\right)\right] + \epsilon_{6mkt+1}\end{aligned} \quad (26)$$

The ϵ's are unobserved, additive error components which represent sampling error or unobserved heterogeneity at the skill-metropolitan-year level in changes in determinants of labor supply and wages. I allow them to be correlated at the skill-metropolitan-year level. The parameters of interest are: σ, the elasticity of hours with respect to $1-MTR$; η_F and η_I, the participation elasticities; the elasticity of substitution between different education groups, ρ_e, and the elasticity of substitution between formal and informal labor, ρ_{IF}. Identification of the hours supply and participation elasticities comes from within-skill and metropolitan area, across-time variation in marginal and average tax rates. Trade liberalization-induced variation in aggregate and sectoral aggregate labor used for production across metropolitan areas identifies the labor demand elasticities.

The first term in each wage equation captures the evolution of total-factor productivity and the capital-to-labor ratio. Ideally, these terms would be controlled for with metropolitan area-year fixed effects. However, I cannot include them because I use variation at the metropolitan-year level in order to identify the elasticity of substitution between formal and informal labor inputs, ρ_{IF}. Therefore, I include year fixed effects to control for common trends in these terms and metropolitan area fixed effects to control for time-invariant characteristics that are potentially correlated with these terms and with the change in aggregate labor at the metropolitan-level (e.g. location and climate). My identifying assumption is that the variation in how capital and technology evolve across metropolitan areas is independent of the initial skill distribution across metropolitan areas.[54]

In labor supply analyses of taxation that do not account for general equilibrium effects, the wage terms in the labor supply equations (equations 21 - 24) can be viewed as omitted variables. Their omission could yield downward bias estimates of the labor supply elasticities σ and the η's. For example, suppose the net-of-marginal tax rate $1-MTR$ or average tax rate $1-ATR$ increase: this would cause an increase in formal labor supply and a decrease in formal pre-tax wages, leading to a smaller increase in formal labor supply than would be observed if labor demand is perfectly elastic. Therefore, the estimated labor supply elasticities with omitted wage terms would exhibit downward bias. As the descriptive evidence shows, wages change over the period of consideration and these changes are important to account for.

Similarly, allowing for skill-biased technical change (SBTC) in the wage equations accounts for changes in the relative wages of skill groups due to shifts in the production technology. It is important to control for these shifts because the wage effects of tax-induced changes in the relative labor supply of skill groups could be confounded by SBTC if the two are correlated.

Before I can estimate the full system of equations, I require measures of the aggregate and sectoral aggregate labor terms: L_{mt}, L_{Fmt} and L_{Imt}. Using methods similar to those of Ottaviano and Peri (2008) and Card and Lemieux (2001), I proceed with my estimation in three steps. In the first step, I calculate the sectoral aggregate labor terms: L_{Fmt} and L_{Imt}. In the second step, I use those estimates to calculate aggregate labor L_{mt}. In the third step, I simultaneously estimate equations 21 - 26 via Three-Stage Least Squares (3SLS).

Step 1: Calculating Sectoral Aggregate Labor

To calculate the sectoral aggregate labor terms, I require estimates of the elasticity of substitution between education groups, ρ_e, and the time-varying relative productivity terms, the β_{Fkt}'s and β_{Ikt}'s. Equations 12 and 13 show that the sectoral (log) wage is equal to the marginal product of labor for education group k in time t and metropolitan area m. I use the following specifications of these equations to estimate ρ_e and the relative efficiency terms:

$$\ln w_{Fmkt} = a_{tm} + b_t + c_{kt} - \frac{1}{\rho_e}(\ln L_{Fmkt}) + v_{mkt} \tag{27}$$

$$\ln w_{Imkt} = d_{tm} + e_t + f_{kt} - \frac{1}{\rho_e}(\ln L_{Imkt}) + u_{mkt} \tag{28}$$

where the metropolitan area-year fixed effects, a_{tm} and d_{tm}, control for the first, third and

[54] In Section 5.5, I present results from a subset of years in which I calculate κ and A and explicitly control for them in the wage equations.

fifth terms in equations 12 and 13, year fixed effects b_t and e_t control for the second term in each equation, and skill group-year fixed effects, c_{kt} and f_{kt}, control for the fourth term in each equation. The terms L_{Fkt} and L_{Ikt} are endogenous and simultaneously determined. I use the simulated marginal and average tax rates for group k at time t as instruments for sectoral aggregate labor and simultaneously estimate the equations using 3SLS, restricting the coefficient on each labor term (L_{Fkt} and L_{Ikt}) to be the same.

I use estimates of the fixed effects $\hat{c}_{kt}$ and $\hat{f}_{kt}$, which capture time-varying relative productivity specific to skill-sector groups, and impose the standardization that they add up to one for each sector and year as shown below.

$$\hat{\beta}_{Fkt} = \frac{exp(\hat{c}_{kt})}{\sum_k exp(\hat{c}_{kt})}, \ \hat{\beta}_{Ikt} = \frac{exp(\hat{f}_{kt})}{\sum_k exp(\hat{f}_{kt})} \tag{29}$$

I measure sectoral aggregate labor at the metropolitan area-year level as:

$$\hat{L}_{Fmt} = \left(\sum_k \hat{\beta}_{Fkt} L_{Fmkt}^{\frac{\hat{\rho}_e - 1}{\hat{\rho}_e}} \right)^{\frac{\hat{\rho}_e}{\hat{\rho}_e - 1}}, \hat{L}_{Imt} = \left(\sum_k \hat{\beta}_{Ikt} L_{Imkt}^{\frac{\hat{\rho}_e - 1}{\hat{\rho}_e}} \right)^{\frac{\hat{\rho}_e}{\hat{\rho}_e - 1}} \tag{30}$$

where the values of $\hat{\beta}_{Fkt}$, $\hat{\beta}_{Ikt}$ and $\hat{\rho}_e$ are those estimated in the first step. Sectoral aggregate labor is measured in effective labor hours of the group with the lowest skill.

Step 2: Calculating Aggregate Labor

In the second step of my estimation process, I calculate total effective labor, L_{mt}. To measure it, I require estimates of the elasticity of substitution between formal and informal labor, ρ_{IF}, and the time-varying relative productivity terms, the θ_{Ft}'s and θ_{It}'s. The production function, together with marginal cost pricing, implies that the compensation going to the sectoral aggregate labor inputs L_{Fmt} and L_{Imt} satisfy the following expressions:

$$\ln \bar{w}_{Fmt} = \ln(\alpha A_{mt} \kappa_{mt}^{1-\alpha}) + \ln \theta_{Ft} + \frac{1}{\rho_{IF}}(\ln L_{mt}) - \frac{1}{\rho_{IF}}(\ln L_{Fmt}) \tag{31}$$

$$\ln \bar{w}_{Imt} = \ln(\alpha A_{mt} \kappa_{mt}^{1-\alpha}) + \ln \theta_{It} + \frac{1}{\rho_{IF}}(\ln L_{mt}) - \frac{1}{\rho_{IF}}(\ln L_{Imt}) \tag{32}$$

where $\bar{w}_{Fmt}$ and $\bar{w}_{Imt}$ are the corresponding formal and informal average wages, weighted by group-level labor supply. These equations imply that the relative average wage in the formal and informal sectors in metropolitan area m at time t is:

$$\ln \left(\frac{\bar{w}_{Fmt}}{\bar{w}_{Imt}} \right) = \ln \left(\frac{\theta_{Ft}}{\theta_{It}} \right) - \frac{1}{\rho_{IF}} \ln \left(\frac{L_{Fmt}}{L_{Imt}} \right) \tag{33}$$

I use the following, analogous regression equation to estimate ρ_{IF} and the time-varying sectoral relative productivity terms:

$$\ln\left(\frac{\bar{w}_{Fmt}}{\bar{w}_{Imt}}\right) = a_t - \frac{1}{\rho_{IF}} \ln\left(\frac{\hat{L}_{Fmt}}{\hat{L}_{Imt}}\right) \tag{34}$$

where the dependent variable is the natural log of the ratio of the average sector wage, weighted by group-level labor supply. The term $\frac{\hat{L}_{Fmt}}{\hat{L}_{imt}}$ is endogenous: I use the simulated average average tax rates, weighted by group-level labor supply, as an instrument for the ratio of sectoral aggregate labor. I use the parameter estimates to measure aggregate labor at the metropolitan area-year level. I impose the standardization that the sectoral relative productivity terms add up to one within a year ($\hat{\theta}_{Ft}+\hat{\theta}_{It} = 1$). I construct the CES aggregate labor composite as:

$$\hat{L}_{mt} = \left(\hat{\theta}_{Ft}\hat{L}_{Fmt}^{\frac{\hat{\rho}_{IF}-1}{\hat{\rho}_{IF}}} + \hat{\theta}_{It}\hat{L}_{Imt}^{\frac{\hat{\rho}_{IF}-1}{\hat{\rho}_{IF}}}\right)^{\frac{\hat{\rho}_{IF}}{\hat{\rho}_{IF}-1}} \tag{35}$$

where the values of $\hat{\theta}_{Ft}$, $\hat{\theta}_{It}$ and $\hat{\rho}_{IF}$ are those estimated in the second step.

Step 3: Final Estimation

In my third step, I simultaneously estimate equations 21 - 26 using 3SLS. By simultaneously estimating this system of equations, I allow for the error terms (the ϵ's) to be correlated within a skill-group, metropolitan area and year. As necessary, I impose constraints with regard to the parameter estimates. For example, among the 17 such constraints, one is that the σ from equation 21 is the same as the σ in equation 22.

I lose the first two years of data (1988 and 1989) for two reasons. First, I use simulated instruments for the tax rates and the (inflation-adjusted) pre-tax income from 1988 is used to create a simulated average tax rate for 1989 by calculating the average tax rate under the 1989 schedule if pre-tax income were equal to what it was in 1988, but no such instrument is available for 1988. Second, my observations are in *changes* in the dependent and explanatory variables of interest and 1990 is the first year of data that can be calculated in terms of changes over the previous year. I run the first two steps on the 1989-2004 sample because the variables are in levels. For the first step, this yields sample sizes of 3390 and 16,894 for the education and education-group definitions, respectively. The regression run in the second step is estimated at the metropolitan-area year level and has a sample size of 597 using either skill group definition. The final step is run on data from 1990-2004 with sample sizes of 3160 and 15,454 for the education and education-group definitions, respectively.

4 Results

As discussed in the previous section, my estimation proceeds in 3 steps. Before I estimate the full system of equations shown in equations 21 - 26, I calculate the aggregate and sectoral aggregate labor terms, L_{mt}, L_{Fmt} and L_{Imt}. I use methods similar to those of Ottaviano and Peri (2008) and Card and Lemieux (2001). In the first step, I estimate the parameters associated with and calculate the sectoral aggregate labor terms L_{Fmt} and L_{Imt}. In the second step, I estimate the parameters associated with and calculate aggregate labor L_{mt}. In the third step, I simultaneously estimate equations 21 - 26 via Three-Stage Least Squares (3SLS). I present results using two definitions of skill: education and education-age groups. In the first, I define 6 education groups. In the second specification, I define 30 education-experience groups (6 education groups by 5 age groups).

4.1 Results from the Preliminary Estimation Steps

In this section, I present estimates of the parameters that are used to calculate the aggregate and sectoral aggregate labor measures.[55] In Step 1, I estimate the parameters needed to calculate aggregate formal and informal labor. I estimate these by instrumenting for wages with simulated tax instruments, as described in the previous section. The results from step 1 – 3SLS regressions of equations 27 and 28 – are shown in Tables 3 and 4. Table 3 shows the results from the first-stage: tax rates have large and statistically significant effects on formal and informal labor in the expected directions, resulting in F-statistics of around 100. Table 4 shows the effects of formal and informal labor on wages as estimated in my first step. I obtain an efficient estimate of ρ_e in the estimation of the full system of equations in step 3, so I defer a discussion of the estimated parameter value until then.

Using the estimates implied by the first step, I calculate formal and informal aggregate labor at the metropolitan area-level for each year. For example, Figure 17 shows the total effective formal and informal labor, measured in the hours of the lowest skill group, over the period. Figures 18 and 19 graph the percent change in formal and informal aggregate labor, as calculated using results from the education group definition of skill, across the 10 largest metropolitan areas over time.[56] The formal and informal labor evolves in the same direction in many years, yet there is substantial variation in the percent change in aggregate labor across metropolitan areas for any particular year.[57]

[55]Two of these parameters, ρ_{IF} and ρ_e, are estimated again in the main simultaneous equations specification, discussed in the next section. While the estimates are similar across specifications, the two sets of estimates come from different estimators and different variation is used for identification. I take the final results, presented in the next section, as preferable because they are efficient.

[56]The metropolitan areas are: Mexico City, Guadalajara, Monterrey, Puebla, Len, Torren, San Luis Potos, Mrida, Chihuahua and Tampico.

[57]The aggregate labor variables and graphs are similar when I use the education-age definition of skill.

The results from my second step, 2SLS regressions of equation 34 which will yield estimates of the elasticity of substitution between formal and informal labor inputs ρ_{IF}, are presented in Tables 5 and 6, where column (1) corresponds to results using the education group definition of skill and column (2) corresponds to results using education-age groups. Table 5 shows the results from the first-stage, again using simulated tax instruments, which again have large and significant effects on the (natural log of the) ratio of formal and informal labor aggregates in the expected directions. Table 6 shows the effects of relative formal and informal labor on relative average wages. The coefficient is the negative inverse elasticity of substitution across formal and informal labor, and the estimates indicate that the elasticity of substitution is between 1.76 and 1.85, depending on the skill definition used. These points estimates imply that formal and informal total effective labor are substitutes in aggregate production. To my knowledge, there are no existing estimates of this parameter.

I calculate effective aggregate labor at the metropolitan area-level for each year using the estimates from the second step. Figure 20 shows the percent change in aggregate labor as calculated using results from the education group definition of skill across the 10 largest metropolitan areas over time. Aggregate labor trends in the same direction over time, and there is substantial variation across metropolitan areas within a particular year.

4.2 Main Estimation Results

The tax and trade shock instruments are strong and have statistically significant effects on labor supply and wages. The F-statistics for each equation in the system of equations are the following: 39.2 for the formal hours equation; 27.1 for the informal hours equation; 43.8 for the formal participation equation; 59.7 for the informal participation equation; 53.1 for the formal wage equation; and 63.9 for the informal wage equation. Table 7 provides the results from my main specification: the 3SLS regression of equations 21 - 26. All of my parameter estimates are statistically significant. The intensive-margin labor supply elasticity σ ranges from 0.082 to 0.088, depending on the skill group definition, and implies that a 1% increase in the net-of-marginal tax rate or pre-tax wage causes a 0.08% increase in hours supply. Thus, both point estimates are small and similar in magnitude to the intensive-margin elasticities calculated in the context of the U.S.. These magnitudes are also consistent with the general findings of inelastic labor supply in other developing countries (Bardhan, 1979; Rosenzweig, 1978; Goldberg, 2013). In Section 5.3, I present results from the calculation of bounds on these elasticities when there are unobserved optimization frictions, both for the full model and by sector. Bounds on the structural elasticity are similar across sectors and also suggest a small elasticity that ranges from 0.01-0.21.

Estimates of the formal participation elasticity η_F are larger, at 0.39 to 0.4, and imply that a 1% increase in the net-of-average tax rate (or relative after-tax income) causes a 0.4%

increase in formal sector participation. The informal participation elasticity η_I is about 20% larger, ranging from .49-.52. Both elasticities imply substantial extensive responses to taxation. For example, upon implementation of the tax credit, average tax rates decreased for the lowest skill group by an average of 30%: the estimate of η_F suggests that this caused an average 12% increase in formal sector participation *holding relative after-tax income constant* among this group of workers.

The labor demand elasticity depends on the estimated elasticity of substitution between different types of labor, and these estimates indicate that labor demand is not perfectly elastic. Therefore, wages respond to tax-induced changes in labor supply and formal workers bear part of the incidence of income taxes. The elasticity of substitution across skill groups ranges from 1.47-1.73 and the points estimates are similar to those from the first step. There are not many estimates of the elasticity of labor demand between education groups in developing countries, and none in Mexico. However, Behar (2009)'s estimates of the elasticity of substitution between low- and high-skilled labor inputs range from 1.5-3.[58] The elasticity of substitution between formal and informal labor inputs ranges from 1.69-1.72, and the points estimates are similar to estimates from the second step.

The direct "partial" effect, or the wage elasticity, is ρ_e, the negative inverse of the elasticity of substitution across skill. The estimate of ρ_e indicates that a 1% increase in group k labor supply causes a 0.57-0.68% decrease in the (pre-tax) wage for group k *holding the aggregate and sectoral aggregate labor supplies constant.* This estimate is towards the high end of Hammermesh's "best guess" of the elasticity of demand for homogeneous labor. He suggests a range of -.15 to -.75. However, recent estimates indicate a wider range of possible values. For example, the immigration literature finds estimates that indicate immigration has no effect on native wages, implying $\rho_e = -\infty$ (Card, 1990), as well as estimates that indicate small effects with elasticities around -.25 (Borjas, 2003; Borjas and Katz, 2007).

I use the estimated elasticities to calculate how much sectoral mobility – movement between the sectors – the average tax rate explains. For each observation, I calculate what the participation rate would have been if the average tax rate had not changed from the previous year. I assume that the elasticity of formal participation with respect to after-tax income is 0.4, the elasticity of informal participation with respect to after-tax income is 0.52, the elasticity of hours with respect to marginal wages is 0.082, and the elasticity of substitution across skill groups is 1.47. I find that on average, 25.1% of sectoral mobility is explained by changes in the average tax rate alone. My findings indicate that while labor supply is inelastic, the behavioral responses to taxation explain a substantial portion of sectoral participation. This is a new, and quantitatively important, measure of taxation response.

[58] His estimates are not directly comparable to those presented here because he uses Brazilian data and his estimates come from variation in labor and wages between only two skill groups. In addition, Behar (2009) does not differentiate between formal and informal labor inputs and the labor terms are assumed to be exogenous.

4.3 Incidence

The extent to which pre-tax wages are affected by taxation depends on the labor supply elasticities, σ, η_F and η_I, and the elasticity of substitution across skill groups, ρ_e. Using equations 14 - 19, which show the effect of changes in the marginal and average tax rates on hours, participation and wages, I derive the overall effects of changes in the average tax rate on labor supply and pre-tax wages for both sectors. For example, the overall effect of a one percentage point increase in the net-of-average tax rate $1 - ATR$ on the formal pre-tax wage is $\frac{\eta_F\eta_I - \eta_F(\rho_e+\eta_I+\sigma)}{(\rho_e+\eta_F+\sigma)(\rho_e+\eta_I+\sigma)-\eta_F\eta_I}$. The effect on formal participation is $\eta_F\left(1 + \frac{2\eta_F\eta_I - \eta_F(\rho_e+\eta_I+\sigma)-\eta_I(\rho_e+\eta_F+\sigma)}{(\rho_e+\eta_F+\sigma)(\rho_e+\eta_I+\sigma)-\eta_F\eta_I}\right)$.

I derive the overall effects of the net-of-average tax rate on formal and informal hours, participation and wages.[59] Table 8 reports the overall effects of increases in net-of-average tax rates on labor supply and pre-tax wages. I use the estimated labor supply parameter values that are presented in the previous section for the education-age group definition of skill: I assume that the elasticity of formal participation with respect to after-tax income is 0.4, the elasticity of informal participation with respect to after-tax income is 0.52, and the elasticity of hours with respect to marginal wages is 0.082. I consider values of ρ_e, the partial wage effect, of ∞, 1.8, 1.47, and 0. This was estimated as 1.47 and 1.8 and discussed in the previous section. I present the overall effects for different values of this parameter to highlight the importance of allowing for equilibrium wage effects.

Table 8 reveals several interesting results. First, it shows that as demand becomes inelastic, the equilibrium labor responses decrease and the effect on wages increases. A one percentage point increase in the net-of-average tax rate causes a much smaller increase in formal participation when labor demand is perfectly inelastic (+0.03%) compared to when labor demand is perfectly elastic (+0.40%). This is because the offsetting decrease in formal pre-tax wages due to tax-induced increases in formal labor supply is larger when labor demand is inelastic, which causes a smaller increase in after-tax income. These incidence results elucidate the extent to which the wage responses limit the effectiveness of tax instruments designed to encourage formal sector employment, for example, Credito al Salario. Second, the incidence results also highlight the importance of allowing for equilibrium effects in estimation of the labor supply elasticities. As discussed in Section 3.3, in labor supply analyses of taxation that do not account for general equilibrium effects, the wage terms in the labor supply equations are omitted variables. Their omission yields downward bias estimates of the labor supply elasticities σ and the η's. If one assumed that labor demand was perfectly elastic and instead $\rho_e = 1.8$, a true formal participation elasticity of 0.401 would be estimated as 0.27, a substantial underestimate.

[59] Analogous effects could be derived for marginal tax rates.

In labor markets where labor demand is perfectly elastic, the incidence of tax changes is entirely on firms. That is, if the elasticities of substitution between skill groups and sectoral aggregate labor inputs are infinite, $\rho_e = \infty$ and $\rho_{IF} = \infty$, the burden of taxation is on firms. However, because labor demand is not perfectly elastic, a portion of tax changes are passed on to workers via wages. I use the labor supply and labor demand parameters estimated to calculate the incidence on formal workers, informal workers and formal employers.[60] The tax incidence on formal workers is 0.30, the incidence on informal workers is 0.18, and the incidence on employers is 0.51. A substantial portion of tax changes are passed on to workers via wages.

4.4 Marginal Excess Burden

Taxation is associated with efficiency costs and the concentration of labor supply responsiveness along the sectoral participation margin has important implications for the welfare evaluation of tax policy. While a complete analysis of optimal income tax schedules in settings with a large, informal sector is beyond the scope of this paper, in this section I present calculations of the marginal excess burden of taxation. The marginal excess burden measures the efficiency costs of taxation and abstracts from the distributional effects of tax reforms. The optimal income tax literature brings together the efficiency costs of taxation and welfare weights that capture such distributional considerations. In both types of analyses, the behavioral elasticities measured in this paper are key parameters.

The welfare effects from extensive-margin labor supply responses (participation) are distinct from that of the intensive-margin (hours). This is because the welfare effect associated with the participation margin is related to the average tax wedge, while that associated with the hours margin is related to the marginal tax wedge. These two rates tend to differ in terms of both pre-reform levels and changes due to a reform. To measure the marginal excess burden per peso of extra taxes collected, I use the hours margin and participation margin formulas developed in Eissa et al. (2004).[61]

The welfare loss associated with hours responses due to a tax reform is $\frac{MTR}{1-MTR} \cdot \frac{\partial MTR}{\partial z} \cdot \sigma$, where $\frac{MTR}{1-MTR}$ represents the pre-reform ratio of the marginal tax rate to the net-of-marginal tax rate and $\frac{\partial MTR}{\partial z}$ represents the change in the marginal tax rate due to the tax reform. The deadweight loss depends on the initial level of the marginal tax rate, the change in the rate and the sensitivity of hours behavior, as measured by the elasticity of hours σ. Analogously, the marginal deadweight burden associated with formal sector participation responses is

[60] This is done by implicitly differentiating the formal and informal labor market equilibrium conditions and solving for dw_F/dt and dw_I/dt.

[61] Their derivations depend on a quasi-linear utility specification that is the same as in this paper and given by equation 1. The extensive margin of interest in their study is with respect to labor force participation. However, their definition of the labor force participation elasticity is analogous to the definition of the sectoral participation elasticity in this paper and thus enables me to use their formulas with this substitution.

$\frac{ATR}{1-ATR} \cdot \frac{\partial ATR}{\partial z} \cdot \eta_F$. The welfare cost associated with participation responses is related to the tax that applies to the extensive margin, the average tax rate ATR, and the sensitivity of participation behavior, as measured by the elasticity of formal sector participation with respect to net-of-tax income, η_F.

In order to accurately quantify the aggregate welfare effects of a tax reform that differentially affects individuals across the income distribution, I would need to sum the intensive and extensive margin effects for all of the individuals and calculate a weighted sum of the individual welfare effects with shares used as weights, for example, wage shares. Instead, I use a representative agent approach: the welfare cost from the hours margin is calculated by using the means of the marginal tax ratio and the marginal tax rate change. To calculate the welfare cost associated with the participation margin, I use the means of the average tax ratio and the average tax rate change. I use the change in marginal and average tax rates absent any behavioral response, i.e., the average simulated tax rate change. The average change in the marginal tax rate is 0.02 and the average change in the average tax rate is -0.03. I assume that the hours elasticity σ is 0.082 and the formal participation elasticity η_F is 0.401. The estimated welfare gain from the average decrease in the average tax rate is 7.5% of wage income. In contrast, the estimated welfare loss from the average increase in the marginal tax rate is only 0.04%, a small effect owing to the small intensive-margin elasticity. The marginal cost of public funds, that is, the cost of each peso of public funds taking into account the deadweight loss from raising those funds, is $1.081.

5 Robustness Checks

In this section, I present five robustness checks. First, I provide empirical support for the assumption that the total size of the participating labor force did not change due to changes in taxes or trade shocks. Second, I present evidence that indicates that it is unlikely that individuals return to school to take advantage of the increased returns to education due to trade liberalization. Third, I derive bounds on the structural intensive-margin elasticity σ separately for the formal and informal sectors. These bounds inform the extent to which sector-varying optimization frictions affect the observed hours elasticity. Fourth, I present results from a sensitivity analysis in which I estimate the sectoral participation elasticity as the percent change in the proportion of workers who work in a sector due to a percentage change in the difference in indirect utility associated with sectoral participation, instead of relative after-tax income. Finally, I explore the sensitivity of my results to various assumptions with regard to capital adjustment.

5.1 Skill Group Size

I assume that the total size of the participating labor force at the skill group-metropolitan area-year level does not change due to changes in taxes or trade shocks. The main reason I make this assumption is because modeling labor force participation presents additional theoretical and identification complications and there is no evidence that labor force participation among working-age men responds to tax rates or contemporaneous trade shocks. In addition, there is sampling variability in what I observe as the total size of the participating labor force at the skill group level. Sampling weights are available and based on sex, age and geography, but not education. Therefore, including the percent change in the total size of the participating labor force at the skill group level, even as a control, introduces substantial measurement error.

There are two potential problems with this assumption: omitted variable bias and endogenous skill upgrade. I discuss the former in this section and the latter in the following section. The percent change in the total size of the participating labor force at the skill group-metropolitan area level could be an omitted variable in the wage equations. Because I instrument for the variables that it is most likely to be correlated with, for example, the percent change in hours, sectoral participation, and aggregate labor, omitting the term would only be a problem if it were correlated with the instruments I use for those variables – simulated tax rates and the change in export jobs. As previously discussed, I do not find any statistically significant reduced-form relationship between the size of the total participating labor force and tax rates or contemporaneous export shocks. However, if I were to explicitly control for it, the percent change in the total size of the participating labor force would enter the formal and informal wage equations. These equations already include metropolitan fixed effects, year fixed effects and skill group-year fixed effects. Therefore, as long as the total size of the participating labor force at the skill-group level evolved similarly across metropolitan areas, the fixed effects control for it.

As discussed in Section 3.1 and shown in Figure 7, the population of men in urban areas increased over the period, and more so for younger birth cohorts. This occurred across all regions in a similar magnitude for a given cohort.[62] Figure 21 shows the percent change in the total size of the participating labor force at the skill-group level across regions and over time.[63] For most years, the percent change in the total size of a skill group is similar across geographic areas. However, in 1992 there was a huge increase in the measured size of all skill groups, over 100% in many regions. The actual population did not double that year. Instead, the sample size increased in the early 1990s: new metropolitan areas were added and more individuals were sampled in old areas. Similarly, the survey started winding

[62] In addition, the average education of men increased over time, as shown in Figure 8.
[63] Graphs at the metropolitan-area level are similar.

down in 2002, with a decrease in sample size, because it was replaced in 2005.[64] Figure 21 demonstrates how much measurement error there is due to sampling variability.

To get a sense of how much variation the fixed effects in the wage equations explain, I regress the percent change in the total size of the labor force on metropolitan fixed effects, year fixed effects and skill-year fixed effects. The F-statistic is 48.32 and the R-squared is 0.89, which indicates that the fixed effects in my estimating equations capture a lot of the variation in the total size of the labor force. In addition, when I regress the percent change in the formal pre-tax wage on the total size of the labor force, the coefficient on the total size of the labor force is -0.096 and statistically different from zero at the 1% level. However, when I include metropolitan fixed effects, year fixed effects and skill-year fixed effects, the coefficient on the total size of the labor force is -0.001 and imprecisely estimated (a p-value of 0.205). These regression results indicate that after including the specified fixed effects, there is a very small and statistically insignificant effect of the total size of the labor force on wages.[65]

5.2 Endogenous Skill Upgrade

As I discuss in Section 3.1, the primary feature of skill in the model is that workers with the same skill are perfect substitutes in production. I create skill groups that are defined by the characteristics of education and age, which are commonly used to define skill groups. However, given that the return to education changes differentially across education groups over the period of study, the trade shocks could have caused some working-age men to return to school and change skill groups.[66] If this occurred, then my definition of skill is problematic because changes in the differential returns to education could drive skill-group switching. Empirically, this would be an issue because the average change in labor supply of a particular group would not equal the labor supply shock to the average skill member's labor market. In other words, the effect of a wage change for a particular skill group would cause a change in hours, sectoral participation *and* labor force participation via return-to school.

As Figure 8 shows, the average education of age cohorts does not change once the cohort is 22 or older. To further explore whether there was a systematic change in the return-to-school rate over time and across regions, I use the panel nature of the data. Individuals are interviewed for 5 consecutive quarters and I observe individual-level education, school status and work status in each interview. However, there is substantial attrition between

[64] Unfortunately, the sampling weights are based on age, sex and geography, and not education.

[65] The results presented were run on the education skill group sample. The qualitative results are similar for the education-age group sample and when I use informal wages as the dependent variable.

[66] This is not a problem with regard to differential tax changes because the low-skilled groups experienced the largest decrease in average tax rates and individuals cannot decrease their education.

interviews: about 80% of individuals are interviewed more than once. Table 9 presents the summary statistics at the individual level for this panel sample. On average, panel individuals have: less education and higher wages compared to the main sample. Average age, sectoral participation and weekly hours are similar. Another limitation of the panel sample is that it is only available for years 1994-2004.

For these years among 22-55 year-old men, I find that annually: 1% switched from being in school full-time to employed, .054% switched from employed to being in school full-time, and 1.7% were in school while working. Figure 22 graphs the return-to-school rate across time and by region. The return-to-school rate is small and relatively stable over time and across all regions. If return-to-school was a problem, I would expect the rate to increase in the northern region, where the wage differential increased the most because of trade liberalization. This does not occur and, in fact, the north has the lowest return-to-school rate. This descriptive evidence suggests that endogenous skill upgrade is unlikely to be a problem among working-age men over the period.

5.3 Optimization Frictions

In my analysis, I assume that the hours elasticity is the same in both sectors. While it is likely that the structural hours elasticity is the same among workers in both sectors, it may be that workers face different optimization frictions in the two sectors. Optimization frictions may take the form of adjustment costs – the cost associated with adjusting hours to their desired optimum in response to changes in wages or marginal tax rates – or inattention with respect to the tax schedule. Importantly, these optimization frictions may vary by sector, in which case the observed elasticity would vary by sector. Rather than specifying the form that such frictions take, I use the method described in Chetty (2012) to derive bounds on the structural intensive-margin (hours) elasticity σ separately for the formal and informal sectors. These bounds inform the extent to which sector-varying optimization frictions affect the observed hours elasticity.

The bounds are a function of the observed effect of a tax or wage change on hours supply (the observed elasticity $\hat{\sigma}$), the size of the tax and/or wage changes, and the degree of optimization frictions.[67] I assume that workers choose hours near their frictionless optimum and that they deviate from the model's prediction as long as the cost of doing so is less than δ percent of expenditure. This assumption is satisfied in standard dynamic adjustment cost models where, on average, workers remain within some utility threshold of their optimum. I allow for frictions with $\delta = 1\%$, as in Chetty (2012): the utility cost of ignoring tax changes and instead choosing the optimal pre-reform level of work hours are less than 1% of post-tax earnings.

[67] See Chetty (2012) for his derivation of the bounds: his derivation uses the same utility functional form as in this paper.

The range of structural elasticities consistent with an observed intensive elasticity $\hat{\sigma}$ is approximately (σ_L, σ_U), where

$$\sigma_L = \hat{\sigma} + \frac{4\delta}{(\Delta logp)^2}(1-\mu) \; and \; \sigma_U = \hat{\sigma} + \frac{4\delta}{(\Delta logp)^2}(1+\mu) \tag{36}$$

where $\mu = (1 + \frac{1}{2}\frac{\hat{\sigma}}{\delta}(\Delta logp)^2)^{1/2}$ and the magnitude of the observed price change is $\Delta logp$. These bounds map the observed price change $\Delta logp$, the observed elasticity $\hat{\sigma}$, and the degree of frictions to bounds on the structural elasticity σ when flow utility is quasilinear.[68]

To obtain separate estimates by sector of the intensive-margin elasticity $\hat{\sigma}$ to plug into equation 36, I depart from my equilibrium model and take advantage of the panel nature of the data in order to observe hours changes within sectors. Individuals are interviewed for 5 consecutive quarters, although there is substantial attrition between interviews: about 80% of individuals are interviewed more than once. Table 9 presents the summary statistics at the individual level for this panel sample. On average, panel individuals have: less education and higher wages compared to the main sample. Average age, sectoral participation and weekly hours are similar.

To estimate the formal sector hours elasticity, I calculate first-differences in hours, pre-tax wages, and marginal tax rates *among formal workers who do not switch sectors* over the course of 3, 6, 9 and 12 months. I then average these first-differences at the education-group, metropolitan area, year level. The following equation shows the effects of changes in the marginal tax rate $dMTR$ and the formal pre-tax wage w_{Fmkt} on the average formal hours of skill group k in metropolitan area m between the years t and $t+1$, among formal workers who do not change jobs:

$$\ln\left(\frac{h_{Fmkt+1}}{h_{Fmkt}}\right) = \sigma\left[\ln\left(\frac{w_{Fmkt+1}}{w_{Fmkt}}\right) - dMTR_{mkt+1}\right] + \epsilon_{mkt+1} \tag{37}$$

I use (average) simulated marginal tax rates as instruments for the (average) marginal tax rate and skill-level trade shocks as instruments for skill-level wages: the first stages are highly significant. I estimate the (observed) hours supply elasticity $\hat{\sigma}$ using 2SLS for workers in the formal sector. I do a similar analysis for informal workers who do not switch sectors. One limitation of this method is that identification of the hours elasticities comes from within-sector changes in marginal tax rates and wages. As the labor supply model in Section 2.1 elucidates, changes in the marginal tax rate (or wages) cause intensive and extensive responses. The hours supply responses for both sectors are in each sectoral participation equation. This is because any change in hourly after-tax wages - through changes in the MTR or pre-tax wages - induces an intensive-margin response, which in turn causes a participation response. Therefore, the hours elasticities calculated using the panel sample ignore the

[68] When utility is not quasilinear, the bounds apply to the Hicksian elasticity.

composition effects of participation responses on skill-group average hours.

Table 10 shows the estimated (observed) elasticities for the formal and informal sectors and from the earlier full model, where I assume the hours elasticity is the same. Consistent with the expectation that work hours are more easily adjusted in the informal sector, I find that the intensive-margin is slightly higher in the informal sector: 0.087 versus 0.078 in the formal sector. However, both elasticities are quite small and close to zero, as in the full model estimation, and insignificant. The structural elasticity bounds – accounting for optimization frictions – are similar and suggest a structural elasticity between 0.01-0.21.

5.4 Participation Elasticity

In my analysis, I define the participation elasticity as the percent change in the proportion of workers who work in a sector due to a percentage change in relative after-tax income. That is, I assume that the difference in disutility a worker gets from small differences in optimal hours in each sector do not affect participation decisions. If hours differences affect participation, the participation equations are nonlinear, requiring a different estimation approach. Because the average hours in each sector are similar across skill groups and over time, the disutility a worker gets from working, for example, 47.1 versus 47.5 hours in the formal and informal sectors, respectively, seems unlikely to drive participation responses. However, this may be a strong assumption given the utility specification in equation 1. In this section, I present results from a sensitivity analysis in which I estimate the participation elasticity as the percent change in the proportion of workers who work in a sector due to a percentage change in the difference in indirect utility associated with sectoral participation.[69] The difference in indirect utility is comprised of the difference in after-tax income and a term which represents the difference in the disutility of work hours.

A worker in group k participates in the formal sector if the utility from formal participation $u(w_{Fk}h_{Fk} - T(w_{Fk}h_{Fk}), h_{Fk}) + q$ is greater than that from informal participation $u(w_{Ik}h_{Ik}, h_{Ik})$, where q is an individual's unobserved fixed cost associated with working in the informal sector. I assume that q is distributed as a power function on the interval $[q_{min}, q_{max}]$ with a distribution function $F(q) = \left(\frac{q-q_{min}}{q_{max}-q_{min}}\right)^{\eta}$, implying a participation elasticity η.[70] An individual works in the informal sector if $q \leq u(w_{Ik}h_{Ik}, h_{Ik}) - u(w_{Fk}h_{Fk} - T(w_{Fk}h_{Fk}), h_{Fk}) \equiv \bar{q}_k$, where $\bar{q}_k$ is the threshold gain of working in the informal sector exclusive of the fixed cost q, and defined at the skill-group level. Workers with a fixed cost, $q < \bar{q}_k$, are employed in the informal sector.

The informal participation rate of group k is $p_{Ik} \equiv F(\bar{q}_k)$ and the formal participation

[69] Indirect utility is measured as a money metric given quasi linearity of the utility function.

[70] This specification of preferences is similar to that used by Kleven et al. (2009) in their study on the optimal income taxation of couples. They make this distributional assumption on the fixed cost associated with labor force participation for secondary earners and assume that $q_{min} = 0$.

rate is $p_{Fk} = 1 - F(\bar{q}_k)$. The sectoral participation rates are implicit functions of relative wages, hours and the average tax rate. For changes in wages and tax rates, the change in the informal participation rate is the following:

$$\ln\left(\frac{p_{Ikt+1}}{p_{Ikt}}\right) = d\log p_{Ik} = \frac{dp_{Ikt+1}}{p_{Ikt}} = \frac{F'(\bar{q}_{kt}) \cdot d\bar{q}_{kt+1}}{F(\bar{q}_{kt})} = \eta\frac{d\bar{q}_{kt+1}}{\bar{q}_{kt}} \tag{38}$$

Given the functional form of utility, $\bar{q_k} = w_{Ik}h_{Ik} - (1 - ATR_k)w_{Fk}h_{Fk} - \frac{\alpha^{\frac{1}{\sigma}}}{1+\frac{1}{\sigma}}(h_{Ik}^{1+\frac{1}{\sigma}} - h_{Fk}^{1+\frac{1}{\sigma}})$ and $d\bar{q_k} = w_{Ik}h_{Ik}d\ln w_{Ik} - (1 - ATR_k)w_{Fk}h_{Fk}(d\ln w_{Fk} + d\ln(1 - ATR_k))$, by the Envelope Theorem. I substitute for hours with the optimal hours functions to derive the following equation, which shows the percent change in the informal participation rate for skill group k in metropolitan area m between periods t and $t + 1$:

$$\begin{aligned}\ln\left(\frac{p_{Imkt+1}}{p_{Imkt}}\right) =& \eta\Bigg(\frac{(1+\sigma)w_{Imkt}^{1+\sigma}}{xw_{Imkt}^{1+\sigma} - w_{Fmkt}^{1+\sigma}(1 - MTR_{mkt})^{\sigma}((1+\sigma)(1 - ATR_{mkt}) - \sigma(1 - MTR_{mkt}))}\ln\left(\frac{w_{Imkt+1}}{w_{Imkt}}\right) \\ &- \frac{(1+\sigma)w_{Fmkt}^{1+\sigma}(1 - MTR_{mkt})^{\sigma}(1 - ATR_{mkt})}{xw_{Imkt}^{1+\sigma} - w_{Fmkt}^{1+\sigma}(1 - MTR_{mkt})^{\sigma}((1+\sigma)(1 - ATR_{mkt}) - \sigma(1 - MTR_{mkt}))}\ln\left(\frac{w_{Fmkt+1}}{w_{Fmkt}}\right) \\ &- \frac{(1+\sigma)w_{Fmkt}^{1+\sigma}(1 - MTR_{mkt})^{\sigma}(1 - ATR_{mkt})}{xw_{Imkt}^{1+\sigma} - w_{Fmkt}^{1+\sigma}(1 - MTR_{mkt})^{\sigma}((1+\sigma)(1 - ATR_{mkt}) - \sigma(1 - MTR_{mkt}))}\ln\left(\frac{1 - ATR_{mkt+1}}{1 - ATR_{mkt}}\right)\end{aligned} \tag{39}$$

Relative to the informal participation equation in the main analysis, shown in equation 24, the change in informal participation is a *weighted average* of the changes in informal and formal wages and the net-of-average tax rate. This participation equation is more complicated in that the explanatory variables of interest – the changes in informal and formal wages and the net-of-average tax rate – are weighted in part by terms that are determined in period t. The effect of a one percent change in the informal wage, formal wage or ATR on the informal participation rate depends on the initial informal wage relative to the difference between informal and formal indirect utility. For example, if informal and formal indirect utility are very similar initially (the difference is small), then a change in the informal wage will have a much larger affect on participation than if informal and formal indirect utility are very different.[71]

Estimation of equation 39 is not straightforward for two reasons. First, it is non-linear in the variables and parameters of interest. Second, it is one equation in a system of equations where the wage terms are endogenous, dependent variables in other equations, which are themselves functions of the participation rates. The estimating equations for the variables $\ln\left(\frac{w_{Imkt+1}}{w_{Imkt}}\right)$ and $\ln\left(\frac{w_{Fmkt+1}}{w_{Fmkt}}\right)$ are linear in the primitives from labor demand theory. However, the weights vary over time, across skill groups and across groups within metropoli-

[71] There is an analogous formal participation equation. However, to estimate it I must specify q_{max}. Because the participation elasticity η could be estimated from either the formal or informal participation equation and I do not simultaneously estimate both equations, I use the informal equation.

tan areas and have no discernible pattern for reasonable values of σ. They are nonlinear functions of labor demand primitives and tax rates. 3SLS estimation is not feasible in this context. Instead, I calculate the 3 main terms in (39) and estimate it via 2SLS for different combinations of the parameters σ and x, described below.

The parameter η is the participation elasticity measured as the percent change in the proportion of workers who work in a sector due to a percentage change in the difference in indirect utility associated with sectoral participation. To estimate η, I calculate the 3 main terms in equation 39 for different combinations of σ and x. The parameter x is related to the q_{min} of sectoral preferences as follows. For the individual with the lowest formal utility gain (the worker who most strongly prefers the informal sector), their sectoral indifference point is where formal indirect utility is a multiple x of that of the informal indirect utility: $V_F = xV_I$. For example, $q_{min} = 0$ implies that the individual with the lowest formal utility gain is indifferent between sectors when indirect utility is the same, $V_F = V_I$, which corresponds to $x = 1$. A $q_{min} = 0$ implies that everyone prefers to work in the formal sector, which is inconsistent with the empirical equilibrium because there are some workers in the informal sector who would face negative ATRs if they worked in the formal sector and therefore they must have sectoral preferences such that they prefer the informal sector even if after-tax formal income is higher. Therefore, it seems likely that $x > 1$.

To estimate equation 39, I consider values of x from 1-4 and values of σ ranging from 0-.30.[72] I instrument for the wage total terms with interactions between an instrument for the weight and skill-sector specific trade shocks, and for the $1 - ATR$ total terms with an interaction between an instrument for the weight and the simulated average tax rate. To calculate instruments for the weights, I calculate the weight terms using simulated tax rates and wages predicted from trade shocks. I use the following equations to predict formal and informal wages for skill group k in metropolitan area m and year t:

$$w_{Fmkt} = a_{tm} + b_t + c_{kt} + export_{Fmkt} + \epsilon_{mkt} \tag{40}$$

$$w_{Imkt} = d_{tm} + e_t + f_{kt} + export_{Imkt} + \mu_{mkt} \tag{41}$$

where $export_{Fmkt}$ is the growth in formal export jobs over the previous year in skill group k and metropolitan area m: $export_{Fmkt} = \frac{\triangle exportemployment_{Fmkt}}{working-agepopulation_{mkt}}$. The analogous measure applies to the growth in informal export-intensive jobs, $export_{Imkt}$. Metropolitan-year fixed effects control for changes in technology, aggregate labor and sectoral aggregate labor common to all skill groups within a metropolitan area. Year fixed effects control for sector-biased technical change that are common to all regions and skill groups and skill-year fixed effects

[72] In the main analysis, estimates of σ range from 0.08-0.09. Allowing for optimization frictions yields bounds on σ of 0.01-0.21.

control for skill-biased technical change. The coefficients on both export variables are large in magnitude, negative and highly significant (not shown).

I use the predicted wages, $\hat{w}_{Fmkt}$ and $\hat{w}_{Imkt}$, and simulated average and marginal tax rates, $A\hat{T}R$ and $M\hat{T}R$ with a slight abuse of notation, to calculate the weights in equation 39 for various values of x and σ. The instruments for the first, second and third terms in equation 39, respectively, are:

$$\frac{(1+\sigma)\hat{w}_{Imkt}^{1+\sigma}}{x\hat{w}_{Imkt}^{1+\sigma} - \hat{w}_{Fmkt}^{1+\sigma}(1-M\hat{T}R_{mkt})^{\sigma}((1+\sigma)(1-A\hat{T}R_{mkt}) - \sigma(1-M\hat{T}R_{mkt}))} * export_{Imkt+1} \tag{42}$$

$$\frac{(1+\sigma)\hat{w}_{Fmkt}^{1+\sigma}(1-M\hat{T}R_{mkt})^{\sigma}(1-A\hat{T}R_{mkt})}{x\hat{w}_{Imkt}^{1+\sigma} - \hat{w}_{Fmkt}^{1+\sigma}(1-M\hat{T}R_{mkt})^{\sigma}((1+\sigma)(1-A\hat{T}R_{mkt}) - \sigma(1-M\hat{T}R_{mkt}))} * export_{Fmkt+1} \tag{43}$$

$$\frac{(1+\sigma)\hat{w}_{Fmkt}^{1+\sigma}(1-M\hat{T}R_{mkt})^{\sigma}(1-A\hat{T}R_{mkt})}{x\hat{w}_{Imkt}^{1+\sigma} - \hat{w}_{Fmkt}^{1+\sigma}(1-M\hat{T}R_{mkt})^{\sigma}((1+\sigma)(1-A\hat{T}R_{mkt}) - \sigma(1-M\hat{T}R_{mkt}))} * \ln\left(\frac{1-A\hat{T}R_{mkt+1}}{1-A\hat{T}R_{mkt}}\right) \tag{44}$$

I estimate equation 39 using these instruments and restricting the coefficient on all 3 terms to be the same. The first stages are highly significant across all specifications. Table 11 shows the final results for different values of x and σ. In the main analysis, the estimated informal participation elasticity ranges from 0.491-0.517. For $x = 1$, the η estimate is zero, insignificant for reasonable values of σ, and the F-statistic in all cases is less than 10. For $x = 2$, the estimates are similar to those in the main analysis: they range from 0.437-0.513. For $\sigma = .10$, the estimated $\eta = .496$. For most values of σ, the estimate is significant and F-statistic is over 10. The point estimates for $x = 3$ are similar in magnitude, though less statistically significant.

To determine the most reasonable value of x, I could consider what a given value of x, an analogous measure y for q_{max}, relative formal and informal indirect utility, and the corresponding estimated elasticity η imply about the informal participation rate.[73] For example, if I assume $\sigma = 0.10$, $x = 2$, $y = 3$, $\eta = 0.496$, and formal and informal indirect utility are equal, the informal participation rate is 0.577. However, because the assumptions on x, y and the relative indirect utilities affect the informal participation rate substantially, there are many combinations of them that yield reasonable participation rates. Given the actual participation rates and the likelihood that $q_{max} > q_{min}$, x is likely much smaller than 3.

There are couple of caveats to this analysis. First, I can only implement this sensitivity analysis for skill groups defined at the education-group level. Unfortunately, the first stage is not highly significant when I use education-age groups because the trade shock is quite small at that group level. Second, this analysis makes a strong assumption about sectoral preferences across skill groups. I assume that the support of preferences $[q_{min}, q_{max}]$ is the

[73] y represents the sectoral indifference point for the worker who most prefers the formal sector: $V_I = yV_I$. That is, how much more informal indirect utility would have to be, relative to formal indirect utility, for the person who most prefers the formal sector to switch.

same across skill groups. Relaxing this assumption would require that I estimate or calibrate the support for every skill group, which is outside the scope of this paper. Finally, there is no systematic way to determine the precise value of x, y, and corresponding value of η. However, this analysis provides supporting evidence that the participation elasticity is similar when defined by after-tax income or indirect utility.

5.5 Capital Adjustment

The first term in each of the wage equations 25 and 26 captures the evolution of total-factor productivity (TFP) and the capital-to-labor ratio at the metropolitan area-year level. There are 4 potential specifications I could use to control for these terms. First, I could assume that there are no changes in TFP or the capital-labor ratio – that there is full capital adjustment in response to tax- and trade-induced changes in labor. Second, I could include year fixed effects to control for common trends in these terms and metropolitan fixed effects to control for time-invariant characteristics that are potentially correlated with these terms and the change in aggregate labor at the metropolitan-level, such as location and climate. This is the specification I use in my main analysis. Third, I could include metropolitan-year fixed effects, in which case I would adequately control for these terms but I would not be able to identify the elasticity of substitution between formal and informal labor inputs, ρ_{IF}. And finally, I could calculate and control for the changes in TFP and the capital-labor ratio. In this section, I contrast my main results with those from the third and fourth specifications.

I calculate the TFP and capital-labor ratio for the subset of sample years 1998-2004 at the firm level. I use firm-level data from Mexico's Economic Census for 1998, 2003 and 2008.[74] The census captures the economic activities of 3.6 million firms of all sizes, in all sectors of the economy that take place in private establishments with fixed locations in urban areas. Specifically, it measures firm sales, value added, number of workers, labor renumerations, material costs and the value of fixed capital stock. Summary statistics of these variables at the municipality level are shown in Table 12. The value of total output, the number of firms and the number of workers increased substantially between 1998 and 2008.

I measure the capital-labor ratio at the firm level as the value of the fixed capital stock per worker in 2002 pesos. I aggregate up to the metropolitan-area level in two steps. First, I calculate a weighted average of the firm capital-labor ratio at the industry level, where firm output shares are the weights. Second, I calculate industry output-weighted ratios at the metropolitan area level. Figure 23 plots the distribution of capital per worker for each census. To calculate the change in capital per worker between two years, I linearly interpolate capital per worker between non-census years at the metropolitan-area level. This likely introduces

[74] I thank Natalia Martinez at INEGI for her help with this data.

measurement error; however, it is the best I can do with the available data.[75] Figure 24 shows the percent change in capital per worker over the subset of years for which data is available, 1999-2004, for the ten largest metropolitan areas. For many areas, the observed trend in capital per worker changes between 2003 and 2004 because 2003 is a census year.

I use the Solow residual method to calculate TFP at the firm level. Specifically, I measure TFP as the residual from OLS regressions of the (log of) value added on the (logs of) the value of the fixed capital stock, labor renumerations and material costs. I aggregate TFP up to the metropolitan-area level and linearly interpolate TFP between census years in the same way as for the capital-labor ratio. Figure 25 plots the percent change in TFP for the ten largest metropolitan areas for 1999-2004.

Table 13 presents the results from the 3 specifications discussed above for the years that the capital terms are available, 1998-2004. All 3 specifications are 3SLS regression of equations 21 - 26. Column (1) presents results from the specification with metropolitan fixed effects and year fixed effects to control for the capital-labor ratio and total factor productivity. These results are very similar to those for the main analysis, which uses data from years 1988-2004. Column (2) presents results for the specification with metropolitan-year fixed effects to control for the capital terms and column (3) presents results for the specification with these terms calculated as described above. All 3 specifications yield similar point estimates that are highly statistically significant for the labor supply and labor demand parameters. The hours elasticity σ is around 0.08, the formal participation elasticity is 0.39, the elasticity of substitution across skill groups is around 1.7, and the elasticity of substitution across formal and informal labor inputs is around 1.6. Several parameter estimates from the first specification – no fixed effects or capital terms – are more than twice as large as those from the other specifications. I do not present those results here because the magnitudes are unreasonable. These results indicate that controlling for the capital-labor ratio and TFP are important; however, the way in which I control for them does not make a substantive difference in the parameter estimates. For this reason, my main specification is that which includes metropolitan area fixed effects and year fixed effects because I can use all years and identify all of the labor demand parameters.

6 Conclusions

This paper examines the effects of personal income taxation on equilibrium sectoral participation, work hours and wages in the context of a developing country with a large informal sector. To study these effects, I exploit uniquely advantageous sources of variation in worker

[75] Annual, and quarterly for some years, panel data is available for firms in certain industries, such as manufacturing. However, this data is insufficient for calculating the capital-labor ratio and TFP at the metropolitan area level because the manufacturing industry is not representative of the entire local economy.

and firm incentives generated by the Mexican tax and trade policies in the 1990s. I find that individuals are sensitive to income taxation. Increases in average tax rates cause workers to move out of the formal sector and into the informal sector: a ten percent increase in the net-of-average tax rate causes a 4% increase in formal sector participation. However, individuals are relatively unresponsive to small changes in marginal tax rates: a ten percent increase in the net-of-marginal tax rate causes individuals in the formal sector to increase work hours by 0.82%. I find that wages respond to changes in the relative supplies of labor inputs. Tax-induced changes in formal and informal labor supply, for example due to Credito al Salario, decreased pre-tax wages in the formal sector and increased wages in the informal sector. A ten percentage point increase in the net-of-average tax rate causes an increase in formal participation of 2.5%: an effect two-thirds the size of that when labor demand is perfectly elastic. These equilibrium effects reduce the intended benefit to formal workers and provide an unintended transfer to informal workers, thus limiting the credit's effectiveness.

To my knowledge, this paper represents the first effort at analyzing the equilibrium effects of income taxation on formal and informal labor markets. My findings have important implications for the tax policy of developing countries. While an increase in average tax rates causes a decrease in formal sector participation, the net effect on tax revenue is positive. However, the behavioral responses analyzed here indicate efficiency costs of taxation and, likely, productivity costs. Tax policy may have indirect effects on productivity and economic growth in ways that are previously unexplored. I can use the elasticities estimated here to study optimal income tax schedules in settings with a large informal sector. Understanding and designing optimal tax policy is crucial for policymakers: it can help countries increase their fiscal capacity, rely less on external financial assistance, and foster economic growth.

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Table 1: Summary Statistics of Labor Data

Variable	Mean	Std. Dev.	Min	Max	Obs
Panel A: Individual Level					
Age	35.61	9.05	22	55	3,506,167
Education (Years)	10.67	5.43	0	23	3,506,167
Formal	0.54	0.50	0	1	3,506,167
Hours if Formal	47.49	11.85	2	98	1,890,739
Hours if Informal	47.69	14.86	1	98	1,615,428
Pre-Tax Wage Formal	30.57	30.65	0.03	297.87	1,890,739
After-tax Wage Formal	25.80	21.14	3.28	196.69	1,890,739
Wage Informal	24.25	22.66	3.28	196.69	1,615,428
Average Tax Rate	0.06	0.32	-3.71	0.44	1,890,739
Marginal Tax Rate	0.17	0.09	0.03	0.50	1,890,739
Panel B: Education Group Level					
Group Size	112,997	327,375	631	3,640,874	3678
Formal Participation Rate	0.55	0.12	0.15	0.83	3678
Avg. Hours Formal	48.13	3.20	39.98	64.32	3678
Avg. Hours Informal	47.96	3.08	39.11	61.89	3678
Avg. Pre-Tax Wage Formal	28.07	13.41	8.76	78.83	3678
Avg. After-Tax Wage Formal	24.03	9.48	9.52	58.58	3678
Avg. Wage Informal	25.14	9.66	9.09	67.53	3678
Avg. Average Tax Rate	0.05	0.11	-1.82	0.22	3678
Avg. Marginal Tax Rate	0.17	0.04	0.10	0.30	3678
Panel C: Education-Age Group Level					
Group Size	22,680	70,512	26	1,188,384	18323
Formal Participation Rate	0.53	0.15	0.03	0.96	18323
Avg. Hours Formal	47.84	4.23	20.00	94.00	18323
Avg. Hours Informal	47.89	4.49	12.17	87.33	18323
Avg. Pre-Tax Wage Formal	29.94	16.09	3.70	171.63	18323
Avg. After-Tax Wage Formal	25.36	11.29	5.53	118.29	18323
Avg. Wage Informal	25.82	11.23	4.76	110.01	18323
Avg. Average Tax Rate	0.06	0.12	-3.11	0.31	18323
Avg. Marginal Tax Rate	0.17	0.05	0.09	0.38	18323

Summary statistics of men, ages 22-55, who worked in the previous week and with non-missing earnings, hours, education and health benefit variables. Sample trimmed by top and bottom 1% of after-tax wages. Panels A, B and C show statistics at individual, education group and education-age group levels, respectively.

Table 2: Skill Group Distribution

	Age Group					
Education Group	Age 22-27	Age 28-34	Age 35-41	Age 42-48	Age 49-55	Total
Primary or Less	4.17%	4.97%	5.80%	5.70%	4.84%	25.47%
Some Secondary	1.61%	1.60%	1.30%	0.98%	0.67%	6.15%
Finished Secondary	6.43%	6.24%	4.19%	2.52%	1.40%	20.78%
Some H.S.	4.01%	3.60%	2.53%	1.50%	0.87%	12.52%
Finished H.S.	2.77%	2.92%	2.09%	1.16%	0.62%	9.56%
More than H.S.	4.35%	6.95%	6.77%	4.80%	2.65%	25.52%
Total	23.34%	26.27%	22.67%	16.66%	11.06%	100.00%

Composition of sample across education and age groups.

Table 3: First Stage Results for Sectoral Aggregate Labor Parameters

	(1)	(2)	(3)	(4)
	lnL_{Fkt}	lnL_{Ikt}	lnL_{Fkt}	lnL_{Ikt}
Average Tax Rate	-9.61	16.8	-22.7	20.15
Standard Error	(0.42)	(0.26)	(0.34)	(0.27)
Marginal Tax Rate	-3.01		-11.99	
Standard Error	(0.49)	(1.76)	(0.47)	
Education-Year FE	X	X		
Education Age-Year FE			X	X
Year FE	X	X	X	X
Metropolitan Area-Year FE	X	X	X	X
R-Squared	0.75	0.77	0.75	0.77
F-Statistic	94.71	101.64	100.38	104.17
N	3390	3390	16894	16894

First stage results from 3SLS regressions of formal and informal labor supply on marginal and average tax rates. Observations at the skill-group, metropolitan-area, year level.

Table 4: 3SLS Results for Sectoral Aggregate Labor Parameters

	(1)	(2)
Neg. Inverse of ρ_e	-0.71	-0.56
Standard Error	(0.01)	(0.01)
Elasticity: ρ_e	1.408	1.786
Education-Year FE	X	
Education Age-Year FE		X
Year FE	X	X
Metropolitan Area-Year FE	X	X
N	3390	16894

Results from 3SLS regressions of formal and informal log wages on formal and informal labor supply. Observations at the skill-group, metropolitan-area, year level.

Table 5: First Stage Results for Aggregate Labor Parameters

	(1) $\ln\left(\frac{L_{Ft}}{L_{It}}\right)$	(2) $\ln\left(\frac{L_{Ft}}{L_{It}}\right)$
Average Tax Rate	-7.76	-8.75
Standard Error	(1.06)	(0.95)
Year FE	X	X
R-Squared	0.96	0.96
F-Statistic	297.31	310.33
N	597	597

First stage results from 2SLS regressions of the natural log of the ratio of formal and informal aggregate labor on group labor supply-weighted average tax rates. Observations at the metropolitan-area, year level.

Table 6: 2SLS Results for Aggregate Labor Parameters

	(1)	(2)
Neg. Inverse of ρ_{IF}	-0.566	-0.539
Standard Error	(0.16)***	(0.21)***
Elasticity: ρ_{IF}	1.767	1.855
Year FE	X	X
N	597	597

2SLS results from regressions of the natural log of the ratio of formal and informal average wages, weighted by group labor supply, on the natural log of the ratio of formal and informal aggregate labor. Observations at the metropolitan-area, year level.

Table 7: 3SLS Results for Full Set of Parameters

	Education Group		Education-Age Group	
Parameter	Estimate	S.E.	Estimate	S.E.
Hours Elasticity σ	0.088	0.011***	0.082	0.013***
Formal Participation Elasticity η_F	0.389	0.018***	0.401	0.014***
Informal Participation Elasticity η_I	-0.491	0.019***	-0.517	0.013***
Neg. Inverse of ρ_e	-0.575	0.132***	-0.682	0.100***
Elasticity of Substitution Across Skill ρ_e	1.739		1.466	
Inverse of ρ_{IF}	0.591	0.005***	0.582	0.104***
Elasticity of Substitution Across Sector ρ_{IF}	1.692		1.718	
N	3160		15454	

Results from 3SLS regressions of: effect of formal wage and net-of-marginal tax rate on formal hours; effect of informal wage on informal hours; effect of formal and informal wages, hours and net-of-average tax rate on formal and informal participation; effect of formal and informal hours, participation, sectoral aggregate labor, and aggregate labor on sectoral wages. Estimates from model that allows for imperfect substitution between skill groups and imperfect substitution between formal and informal labor, with sectoral labor as the outer CES nest and skill-biased technical change. Observations at the skill-group, metropolitan-area, year level.

Table 8: Effects of 1 Percentage Point Increase in Net-of-ATR on Labor Supply and Wages, by Elasticity of Demand ρ_e

	$\rho_e = \infty$	$\rho_e = 1.80$	$\rho_e = 1.47$	$\rho_e = 0$
Change in Formal Hours (%)	0.00	-0.01	-0.01	-0.03
Change in Informal Hours (%)	0.00	0.02	0.02	0.04
Change in Formal Participation (%)	0.40	0.27	0.25	0.03
Change in Informal Participation (%)	-0.52	-0.35	-0.32	-0.04
Change in Formal Wage (%)	0.00	-0.14	-0.16	-0.40
Change in Informal Wage (%)	0.00	0.18	0.21	0.52

Table shows the effect of a 1 percentage point increase in the ATR. Change in wage refers to the pre-tax hourly wage. I assume the following labor supply parameters: intensive margin elasticity $\sigma = 0.082$, formal participation elasticity $\eta_F = 0.401$, and informal participation elasticity $\eta_I = 0.517$. ρ_e is the elasticity of substitution across skill groups and also represents the partial wage elasticity.

Table 9: Summary Statistics at Individual Level for Panel Sample

Variable	Mean	Std. Dev.	Min	Max	Obs
Age	35.73	8.91	22	55	1,468,651
Education (Years)	8.77	3.57	0	21	1,468,651
Formal	0.54	0.50	0	1	1,468,651
Hours if Formal	48.07	12.29	2	98	791,692
Hours if Informal	48.77	15.17	1	98	676,574
Pre-Tax Wage Formal	30.83	42.85	1.43	1062.97	791,692
After-tax Wage Formal	25.65	38.14	1.44	714.29	791,692
Wage Informal	27.60	39.32	1.44	714.29	676,574
Average Tax Rate	0.28	0.05	-0.32	0.37	791,692
Marginal Tax Rate	0.33	0.03	0.10	0.40	791,692

Summary statistics of men, ages 22-55, who worked in the previous week and with non-missing earnings, hours, education and health benefit variables and are observed for at least two interviews. Panel sample limited to 2nd quarter of 1994-2004.

Table 10: Intensive Elasticities with Bounds

Parameter	Point	S.E.	Frictions	Bounds	Bounds	Bounds	Bounds
	Estimate			ϵ_L	ϵ_U	95% CI	95% CI
σ, Formal	0.078	0.056	0.01	0	0.19	0	0.26
σ, Informal	0.087	0.06	0.01	0.01	0.19	0	0.29
σ, Full Model	0.088	0.011***	0.01	0.01	0.21	0.01	0.21

Estimates and bounds on the intensive-margin elasticity separately for the formal and informal sectors. Bounds calculated as in Chetty (2012).

Table 11: RESULTS FOR INFORMAL PARTICIPATION WITH VARYING q_{min}, EDUCATION GROUPS

Value of X		$\sigma = 0$	$\sigma = 0.05$	$\sigma = 0.10$	$\sigma = 0.15$	$\sigma = 0.20$	$\sigma = 0.25$	$\sigma = 0.30$
$X = 1$	Estimate of η	0	0	0	0	0	0	0
	S.E	(0.000)***	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)*	(0.000)
	F-Statistic	1.2	2.23	7.39	6.04	7.85	5.39	6.77
$X = 2$	Estimate of η	0.197	0.475	0.496	0.513	0.471	0.437	0.002
	S.E	(0.035)***	(0.012)***	(0.106)***	(0.093)***	(0.001)***	(0.006)***	(0.003)
	F-Statistic	8.97	10.05	14.56	12.14	10.35	11.76	6.2
$X = 3$	Estimate of η	0.343	0.406	0.472	0.491	0.462	0.389	0.189
	S.E	(0.329)	(0.11)***	(0.118)***	(0.127)***	(0.177)**	(0.158)**	(0.228)
	F-Statistic	8.71	9.53	10.4	9.11	8.83	6.45	2.09
$X = 4$	Estimate of η	0.559	0.505	0.456	0.412	0.372	0.337	0.304
	S.E	(0.505)	(0.271)*	(0.439)	(0.411)	(0.385)	(0.361)	(0.339)
	F-Statistic	1.54	3.18	6.11	5.39	3.43	2.9	3.01
	N	3,102	3,102	3,102	3,102	3,102	3,102	3,102

Results from 3SLS regressions of weighted average of change in informal wage rate, formal wage rate and net-of-average tax rate on change in informal participation for various values of x and σ. x measures the sectoral indifference point for the individual with the lowest formal utility preference and σ measures the intensive (hours) labor supply elasticity. Observations at the skill-group, metropolitan-area, year level for education skill groups.

Table 12: Summary Statistics of Firm Data at the Municipality Level

	1998		2003		2008	
Variable	Mean	S.D.	Mean	S.D.	Mean	S.D.
Number of Firms	7,217	11,635	7,612	11,833	16,290	16,059
Number of Workers	47,402	90,424	50,746	90,455	61,739	103,346
Capital Stock (Pesos)	12.4 M	28.7 M	11.5 M	25.6 M	15.1 M	34.5 M
Capital Per Employee (Pesos)	235	293	179	241	172	179
Value Added (Pesos)	8.5 M	20.3 M	10.7 M	29.2 M	13.4 M	38.8 M
Total Production (Pesos)	19.7 M	43.2 M	20.8 M	45.7 M	67.1 M	105 M
Labor Costs (Pesos)	2.97 M	8.25 M	2.9 M	7.35 M	3.2 M	6.7 M
Compensation Per Employee (Pesos)	60	33	63	31	63	31
Material Costs (Pesos)	22.4 M	57.5 M	20 M	40.4 M	31.6 M	73 M
N	232		232		232	

Summary statistics of firm data, aggregated to the municipality level by using output and industry share weights, from the Economic Census 1998, 2003, 2008.

Table 13: 3SLS Results for Capital Adjustment Specifications, Education Groups

	(1)		(2)		(3)	
Parameter	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Hours Elasticity σ	0.08	0.010***	0.075	0.009***	0.082	0.012***
Formal Participation Elasticity η_F	0.393	0.017***	0.389	0.011***	0.384	0.05***
Informal Participation Elasticity η_I	-0.489	0.018***	-0.475	0.003***	-0.474	0.077***
Neg. Inverse of ρ_e	-0.58	0.135***	-0.607	0.117***	-0.568	0.174**
Elasticity: ρ_e	1.724		1.647		1.761	
Inverse of ρ_{IF}	0.61	0.005***			-0.593	0.15***
Elasticity: ρ_{IF}	1.639				1.686	
N	1476		1476		1476	

Results from 3SLS regressions of: effect of formal wage and net-of-marginal tax rate on formal hours; effect of informal wage on informal hours; effect of formal and informal wages, hours and net-of-average tax rate on formal and informal participation; effect of formal and informal hours, participation, sectoral aggregate labor, and aggregate labor on sectoral wages. Sample pertains to years 1998-2004. Column (1) presents results from specification with metropolitan fixed effects and year fixed effects to control for capital-labor ratio and total factor productivity. Column (2) presents results for specification with metropolitan-year fixed effects to control for the same terms and Column (3) presents results for specification with these terms calculated from the Economic Census, with data in non-census years linearly interpolated.

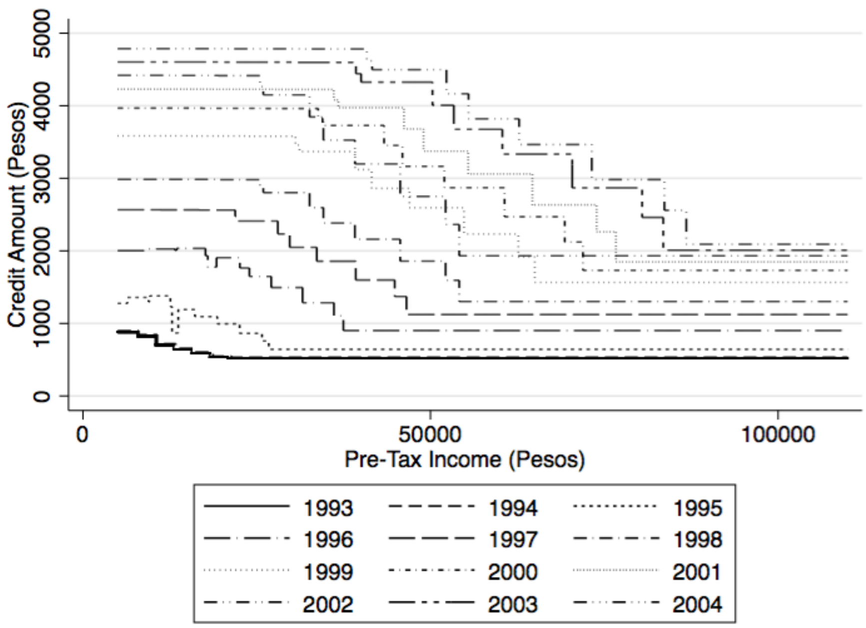

Figure 1: 1993-2004 Credito al Salario in Levels
Figure plots the annual formal employment tax credit received in levels across the pre-tax income distribution from the year of its implementation, 1993, through 2004.

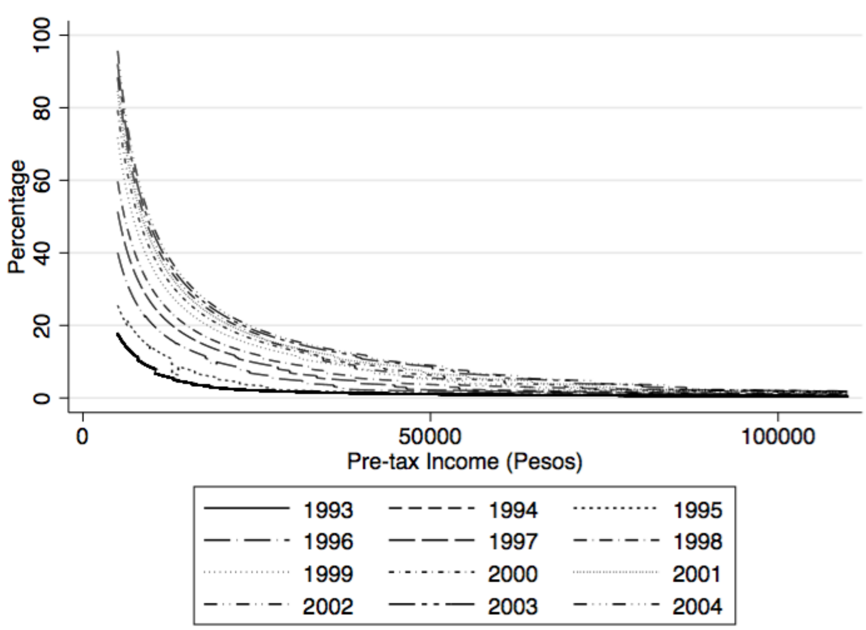

Figure 2: 1993-2004 Credito al Salario as Percentage of Pre-Tax Income
Figure plots the annual formal employment tax credit received as a percentage of pre-tax income across the pre-tax income distribution from the year of its implementation, 1993, through 2004.

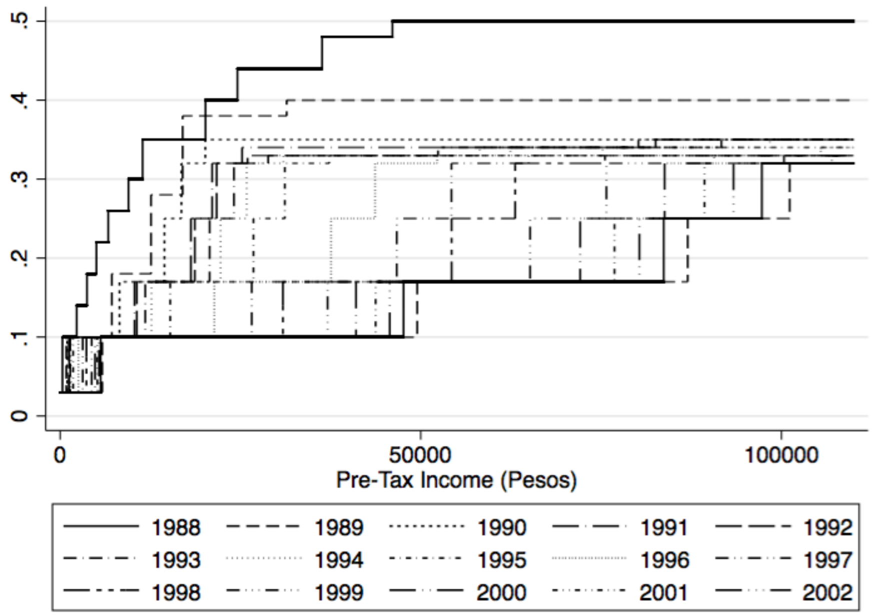

Figure 3: 1988-2004 Marginal Tax Rates
Figure plots the marginal tax rate across the pre-tax income distribution from 1988-2004.

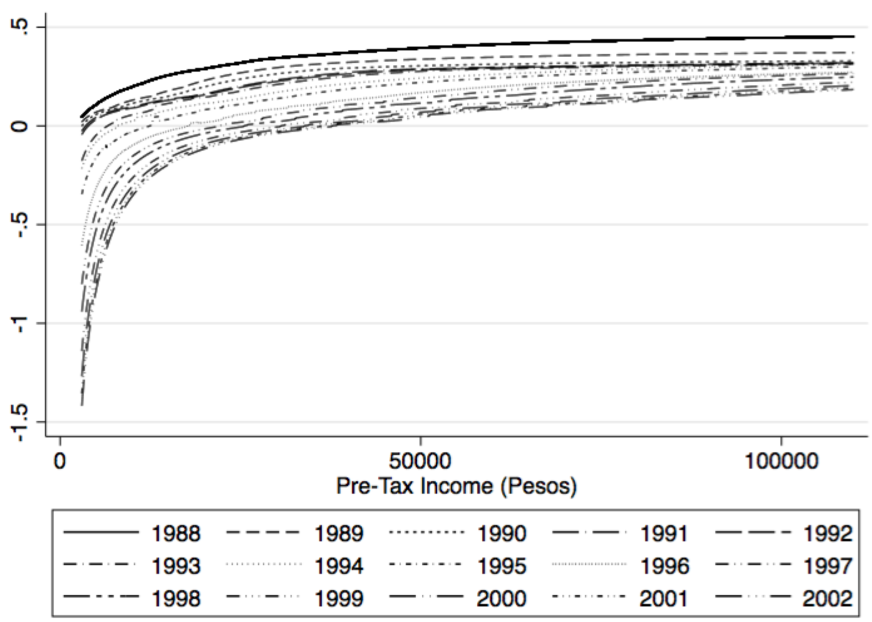

Figure 4: 1988-2004 Average Tax Rates
Figure plots the average tax rate across the pre-tax income distribution from 1988-2004.

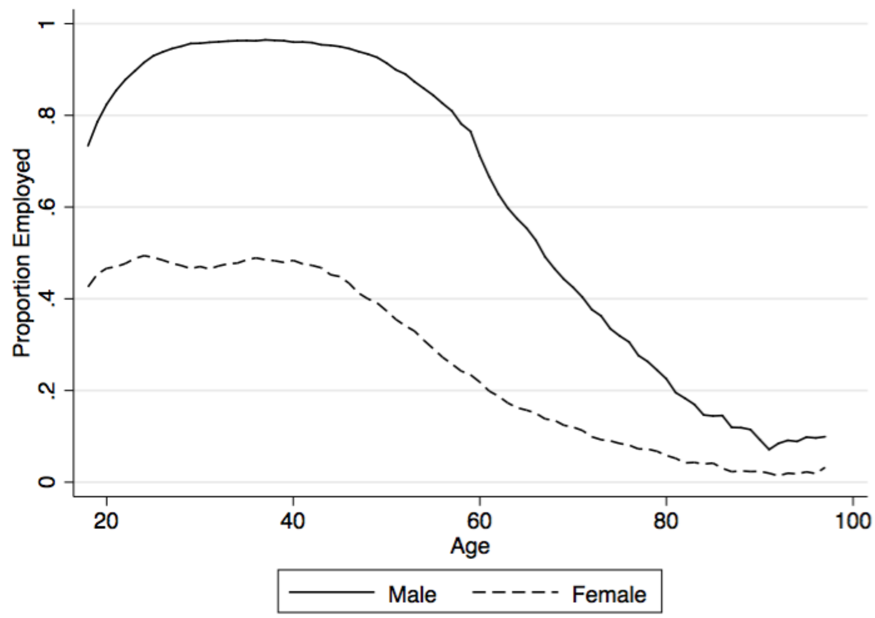

Figure 5: Employment Rates by Age
Figure plots the proportion of men and women employed from 1988-2004 across ages 20 and older.

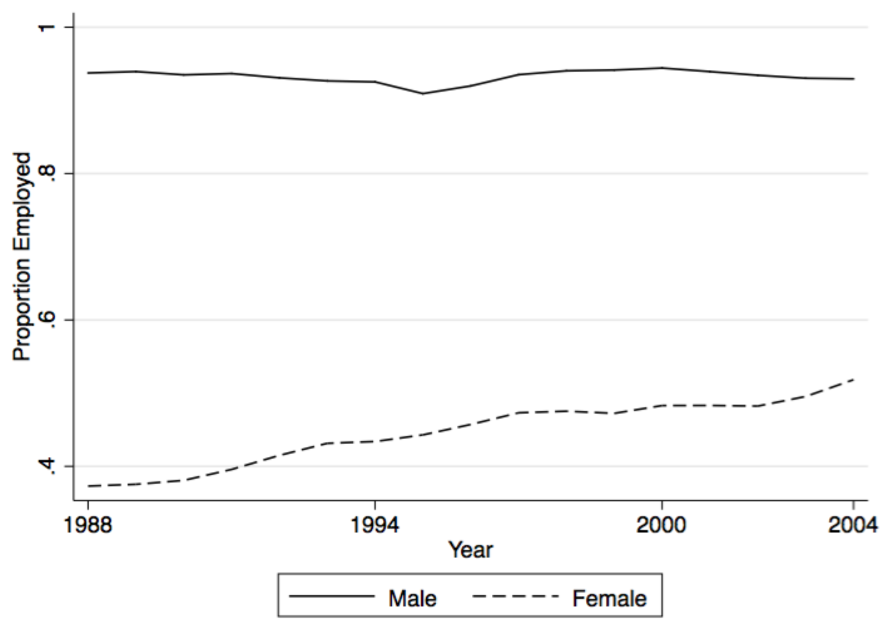

Figure 6: Employment Rates by Year
Figure plots the proportion of men and women employed, ages 22-55, by year from 1988-2004.

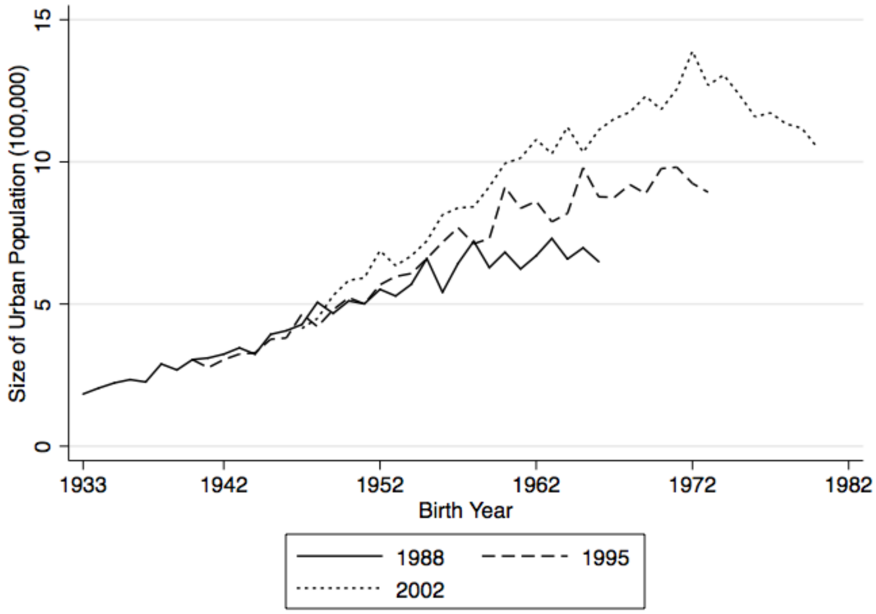

Figure 7: Size of Birth Cohorts
Figure plots the total urban population of men, ages 22-55, by birth year, as measured in 1988, 1995 and 2002. Sampling weights are used.

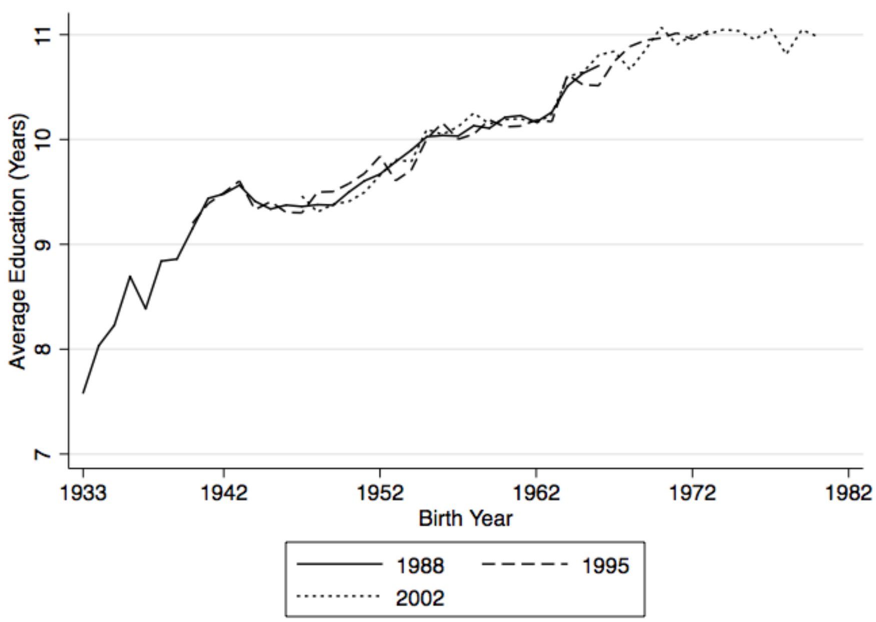

Figure 8: Average Education of Birth Cohorts
Figure plots the average education of men, ages 22-55, in urban areas by birth year, as measured in 1988, 1995 and 2002. Sampling weights are used.

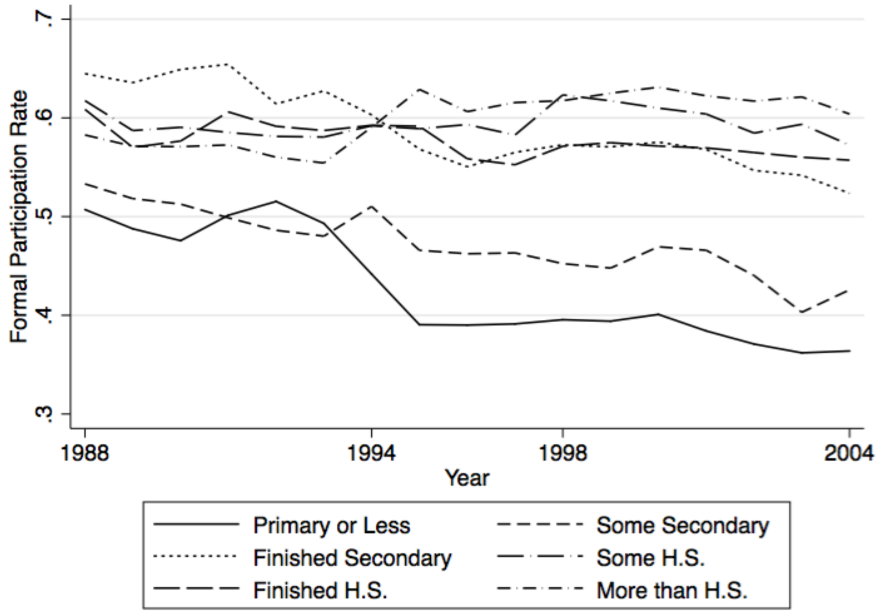

Figure 9: Formal Participation by Year and Education

Figure plots the formal participation rate, by education and year from 1988-2004.

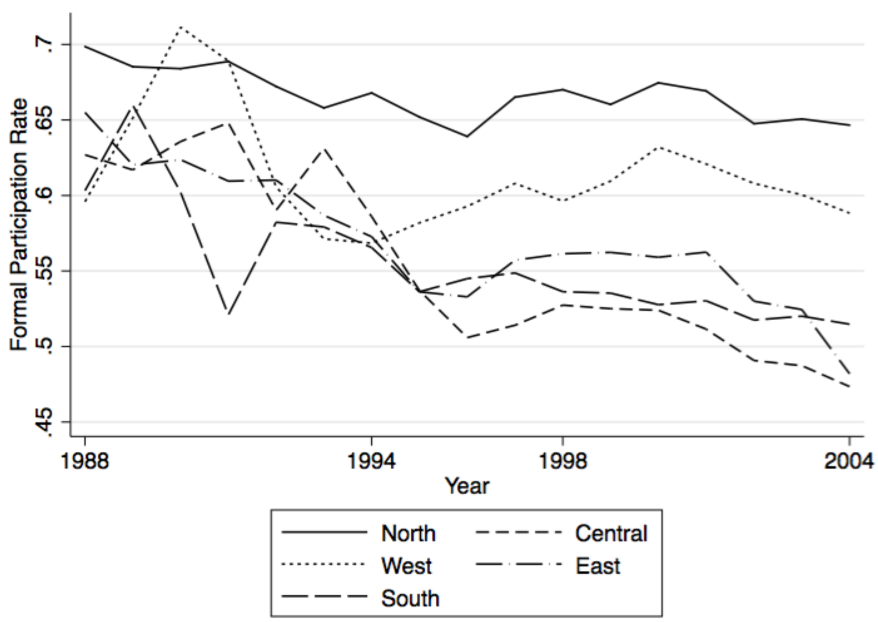

Figure 10: Formal Participation for Median Education by Year and Region

Figure plots the formal participation rate for individuals who completed secondary schooling by geographic region and year from 1988-2004.

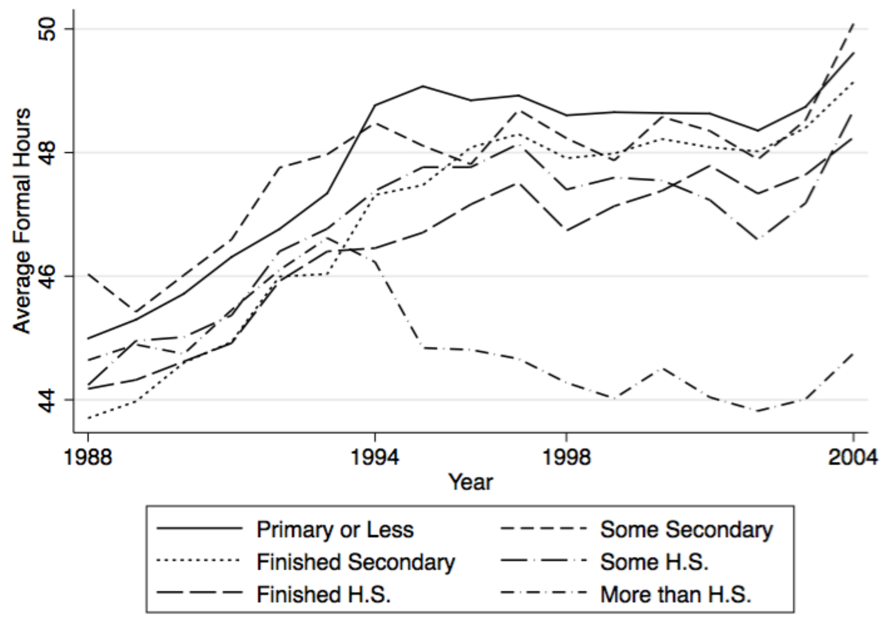

Figure 11: Formal Hours by Year and Education

Figure plots average formal weekly hours by education group and year from 1988-2004.

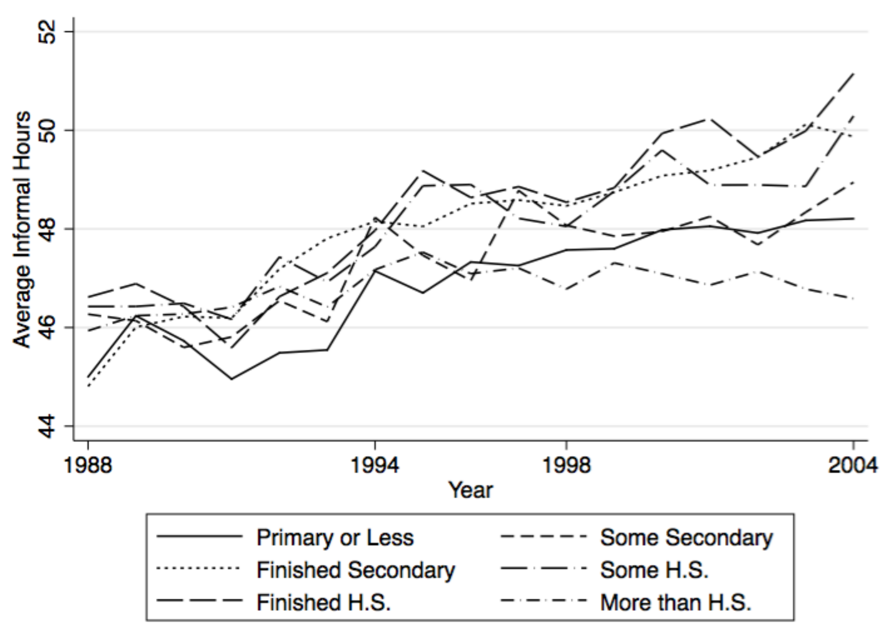

Figure 12: Informal Hours by Year and Education

Figure plots average informal weekly hours by education group and year from 1988-2004.

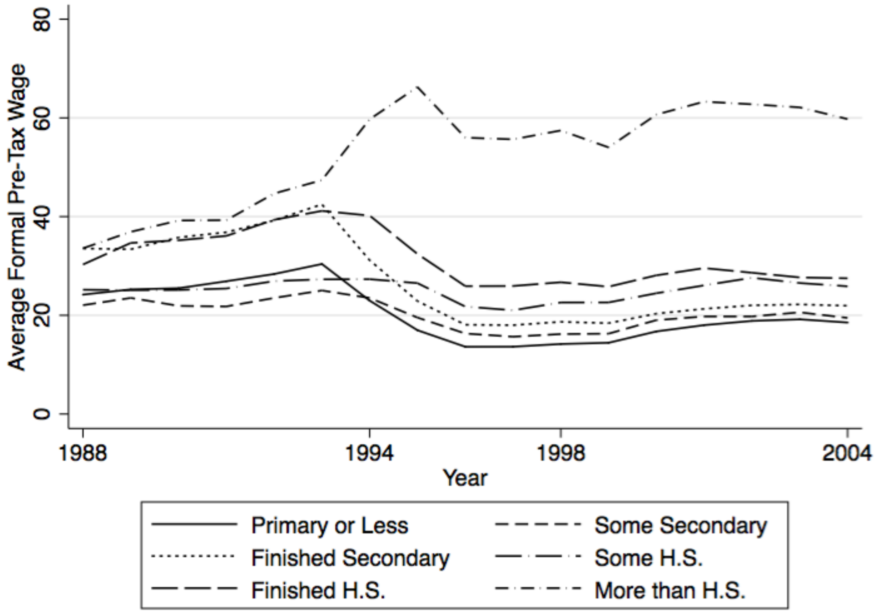

Figure 13: Formal After-Tax Wages by Year and Education
Figure plots average formal after-tax wages by education group and year from 1988-2004, in 2004 pesos.

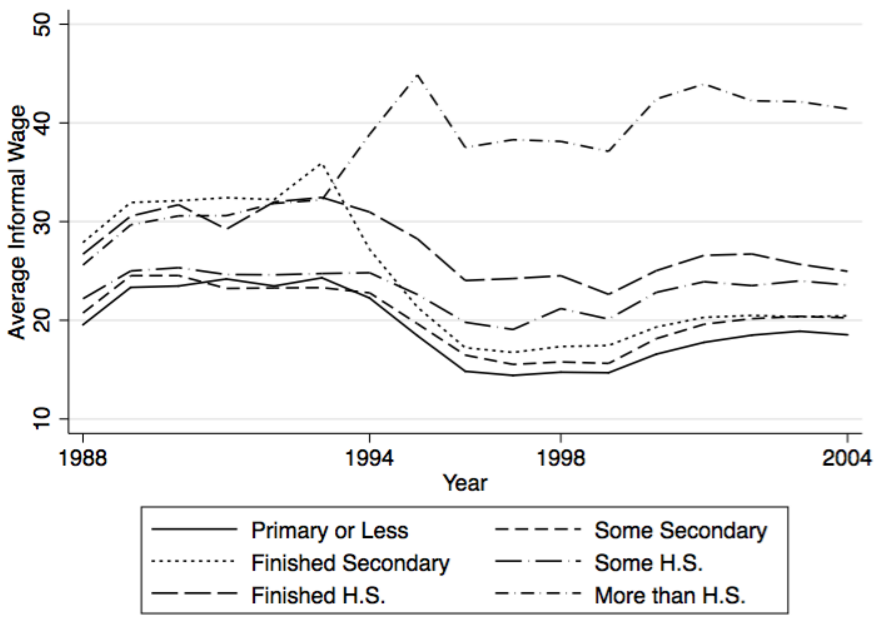

Figure 14: Informal Wages by Year and Education
Figure plots average informal wages by education group and year from 1988-2004, in 2004 pesos.

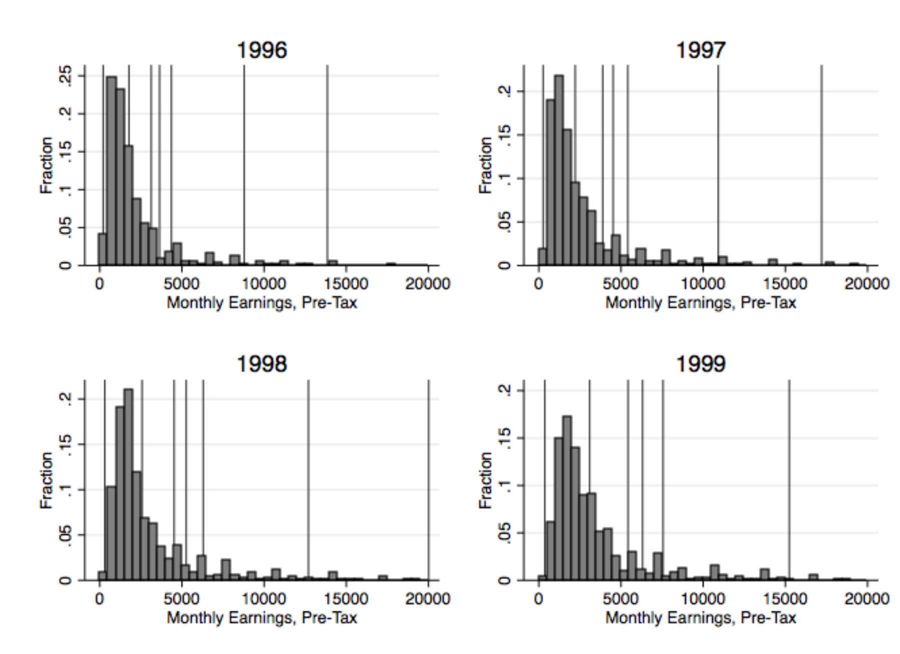

Figure 15: Pre-Tax Formal Annual Income Distribution
Figure shows the distribution of pre-tax annual income among formal workers for 1996-1999. The vertical lines represent tax kinks in the tax schedule for that year.

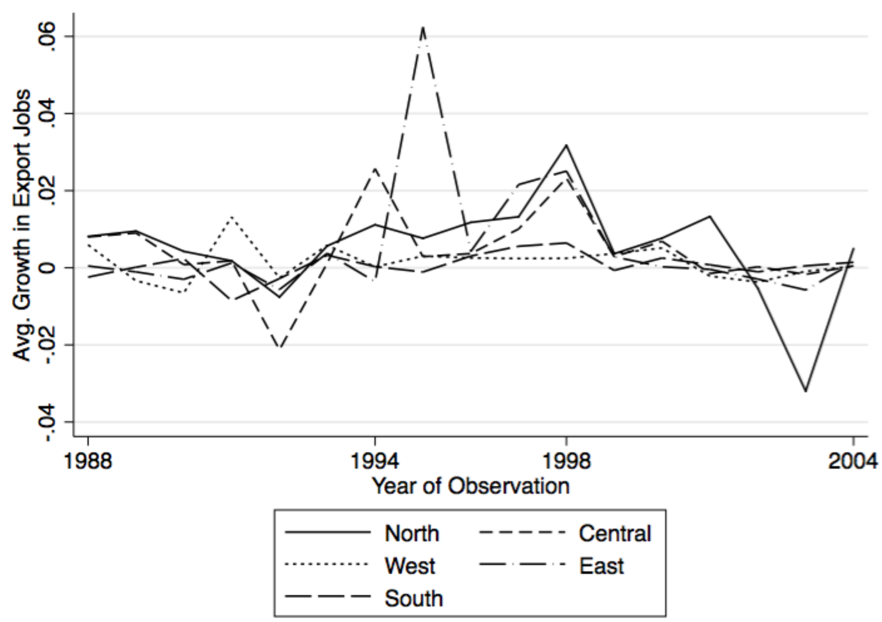

Figure 16: Average Trade Shock by Year and Geographic Region
Figure plots the average growth in export manufacturing jobs across metropolitan areas within a given geographic region and over time.

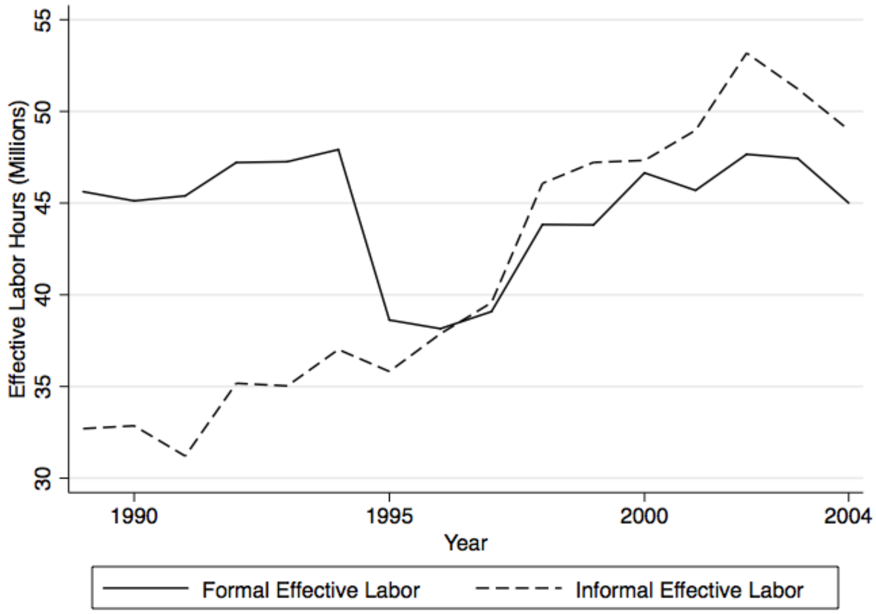

Figure 17: Total Sectoral Aggregate Labor in Mexico City
Figure plots formal and informal aggregate labor, calculated using education groups, for Mexico City, by year from 1990-2004. The vertical axis measures total effective labor in the hours of workers in the lowest skill group, primary school or less.

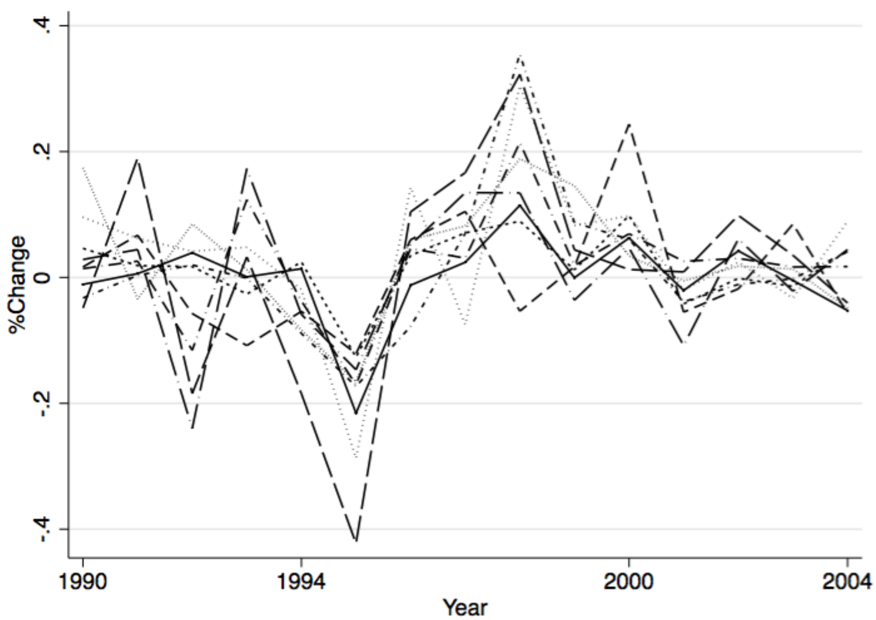

Figure 18: Percent Change in Formal Aggregate Labor (Education Groups)
Figure plots the percent change in formal aggregate labor, calculated using education groups, for Mexico City, Guadalajara, Monterrey, Puebla, Len, Torren, San Luis Potos, Mrida, Chihuahua and Tampico, by year from 1990-2004.

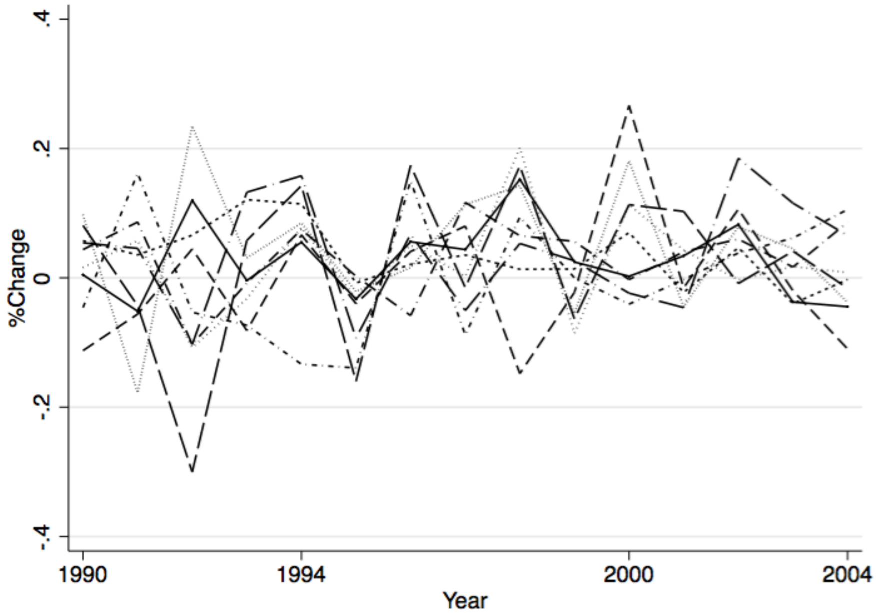

Figure 19: Percent Change in Informal Aggregate Labor (Education Groups)
Figure plots the percent change in informal aggregate labor ,calculated using education groups, for Mexico City, Guadalajara, Monterrey, Puebla, Len, Torren, San Luis Potos, Mrida, Chihuahua and Tampico, by year from 1990-2004.

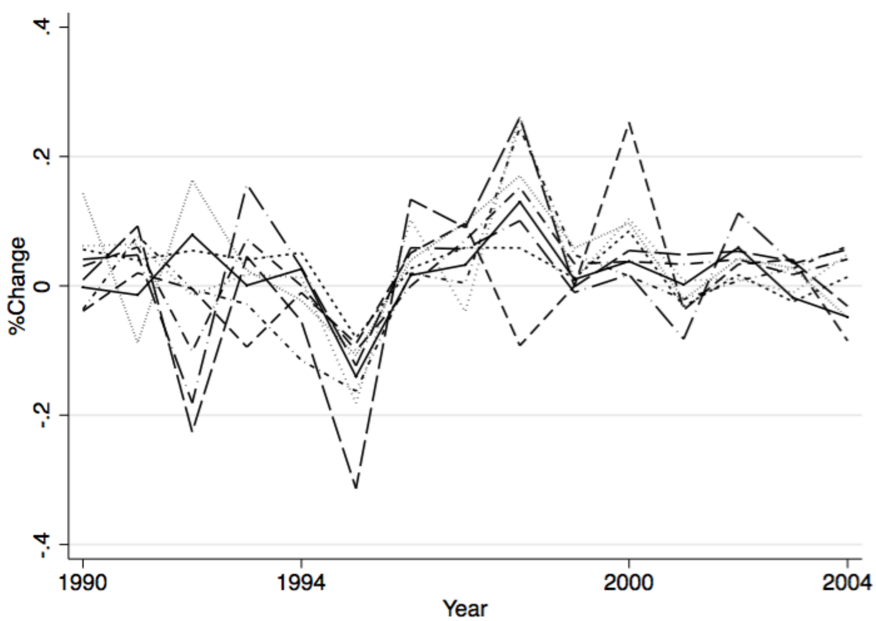

Figure 20: Percent Change in Aggregate Labor (Education Groups)
Figure plots the percent change in aggregate labor, calculated using education groups, for Mexico City, Guadalajara, Monterrey, Puebla, Len, Torren, San Luis Potos, Mrida, Chihuahua and Tampico, by year from 1990-2004.

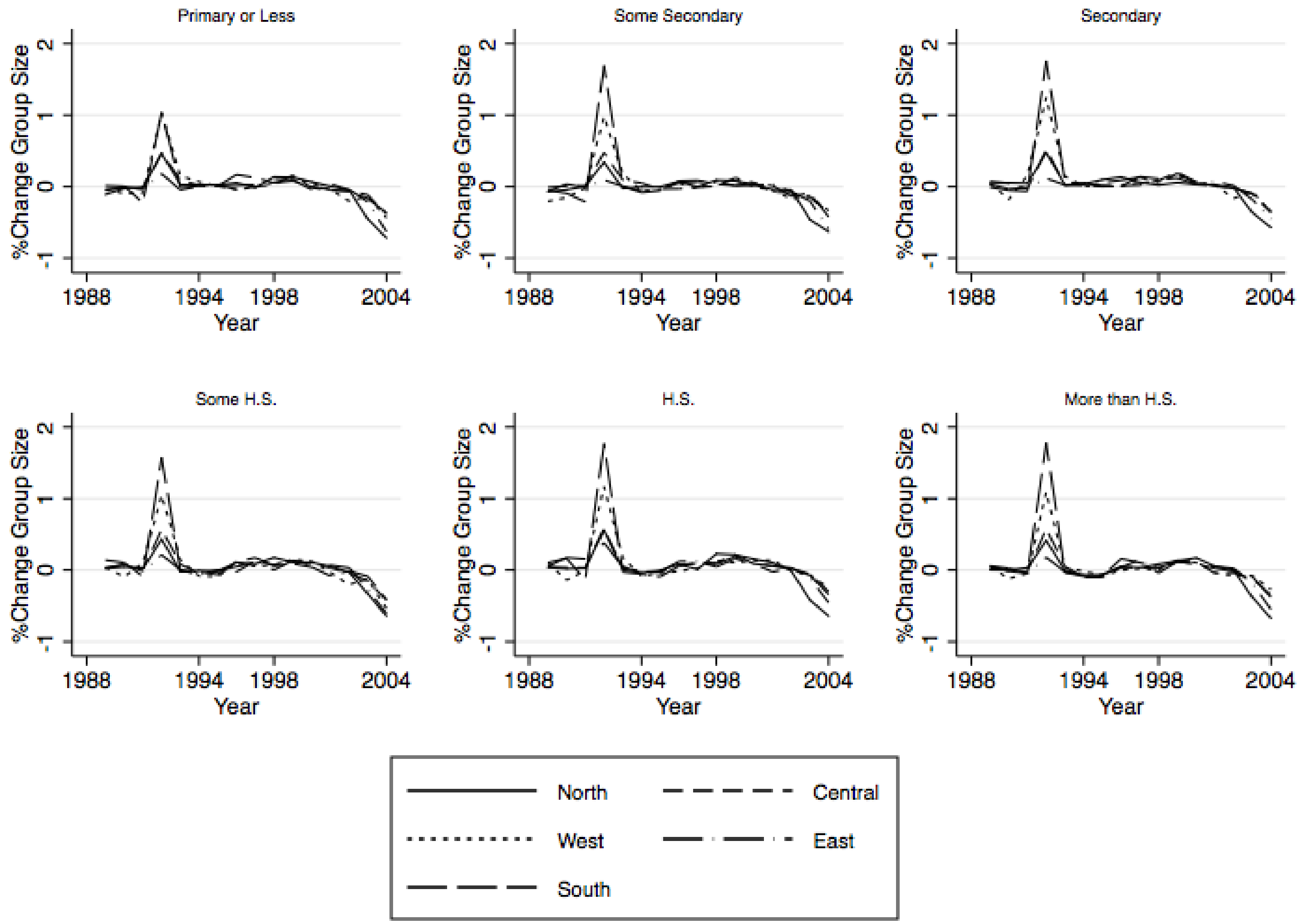

Figure 21: Percent Change in Size of Labor Force by Education Group and Region
Figure plots the percent change in the total size of the participating labor force at the education-group level across geographic regions, by year from 1989-2004.

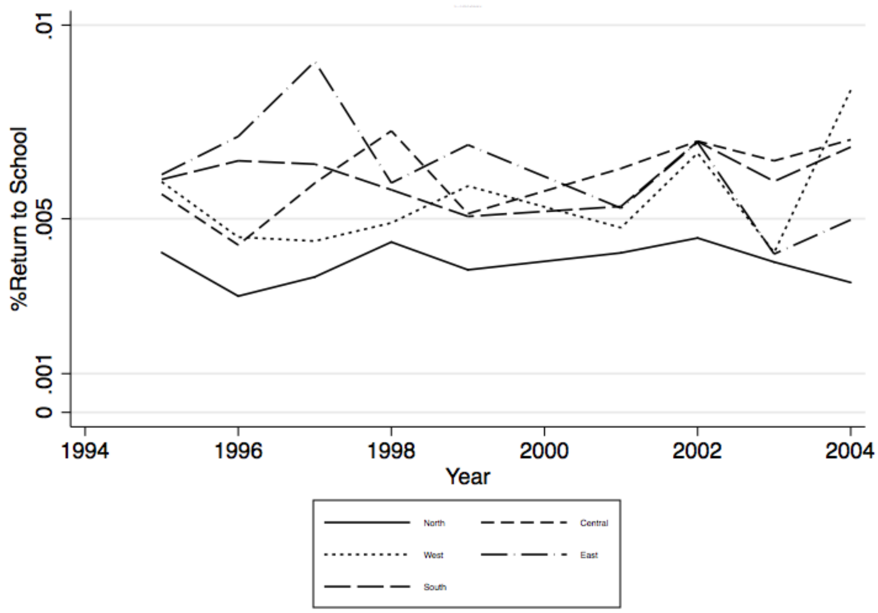

Figure 22: Return-to-School Rate
Figure plots the percent of men, ages 22-55, who return-to-school annually for years 1995-2004, by geographic region.

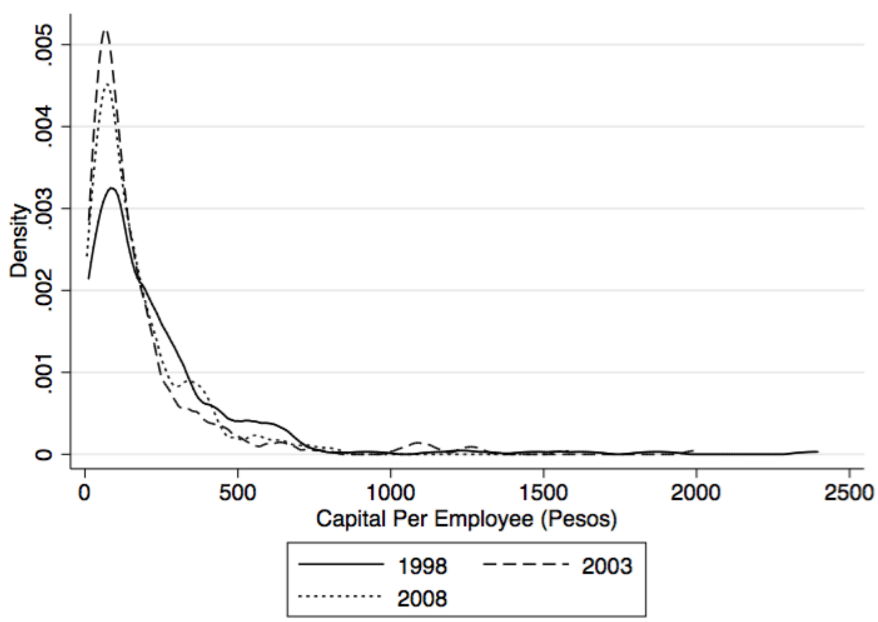

Figure 23: 1998-2008 Capital Per Worker (2002 Pesos)
Figure plots the distribution of capital per worker for the 1998, 2003, and 2008 Economic Census.

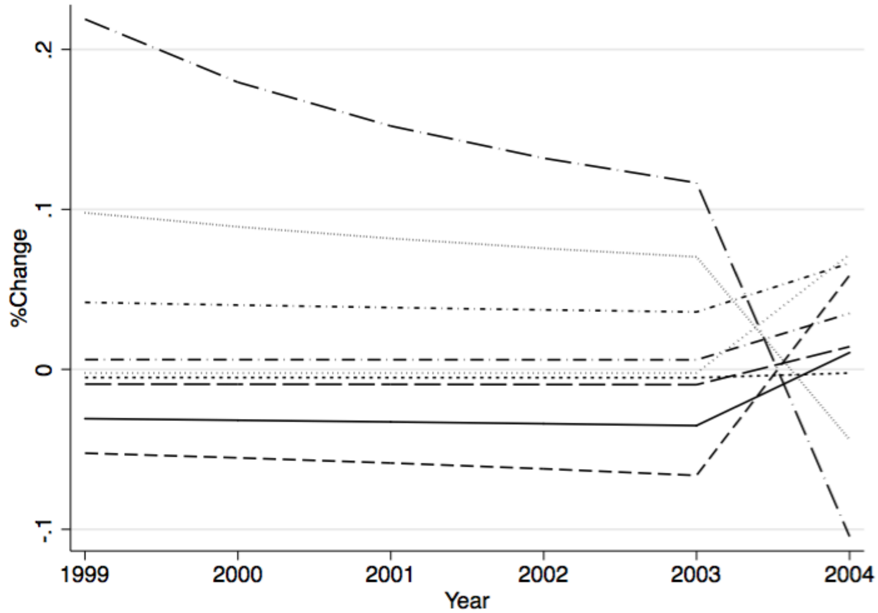

Figure 24: 1999-2004 Change in Capital Per Worker
Figure plots the percent change in capital per worker for Mexico City, Guadalajara, Monterrey, Puebla, Len, Torren, San Luis Potos, Mrida, Chihuahua and Tampico.

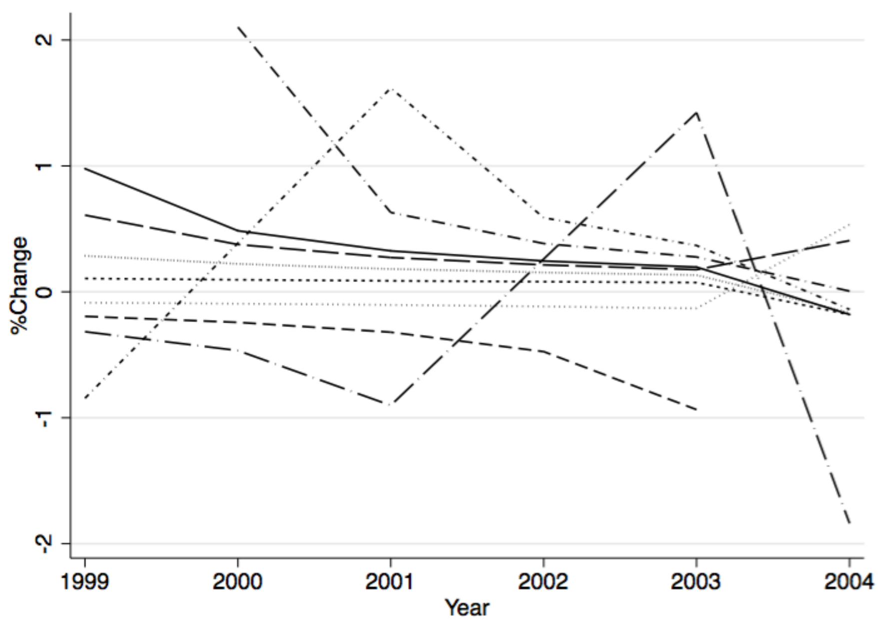

Figure 25: 1999-2004 Change in Total Factor Productivity
Figure plots the percent change in total factor productivity calculated using the Solow residual method for Mexico City, Guadalajara, Monterrey, Puebla, Len, Torren, San Luis Potos, Mrida, Chihuahua and Tampico.