# What Drives Underdevelopment? *

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**Abstract**
In Mexican census data, the mean labor tax wedge increases with plant size within most manufacturing industries as does the mean overall labor wedge, inferred from theory and data. These calculations defend the claim that size-dependent taxation is a driver of low productivity in Mexico. A formula is derived for the marginal productivity change from reallocating inputs that is stated in terms of input wedges. Using Mexican data, reallocating more labor to high labor input plants produces positive marginal productivity gains but reallocating more intermediate input to high intermediate input plants produces essentially zero gains. These results hold as there is a positive size gradient to the labor wedge but approximately a zero size gradient to the intermediate input wedge.

**Keywords**: Development, Productivity, Misallocation, Manufacturing, Labor Wedge

**JEL Classification:** O1, H2, E2

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# 1 Introduction

What drives underdevelopment? One view is that a wide variety of domestic, policy-related distortions are key. In this view, underdevelopment is, in part, self-inflicted.

Levy (2018) "Under-Rewarded Efforts: The Elusive Quest for Prosperity in Mexico" provides one articulation of this view. He argues that a combination of tax, labor contracting and enforcement policies imply that some large Mexican establishments face high marginal tax rates on both revenues and labor costs and many small establishments face low tax rates. He then conjectures that alternative policies that address size-dependent input misallocation are likely to be important for increasing productivity.

This paper assesses the Levy narrative and has two main contributions. First, a labor tax wedge is constructed for each manufacturing plant in the Mexican census based on social security and value-added tax payments and on imputed income taxes. This wedge equals one plus the marginal tax rate on labor expenditures as a ratio to one minus the marginal tax rate on revenue. In theory a larger labor tax wedge reduces plant size, other things equal. We document that the mean labor tax wedge robustly increases with plant size within industries. This finding supports the first part of the Levy narrative: larger plants face larger labor tax wedges.

In theory, any source of dispersion in overall labor wedges (i.e. the ratio of price to the marginal cost of production using labor) is associated with production inefficiency so that a reallocation of labor inputs can increase output within industries. Labor tax wedges are a source of variation in the overall wedge but other sources (e.g. differences in market power, government or private-sector extortion and regulation) are possible.[1] Size variation in the overall labor wedge is inferred using theory and data. The mean overall wedge robustly increases with size within industries and its size gradient exceeds the size gradient of the labor tax wedge. This suggests that the tax system does not moderate the gradient of overall labor wedges but instead further increases misallocation by increasing size-dependence in the labor wedge.

The second contribution analyzes the productivity consequences of input reallocations. We derive a formula for the marginal productivity gain or loss in industry output from input reallocations that is stated in terms of input wedges and reallocations. The theory is quite general as it makes no parametric assumptions on functional forms for production functions or on the distribution of productivity and product quality across plants. After applying this formula to data, labor reallocations from small to large plants are found to increase productivity robustly within industries, whereas the corresponding intermediate input reallocations, from

[1] An account of extortion in the tortilla business in Mexico is presented in "How Mexico's Cartels Infiltrated the Tortilla Business", Washington Post, May 23, 2024, by M. Sheridan, L. Rios and F. Ramos.

small to large, have a negligible marginal impact on productivity. These results hold because in theory productivity increases when positive input reallocations occur on average at high wedge plants, for that input, and because in the data the labor wedge has a positive size gradient but the intermediate input wedge has approximately a zero size gradient.

# 2 Related Literature

1. Development Accounting:

   Many papers (Inter-American Development Bank (2010), Kehoe and Ruhl (2010), Hanson (2010) and Restuccia (2013)) calculate levels and growth rates of GDP per person and total factor productivity (TFP) in Latin American countries and in comparison countries. According to Restuccia (2013), the main source of low GDP per person in Latin American countries relative to the US is not differences in employment rates, hours per worker, capital-output ratios or measured educational levels relative to the US. Instead, it is attributed to persistently low relative values of aggregate TFP. He concludes that the Latin American development problem is a TFP problem. The Levy narrative suggests that low TFP in Mexico arises, in part, from size-dependent labor wedges originating in the tax system and related institutions.

2. Misallocation and Size Dependence:

   Hopenhayn (2014) and Restuccia and Rogerson (2017) review the misallocation literature. They emphasize that the early literature calculates productivity increases from the hypothetical elimination of all wedges.[2] Our work is related to Hsieh and Klenow (2009), who infer wedge dispersion properties from data, first-order conditions and functional form assumptions. We differ by providing evidence on size dependence for two labor wedges and the two intermediate input wedges and by providing evidence of the productivity consequences of size-dependent input reallocations.

   Asker, Collard-Wexler and De Loecker (2014) document that the dispersion in the average revenue product of capital (ARPK) is greater in US industries with larger revenue TFP shocks. They argue that this fact is well explained by standard models with shocks impacting revenue TFP and with frictions (i.e. time-to-build or capital adjustment costs). They do not view ARPK dispersion as reflecting capital misallocation.[3] We focus on

[2]Guner, Ventura and Xu (2008) and Restuccia and Rogerson (2008) analyze the hypothetical elimination of size-dependent wedges. Garicano, Lelarge, and Van Reenen (2016) infer the structure of a size-dependent regulation cost to account for a bulge in the French firm size distribution.

[3]David, Venkateswaran, Cusolito, and Didier (2021) argue that distortions play a significant role in measured

misallocation arising from variable input choices (e.g. labor and intermediate input) where such frictions seem less relevant.

Our evidence on size dependence is unaffected by proportional measure error (see Theorem 1). Measurement error is a major issue in interpreting levels and trends in allocative efficiency or misallocation calculations in the literature. See Hsieh and Klenow (2009), Blackwood, Foster, Grim Haltiwanger and Wolf (2021) and Rotemberg and White (2021) for perspectives on this issue.

3. Mexican Data:

   Levy (2018) describes plant size and productivity distributions, legal forms of labor contracting, different types of firm-level taxes and provides a narrative for the productivity consequences of labor contracting, firm taxation and enforcement policies. Many papers use Mexican data and the Hsieh-Klenow methodology to calculate productivity gains from hypothetically eliminating all wedges.[4] Our work differs by providing evidence on size dependence in wedges. Documenting size dependence in any one tax rate does not document that any tax-based wedge is size dependent as this property depends on multiple taxes.[5] Our work also differs in its focus on marginal productivity gains from reallocations. These gains can be calculated without making strong assumptions on primitives, whereas Hsieh-Klenow productivity calculations use many parametric assumptions (e.g. Cobb-Douglas production and a CES aggregator among others) and treat capital as a variable input. Many papers analyze policy counterfactuals based on Mexican data: Sanchez-Vela and Valero-Gill (2011), Anton, Hernandez and Levy (2012), Leal-Ordonez (2014), and Alvarez and Ruane (2019). We differ by ... .

# 3 Wedges: Theory

This section provides theory that (i) shows how size dependence in wedges can be inferred from observables, (ii) connects dispersion in wedges to production inefficiency and (iii) shows that properties of wedges determine the magnitude of productivity gains from input reallocations.

ARPK dispersion in many countries. Kaymak and Schott (2024) analyze capital misallocation in US data based on firm-level corporate tax rates.

[4]See Inter-American Development Bank (2010), Busso, Madrigal and Pages (2013), Levy (2018) and Orozco Vazquez (2023) among others.

[5]Busso, Levy and Torres (2019) document that social security tax rates increase with plant size. Bachas, Fattal Jaef and Jensen (2019) document that tax enforcement and compliance increase with firm size in many countries including Mexico. Bachas, Brockmeyer, Dom and Semelet (2023) document that average corporate tax rates increase with corporate profits in many countries including Mexico.

## 3.1 Infering Size Dependence in Wedges

Assume that plants within an industry differ in a state variable $v = (z_1, z_2, \tau) \in V$ and solve problem P1 by choosing variable inputs $(x_1, ..., x_J)$ to maximize after-tax profits.[6]

$$P1 \;\; \max P(y, z_2, Y)y - \textstyle\sum_{j=1}^{J} w_j x_j - T(w_1 x_1, ..., w_J x_J, P(y, z_2, Y)y; \tau) \; s.t. \; y = z_1 F(x_1, ..., x_J)$$

In the analysis that follows (i) $P(y, z_2, Y)$ is the relationship between the plant's output, output quality, aggregate output $(y, z_2, Y)$ and price, (ii) $y = z_1 F(x_1, ..., x_J)$ is a plant's production function, where $z_1$ is productivity, (iii) $w_j$ is the price of input $j$ and (iv) $T$ is a tax function, where $\tau$ is a plant-specific vector affecting taxes paid.

The first equation below is a first-order necessary condition for a solution to P1. It states that marginal revenue of an extra unit of output equals the marginal cost of producing an extra unit of output with input $j$ after accounting for marginal tax rates on revenue and the input expenditure. The marginal tax rate on input expenditure $j$ and revenue are denoted $T_j = \partial T / \partial w_j x_j$ and $T_{J+1} = \partial T / \partial P(y, z_2, Y)y$, whereas the marginal product of input $j$ is denoted $z_1 F_j = z_1 \partial F / \partial x_j$. The second equation restates this first-order condition and says that the price equals the product of the marginal cost of production exclusive of taxes and an overall wedge term. The overall wedge term $wedge_j$ can be viewed as the ratio of price to the marginal cost of production using input $j$. It can be decomposed as the product of a markup wedge and a tax wedge specific to input $j$. The *tax* $wedge_j$ is one plus the marginal tax rate on input expenditure $j$ as a ratio to one minus the marginal tax rate on output expenditure (i.e. total revenue). The third equation restates the first-order condition in terms of the revenue-expenditure ratio. The fourth equation replaces the elasticity of a plant's output with respect to variable input $j$ with a constant value $\alpha_j$, which holds when production functions are Cobb-Douglas $y = z_1 F(x_1, ..., x_J) = z_1 \prod_{j=1}^{J} x_j^{\alpha_j}$.

$$P_1(y, z_2, Y)y + P(y, z_2, Y) = \tfrac{w_j}{z_1 F_j(x_1, ..., x_J)} \left( \tfrac{1 + T_j(w_1 x_1, ..., w_J x_J, P(y, z_2, Y)y; \tau)}{1 - T_{J+1}(w_1 x_1, ..., w_J x_J, P(y, z_2, Y)y; \tau)} \right)$$

$$P(y, z_2, Y) = \tfrac{w_j}{z_1 F_j(x_1, ..., x_J)} \underbrace{\frac{1 + T_j}{1 - T_{J+1}}}_{tax \; wedge_j} \underbrace{\frac{1}{1 + \frac{P_1(y, z_2, Y)y}{P(y, z_2, Y)}}}_{markup \; wedge} = \tfrac{w_j}{z_1 F_j(x_1, ..., x_J)} wedge_j$$

$$\ln \tfrac{P(y, z_2, Y)y}{w_j x_j} = \ln \tfrac{1}{z_1 F_j} \tfrac{y}{x_j} + \ln wedge_j$$

$$\ln wedge_j = \ln \tfrac{P(y, z_2, Y)y}{w_j x_j} + \ln \alpha_j$$

[6] Problem P1 may be part of the solution to a larger problem, which can be dynamic and have other inputs (e.g. capital). The key assumption is that variable input choices $(x_1, ..., x_J)$ are optimal, conditional on values of current and past choices (e.g. capital), state variables, input prices and the tax function.

Theorem 1 states assumptions so that size dependent wedge properties can be inferred from observables. Assumption $A1$ restates the first-order condition and defines the measurement error $\epsilon_j$. In $A1$, $\frac{Rev}{w_j x_j}$ and $\frac{\tilde{Rev}}{w_j x_j}$ denote true and measured values of the revenue-expenditure ratio. The revenue-expenditure ratio is stated as $\frac{Rev}{w_j x_j}$ rather than $\frac{P(y,z_2,Y)y}{w_j x_j}$. Assumption $A1$ implies that $(*)$ holds. Assumption $A2$ and $A3$ are assumptions on the measurement error in relation to a measure of size $s$.

A1 $\ln wedge_j = \ln \frac{Rev}{w_j x_j} + \ln \alpha_j$ and $\ln \frac{\tilde{Rev}}{w_j x_j} = \ln \frac{Rev}{w_j x_j} + \epsilon_j$

A2 $E[\epsilon_j|s]$ is invariant to $s$

A3 $Var(\epsilon_j|s)$ and $Cov(\ln \frac{\tilde{Rev}}{w_j x_j}, \epsilon_j|s)$ are invariant to $s$

$$(*)\ \ln wedge_j = \ln \frac{\tilde{Rev}}{w_j x_j} + \ln \alpha_j - \epsilon_j$$

**Theorem 1:** *Assume A1. Then for all size values $s, s_0$ and any $j = 1, ..., J$*

*(i)* $E[\ln wedge_j|s] - E[\ln wedge_j|s_0] = E[\ln \frac{\tilde{Rev}}{w_j x_j}|s] - E[\ln \frac{\tilde{Rev}}{w_j x_j}|s_0]$ *provided A2 holds.*

*(ii)* $Var(\ln wedge_j|s) - Var(\ln wedge_j|s_0) = Var(\ln \frac{\tilde{Rev}}{w_j x_j}|s) - Var(\ln \frac{\tilde{Rev}}{w_j x_j}|s_0)$ *provided A3 holds.*

Proof:

(i) Take the conditional expectation of $(*)$ and calculate differences to produce the equation below. Assumption $A2$ produces the conclusion.

$$E[\ln wedge_j|s] - E[\ln wedge_j|s_0] = E[\ln \frac{\tilde{Rev}}{w_j x_j}|s] - E[\ln \frac{\tilde{Rev}}{w_j x_j}|s_0] - E[\epsilon_j|s] + E[\epsilon_j|s_0]$$

(ii) Take the conditional variance of $(*)$ to produce the equation below. The conclusion follows by calculating differences and applying assumption $A3$.

$$Var(\ln wedge_j|s) = Var(\ln \frac{\tilde{Rev}}{w_j x_j}|s) + Var(\epsilon_j|s) - 2Cov(\ln \frac{\tilde{Rev}}{w_j x_j}, \epsilon_j|s) \quad \|$$

Comment: Proportional measurement error in the revenue-expenditure ratio produces an additive log error $\epsilon_j$. Independence of $\epsilon_j$ and $s$ imply that $E[\epsilon_j|s]$ is invariant to $s$. Thus, proportional measurement error that is independent of a measure of size are sufficient to imply $A2$.

## 3.2 Wedges and Production Efficiency

Production efficiency occurs when it is not possible to reallocate inputs to increase output. To connect properties of wedges to production efficiency, theorize that a competitive bundler produces a final good using the differentiated output of all the plants. The bundler maximizes profit (i.e. output $Y$ less input costs $\int_V p(v)y(v)d\mu$), taking input prices $p(v)$ as given. Input prices are stated in units of the bundler's output. The bundler's output $Y$ satisfies the production relationship $\int_V z_2\mathcal{Y}(y(v)/Y)d\mu = 1$, where $\mathcal{Y}$ is a Kimball (1995) aggregator, $v \in V$ is a state variable and $\mu$ is a measure of plants over the set $V$ of state variables. Profit maximization implies that the first-order condition $p(v) = z_2\mathcal{Y}'(\frac{y(v)}{Y})/\int_V z_2\mathcal{Y}'(\frac{y(v)}{Y})\frac{y(v)}{Y}d\mu$ holds and generates the demand relationship $P(y, z_2, Y)$ that was assumed in problem $P1$.[7]

$$P(y, z_2, Y) = z_2\mathcal{Y}'(\tfrac{y}{Y})/\int_V z_2\mathcal{Y}'(\tfrac{y(v)}{Y})\tfrac{y(v)}{Y}d\mu$$

Given a measure $\mu$, $(x(v), y(v), Y)$ is a feasible allocation provided (i) $y(v) = z_1F(x(v))$, where $x(v) = (x_1(v), ..., x_J(v))$, (ii) $\int_V x_j(v)d\mu = 1$ for $j = 1, ..., J-1$, (iii) $\int_V z_2\mathcal{Y}(y(v)/Y)d\mu = 1$ and (iv) $\hat{Y} \equiv Y - \int_V x_J(v)d\mu > 0$. Thus, $\hat{Y}$ is the final production of the ouput good and part of the total production $Y$ is used as intermediate input.

Given primitives $(F, \mathcal{Y}, \mu)$, Theorem 2 establishes two points. First, production efficiency implies that there is no dispersion in the marginal product of input $j$ for the final output good when the marginal input is channeled to any plant and the plant's marginal output is then channeled to the bundler. Second, there can be no dispersion in any wedge if production efficiency is to hold within this market structure. The Levy (2018) narrative highlights one possible source of dispersion in wedges: size dependence in $tax\ wedge_j$ that arises from the tax system and related institutions.

**Theorem 2:** *Assume $(x(v), y(v), Y)$ is feasible.*

*(i) If $(x(v), y(v), Y)$ is production efficient, then $z_2\mathcal{Y}'(y(v)/Y)z_1F_j(x(v))$ is constant for each $j = 1, ..., J$.*

*(ii) If $(x(v), y(v), Y)$ is production efficient and consistent with solutions to the plants' and the bundler's problem, then there is no dispersion in $wedge_j$ for $j = 1, ..., J$.*

[7] Profit maximization implies cost minimization. The Lagrangean for the cost minimization problem is $\mathcal{L}(y, Y) = \int_V p(v)y(v)d\mu + \lambda(1 - \int_E z_2\mathcal{Y}(y(v)/Y)d\mu)$. Apply Luenberger (1969, Thm. 2, Ch. 7.7) to argue that at a minimum, there is a Lagrange multiplier $\lambda$ so that the Gateaux derivative $\delta\mathcal{L}(y, Y; h)$ in direction $h$ satisfies $\delta\mathcal{L}(y, Y; h) = \int_V [p(v) - \frac{\lambda}{Y}z_2\mathcal{Y}'(\frac{y(v)}{Y})]h(v)d\mu = 0$ for all directions $h$. This condition and zero profits produces the condition in the text. A Kimball aggregator, where $\mathcal{Y}(1) = 1, \mathcal{Y}'(x) > 0, \mathcal{Y}''(x) < 0$, implies a downward sloping demand curve.

Proof:

(i) Let $H(Y,\alpha;x,\bar{x}) \equiv \int_V z_2\mathcal{Y}(\frac{z_1F(x(v)+\alpha\bar{x}(v))}{Y})d\mu - 1$, where $\bar{x}$ is a zero-mean input reallocation (i.e. $\int_V \bar{x}(v)d\mu = \vec{0}$). By feasibility, $H(Y,0;x,\bar{x}) = 0$. If $(x(v),y(v),Y)$ is production efficient, then there is no $\alpha$ and no $\bar{x}$ that increases the bundler's output. The Implicit Function Theorem and production efficiency imply $\frac{dY}{d\alpha}(0) = -\frac{H_2(Y,0;x,\bar{x})}{H_1(Y,0;x,\bar{x})} = \frac{\int_V z_2\mathcal{Y}'(\frac{y(v)}{Y})\frac{\sum_j z_1F_j(x(v))\bar{x}_j(v)}{Y}d\mu}{\int_V z_2\mathcal{Y}'(\frac{y(v)}{Y})\frac{z_1F(x(v))}{Y^2}d\mu} = 0$ for all zero-mean input reallocations $\bar{x}$. For this to hold $z_2\mathcal{Y}'(y(v)/Y)z_1F_j(x(v))$ must be constant for each $j = 1,...,J$.

(ii) Combine the plants' and the bundler's first-order condition to produce the leftmost equation below. Thus, there is a price function solving the bundler's problem and common factor prices $w_j$ that satisfy the plants' first-order condition. Achieving production efficiency, with this market structure, requires by Theorem 2(i) that $wedge_j$ is equal across plants.

$$\frac{z_2\mathcal{Y}'(\frac{y(v)}{Y})}{\int_V z_2\mathcal{Y}'(\frac{y(v)}{Y})\frac{y(v)}{Y}d\mu} = P(y(v),z_2,Y) = \frac{w_j}{z_1F_j(x(v))}wedge_j(v) \;\Rightarrow\; \frac{z_2\mathcal{Y}'(\frac{y(v)}{Y})z_1F_j(x(v))}{\int_V z_2\mathcal{Y}'(\frac{y(v)}{Y})\frac{y(v)}{Y}d\mu} = w_j\ wedge_j(v)$$
$$\|$$

## 3.3 Wedges and Productivity Gains

Using system $(**)$, define the productivity gain $\Omega(\lambda)$ of moving a fraction $\lambda \in [0,1]$ of the way from feasible allocation $(x(v),y(v),Y)$ towards feasible allocation $(x^*(v),y^*(v),Y^*)$.

$$(**)\quad 1+\Omega(\lambda) = \frac{Y(\lambda) - \int_V (x_J(v) + \lambda(x_J^*(v) - x_J(v)))d\mu}{Y - \int_V x_J(v)d\mu}$$

$$\int_V z_2\mathcal{Y}(\frac{z_1F(x(v)+\lambda(x^*(v)-x(v)))}{Y(\lambda)})d\mu = 1$$

Theorem 3 provides a formula for the marginal productivity gain of moving towards an alternative allocation. The marginal gain is the factor share weighted sum of the reallocation gains arising from adjusting each input. The reallocation gain is stated in terms of the input wedges and the inputs reallocated, where $\hat{E}_j$ is the cost weighted expectations operator for input $j$. The reallocation term is zero for each primary input absent wedge dispersion, consistent with Theorem 2, and is positive when input is shifted towards higher wedge plants.

**Theorem 3:** *Assume $(x(v),y(v),Y)$ and $(x^*(v),y^*(v),Y^*)$ are feasible, where $(x(v),y(v),Y)$ is consistent with solutions to the plants' and the bundler's problem. Then $\Omega(\lambda) = \int_0^\lambda \Omega'(\bar{\lambda})d\bar{\lambda}$ and $\Omega'(0) = \sum_{j=1}^J \omega_j\hat{E}_j[wedge_j\frac{(x_j^*-x_j)}{x_j}] - \frac{\int_V(x_J^*-x_J)d\mu}{[Y-\int_V x_Jd\mu]}$, where $\omega_j = \frac{\int_V w_jx_jd\mu}{Y-\int_V x_Jd\mu}$ is the share of final output paid for input $j$.*

Proof: $\Omega(\lambda) - \Omega(0) = \int_0^\lambda \Omega'(\bar{\lambda})d\bar{\lambda}$ follows from the Fundamental Theorem of Calculus. The result follows as $\Omega(0) = 0$. Define $x(v;\lambda) = x(v) + \lambda(x^*(v) - x(v))$ and $y(v;\lambda) = z_1 F(x(v;\lambda))$. Feasibility implies

$$Y'(\lambda) = Y(\lambda) \int_V \frac{z_2 \mathcal{Y}'(\frac{y(v;\lambda)}{Y(\lambda)})}{\int z_2 \mathcal{Y}'(\frac{y(v;\lambda)}{Y(\lambda)}) y(v;\lambda) d\mu} \sum_{j=1}^{J} z_1 F_j(x(v;\lambda))(x_j^*(v) - x_j(v)) d\mu$$

$$\Omega'(\lambda) = \frac{Y(\lambda) \int_V \frac{z_2 \mathcal{Y}'(\frac{y(v;\lambda)}{Y(\lambda)})}{\int z_2 \mathcal{Y}'(\frac{y(v;\lambda)}{Y(\lambda)}) y(v;\lambda) d\mu} \sum_{j=1}^{J} z_1 F_j(x(v;\lambda))(x_j^*(v) - x_j(v)) d\mu - \int_E (x_J^*(v) - x_J(v)) d\mu}{Y - \int_V x_J(v) d\mu}$$

Restate the marginal productivity gain using $P(y, z_2, Y) = z_2 \mathcal{Y}'(\frac{y}{Y}) / \int_V z_2 \mathcal{Y}'(\frac{y(v)}{Y}) \frac{y(v)}{Y} d\mu$ and the first-order condition $P(y(v), z_2, Y) z_1 F_j(x(v)) = w_j wedge_j(v)$. Let $\omega_j = \int_V w_j x_j d\mu / [Y - \int_V x_J d\mu]$, $E[\cdot]$ denote the expectation operator based on the probability measure $\mu(\cdot)/\mu(V)$ and $\hat{E}_j[\cdot]$ denote the cost weighted expectation operator for input $j$.

$$\Omega'(0) = \sum_j \int_V \frac{P(y, z_2, Y) z_1 F_j(x)(x_j^* - x_j)}{Y - \int_V x_J d\mu} d\mu - \frac{\int_V (x_J^* - x_J) d\mu}{Y - \int_V x_J d\mu}$$

$$\Omega'(0) = \sum_j \omega_j E[\frac{w_j x_j}{E[w_j x_j]} wedge_j \frac{(x_j^* - x_j)}{x_j}] - \frac{\int_V (x_J^* - x_J) d\mu}{Y - \int_V x_J d\mu}$$

$$\Omega'(0) = \sum_j \omega_j \hat{E}_j[wedge_j \frac{(x_j^* - x_j)}{x_j}] - \frac{\int_V (x_J^* - x_J) d\mu}{Y - \int_V x_J d\mu} \quad \| $$

Comment: The formula holds without making parametric assumptions on the primitives $(F, \mathcal{Y}, \mu)$. It will be applied to data in the next section. One application is to small input reallocations so that $\Omega'(0)$ is likely to closely approximate the overall productivity gain or loss $\Omega(1)$. When reallocations are not small the formula might still be useful. For example, Appendix C shows that it serves as an upper bound on overall productivity gains (i.e. $\Omega'(0) \geq \Omega(1)$) when it can be established that $\Omega''(\lambda) \leq 0$. While the formula is naturally applied to a single industry, a generalization to many industries is straightforward. Proposition C.3 in Appendix C shows that the marginal productivity gains formula for a sector with $S$ industries is $\Omega'(0) = \sum_{s=1}^{S} \sum_{j=1}^{J} \omega_{js} \hat{E}_{js}[wedge_{js} \frac{(x_{js}^* - x_{js})}{x_{js}}] - \frac{\sum_s \int_V (x_{Js}^* - x_{Js}) d\mu_s}{Y - \sum_s \int_V x_{Js} d\mu_s}$, where $\omega_{js}$ is the expenditure on input $j$ in industry $s$ as a share of final output and $\hat{E}_{js}$ is the industry cost-share weighted expectations operator for input $j$. The framework employs a bundler for each industry, a bundler for the final (sector) output good and monopolistic firms producing differentiated goods.

# 4 Empirical Results

This section describes (i) sample selection, (ii) employment structure, (iii) average tax rates, (iv) size dependence in wedges and (v) marginal productivity gain calculations.

## 4.1 Sample Selection

Mexican census data is available for the census years 1999, 2004, 2009, 2014 and 2019. The data include in principle all establishments with a fixed location within sufficiently large urban areas. Our focus is on establishments (i.e. plants) in the manufacturing sector.

Table 1: Sample Selection and Sample Properties

| Description | 1999 | 2004 | 2009 | 2014 | 2019 |
|---|---|---|---|---|---|
| Manufacturing Establishments | 342711 | 328718 | 436851 | 489530 | 579828 |
| Sample 1: 400+ plants | 307066 | 296682 | 402897 | 461260 | 544916 |
| Sample 2: Sample 1 and tax data | 0 | 0 | 402897 | 461260 | 544916 |
| Sample 1 Properties | | | | | |
| Firms w/ 1 Establishment (%) | | | 99.9 | 99.8 | 99.8 |
| Number 6-Digit Industries | 89 | 81 | 84 | 84 | 100 |
| Ave. Estab. per Industry | 3450 | 3663 | 4796 | 5491 | 5449 |
| Median Estab. Size (Employment) | 2 | 2 | 2 | 2 | 2 |
| Median Estab. Size (Revenue) | 84 | 134 | 108 | 120 | 173 |

Note: Sample 1 eliminates plants within six-digit industries with under 400 plants and for which gross output, intermediate input expenditures and total workers are not strictly positive. Sample 2 is Sample 1 after excluding entire years in which value added tax data is missing. Revenue is in units of thousands of Mexican pesos.

Sample 1 contains all manufacturing plants that are in six-digit industries with at least 400 plants and which satisfy some basic positivity restrictions. Table 1 shows that there are more than 80 six-digit industries in any census year and that more than 99 percent of firms have only one plant. Sample 2 eliminates all plants in census year 1999 as all value-added tax information is missing. Sample 2 is used to calculate tax wedges.

## 4.2 Employment Structure

Figure 1 documents the employment structure for our sample based on size bins determined by the total number of workers at a plant. Workers are put into three groups based on classes of

worker types: (1) Owners, Family and Other Non-remunerated Workers, (2) Outsourced and Commisioned Workers and (3) Salaried Workers. Workers in Mexico can be hired on a salaried or a non-salaried basis. Levy (2018, CH. 2) states that a *"salaried worker is a subordinated employee performing the tasks set by the boss/entrepreneur in the location and at the time of the boss's choosing"*. Salaried workers are entitled to social security benefits and the firm is responsible for making social security payments for such workers.[8] Non-salaried workers are not subordinated employees, at least in legal terms if not in reality. They receive some social security benefits, but the firm does not pay social security taxes for these workers.

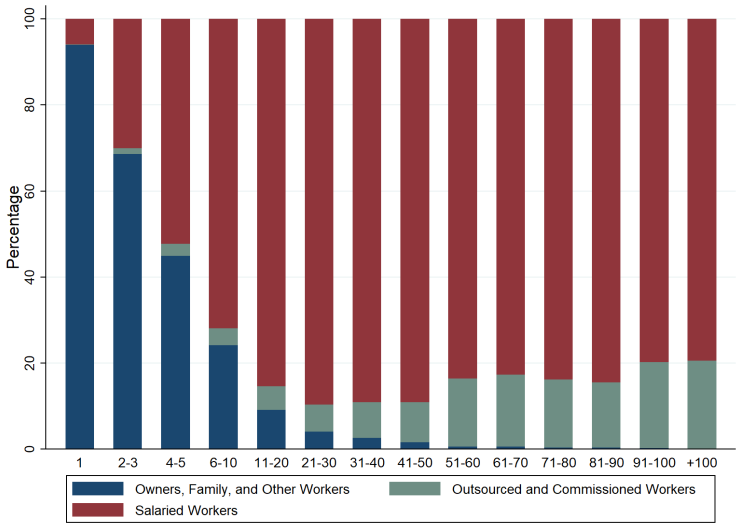



Figure 1: Employment Structure by Plant Size, 2019

Figure 1 shows that small plants employ a much higher fraction of non-salaried workers than larger plants. Specifically, they employ a large fraction of workers in the category "owners, family and other workers" for which the plant does not pay social security taxes. In fact, across all census years, the median value of total social security taxes paid for a plant in our sample is zero.

## 4.3 Average Tax Rates

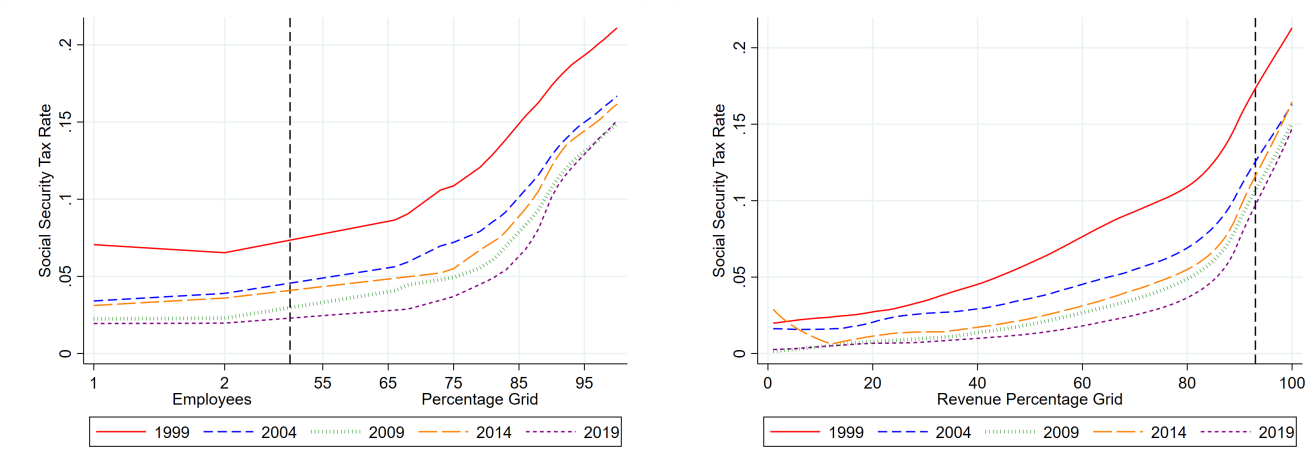
Properties of tax rates are documented for social security, value added and firm income taxes. Small firms in many Latin American countries face a simplified income tax regime. In Mexico, this is the Régimen de Pequeños Contribuyentes (Repeco) for census years 1999, 2004, 2009

[8]Levy (2008, Table 3.7) and Levy (2018, Ch. 2) summarizes the bundled social security benefits (retirement, health, disability, housing, daycare, recreation centers and firing protections) associated with salaried work.

and 2014 and the Régimen de Incorporacion Fiscal (RIF) for 2019. The vast majority of manufacturing firms are Repeco and RIF firms. Under Repeco, firms with revenue below 2 million Mexican pesos pay a tax based on revenues that is administered at the state level. Under RIF, firms with revenue below the same threshold pay income tax under the general regime schedule but are entitled to a percentage reduction in these taxes as well as social security and value added taxes (falling from 100 percent to 0 percent reduction after 10 years within RIF). Firms beyond the threshold fall under the general regime and pay income taxes based on profits. Appendix A provides a general discussion of firm taxation in Mexico.

### 4.3.1 Social Security Tax Rate

Figure 2 plots average social security tax rates in each year as a function of measures of plant size. The social security tax rate for a plant within a size bin is only calculated if the plant makes payments to salaried workers. Thus, it is important to stress that the tax rates are averages among the plants within a size bin that make payments to salaried workers. Across all census years, the median plant social security tax payment is zero.




(a) By Number of Employees (b) By Revenue

Note: The social security tax rate is calculated as the ratio of total social security taxes to wages and salaries of salaried workers. Each point represents the average tax rate for plants within a specific size category, measured by the number of employees (left panel) or revenue (right panel). In the left panel, the horizontal axis left of the vertical line shows plants with one or two employees, while the right side displays a percentage grid starting from three employees. In the right panel, the vertical line marks the percentage grid for the 2-million-peso revenue threshold in 2019.

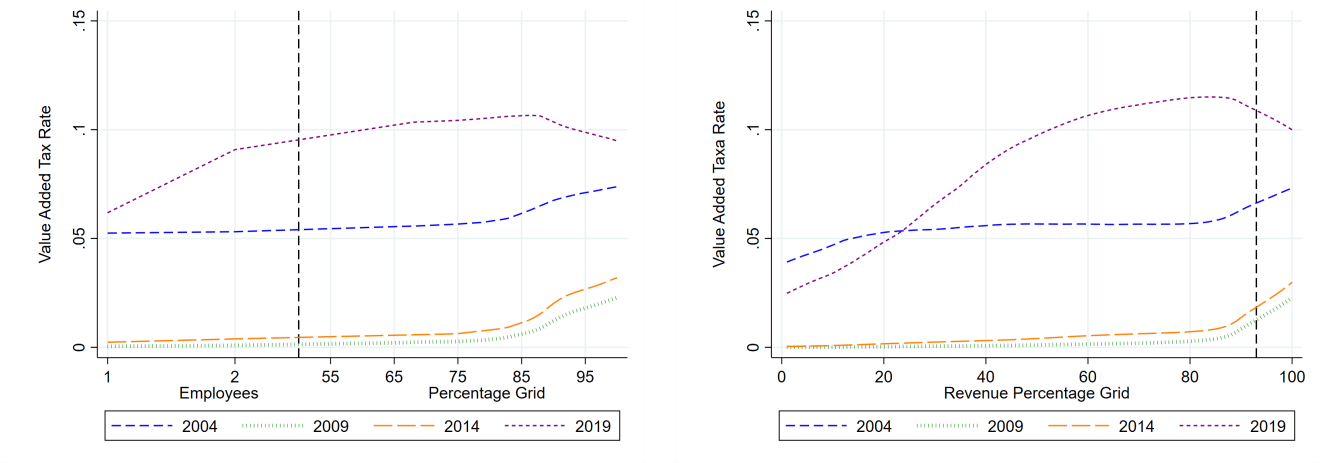
Figure 2: Average Social Security Tax Rate by Plant Size

Figure 2 shows that average social security tax rates generally increase with size, measured by total workers or revenue, in all census years. Plants that are in the largest size bin in a given census year pay a social security tax rate between 15 and 20 percent on average. The size

profile in 2019 in Figure 2(b) is below the profiles in earlier census years. This is consistent with the structure of RIF whereby firms with revenue below the threshold are granted percentage reductions in social security taxes paid.

### 4.3.2 Value Added Tax Rate

Figure 3 plots average value-added tax rates in each year on sales as a function of measures of plant size. Value-added tax rates typically rise with plant size bin, although the pattern in 2019 is quite different. Before 2019, less than 10 percent of the plants in our sample charge positive value-added taxes, whereas in 2019 approximately 68 percent of plants in our sample charge value-added taxes. Thus, a narrative is that reforms applying after the 2014 census year substantially impacted the fraction of plants charging value-added taxes.




(a) By Number of Employees (b) By Revenue

Note: The value added tax rate is calculated as the total value added tax charged divided by total revenue. Each point represents the average tax rate for plants within a specific size category, measured by the number of employees (left panel) or revenue (right panel). In the left panel, the horizontal axis left of the vertical line shows plants with one or two employees, while the right side displays a percentage grid starting from three employees. In the right panel, the vertical line marks the percentage grid for the 2-million-peso revenue threshold in 2019.

Figure 3: Average Value Added Tax Rate by Plant Size

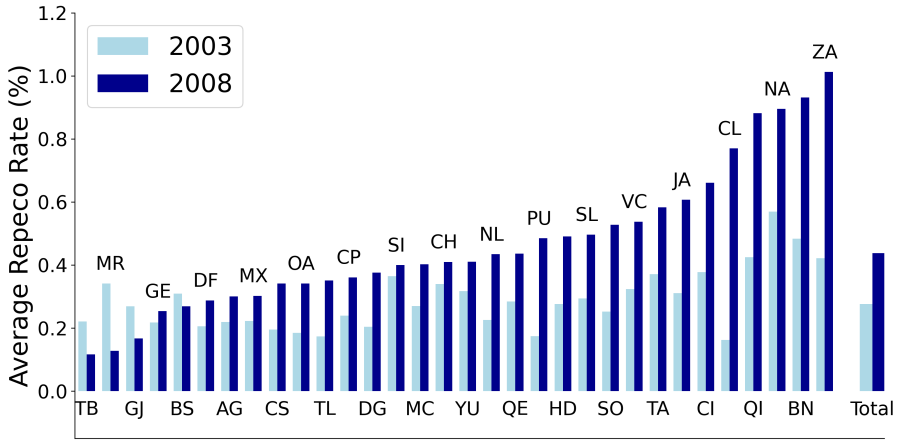
Over the period 1999-2019, the statutory value-added tax rate was 15 percent up until the 2009 tax year and was constant at 16 percent afterwards. Firms that operate in border states and make sales in these border states were granted reduced value-added tax rates in some years. Independent of location, specific goods qualify for a tax rate of 0 percent or are exempt from value-added taxation.[9] Based on these facts, it is not surprising that average value-added tax rates for all size groups are below 15 percent in Figure 3 in all years.

[9] Anton and Hernandez (2010, Table 3) calculate that approximately 45 percent of the expenditures on goods from the manufacturing sector are either zero rated or exempt.

Firms that would qualify as a Repeco lie below the 93 percentile revenue bin in Figure 3. According to Anton et al. (2012, pp. 13-14), Repeco firms were prohibited from issuing invoices charging value-added taxes to firms that pay taxes under the normal value-added tax regime. This would appear to account for the near zero average value added tax rate for plants below this threshold in Figure 3 in 2009 and 2014.[10] The tax rate patterns in 2004 do not seem to fit this narrative as average tax rates for plants well below the Repeco threshold are far from zero and as the statutory rate changed very little across years.

### 4.3.3 Repeco and Firm Profit Tax Rates

Figure 4 plots average Repeco tax rates by state. Average Repeco revenue tax rates are approximately 1 percent or less in any state in any year. Firms that are beyond the Repeco revenue threshold pay income taxes under the general regime. Under the general regime, taxes are flat rate taxes based on firm profits. Across the census years, the flat rate on profits varied from a low of 28 percent to a high of 34 percent - see Table A.5 in Appendix A.



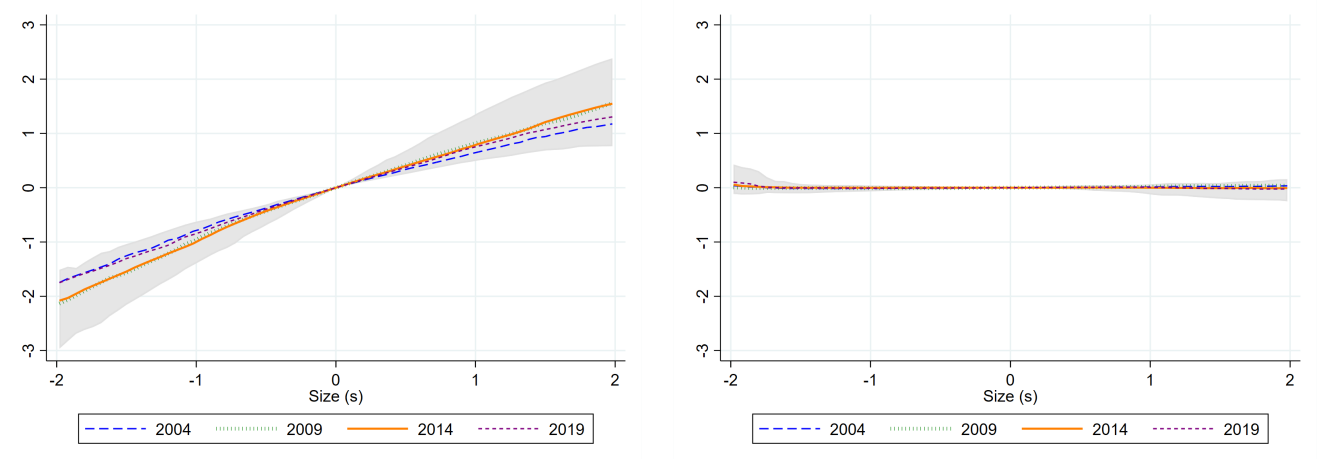

Note: Average Repeco tax rates equal state Repeco tax revenue, reported by Fuentes-Castro et al. (2011, Table 3), divided by total state revenue of Repecos, which is calculated by summing revenue within the universe of all establishments (not just in manufacturing) in the census in a state that have revenue below 2 million pesos. The 2004 and 2009 census correspond to tax years 2003 and 2008. State initials (e.g. GJ is Guanajuato) are employed.

Figure 4: Average Repeco Tax Rates by State

[10]Possible reasons for why average tax rates are non-zero before 2019, for size bins below the threshold, are that the firm/plant crossed the threshold in a previous year and thus no longer qualifies as a Repeco or that the plant is part of a multi-plant firm.

## 4.4 Size Dependence in Wedges

Figure 5 documents size dependence in the mean overall wedge. Based on Theorem 1, size dependence in $E[\ln wedge_j|s] - E[\ln wedge_j|s=0]$ is inferred via a calculation of $E[\ln \frac{\tilde{Rev}}{w_j x_j}|s] - E[\ln \frac{\tilde{Rev}}{w_j x_j}|s=0]$. The construction of revenue, labor expenditures and intermediate input expenditures used in these calculations is described in Appendix B. Plant size measures are demeaned and standardized so that a size measure of $s=0$ is the mean (log) industry size and a size measure of $s=-1,1$ are one standard deviation below and above the mean (log) size measure for the industry, respectively.[11] The conditional mean function $E[\ln \frac{\tilde{Rev}}{w_j x_j}|s]$, for a given variable input $j$, is estimated nonparametrically for each industry.[12]




(a) Labor Wedge (b) Intermediate Input Wedge

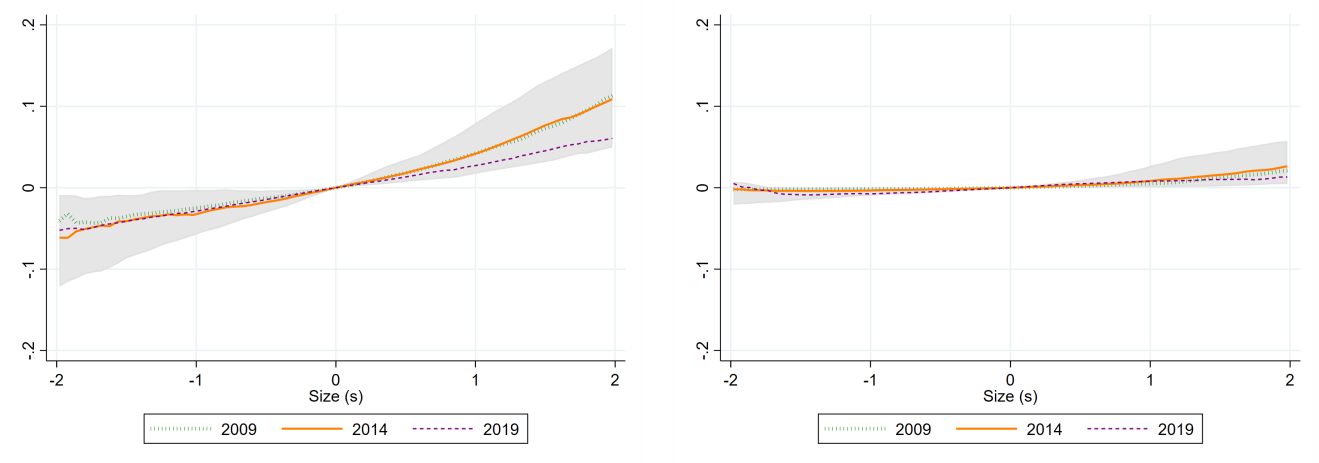
Note: The vertical axis plots $E[\ln wedge_j|s] - E[\ln wedge_j|s=0]$. Size $s$ is measured by log intermediate input expenditure, normalized to standard deviations from the industry mean, for the left panel and normalized log labor expenditure for the right panel. The plotted line shows the median value of $E[\ln wedge_j|s] - E[\ln wedge_j|s=0]$ across industries in a given year. The shaded area represents the 90th to 10th percentile range across industries for year 2014. Industry conditional mean profiles are estimated nonparametrically using an Epanechnikov kernel and a 0.5 bandwidth.

Figure 5: Mean Wedge Size Profiles Inferred from Revenue-Expenditure Ratios

Figure 5 plots the median (pointwise) value of $E[\ln wedge_j|s] - E[\ln wedge_j|s=0]$ across industries for each census year. The labor wedge increases with size each census year. Moreover, as size increases from $s=0$ to $s=1,2$ the labor wedge increases across the vast majority of industries. In contrast, the intermediate input wedge is quite flat across census years. Properties of size dependence above the mean size are emphasized as the vast majority of the inputs used

[11] If the size measure $s = \ln(size)$ were normally distributed then roughly 16 percent and 2 percent of the plants within an industry would have a size value $s$ in excess of $s=1$ and $s=2$ respectively.

[12] Given data $\{(\frac{Rev_i}{Exp_i}, s_i)\}_{i=1}^n$, our estimator for $E[\ln \frac{\tilde{Rev}}{w_j x_j}|s]$ is $\frac{1}{n}\sum_{i=1}^n W_{hi}(s) \ln \frac{Rev_i}{Exp_i}$. The weight function $W_{hi}(s) = \frac{K_h(s-s_i)}{\frac{1}{n}\sum_i K_h(s-s_i)}$ employs the Epanechnikov kernel $K_h$ with bandwidth $h$. See Hardle (1992, Ch. 3).




(a) Labor Tax Wedge (b) Intermediate Input Tax Wedge

Note: The vertical axis plots $E[\ln taxwedge_j|s] - E[\ln taxwedge_j|s=0]$. Size $s$ is measured by log intermediate input expenditure, normalized to standard deviations from the industry mean, for the left panel and normalized log labor expenditure for the right panel. The plotted line shows the median value of $E[\ln taxwedge_j|s] - E[\ln taxwedge_j|s=0]$ across industries in a given year. The shaded area represents the 90th to 10th percentile range across industries for year 2014. Industry conditional mean profiles are estimated nonparametrically using an Epanechnikov kernel and a 0.5 bandwidth. Appendix B documents the computation of tax wedges.

Figure 6: Mean Tax Wedge Size Profiles

and output produced occurs at such plants.

Figure 6 documents size dependence in the tax wedges $E[\ln taxwedge_j|s] - E[\ln taxwedge_j|s = 0]$. Recall that $taxwedge_j = (1+T_j)/(1-T_{J+1})$ is one plus the marginal tax rate on the expenditures of input $j$ divided by one minus the marginal tax rate on revenue - see Problem P1. Appendix B describes how tax wedges are computed using social security and value added tax data and imputing tax rates on income measures based on the simplified or the general income tax regime.

Figure 6 shows that the labor tax wedge increases with size, whereas the intermediate input tax wedge is flat in comparison. These patterns hold for two main reasons. First, the social security tax rate shows substantial size variation. Recall that more than half of all plants pay no social security tax in any census year but that large plants have a high average tax rate. Small plants pay no tax partly because they hire mostly nonsalaried labor - see Figure 1. Levy (2018) views non-salaried labor as a way for many small firms to avoid paying social security taxes. Second, the vast majority of plants charge more value-added tax on their output than they pay on inputs. Such plants pay no marginal (value added) tax on a marginal increase in intermediate input expenditures.[13] Thus, the numerator of the labor tax wedge increases with size, whereas the numerator of the intermediate input tax wedge does not vary with size for the

[13]Appendix B documents the fraction of plants that charge more VAT than they pay or pay more VAT than they charge for each census year.

vast majority of plants. The labor tax wedge displays more than three times the variation (in log points) compared to the intermediate input tax wedge as size moves from $s = 0$ to $s = 2$.

## 4.5 Productivity Gain Calculations

Consider an alternative allocation that changes only one input across plants without changing aggregate industry input. Using Theorem 3, the marginal productivity gain for reallocating input $j = 1$ is given by the leftmost equality below. The rightmost equality evaluates the formula within the sample.

$$\Omega'(0) = \omega_1 \hat{E}_1[wedge_1 \tfrac{(x_1^* - x_1)}{x_1}] = \omega_1 \tfrac{1}{n} \textstyle\sum_{i=1}^n (\tfrac{w_1 x_{1i}}{\frac{1}{n}\sum_i w_1 x_{1i}}) wedge_{1i} (\tfrac{x_{1i}^* - x_{1i}}{x_{1i}})$$

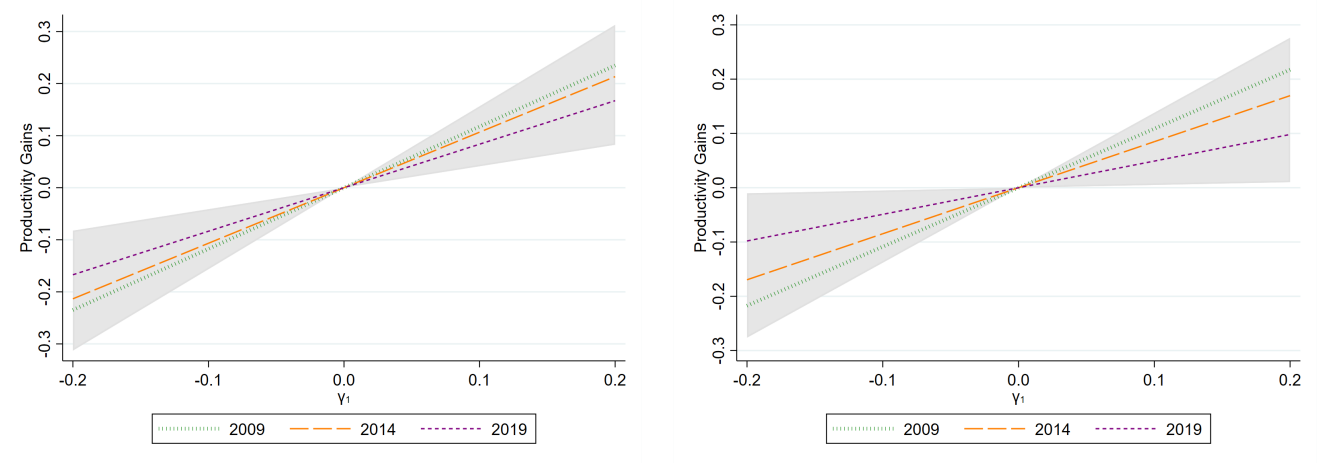
We analyze a simple type of size-dependent reallocation. Consider reallocations $x_1^*$ that raise input $j = 1$ for plants above a threshold $\bar{x}_1$ by a factor $(1+\gamma_1)$ and lower it for plants below the threshold by a factor $(1-\gamma_2)$. In practice, $\bar{x}_1$ is set to the industry mean and $\gamma_2$ is set so the reallocation is feasible. Below we indicate how the formula inputs are measured from census data.

$$\sum_{i=1}^n x_{1i}^* = \sum_{i=1}^n x_{1i}(1+\gamma_1)\mathcal{I}(x_{1i} \geq \bar{x}_1) + \sum_{i=1}^n x_{1i}(1-\gamma_2)\mathcal{I}(x_{1i} < \bar{x}_1) = \sum_{i=1}^n x_{1i}$$

$$\Rightarrow \gamma_2 = \gamma_1 \frac{\sum_i x_{1i}\mathcal{I}(x_{1i} \geq \bar{x}_1)}{\sum_i x_{1i}\mathcal{I}(x_{1i} < \bar{x}_1)}$$

Measurement: $x_{1i} = Exp_{1i}, x_{2i} = Exp_{2i}, wedge_{1i} = \frac{Rev_i}{Exp_{1i}}\alpha_{1i}$, where $(Rev_i, Exp_{1i}, Exp_{2i})$ are revenue, labor and intermediate goods expenditure and $\alpha_{1i}$ is the output elasticity of labor for plant $i$. The cost share is $\frac{w_1 x_{1i}}{\frac{1}{n}\sum_i w_1 x_{1i}} = \frac{x_{1i}}{\frac{1}{n}\sum_i x_{1i}} = \frac{Exp_{1i}}{\frac{1}{n}\sum_i Exp_{1i}}$ and the weight is $\omega_1 = \frac{\sum_i Exp_{1i}}{\sum_i (Rev_i - Exp_{2i})}$. Table B1 in Appendix B describes the construction of plant revenue and expenditures.

Figure 7(a) shows that reallocating more labor towards large plants (i.e. those using more than the mean labor for an industry) and away from small plants robustly produces productivity gains within industries. Intuitively, this result holds (see Figure 5) as such reallocations are to plants with higher labor wedges at least on average and away from plants with on average lower labor wedges. Proposition C.2 in Appendix C establishes that this logic follows from Theorem 3: differences in average wedges across the two groups drive productivity gains in such reallocations. Figure 7(b) shows that reallocating both labor and intermediate input in this way does not systematically increase the marginal productivity gain above that from




(a) Reallocate Labor (b) Reallocate Labor and Intermediate Input

Note: Plotted are the (median) marginal productivity gains from input reallocation by varying the degree of reallocation, $\gamma_1$, above the mean $\bar{x}_1$. Output elasticity $\alpha$ is assumed to be common across sectors and set to one. The calculation is done by industry for industries with number of establishments $\geq 400$. The left panel plots the gains from reallocating labor only; the right panel plot the gains from reallocating both labor and intermediate input. The shaded area represents the 75th to 25th percentile range across industries for year 2014.

Figure 7: Marginal Productivity Gains from Input Reallocation

the labor-only reallocation. This holds as there is approximately a zero size gradient for the intermediate input wedge in any year in any industry (see Figure 5). Thus, the data and Theorem 3 dictate that there is a productivity gain derived from this type of reallocation of labor but that there is very little productivity gain to be derived from this type of reallocation of intermediate inputs within an industry.

# 5 An Equilibrium Analysis

This section has two main goals. First it provides an equilibrium account of properties of Mexican overall wedges and tax wedges. Second, it analyzes the degree to which alternative model tax systems, that alter the size dependence in the labor tax wedge, act to increase or decrease equilibrium productivity. Thus, it provides an equilibrium perspective to the type of empirical productivity gain calculations explored in the previous section.

## 5.1 Model

The model is Lucas (1978) but modified to allow for monopolistic competition, intermediate inputs and a tax system.

1. Agents have utility $u(c)$ over consumption $c$ and choose to be a worker, and supply 1 unit

of labor at wage $w$, or an entrepreneur and receive profit $\pi(z,\tau)$. Agents differ in a state variables $(z,\tau)$. A probability measure $\mu$ describes the distribution of agents over $(z,\tau)$, where $z$ is entrepreneurial ability and $\tau$ is a parameter describing the agent's tax function $T(wx,py;\tau)$ if the agent chooses to be an entrepreneur.

2. Intermediate goods production: $y = zF(x)$

3. Competitive bundler has a CRS production $1 = \int_E \mathcal{Y}(y(z,\tau)/Y)d\mu$ in producing a final good $Y$ from intermediate goods, where $E$ is the set of active entrepeneurs producing differentiated intermediate goods.

4. Government consumption $G$ is financed with taxes.

**Definition:** *Given $G$, an equilibrium is $(c(z,\tau), s(z,\tau), x(z,\tau), y(z,\tau), \pi(z,\tau), P(y,Y), w, Y)$ such that*

1. *agents:* $(c(z,\tau), s(z,\tau)) \in argmax_{c,s}[u(c)|\ c = s\pi(z,\tau) + (1-s)w$ *and* $s \in \{0,1\}]$ *for all* $(z,\tau)$. $E = \{(z,\tau) : s(z,\tau) = 1\}$ *is the set of active entrepreneurs.*

2. *entrepreneur:* $\pi(z,\tau,Y) = P(y(z,\tau),Y)y(z,\tau) - wx(z,\tau) - T(wx(z,\tau), P(y(z,\tau),Y)y(z,\tau);\tau)$ *and* $(x(z,\tau), y(z,\tau)) \in argmax_{x,y} P(y,Y)y - wx - T(wx, P(y)y;\tau)$ *s.t.* $y = zF(x)$ *for all* $(z,\tau)$

3. *bundler:* $y \in argmax_y[Y - \int_E p(z,\tau)y(z,\tau,Y)d\mu]$ *s.t.* $1 = \int_E \mathcal{Y}(y(z,\tau)/Y)d\mu$, *where* $p(z,\tau,Y) = P(y(z,\tau),Y)$ *and* $P(y,Y) = \mathcal{Y}'(\frac{y}{Y}) / \int_E \mathcal{Y}'(\frac{y(z,\tau)}{Y})\frac{y(z,\tau)}{Y}d\mu$.

4. *government:* $G = \int_E T(wx(z,\tau), P(y(z,\tau))y(z,\tau);\tau)d\mu$

5. *feasibility:* $\int c(z,\tau)d\mu + G = Y$ *and* $\int_E x(z,\tau)d\mu = 1 - \mu(E)$

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# Online Appendix: What Drives Underdevelopment?

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**Appendix A Firm Taxation in Mexico** **2**

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# Appendix A Firm Taxation in Mexico

The section summarizes four types of firm taxes in Mexico: social security, value added, simplified regime and general regime income taxes.

## A.1 Social Security Tax

Social Security (SS) contributions in Mexico are established in the LSS (Ley del Seguro Social) and are calculated based on the employee's base salary (salario base de cotización) which includes wages, bonuses, commissions, and other compensation (Article 27), and is capped at 25 times the minimum salary (Article 28).[1] Contributions are shared between employers, employees, and in some cases the government.

The SS Law considers compulsory the contribution to five insurances (Article 11): labor risk; sickness and maternity; disability and life; retirement pensions and severance payment; and childcare and social benefits. Table A.1 indicates the SS Tax rate for firm contributions to each benefit.

Table A.1: Social Security Rates

| Year | Employer | Article |
|---|---|---|
| Fix rate | 20.40% | |
| Risk premium | (0.54% - 7.58%) | 73 |
| Sickness and maternity | 0.07% | 107 |
| Disability and life | 1.75% | 147 |
| Pensions | 1.05% | 25 |
| Retirement | 1.00% | 168 (2% bimonthly) |
| Elder | 3.15% | 2, transient |
| Childcare and social benefits | 1.00% | 211 |
| Total | (28.96% - 36.01%) | |

Note: Elaborated by the authors with information from the SS Law. The SS rates are applied to the base salary that is the salary truncated on 25x minimum wages. The risk premium depends on the firm economic activity specified in the Secondary Rules.

The risk premium depends on the firm economic activity, which are classified in five classes as shown in Table 5. The Secondary Rules of the SS Law assign economic activities to classes. The rate is determined annually and range from 0.54% to 7.58% of the employee's base salary. The risk premium can also be adjusted by the history of workplace accidents.

[1] https://www.ordenjuridico.gob.mx/Documentos/Federal/pdf/wo9056.pdf

Table A.2: Risk premium by class (%)

| Class | % | Examples* |
|---|---|---|
| I | 0.54355 | Clothing manufacturing |
| II | 1.13065 | Hotels and restaurants |
| III | 2.5984 | Agriculture |
| IV | 4.65325 | Machinery production |
| V | 7.58875 | Mining, plastic products, construction |

Social Security Law, Secondary Regulation.

The Social Security system has undergone significant reforms, particularly with the introduction of mandatory individual retirement accounts (AFORES) in 1997. Before 1997, Social Security contributions funded a pay-as-you-go system for pensions, i.e., current workers' contributions funded retiree benefits. The rates were lower, but the system faced sustainability challenges due to demographic and economic changes. The 1997 Pension Reform, introduced AFORES (private individual retirement accounts), where contributions for retirement savings shifted to individual accounts managed by private institutions (Articles 154-168 of the LSS). The retirement component became more explicit, with employers contributing 2% and employees 1.125% of the base salary.

## A.2 Value Added Tax

The Value Added Tax (VAT) in Mexico is regulated by the VAT Law (Ley de Impuesto al Valor Agregado)[2] and is a general consumption tax applied to the sale of goods, provision of services, leasing of goods, and imported goods and services. Businesses collect VAT on their sales and offset it with VAT paid on their purchases (VAT Law, Article 5). The difference is paid to the tax authority (Servicio de Administración Tributaria - SAT). VAT is filed monthly.

Table A.1 shows the VAT rate determined by Article 1 of the VAT Law. During our analysis period, there were two relevant fiscal reforms, 1995,[3] which increased the VAT rate from 10% to 15%, and 2009 reform,[4] which again increased the VAT rate to 16%, which has been the general rate in Mexico since then.

Historically, the VAT rate has differed for firms in the border regions. In the 1995 fiscal reform, Article 2 increased the VAT rate from 6 to 10% for all trade on the frontier (except for real estate) considering both the north and the south frontiers.[6] The 2009 reform increased the VAT rate on the

[2]https://www.diputados.gob.mx/LeyesBiblio/pdf/LIVA.pdf

[3]https://www.diputados.gob.mx/LeyesBiblio/ref/liva/LIVA_ref20_27mar95.pdf

[4]https://www.diputados.gob.mx/LeyesBiblio/ref/liva/LIVA_ref40_07dic09.pdf

[6]The 1995 reform defined the frontier as the 20-kilometer border strip parallel to the international limits to the north and south of the country, the northern States of Baja California and Baja California Sur, and in the south the State of Quintana Roo, and some additional municipalities of Sonora.

Table A.3: Value Added Tax Rate, 1991-2019

| Reform | VAT rate | VAT rate Frontier |
|---|---|---|
| November 1991 | 10 | 6 |
| March 1995 | 15 | 10 |
| December 2009 | 16 | 11 |
| January 2014* | 16 | 16 |
| January 2019* | 16 | 8 |

Note: Constructed by the authors using information from the Value Added Tax Law of 2021[5] and reforms from 2009, 1995, and 1991, and (*) the Executive Orders of 2013 and 2018.

frontier to 11%, still five percentage points below the general rate.

There were two executive orders modifying the VAT rate in border regions. One occurred in 2014, eliminating the special treatment and equalizing the rate in the entire country.[7] A second executive order occurred in 2019 that reduced the VAT rate relative to 8%, but only in around 40 municipalities of the northern frontier.[8]

The VAT law has a 0% rate for food, prescribed medicine and agricultural products (Article 2-A). In these cases, the seller charges no VAT but can still claim input VAT deductions. The law also has exempts some goods and services (Articles 9 and 15, respectively) from VAT, namely residential mortgages, retirement funds, and public education and public transportation. Exemptions for imports are in Article 24, and Exports in Article 29. The list of goods and services exempt from VAT or taxed at 0% has been adjusted over time.

## A.3 Corporate Profit Tax

The Corporate Profit Tax (CPT) in Mexico is regulated by the CPT Law (Ley del Impuesto Sobre la Renta).[9] Article 9, Title II for firms or legal entities (personas morales), of the CPT Law states the rate that firms have to apply to their fiscal year taxable profits.

Table A.4 presents the changes to the CPT rate from 1990 to 2019. Throughout the 90s, the CPT rate remained stable at 34%, until 1999 when the CPT rate increased by one percentage point to 35%. During the 2000s the CPT rate suffered more changes gradually decreasing the tax rate from 35% in the beginning of the decade to 28% by the end. In 2003 the rate decreased to 34%, in 2004 to 33%, in 2005 to 30%, in 2006 to 29%, and in 2007 to 28% remaining stable for the following two years, to finally increase in 2010 to 30%, which has been the CPT rate until 2025.

[7]https://www.dof.gob.mx/nota_detalle.php?codigo=5328038&fecha=26/12/2013#gsc.tab=0
[8]https://www.dof.gob.mx/nota_detalle.php?codigo=5547485&fecha=31/12/2018#gsc.tab=0
[9]https://www.diputados.gob.mx/LeyesBiblio/pdf/LISR.pdf

Table A.4: Corporate Profit Tax, Computation

| Concept | Description | Articles |
|---|---|---|
| Taxable Income | Income from sales, services, leases, and other activities | 16-24 |
| Allowable Expenses | Wages, purchases, depreciation, interest, and operating expenses | 25-30 |
| Tax Credits | Credits for R&D, renewable energy, double taxation agreement | 27-30 |
| Profit | =Taxable Inc - Allow Exp - Tax Credits | |
| Employee Profit Sharing (PTU) | =Profit x 0.10 | 9.I & Const 123 |
| Cumulative Losses | Losses pending to apply from previous years. | 9.II |
| *Corporate Profit Tax* | (Profit – PTU – Cum losses) x CPT Rate | 9 |

Note: Elaborated by the authors with information from the CPT Law.

In 2008 two new income taxes were created as parallel taxes to ISR for legal entities and business owners, the Impuesto Empresarial a Tasa Única, (IETU)[10] and the Impuesto a Depositos en Efectivo (IDE).[11] The IETU is based on the firm total net income and expenditure from both fully and partially paid customer and supplier invoices ((Income – Expenses) x IETU rate). The IETU went from 16.5% in 2008 to 17% in 2009 and 17.5% in 2010 where it remained. Firms paid the maximum between the resulting payables IETU and CPT. The IED taxed cash bank deposits over 25,000 pesos at a 2% rate in 2008 and 3% on deposits over 15,000 pesos starting in 2010. Both taxes were repealed in 2013, keeping CPT as the primary income tax.

## A.4 Simplified Regimes: REPECO and RIF

The Régimen de Pequeños Contribuyentes (Repeco) was established in 1998 as part of Mexico's fiscal reform to simplify tax compliance for small businesses and individuals with low-income levels. It was designed to reduce the administrative burden on taxpayers and improve tax collection among informal economic units.[12]

Essentially, Repeco taxpayers were those with annual income below 2 million pesos (Article 137 - 140, CPT Law of 1998) and paid a fixed amount of 2% of income tax (ISR), and Value Added Tax (IVA), determined by state and municipal governments based on the type and size of their business

[10] https://www.diputados.gob.mx/LeyesBiblio/abro/lietu/LIETU_abro.pdf
[11] https://www.diputados.gob.mx/LeyesBiblio/abro/lide/LIDE_abro.pdf
[12] Azuara, Azuero, Bosch and Torres (2019) describe statutory aspects of the Repeco and RIF regimes.

Table A.5: Corporate Profit Tax Rate, 1990-2024

| Year | ISR | IETU | IDE |
|---|---|---|---|
| 1990 | 34 | | |
| 1999 | 35 | | |
| 2003 | 34 | | |
| 2004 | 33 | | |
| 2005 | 30 | | |
| 2006 | 29 | | |
| 2007 | 28 | | |
| 2008 | 28 | 17.5 | 2 |
| 2010 | 30 | 17.5 | 3 |
| 2014 | 30 | - | - |

Note: CIEP 2016 and information from the Corporate Profit Tax Law reforms.

activities. No detailed bookkeeping was required; instead, simplified reporting was allowed.

Repeco was repealed as part of Mexico's 2014 fiscal reform and replaced by the Régimen de Incorporación Fiscal (RIF) to modernize tax compliance and bring more taxpayers into the formal economy (Federal Official Gazette - DOF, 2013).

Introduced in 2014 under Articles 111-113 of the CPT Law, RIF aimed to incentivize the formalization of micro and small informal businesses to voluntarily register with the tax authority (Servicio de Administración Tributaria, SAT).

RIF offered taxpayers an annual gross income not exceeding 2 million pesos, a progressive tax reduction that went from a reduction of 100% in the first year to 10% in the 10th year (Article 111, LISR, 2014) of the rate in the general regime. RIF firms were exempt from paying IVA or IEPS if their annual income was lower than 300,000 pesos, and exempt from issuing invoices for sales of less than 250 pesos, if not requested by clients.

RIF also considered simplified reporting requirements allowed declarations every other month instead of monthly, and a package of benefits like access to low-price life insurance for entrepreneurs.

The RIF stopped being available to new taxpayers starting in 2022, as it was replaced by the Régimen Simplificado de Confianza (RESICO) under Articles 113-E of the CPT Law. Roughly, taxpayers already enrolled in RIF can continue using the regime until they exceed eligibility limits or choose to transition to RESICO.

# Appendix B Mexican Census Data

## B.1 Variable Construction

Table B.1 indicates how variables are constructed based on 2019 codes. Table B.2 indicates how variable codenames change across census years.

Table B.1: Variable Construction Using 2019 Census Codes

| Variable | Description | Variable Construction and Code Variable Description |
|---|---|---|
| Rev | Gross Revenue | $Rev = \hat{Rev} + VATax = a111a + m001a$<br>a111a = Producción Bruta Total<br>m001a = IVA Cobrado |
| I | Inter. Input Exp. | $I = a121a$<br>a121a = Consumo Intermedio |
| L1 | Total Workers | $L1 = h000a + i000a$<br>h000a = Total de personal dependiente de la razón social<br>i000a = Total de personal no dependiente de la razón social |
| L2 | Hours Worked | $L2 = h000d + i000d$<br>h000d = Total ... dependiente de la razón social. Horas trabajadas<br>i000d = Total ... no dependiente de la razón social. Horas trabajadas |
| L3 | Labor Exp. | $L3 = j010a + j203a + k610a + k620a + wage_i \times h020a$<br>j010a = Total de salarios al personal de producción, ventas y servicios<br>j203a = Total de sueldos al personal administrativo, contable y de dirección<br>k610a = Pagos a otra razón social que contrató y ...<br>k620a = Gastos por honorarios o comisiones sin sueldo o salario fijo<br>h020a = Propietarios, familiares y otros trabajadores no remunerados<br>$wage_i = \frac{\sum_{k \in K_i} (j010a + j203a)_k}{\sum_{k \in K_i} (h101a + h203a)_k}$ industry i compensation per salaried worker<br>$K_i$ = { plants $k$ in industry i: $j010a + j203a > 0$ holds }<br>h101a = Personal de producción, ventas y servicios. Total<br>h203a = Personal administrativo, contable y de dirección. Total<br>i100a = Personal ... contratado y proporcionado por otra razón social. Total<br>i200a = Personal por honorarios o comisiones sin sueldo o salario fijo. Total |
| VARate | VA Tax Rate | $VARate = VATax/Rev = m001a/Rev$ |
| VARateI | VA Input Rate | $VARateI = VATaxPaid/I = k001a/a121a$<br>k001a = IVA Pagado |
| SSRate | SS Tax Rate | $SSRate = SSTax/Sal = (j300a + j400a + j500a)/(j010a + j203a)$<br>j300a = Contribuciones patronales a regímenes de seguridad social<br>j400a = Otras prestaciones sociales<br>j500a = Utilidades repartidas a los trabajadores |

Note: Gross revenue ($Rev$) is measured as inclusive of value-added taxes, consistent with the formmulation of problem P1 from section 3. Next to each variable code we paste the variable description from the Mexican codebook.

## B.2 Constructing Tax Wedges

This section explains how tax wedges for plant $i$ in census year $t \in \{1999, 2004, 2009, 2014\}$ are constructed. Construction of tax wedges for census year 2019 will be addressed later on.

Step 1: Compute $(\tau_{s,t}^{Repeco}, \tau_t^{corp})$.

$\tau_{s,t}^{Repeco} = Repeco\ Tax_{s,t}/Repeco\ Revenue_{s,t}$

$Repeco\ Tax_{s,t}$ is taken from SAT data reported in Fuentes-Castro et al. (2011, Table 3).

$Repeco\ Revenue_{s,t} = \sum_{i \in K_{s,t}} \hat{Rev}_{it}$, where $K_{s,t}$ is the set of plants $i$ located in state $s$ in census year $t$ (in the entire Census) with revenue measure $\hat{Rev}_{it} \leq 2M$.

$\tau_t^{corp} =$ `Statutory Corporate Profit Tax Rate in census year t`

Two clarifications are important. First, the census year refers to data for the previous calendar year. Thus, $Repeco\ Tax_{s,t}$ for state $s$ in census year $t = 2004$ is the empirical state tax aggregate collected from Repeco firms over the calendar year 2003. Second, as Fuentes-Castro et al. (2011, Table 3) report tax aggregates for the calendar years 2000- 2010, some assumption is needed for census year 1999 and 2014. We set $\tau_{s,1999}^{Repeco} = \tau_{s,2004}^{Repeco}$ and $\tau_{s,2014}^{Repeco} = \tau_{s,2009}^{Repeco}$ for all states $s$. Repeco tax rates by state take on the values previously displayed in Figure 4 in the main text. Statutory corporate tax rates are those reported in Table A.5 in Appendix A.

Step 2: Compute tax rates $(\tau_{it}^{ss}, \tau_{it}^{va}, \tau_{it}^{va,m}, \tau_{it}^{r}, \tau_{it}^{c})$ for plant $i$ for $t \in \{1999, 2004, 2009, 2014\}$.

$$\tau_{it}^{ss} = \begin{cases} SSTax_{it}/Sal_{it} & \text{if } Sal_{it} > 0 \\ 0 & \text{otherwise} \end{cases} \tag{B.1}$$

$$\tau_{it}^{va} = VATax_{it}/Rev_{it} \text{ and } \tau_{it}^{va,m} = VATaxPaid_{it}/I_{it} \tag{B.2}$$

$$\tau_{it}^{r} = \begin{cases} \tau_{s(i),t}^{Repeco} & \text{if } \hat{Rev}_{it} \leq 2M \\ 0 & \text{otherwise} \end{cases} \tag{B.3}$$

$$\tau_{it}^{c} = \begin{cases} \tau_t^{corp} & \text{if } \hat{Rev}_{it} > 2M \\ 0 & \text{otherwise} \end{cases} \tag{B.4}$$

Note: $SSTax_{it} = j300a + j400a + j500a$, $Sal_{it} = j010a + j203a$ and $Rev_{it} = \hat{Rev}_{it} + VATax_{it}$. Table A.1 provides code variable description. The notation $s(i)$ denotes the state in which plant $i$ is located.

Step 3: Compute $(taxwedge_{1,i,t}, taxwedge_{2,i,t})$, for labor and intermediate input. Use the tax function $T$ below and treat plant tax rates from Step 2 as proxies for plant marginal rates.

$$T = \begin{cases} \tau_{it}^{ss} Sal_{it} + \max\{\tau_{it}^{va} Rev_{it}, \tau_{it}^{va,m} I_{it}\} + \tau_{it}^{c}(Rev_{it}(1-\tau_{it}^{va}) - Sal_{it}(1+\tau_{it}^{ss}) - I_{it} - \cdots) & \text{if } \hat{Rev}_{it} > 2M \\ \tau_{it}^{ss} Sal_{it} + \max\{\tau_{it}^{va} Rev_{it}, \tau_{it}^{va,m} I_{it}\} + \tau_{it}^{r} Rev_{it}(1-\tau_{it}^{va}) & \text{otherwise} \end{cases} \tag{B.5}$$

In computing tax wedges, cases 1-2 are for plants above the Repeco threshold, whereas cases 3-4 are for plants below the Repeco threshold.

Case 1: $\hat{Rev}_{it} > 2M$ and $\tau_{it}^{va} Rev_{it} \geq \tau_{it}^{va,m} I_{it}$

Case 2: $\hat{Rev}_{it} > 2M$ and $\tau_{it}^{va} Rev_{it} < \tau_{it}^{va,m} I_{it}$

Case 3: $\hat{Rev}_{it} < 2M$ and $\tau_{it}^{va} Rev_{it} \geq \tau_{it}^{va,m} I_{it}$

Case 4: $\hat{Rev}_{it} < 2M$ and $\tau_{it}^{va} Rev_{it} < \tau_{it}^{va,m} I_{it}$

Table B.2: Distribution of Tax Wedge Cases by Year

| Year | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|
| 2009 | 5.4 | 1.5 | 90.5 | 2.6 |
| 2014 | 5.9 | 1.8 | 86.7 | 5.7 |
| 2019 | 6.7 | 2.2 | 85.2 | 5.9 |

Note: The table reports the percentage distribution of plants that satisfy Cases 1-4.

$$taxwedge_{1,i,t} = \frac{1+T_1}{1-T_3} = \begin{cases} \frac{1+[\tau_{it}^{ss} - \tau_{it}^{c}(1+\tau_{it}^{ss})]}{1-[\tau_{it}^{va} + \tau_{it}^{c}(1-\tau_{it}^{va})]} = \frac{1+\tau_{it}^{ss}}{1-\tau_{it}^{va}} & \text{if case 1} \\ \frac{1+[\tau_{it}^{ss} - \tau_{it}^{c}(1+\tau_{it}^{ss})]}{1-[0+\tau_{it}^{c}(1-\tau_{it}^{va})]} = \frac{(1-\tau_{it}^{c})(1+\tau_{it}^{ss})}{1-\tau_{it}^{c}(1-\tau_{it}^{va})} & \text{if case 2} \\ \frac{1+[\tau_{it}^{ss}]}{1-[\tau_{it}^{va} + \tau_{it}^{r}(1-\tau_{it}^{va})]} = \frac{1+\tau_{it}^{ss}}{(1-\tau_{it}^{r})(1-\tau_{it}^{va})} & \text{if case 3} \\ \frac{1+[\tau_{it}^{ss}]}{1-[0+\tau_{it}^{r}(1-\tau_{it}^{va})]} = \frac{1+\tau_{it}^{ss}}{1-\tau_{it}^{r}(1-\tau_{it}^{va})} & \text{if case 4} \end{cases} \tag{B.6}$$

$$taxwedge_{2,i,t} = \frac{1+T_2}{1-T_3} = \begin{cases} \frac{1+[-\tau_{it}^{c}]}{1-[\tau_{it}^{va} + \tau_{it}^{c}(1-\tau_{it}^{va})]} = \frac{1}{1-\tau_{it}^{va}} & \text{if case 1} \\ \frac{1+[\tau_{it}^{va,m} - \tau_{it}^{c}]}{1-[0+\tau_{it}^{c}(1-\tau_{it}^{va})]} = \frac{1+\tau_{it}^{va,m} - \tau_{it}^{c}}{1-\tau_{it}^{c}(1-\tau_{it}^{va})} & \text{if case 2} \\ \frac{1+[0]}{1-[\tau_{it}^{va} + \tau_{it}^{r}(1-\tau_{it}^{va})]} = \frac{1}{(1-\tau_{it}^{r})(1-\tau_{it}^{va})} & \text{if case 3} \\ \frac{1+[\tau_{it}^{va,m}]}{1-[0+\tau_{it}^{r}(1-\tau_{it}^{va})]} = \frac{1+\tau_{it}^{va,m}}{1-\tau_{it}^{r}(1-\tau_{it}^{va})} & \text{if case 4} \end{cases} \tag{B.7}$$

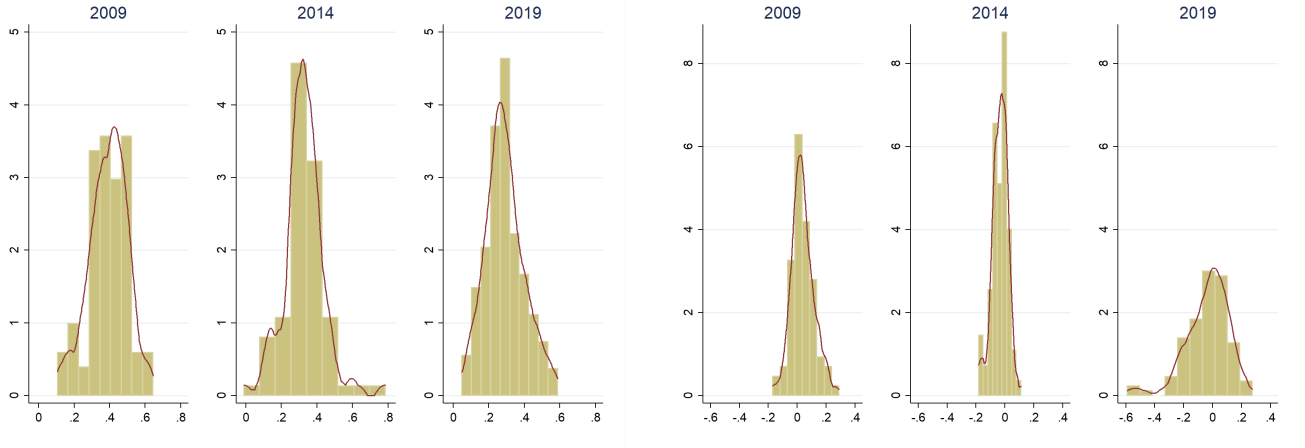
Discussion:

The terms in square brackets above are marginal tax rates $T_1$ for (salaried) labor expenditure, $T_2$ for intermediate goods expenditure and $T_3$ for revenue. Average tax rates $\tau_{it}^{ss}$ on salaried workers are used as the plant's marginal tax rate on all labor expenditure. One argument for this is that if a plant

is off corners in its choice of salaried and non-salaried labor (i.e. hires both salaried and nonsalaried labor) and views both types as perfect substitutes in production that require the same direct wage, then the unobserved expected marginal tax rate on non-salaried labor must equal the marginal rate on salaried labor if it is minimizing expected cost. This argument views the expected cost of non-salaried labor as including probabilistic penalties. For example, when audited, penalties could be based on the portion of non-salaried labor that is determined to infact be salaried labor.

## B.3 Properties of Taxes, Tax Wedges and Revenue

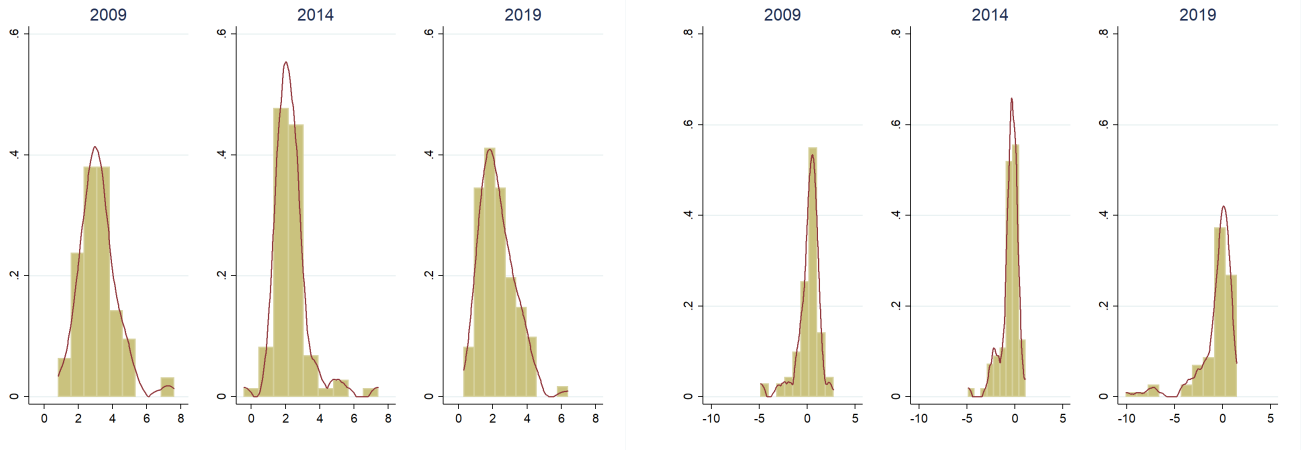
Figure B.1 presents histograms of the industry correlation coefficient between the log wedge and the log taxwedge of an input. Figure B.2 presents histograms of a regression coefficient.




(a) Labor Wedges (b) Intermediate Input Wedges

Note: For each industry, we compute the correlation between $\ln taxwedge_j$ and $\ln \frac{Rev}{w_j x_j}$ across establishments. The figures display histograms and kernel density estimates of these correlation coefficients across industries, based on Sample 2. The left panel is for labor wedges ($j = 1$) and the right panel is for intermediate input wedges ($j = 2$).

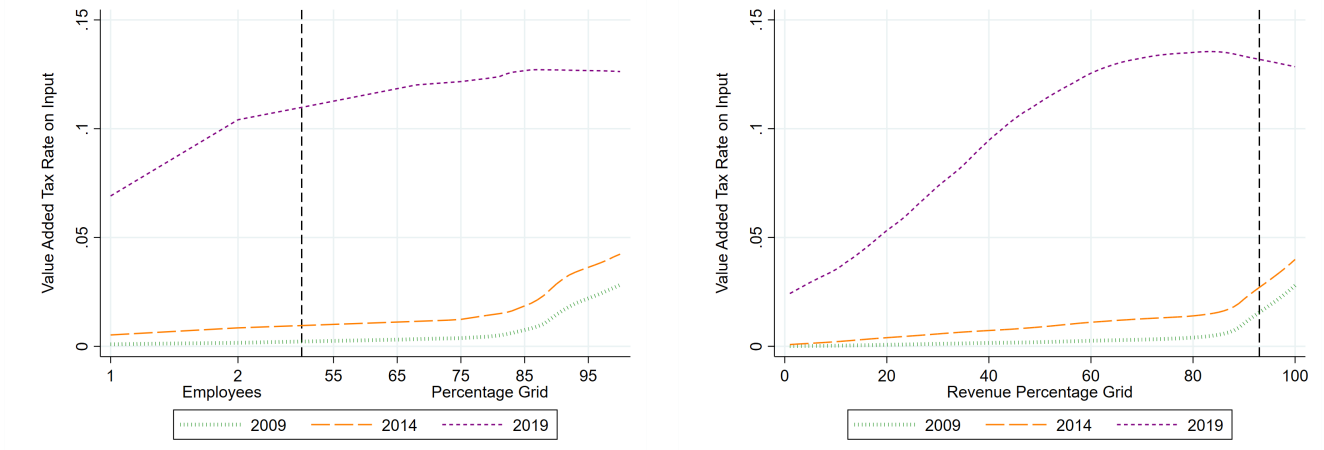
Figure B.1: Cross-Industry Distribution of $Corr(\ln taxwedge_j, \ln \frac{Rev}{w_j x_j})$




(a) Labor Wedges (b) Intermediate Input Wedges

Note: For each industry, we estimate the linear regression $\ln \frac{Rev}{w_j x_j} = \alpha + \beta \ln taxwedge_j + \epsilon$ and collect the regression coefficient $\beta$. The figures display histograms and kernel density estimates of these regression coefficients across industries, based on Sample 2. The left panel is for labor wedges ($j = 1$) and the right panel is for intermediate input wedges ($j = 2$).

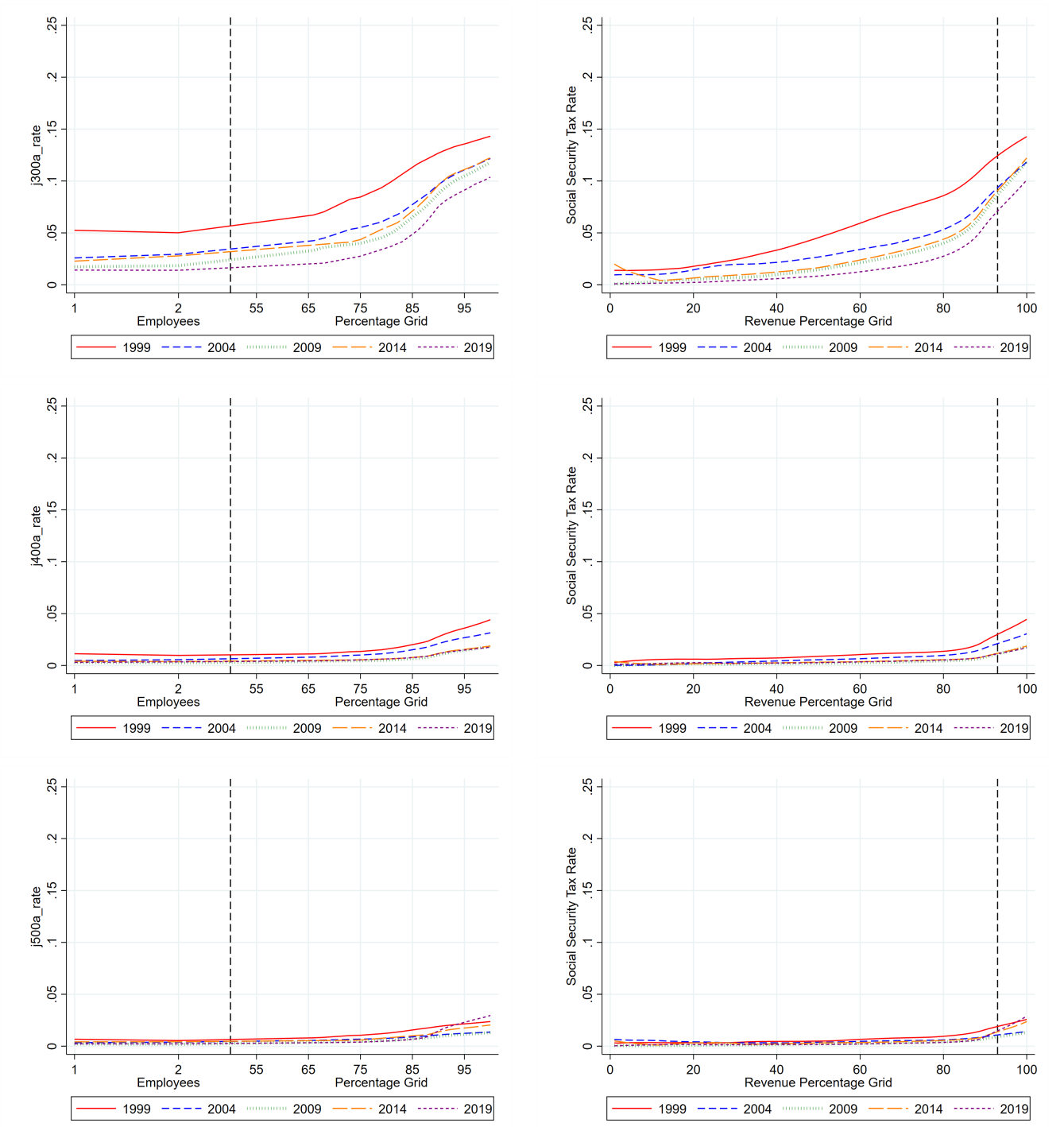
Figure B.2: Cross-Industry Distribution of Wedge Regression Coefficients




(a) By Number of Employees (b) By Revenue

Note: Plotted are value added tax on input divided by intermediate input expenditure.

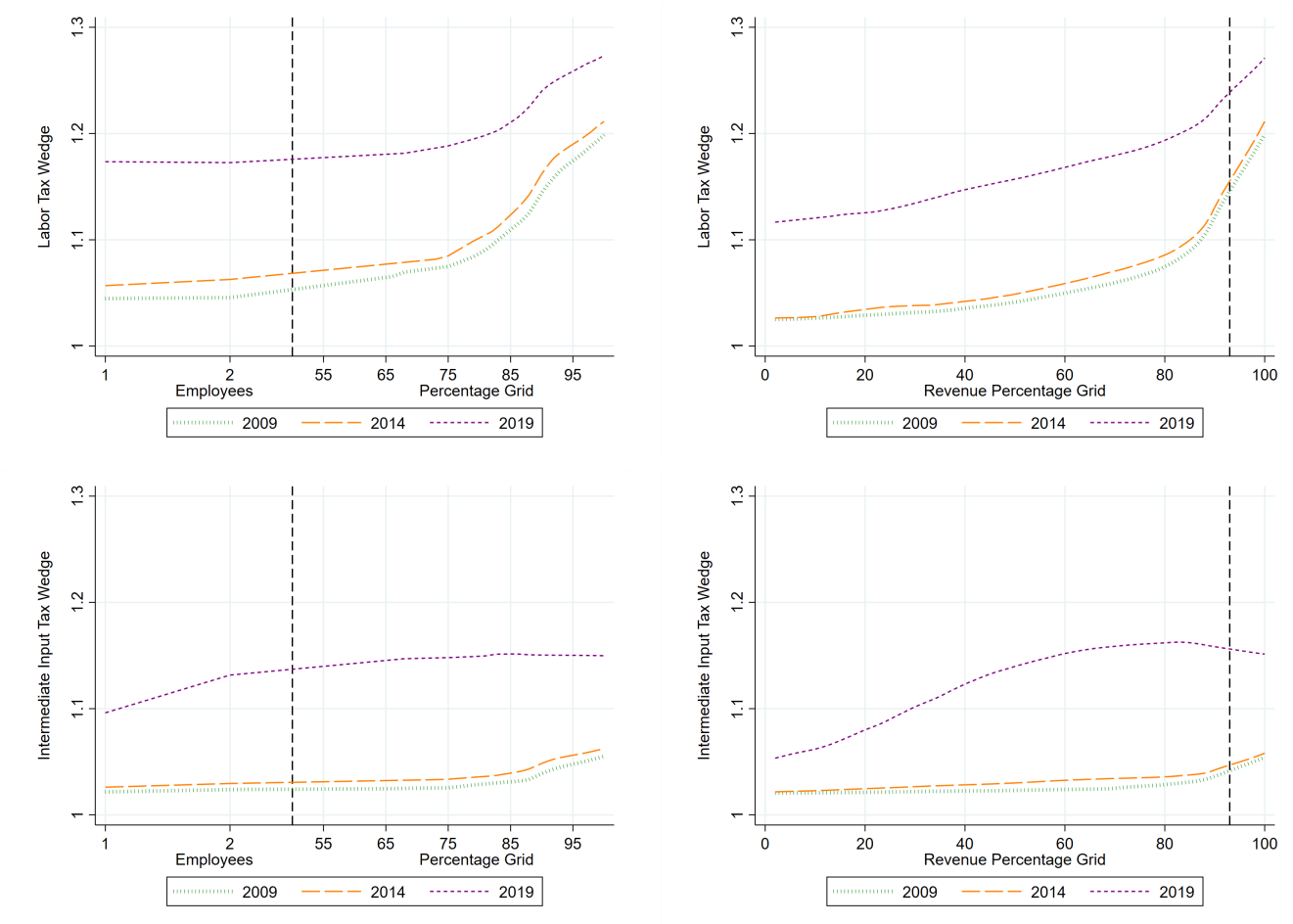
Figure B.3: Value Added Tax Rate on Input by Size




(a) By Number of Employees (b) By Revenue

Note: from top to bottom are j300, j400 and j500 sub components of social security taxes, divided by total salaries.

Figure B.4: Social Security Subcomponents by Size

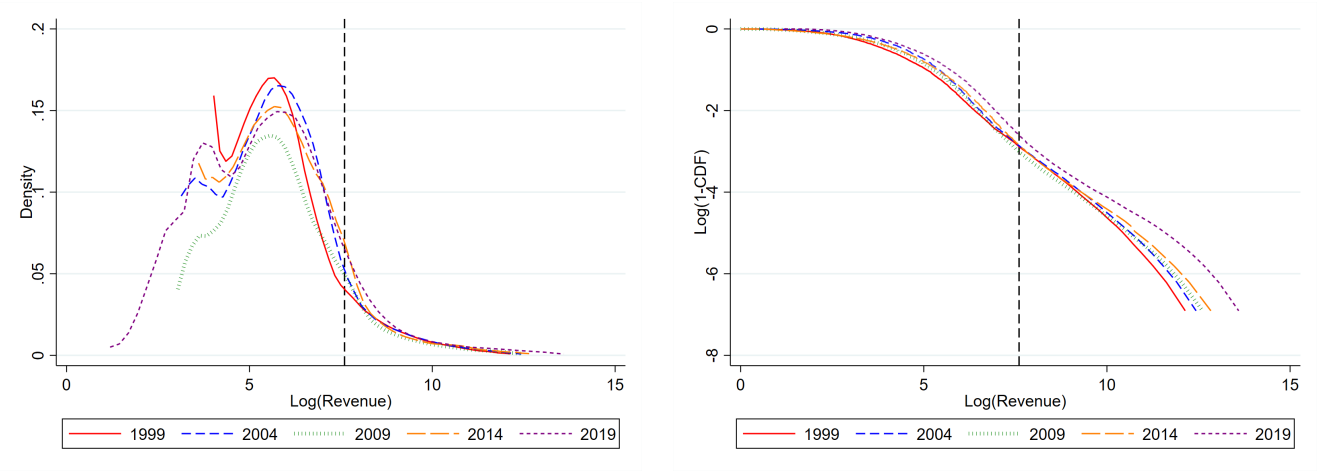



(a) By Number of Employees (b) By Revenue

Note: top are labor tax wedges; bottom are intermediate input tax wedges.

Figure B.5: Tax Wedges By Size

There is no evidence for the presence of a bulge in the revenue distribution near the 2 million Mexican peso Repeco revenue threshold. This will later be a relevant fact, "the dog that didn't bark in the night", for a model-based explanation for how the tax system shapes tax wedges, overall wedges and measures of plant size.[13]




(a) Densities (b) Log Tail Probabilities

Note: Panel (a) shows the kernel density estimates of log revenue (exclusive of value added tax) across establishments for selected years, estimated using an Epanechnikov kernel with bandwidth 0.25. Panel (b) displays log(1-CDF) against log revenue, where CDF is the empirical cumulative distribution function. The vertical dashed line indicates the revenue threshold of 2 million pesos.

Figure B.6: Revenue Distribution

TODOs(Wenlan):

- state-year Repeco tax rates; time varying corporate tax; minor details on phasing out of tax transition for 2019

[13] A firm that qualifies as a Repeco does not pay value-added taxes on the firm's output. Therefore, if a firm would have an upwards jump in the tax liability at the threshold, based on the difference between a profit-based tax and Repeco revenue taxes, then the tax liability jump would be even larger when value-added taxes are included.

## B.4 Extension: Estimate a Translog Production Function

Replace the Cobb-Douglas production function with a translog specification:

$$\ln y = \ln z_1 + \sum_{j=1}^{J} \beta_j \ln x_j + \frac{1}{2} \sum_{j=1}^{J} \sum_{k=1}^{J} \beta_{jk} \ln x_j \ln x_k \tag{B.8}$$

The elasticity of output with respect to input $j$ is:

$$\alpha_j(x) \equiv \frac{\partial \ln y}{\partial \ln x_j} = \beta_j + \sum_{k=1}^{J} \beta_{jk} \ln x_k \tag{B.9}$$

Repeat the analysis of section 3.2 to derive

$$\ln wedge_j = \ln \frac{P(y, z_2)y}{w_j x_j} + \ln \alpha_j(x)$$

$$\ln wedge_j = \ln \frac{\tilde{Rev}}{w_j x_j} + \ln \alpha_j(x) - \epsilon_j \tag{B.10}$$

The difference in conditional means is by assumption A2:

$$E[\ln wedge_j|s] - E[\ln wedge_j|s_0] = E[\ln \frac{\tilde{Rev}}{w_j x_j}|s] - E[\ln \frac{\tilde{Rev}}{w_j x_j}|s_0] + E[\ln \alpha_j(x)|s] - E[\ln \alpha_j(x)|s_0] \tag{B.11}$$

To evaluate the mean wedge difference, one estimates the (industry) parameters of the production function and evaluates the elasticity at each plant's measured input vector $x$ using the estimated parameters.

**Estimation of the Translog production function**

Assume output of firm (establishment) $i$ at time $t$ is such that

$$\ln y_{it} = X'_{it}\beta + \ln z_{it},$$

where $y_{it}$ is output, $X_{it}$ is a vector containing $(\ln x_{1t}, \ln x_{2t})$ and their own/cross interactions, and $z_{it}$ is the productivity. $\omega_{it} \equiv \ln z_{it}$ follows an AR(1) process: $\omega_{it} = \rho\omega_{it-1} + \xi_{it}$, $\beta$ and $\rho$ are parameters to be estimated.

Denote $r_{it} = \ln y_{it} + \ln p_{it}$ the log of revenue.

Following DeRidder et al. (2024; Appendix A.4.4), we use the following moment conditions to

estimate $\widehat{\beta}$ and $\widehat{\rho}$ with a GMM method:

$$\mathbb{E}[X_{it-1}\widehat{\varsigma}_{it}] = 0$$
$$\mathbb{E}[\widehat{\text{tfpr}}_{it-1}\widehat{\varsigma}_{it}] = 0,$$

where $\widehat{\text{tfpr}}_{it} = r_{it} - X'_{it}\widehat{\beta}$, $\widehat{\varsigma}_{it} = \widehat{\text{tfpr}}_{it} - \widehat{\rho}\widehat{\text{tfpr}}_{it-1}$.

We run this estimation by industry and year, for industries that have number of establishment $\geq 400$. Since we do not have an exact panel, but only with observations in 2009, 2014, 2019—with 5 year gaps—, our $t-1$ and $t$ actually are 5-year apart.

In a table keyed by (industry, year), we report the following statistics: (1) counts of number of observations across establishments, by industry-year (gauging how many establishments have enough panel observations for estimation); (2) estimated coefficients, standard errors and estimation statistics (such as $F$-statistics and statistics that help gauge whether identification assumption is met); (3) distribution statistics (mean, standard deviation, min, max and several percentiles) of output elasticity in factors, across establishments, by industry-year. Note output elasticity is calculated as

$$\alpha_{1i,t} = \frac{\partial \ln y_{i,t}}{\partial \ln x_{1i,t}} \text{ and } \alpha_{2i,t} = \frac{\partial \ln y_{i,t}}{\partial \ln x_{2i,t}},$$

which can be calculated with the estimated coefficients $\beta$.

# Appendix C Additional Theory

Consider a one input framework. Given a measure $\mu$ of plants defined over subsets of $V$, a feasible allocation is $(x(v), y(v), Y)$ such that (i) $y(v) = z_1 F(x(v))$, *(ii)* $\int_V x(v)d\mu = 1$, and $\int_V \mathcal{Y}(y(v)/Y)d\mu = 1$, where $v = (z_1, \tau) \in V$ is a state variable for a plant. Using $(**)$, define $\Omega(\lambda)$ as the productivity gain of moving a fraction $\lambda \in [0,1]$ of the way from $(x(v), y(v), Y)$ towards the alternative feasible allocation $(x^*(v), y^*(v), Y^*)$.

$$(**)\ (1+\Omega(\lambda))Y \equiv Y(\lambda), where \int_V z_2 \mathcal{Y}(\frac{z_1 F(x(v)+\lambda(x^*(v)-x(v))}{Y(\lambda)})d\mu = 1$$

Proposition C.1 offers a formula providing an upper bound to the productivity gain $\Omega(1)$ achieved from an alternative allocation based on the concavity of $\Omega$.[14]

**Proposition C.1.** *Let $(x(v), y(v), Y)$ and $(x^*(v), y^*(v), Y^*)$ be feasible allocations, where $(x(v), y(v), Y)$ is consistent with solutions to the plants' and the bundler's problem. Consider a special case with one input: $F' > 0, F'' \leq 0$ and $\mathcal{Y}(x) = x$. Then*

*(i)* $\Omega(\lambda) = \int_0^\lambda \Omega'(\bar{\lambda})d\bar{\lambda}$ *and* $\Omega'' \leq 0$

*(ii)* $\Omega'(0) \geq \Omega(1) = \frac{Y^*}{Y} - 1$ *and* $\Omega'(0) = (\frac{\int w_1 x d\mu}{Y})\hat{E}[wedge_1 \frac{(x^*-x)}{x}]$, *where $\hat{E}[\cdot]$ is the input cost share weighted mean.*

Proof:

(i) The equality is the Fundamental Theorem of Calculus. The sign of $\Omega''$ and $Y''$ are the same. Define $H(Y, \lambda) = \int_V \mathcal{Y}(\frac{y(v;\lambda)}{Y})d\mu - 1$, $y(v;\lambda) = z_1 F(x(v) + \lambda(x^*(v) - x(v)))$ and $x(v;\lambda) = x(v) + \lambda(x^*(v) - x(v))$. Use the feasibility condition to compute $Y'$ and $Y''$.

$$H(Y,\lambda) = \int \mathcal{Y}(\tfrac{y(v;\lambda)}{Y})d\mu - 1$$

$$H_1 = -\int \mathcal{Y}'(\cdot)\tfrac{y}{Y^2}d\mu = -\int \tfrac{y}{Y^2}d\mu$$

$$H_2 = \int \mathcal{Y}'(\cdot)\tfrac{y'}{Y}d\mu = \int \tfrac{y'}{Y}d\mu$$

$$H_{11} = \int[\mathcal{Y}''(\cdot)(\tfrac{y}{Y^2})^2 + \mathcal{Y}'(\cdot)\tfrac{2y}{Y^3}]d\mu = \int \tfrac{2y}{Y^3}d\mu = -\tfrac{2}{Y}H_1$$

$$H_{12} = H_{21} = -\int[\mathcal{Y}''(\cdot)(\tfrac{y}{Y^2})\tfrac{y'}{Y} + \mathcal{Y}'(\cdot)\tfrac{y'}{Y^2}]d\mu = -\int \tfrac{y'}{Y^2}d\mu = -\tfrac{1}{Y}H_2$$

$$H_{22} = \int[\mathcal{Y}''(\cdot)(\tfrac{y'}{Y})^2 + \mathcal{Y}'(\cdot)\tfrac{y''}{Y}]d\mu = \int \tfrac{y''}{Y}d\mu$$

$$H_1 Y' + H_2 = 0 \Rightarrow Y' = -\tfrac{H_2}{H_1} \text{ and } Y'' = -\tfrac{H_{11}(Y')^2 + 2H_{21}Y' + H_{22}}{H_1}$$

[14] The formula bounds any gain or loss. If one views a loss as a positive number, then the formula provides a lower bound $|\Omega'(0)|$ to such a productivity loss.

$$Y'' = -\frac{H_{11}(Y')^2+2H_{21}Y'+H_{22}}{H_1} = -\frac{H_{11}(-\frac{H_2}{H_1})^2+2H_{21}(-\frac{H_2}{H_1})+H_{22}}{H_1} = -[\frac{-\frac{2}{Y}H_1(-\frac{H_2}{H_1})^2-2\frac{H_2}{Y}(-\frac{H_2}{H_1})+H_{22}}{H_1}]$$

$$Y'' = -\frac{H_{22}}{H_1} = \frac{\int \frac{y''}{Y}d\mu}{\int \frac{y}{Y^2}d\mu} = \frac{\int \frac{F''(x^*-x)^2}{Y}d\mu}{\int \frac{y}{Y^2}d\mu} \leq 0$$

(ii) The inequality $\Omega'(0) \geq \Omega(1) = \frac{Y^*}{Y} - 1$ follows from $\Omega$ being concave. The first equation below follows from the computation of $Y'$. The second and third use the first, the price function $P(y,Y) = \mathcal{Y}'(\frac{y}{Y})/\int_V \mathcal{Y}'(\frac{y(v)}{Y})\frac{y(v)}{Y}d\mu$ and the first-order condition $P(y(v),Y)z_1F'(x(v)) = w_1 wedge_1$. The last equation employs the expectations operator $E[\cdot]$ (i.e. $E[f] = \int_V f(v)d\frac{\mu}{\mu(V)}$) and the cost-share-weighted expectations operator $\hat{E}[\cdot]$.

$$\Omega'(0) = \int_V \frac{\mathcal{Y}'(\frac{y(v)}{Y})}{\int \mathcal{Y}'(\frac{y(v)}{Y})y(v)d\mu} z_1F'(x(v))(x^*(v)-x(v))d\mu$$

$$\Omega'(0) = \tfrac{1}{Y}\int_V P(y(v),Y)z_1F'(x(v))(x^*(v)-x(v))d\mu$$

$$\Omega'(0) = \tfrac{1}{Y}\int_V w_1x(v)wedge_1\frac{(x^*(v)-x(v))}{x(v)}d\mu = \frac{\int w_1x(v)d\mu}{Y}\int_V \frac{w_1x(v)}{\int w_1x(v)d\mu}wedge_1\frac{(x^*(v)-x(v))}{x(v)}d\mu$$

$$\Omega'(0) = (\frac{\int w_1x(v)d\mu}{Y})E[\frac{w_1x(v)}{E[w_1x(v)]}wedge_1\frac{(x^*(v)-x(v))}{x(v)}] = (\frac{\int w_1xd\mu}{Y})\hat{E}[wedge_1\frac{(x^*-x)}{x}] \quad \|$$

Proposition C.2 shows what determines marginal productivity gains, from applying Theorem 3, when the reallocation takes a simple form.

**Proposition C.2.** *Divide firms into two sets: $S_{1H} = \{v : x_1(v) \geq \bar{x}_1\}$ and $S_{1L} = \{v : x_1(v) < \bar{x}_1\}$. Define the input expenditure weighted average wedges of the two sets as*

$$\bar{wedge}_{1H} \equiv \frac{\int_{S_{1H}} x_1(v)\cdot wedge_1(v)d\mu}{\int_{S_{1H}} x_1(v)d\mu}, \bar{wedge}_{1L} \equiv \frac{\int_{S_{1L}} x_1(v)\cdot wedge_1(v)d\mu}{\int_{S_{1L}} x_1(v)d\mu}.$$

*Consider the reallocation $x_1^*(v) = x_1(v)(1+\gamma_1)$ if $x_1(v) \geq \bar{x}_1$ and $x_1^*(v) = x_1(v)(1-\gamma_2)$ otherwise and set $\gamma_2$ to maintain feasibility, given $\gamma_1$. Then the marginal productivity gain from this reallocation is $\Omega'(0) = \omega_1\gamma_1\frac{\int_{S_{1H}} x_1(v)d\mu}{\int_V x_1(v)d\mu}\left[\bar{wedge}_{1H} - \bar{wedge}_{1L}\right]$.*

*Proof.* The feasibility condition requires

$$\int_V x_1^*(v)d\mu = (1+\gamma_1)\underbrace{\int_{S_{1H}} x_1(v)d\mu}_{\equiv X_{1H}} + (1-\gamma_2)\underbrace{\int_{S_{1L}} x_1(v)d\mu}_{\equiv X_{1L}} = \underbrace{\int_V x_1(v)d\mu}_{\equiv X_1}$$

$$\Rightarrow \gamma_2 = \gamma_1\frac{X_{1H}}{X_{1L}}$$

Substituting $\gamma_2$ into the formula for $\Omega'(0)$ from Theorem 3:

$$\begin{aligned}\Omega'(0) &= \omega_1\left[\int_{S_{1H}}\frac{x_1(v)}{X_1}wedge_1(v)\cdot\gamma_1 d\mu + \int_{S_{1L}}\frac{x_1(v)}{X_1}wedge_1(v)\cdot\left(-\gamma_1\frac{X_{1H}}{X_{1L}}\right)d\mu\right] \\ &= \omega_1\gamma_1\left[\int_{S_{1H}}\frac{x_1(v)}{X_1}wedge_1(v)d\mu - \frac{X_{1H}}{X_{1L}}\int_{S_{1L}}\frac{x_1(v)}{X_1}wedge_1(v)d\mu\right],\end{aligned}$$

The first and second integral term are restated below:

$$\begin{aligned}\int_{S_{1H}} \frac{x_1(v)}{X_1} wedge_1(v)d\mu &= \frac{1}{X_1}\int_{S_{1H}} x_1(v)wedge_1(v)d\mu \\ &= \frac{X_{1H}}{X_1}\cdot\frac{\int_{v\in S_{1H}} x_1(v)wedge_1(v)d\mu}{X_{1H}} \\ &= \frac{X_{1H}}{X_1}\cdot \bar{wedge}_{1H}\end{aligned}$$

$$\int_{S_{1L}} \frac{x_1(v)}{X_1} wedge_1(v)d\mu = \frac{X_{1L}}{X_1}\cdot \bar{wedge}_{1L}$$

Substituting these expressions into the formula for $\Omega'(0)$ produces the result claimed in the Proposition:

$$\begin{aligned}\Omega'(0) &= \omega_1\gamma_1\left[\frac{X_{1H}}{X_1}\cdot \bar{wedge}_{1H} - \frac{X_{1H}}{X_{1L}}\cdot\frac{X_{1L}}{X_1}\cdot \bar{wedge}_{1L}\right] \\ &= \omega_1\gamma_1\frac{X_{1H}}{X_1}\left[\bar{wedge}_{1H} - \bar{wedge}_{1L}\right]\end{aligned}$$

□

Theorem 3 in the main text assumes one bundler and an industry notion of output. Theorem 3 is now extended to apply to a richer network structure with multiple industries and two bundler levels, employed by Hsieh and Klenow (2009) among others. Differently from Hsieh and Klenow (2009), no parametric assumptions are employed. In the framework below, $Y$ is the total output of the one final good, $Y_s$ is output for industry $s$ and $y_s(v)$ denotes the output of a monopolistic plant with state variable $v$ in industry $s$.

1. $Y = H(Y_1, ..., Y_S)$ and $\int_V z_2\mathcal{Y}_s(\frac{y_s(v)}{Y_s})d\mu_s = 1$ for $s = 1, \cdots, S$
2. $y_s(v) = z_1F(x_s(v); s)$, where $x_s(v) = (x_{1s}(v), ..., x_{Js}(v))$, for $s = 1, \cdots, S$

Given measures $\mu = (\mu_1, ..., \mu_S)$, an allocation $(x_s(v), y_s(v), Y_s, Y)$ is feasible provided (i) $y_s(v) = z_1F(x_s(v); s)$, (ii) $\int_V x_{sj}(v)d\mu_s = X_{sj}$ for $j = 1, ..., J-1$, (iii) $\int_V z_2\mathcal{Y}_s(y_s(v)/Y_s)d\mu_s = 1$ and $Y = H(Y_1, ..., Y_S)$ and (iv) $\hat{Y} \equiv Y - \sum_s \int_V x_{Js}(v)d\mu_s > 0$. Define the productivity gain $\Omega(\lambda)$ of moving a fraction $\lambda$ of the way from $(x_s(v), y_s(v), Y_s, Y)$ towards feasible allocation $(x_s^*(v), y_s^*(v), Y_s^*, Y^*)$ as a solution to system $(**)$.

$$(**)\quad 1 + \Omega(\lambda) = \frac{Y(\lambda) - \sum_s \int_V (x_{sJ}(v) + \lambda(x_{sJ}^*(v) - x_{sJ}(v)))d\mu_s}{Y - \sum_s \int_V x_{sJ}(v)d\mu_s}$$

$$Y(\lambda) = H(Y_1(\lambda), ..., Y_S(\lambda)) \text{ and } \int_V z_2\mathcal{Y}_s(\frac{z_1F(x_s(v) + \lambda(x_s^*(v) - x_s(v)); s)}{Y_s(\lambda)})d\mu_s = 1$$

**Proposition C.3.** *Assume* $(x_s(v), y_s(v), Y_s, Y)$ *and* $(x_s^*(v), y_s^*(v), Y_s^*, Y^*)$ *are feasible, where* $(x_s(v), y_s(v), Y_s, Y)$ *is consistent with solutions to the plants' and the bundler's problem. Then* $\Omega(\lambda) = \int_0^\lambda \Omega'(\bar{\lambda})d\bar{\lambda}$ *and* $\Omega'(0) = \sum_s \sum_j \omega_{js} \hat{E}_{js}[wedge_{js} \frac{(x_{js}^* - x_{js})}{x_{js}}] - \frac{\sum_s \int_V (x_{Js}^* - x_{Js}) d\mu_s}{Y - \sum_s \int_V x_{Js} d\mu_s}$, *where* $\omega_{js} = \int_V w_j x_{js} d\mu_s / (Y - \sum_s \int_V x_{Js} d\mu_s)$ *are the share of final output paid for input* $j$ *in industry* $s$.

Proof: $\Omega(\lambda) - \Omega(0) = \int_0^\lambda \Omega'(\bar{\lambda})d\bar{\lambda}$ follows from the Fundamental Theorem of Calculus. The result follows as $\Omega(0) = 0$. Define $x_s(v;\lambda) = x_s(v) + \lambda(x_s^*(v) - x_s(v))$ and $y_s(v;\lambda) = z_1 F(x_s(v;\lambda))$. Feasibility implies

$$Y_s'(\lambda) = Y_s(\lambda) \int_V \frac{z_2 \mathcal{Y}_s'(\frac{y_s(v;\lambda)}{Y_s(\lambda)})}{\int z_2 \mathcal{Y}_s'(\frac{y_s(v;\lambda)}{Y_s(\lambda)}) y_s(v;\lambda) d\mu_s} \sum_{j=1}^J z_1 F_j(x_s(v;\lambda); s)(x_{js}^*(v) - x_{js}(v)) d\mu_s$$

$$\Omega'(\lambda) = \frac{\sum_s H_s(Y_1(\lambda), \cdots, Y_S(\lambda)) Y_s'(\lambda) - \sum_s \int_V (x_{Js}^*(v) - x_{Js}(v)) d\mu_s}{Y - \sum_s \int_V x_{Js}(v) d\mu_s}$$

Restate the marginal productivity gain, evaluated at $\lambda = 0$, using the first-order condition of each bundler. The price function of the monopolistic firm's good is then $P_s(y, z_2, Y_s) = \frac{P_s Y_s z_2 \mathcal{Y}_s'(\frac{y}{Y_s})}{\int_V z_2 \mathcal{Y}_s'(\frac{y_s(v)}{Y_s}) y_s(v) d\mu_s} = \frac{H_s Y_s z_2 \mathcal{Y}_s'(\frac{y}{Y_s})}{\int_V z_2 \mathcal{Y}_s'(\frac{y_s(v)}{Y_s}) y_s(v) d\mu_s}$, where $P_s$ is the price of industry $s$ output. Apply the first-order condition $P_s(y, z_2, Y_s) z_1 F_j = w_j wedge_{js}$ to produce the second equation below. Define cost shares $\omega_{js} = \int_V w_j x_{js} d\mu_s / (Y - \sum_s \int_V x_{Js}(v) d\mu_s)$ and employ the normalization $\mu_s(\cdot)/\mu_s(V)$ for the expectations operators to get the third and fourth equation below. The last equation employs cost-share weighted expectations operator $\hat{E}_s$.

$$\Omega'(0) = \frac{\sum_s \int_V P_s(y, z_2, Y_s) \sum_{j=1}^J z_1 F_j(x_s(v); s)(x_{js}^*(v) - x_{js}(v)) d\mu_s - \sum_s \int_V (x_{Js}^*(v) - x_{Js}(v)) d\mu_s}{Y - \sum_s \int_V x_{Js}(v) d\mu_s}$$

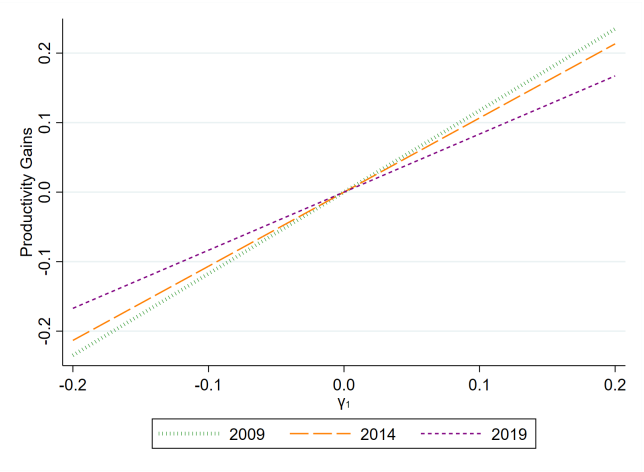
$$\Omega'(0) = \frac{\sum_s \int_V \sum_{j=1}^J w_j wedge_{js}(x_s)(x_{js}^* - x_{js}) d\mu_s - \sum_s \int_V (x_{Js}^* - x_{Js}) d\mu_s}{Y - \sum_s \int_V x_{Js} d\mu_s}$$

$$\Omega'(0) = \sum_s \sum_j \omega_{js} \int_V \frac{w_j x_{js}}{\int_V w_j x_{js} d\mu_s} wedge_{js} \frac{(x_{js}^* - x_{js})}{x_{js}} d\mu_s - \frac{\sum_s \int_V (x_{Js}^* - x_{Js}) d\mu_s}{Y - \sum_s \int_V x_{Js} d\mu_s}$$

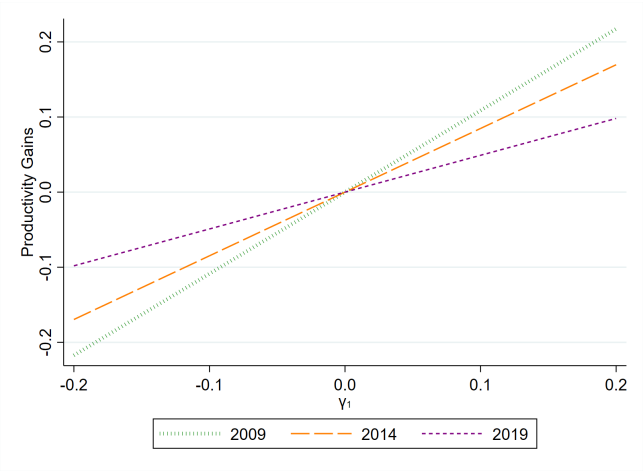
$$\Omega'(0) = \sum_s \sum_j \omega_{js} E_s[\frac{w_j x_{js}}{E_s[w_j x_{js}]} wedge_{js} \frac{(x_{js}^* - x_{js})}{x_{js}}] - \frac{\sum_s \int_V (x_{Js}^* - x_{Js}) d\mu_s}{Y - \sum_s \int_V x_{Js} d\mu_s}$$

$$\Omega'(0) = \sum_s \sum_j \omega_{js} \hat{E}_{js}[wedge_{js} \frac{(x_{js}^* - x_{js})}{x_{js}}] - \frac{\sum_s \int_V (x_{Js}^* - x_{Js}) d\mu_s}{Y - \sum_s \int_V x_{Js} d\mu_s} \quad \|$$

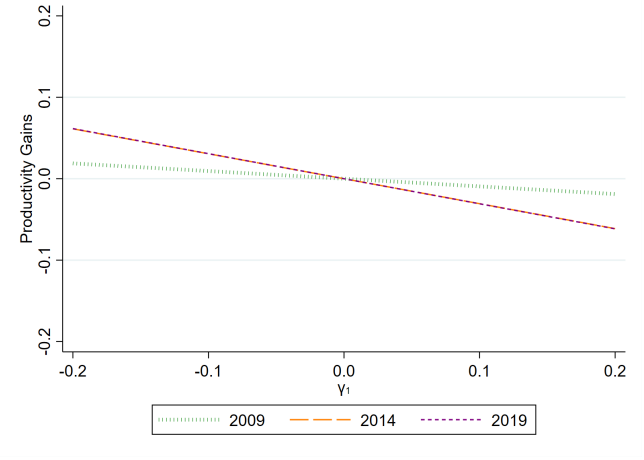
# Appendix D Additional Figures/Tables




(a) Reallocating Labor




(b) Reallocating Labor and Intermediate Input




(c) Reallocating Intermediate Input

Figure D.1: Marginal Productivity Gains from Input Reallocation

# Appendix E Levy Narrative

The introduction compressed some of the themes in Levy (2018) into a two sentence "narrative" that is restated below in bold face. While econometricians celebrate methods for data compression, clearly much is left out with such a compression. This Appendix documents that was was left in is contained in Levy (2018).

Levy (2018) "Under-Rewarded Efforts: The Elusive Quest for Prosperity in Mexico" provides one articulation of this view. **He argues that a combination of tax, labor contracting and enforcement policies imply that some large Mexican establishments face high marginal tax rates on both revenues and labor costs and many small establishments face low tax rates. He then conjectures that alternative policies that address size-dependent input misallocation are likely to be important for increasing productivity.**

Concerning size-dependent taxation Levy (2018, p. 40) states "Smaller firms de facto face lower labor taxes than larger firms." and "Smaller firms face lower statutory corporate tax rates than larger ones."

Concerning policy, Levy (2018, p. 2) states "The book points out that the main policies and institutions impeding growth are those related to taxation, labor and social insurance regulations, and enforcement of contracts." and Levy (2018, p. 283) states "This book argues that current tax, social insurance, and labor protection policies are flawed, that they are the main reason why growth is slow, and that a policy shift is necessary."