# ESTUDIOS DE ECONOMIA

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UNIVERSIDAD DE CHILE
FACULTAD DE ECONOMIA Y NEGOCIOS
DEPARTAMENTO DE ECONOMIA

ESTUDIOS DE ECONOMIA



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Departamento de Economía

# Exclusive dealing in the presence of a vertically integrated firm*

## *Ventas exclusivas en presencia de una empresa verticalmente integrada*

Dang-Long Bui**
Damiana Simanjuntak***
Joe Maganga Zonda****

**Abstract**

*This study constructs a successive Cournot model to investigate the possibility that a separated upstream input supplier can solely sell the intermediate good to a separated downstream manufacturer through an exclusive contract in the presence of a vertically integrated rival. We find that the separated firms are indifferent on whether to sign the exclusive contract or not if the downstream party is less efficient than the integrated firm in producing the final good. Next, the separated firms with an efficient downstream party are indifferent between signing or not signing, willing to sign, and not willing to sign the exclusive contract if the upstream cost differential is relatively low, medium, and high, respectively. Finally, signing such an exclusive contract does not increase consumer surplus and social welfare.*

Key words: *Exclusive dealing, vertical integration, successive Cournot model.*

JEL Classification: *L12, L41, L42.*

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**Resumen**

*Este trabajo construye un modelo sucesivo de Cournot para investigar que un proveedor de insumos realice ventas exclusivas a un productor en presencia de un competidor verticalmente integrado. Se encuentra que las empresas se encontrarán indiferentes en tener un contrato de exclusividad si el productor es menos eficiente en la producción del bien que la firma integrada. Asimismo, la firma de un contrato de exclusividad dependerá del diferencial de costos del proveedor del insumo. Finalmente, un contrato de exclusividad no aumenta el excedente del consumidor o el bienestar social.*



Palabras clave: *Tratos exclusivos, integración vertical, modelo de Cournot.*

Clasificación JEL: *L12, L41, L42.*


## 1. Introduction

Exclusive dealing is a vertical purchase agreement that requires a buyer to consume specific products from only one seller.[1] In some countries (e.g., Australia, Europe, and the United States), such an agreement may violate the antitrust law by lessening the competition in an industry, raising concerns from the antitrust authorities in those countries.[2] However, Posner (1976) and Bork (1978), two prominent advocates of the Chicago School of thought, oppose this view by advancing the well-known classic argument on exclusive dealing that a rational buyer has no incentive to sign an exclusive purchase contract offered by an inefficient supplier.

Since exclusive dealing can be observed in many industries (Lafferty *et al.*, 1984; Heide *et al.*, 1998; Cooper *et al.*, 2005), several researchers employ different frameworks from the model in the Chicago School's classic argument and are able to unearth some conditions under which exclusive dealing occurs (Rasmusen *et al.*, 1991; Yong, 1996; Bernheim and Whinston, 1998; Segal and Whinston, 2000; Farell, 2005; Fumagalli and Motta, 2006; Simpson and Wickelgren, 2007; Abito and Wright, 2008; Fumagalli *et al.*, 2009; DeGraba, 2013; Kitamura *et al.*, 2014, 2017, 2018; Liu and Meng, 2021).

Motivated by the controversy among economists on exclusive dealing, this paper leverages a variant of the successive Cournot model developed by Salinger (1988) to investigate the possibility that a separated upstream input supplier can solely sell the intermediate good to a separated downstream manufacturer

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[1] https://www.ftc.gov/advice-guidance/competition-guidance/guide-antitrust-laws/single-firm-conduct/exclusive-supply-or-purchase-agreements

[2] https://en.wikipedia.org/wiki/Exclusive_dealing

through an exclusive contract in the presence of a vertically integrated rival.[3] The successive Cournot model, where the firms in every production stage compete in quantity, prevents the elimination of double marginalization that arises under Bertrand competition (Gaudet and Van Long, 1996). Indeed, prior studies have mostly focused on price competition among sellers.[4] Therefore, the central novelty of this paper lies in its use of a successive Cournot model to reexamine the Chicago School's classic argument.

Several studies simultaneously consider exclusive dealing and vertical integration. Chen and Riordan (2007) prove that a vertically integrated firm can use an exclusive contract to prevent competition from an equally efficient upstream rival and cartelize the downstream market. However, our paper is interested in exploring conditions that allow a separated upstream firm to use an exclusive contract to prevent competition from a vertically integrated rival. Next, unlike the earlier literature, Nocke and Rey (2018) and Rey and Verge (2020) do not focus on the entry deterrence effect of exclusive contracts but pay attention to the changes in firms' trading behavior post-contract. This feature is also taken into account in our paper. Moreover, we are particularly motivated by the successive Cournot model, which has never been employed in studies on exclusive dealing.

It is salient to note that our model configuration is commonly observed in the real-world setting. For example, in 2019, Taiwan Semiconductor Manufacturing Company (TSMC) won an exclusive contract to provide chips for Apple Inc. [5] In the absence of such an exclusive contract, TSMC would have to compete with other rivals, such as Samsung Electronics Co., Ltd., in the chip market. Indeed, Apple Inc. and Samsung Electronics Co., Ltd. are also rivals in the downstream market, namely the global smartphone market.

The possibility that exclusivity appears in equilibrium in this model depends on two main channels. The first channel indicates that an exclusive contract will be attainable if the seller faces not-too-severe competition in the upstream market. This channel has been discussed by several studies in exclusive dealing literature, such as Yong (1996), Farrell (2005), Fumagalli *et al.* (2009), and Kitamura *et al.* (2017). The second channel is derived from the literature on vertical integration and market foreclosure.[6] It should be noted that an integrated firm may yield profit from both upstream and downstream markets. Its upstream behavior is, therefore, based on the strategic and marginal upstream

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3 The successive Cournot model developed by Salinger (1988) and its variants are well established in theoretical industrial organization. See, for example, Gaudet and Van Long (1996), Spencer and Raubitschek (1996), Ishikawa and Lee (1997), Ishikawa and Spencer (1999), and Lin and Saggi (2007).

4 Farell (2005) allows sellers to engage in Cournot competition in the Chicago three-party model and shows that the exclusivity equilibrium can occur.

5 https://www.taiwannews.com.tw/en/news/3551431?fbclid=IwAR2IhSGMbmWrOaA73BQds7DwFgt94eyZhy75bcEvBXTXzSuOgjISACTpbhI

6 In addition to Salinger (1988), Nocke and White (2007), Wang *et al.* (2011), and Reisinger and Taratino (2015) also discuss vertical integration and market foreclosure.

profit effects that influence its downstream and upstream profits, respectively (Wang *et al.*, 2011).[7]

Based on the two channels mentioned above, the upstream market competition becomes less (more) intense if the marginal upstream profit effect is weak (strong) or the strategic effect is strong (weak), resulting in the exclusivity equilibrium being more (less) likely to occur. In particular, suppose the marginal upstream profit effect is outweighed by the strategic effect. In that case, the vertically integrated firm has no incentive to supply input to its downstream rival, leading to indifference in the separated firms' contract decisions.

We derived three main results as follows. First, the separated firms are indifferent on whether to sign the exclusive contract or not if the downstream party is less efficient than the integrated firm in producing the final good. Second, the separated firms with an efficient downstream party are indifferent between signing or not signing, willing to sign, and not willing to sign the exclusive contract if the upstream cost differential is relatively low, medium, and high, respectively. Third, signing such an exclusive contract does not increase consumer surplus and social welfare.

The remainder of this paper is organized as follows. Section 2 describes the model. Section 3 analyzes a regime in which the separated downstream manufacturer is less efficient than the vertically integrated firm in producing the final good. In Section 4, we discuss a regime in which the condition of the regime considered in the preceding section is reversed. The impact of exclusive dealing on consumer surplus and social welfare will be evaluated in Section 5. Lastly, we conclude the paper in Section 6.

## 2. The Model

This paper considers a variant of the successive Cournot model developed by Salinger (1988), in which a separated upstream input supplier (firm $U$) and a separated downstream manufacturer (firm $D$) compete with a vertically integrated firm (firm $I$) in terms of quantity in the upstream and downstream markets, respectively. The intermediate (final) goods produced in the upstream (downstream) market are assumed to be homogeneous. Firm $U$ can offer an exclusive contract with a non-negative lump-sum reimbursement $F$ to solely sell

---

7 The strategic effect influences the integrated firm to reduce its input supply to its downstream rival. In doing so, the separated downstream firm's marginal cost rises since the input price increases. As a result, the separated downstream firm lowers its final good quantity. The integrated firm then increases its downstream output and earns a higher profit because of strategic substitutes. On the contrary, the marginal upstream profit effect induces the integrated firm to increase its input supply to the separated downstream firm and earns a higher upstream profit.

input to firm $D$.[8] Following the literature on exclusive dealing (e.g., Fumagalli and Motta, 2006), we assume that the seller offering the contract is less efficient than its rival. Specifically, firm $U$ produces the intermediate good with a non-negative marginal cost $m$, while the integrated firm has a lower upstream marginal cost normalized to *zero*. The downstream production of firm $D$ (firm $I$) incurs a transforming cost $c_D$ ($c_I$) by converting one unit of the intermediate good to one unit of the final good. We assume that $\min(c_D, c_I) = 0$ and $\max(c_D, c_I) = c \geq 0$, for simplicity. Thus, $m$ ($c$) can be referred to as the cost differential in the upstream (downstream) market. In addition, the vertically integrated firm produces the final good internally by using its own intermediate good because of the upstream cost advantage.

The final good market, whose inverse demand function is given in a linear form as:[9]

$$p(Q) = 1 - Q \tag{1}$$

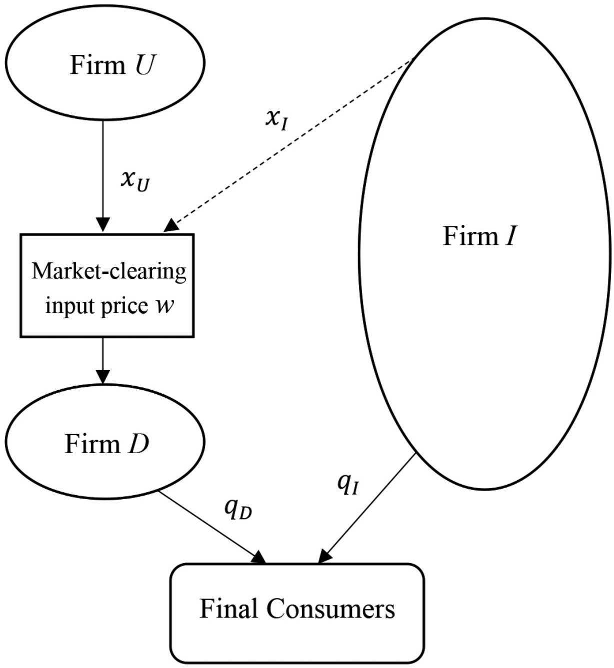
where $p$ denotes the price of the final good, $Q$ is the quantity demanded of the final good, and market clearing requires that $Q$ equals the sum of the downstream outputs by firm $D$ ($q_D$) and firm $I$ ($q_I$), i.e., $Q = q_D + q_I$.

The game in question consists of three stages. In the first stage, firm $U$ offers an exclusive contract to firm $D$ to which the latter decides whether to accept or reject. In stage 2, given the contract status in the first stage, the available upstream firms engage in quantity competition to supply the intermediate good to the separated downstream manufacturer by taking into account firm $D$'s derived demand which is determined at the market-clearing level (Ghosh *et al.*, 2022). Finally, given the market-clearing input price, the final good producers determine their outputs in the third stage. We employ the following figure to clarify the trade structure among the firms in both exclusivity and non-exclusivity cases. It should be noted that the broken line in Figure 1 appears only in the non-exclusivity case, while such a direction vanishes otherwise.

8 The assumption of a lump-sum reimbursement in exclusive contracts has been widely accepted in theoretical studies. See, for example, Fumagalli and Motta (2006), Fumagalli *et al.* (2012), DeGraba (2013), Kitamura *et al.* (2017), and Lin (2022). Since they allow the sellers to choose prices, a per-unit discount is no longer necessary. In contrast, adopting a per-unit discount or a two-part reimbursement in exclusive dealing models with upstream Cournot competition may be interesting. We leave this extension for future research.

9 The result in Section 3 (Regime A) is robust for a general demand function. See Appendix A for the proof.

FIGURE 1
THE MARKET STRUCTURE




In what follows, we analyze two regimes regarding the efficiency of the separated downstream manufacturer and the vertically integrated firm in producing the final good. First, we describe the case in which firm $D$ is less efficient than firm $I$ in producing the final good. We denote this case as Regime A. Next, we consider the setting in which firm $D$ is more efficient than firm $I$ in the downstream market, the case we term Regime B.

## 3. Regime A

Suppose that firm $D$'s marginal downstream transforming cost is higher than that of firm $I$, i.e., $c_D \geq c_I$. As mentioned earlier, we assume that the higher one equals $c$ and the lower one equals *zero*, i.e., $c_D = c$ and $c_I = 0$.

We first analyze the equilibrium results in the absence of an exclusive contract between the separated firms, i.e., firm $D$ rejects the exclusive contract from firm $U$. In this case, firm $I$ can compete with firm $U$ in supplying the intermediate good to the separated downstream firm. By using backward induction, we solve the game from the downstream stage.

Firm *D*'s and firm *I*'s profit functions are expressed as follows:

$$\pi_D^{AN} = \left(p^{AN} - c - w^{AN}\right) q_D^{AN} \tag{2.1}$$

$$\pi_I^{AN} = p^{AN} q_I^{AN} + w^{AN} x_I^{AN} \tag{2.2}$$

where the superscript *"AN"* denotes variables associated with the non-exclusivity case in Regime A, *w* represents the input price offered to firm *D*, and $x_j (j = U,I)$ is firm *j*'s quantity of the intermediate good supplied to firm *D*.

By differentiating $\pi_i^{AN} (i = D,I)$ with respect to $q_i^{AN}$ and letting it equal *zero*, we derive the first-order conditions as follows:

$$\frac{\partial \pi_D^{AN}}{\partial q_D^{AN}} = 1 - 2q_D^{AN} - q_I^{AN} - c - w^{AN} = 0 \tag{3.1}$$

$$\frac{\partial \pi_I^{AN}}{\partial q_I^{AN}} = 1 - q_D^{AN} - 2q_I^{AN} = 0 \tag{3.2}$$

Solving (3.1) and (3.2) simultaneously yields:

$$q_D^{AN} = \frac{1}{3}\left(1 - 2c - 2w^{AN}\right) \tag{4.1}$$

$$q_I^{AN} = \frac{1}{3}\left(1 + c + w^{AN}\right) \tag{4.2}$$

We observe from (4) that a rise in the input price will reduce the downstream output of the separated downstream manufacturer while increasing that of the integrated firm. The rationale behind these comparative statics is that a hike in the input price will increase firm *D*'s marginal cost and decrease its output. Meanwhile, firm *I*'s downstream output will increase because of strategic substitutes.

Note that one unit of the final good requires one unit of the intermediate good, i.e., $q_D = x_U + x_I$. By (4.1), we obtain firm *D*'s derived demand for the intermediate good as:

$$w^{AN} = \frac{1}{2} - c - \frac{3}{2}\left(x_U^{AN} + x_I^{AN}\right) \tag{5}$$

By (4) and (5), we obtain:

(6.1) $$\frac{dq_D^{AN}}{dx_U^{AN}} = \frac{dq_D^{AN}}{dx_I^{AN}} = 1 > 0$$

(6.2) $$\frac{dq_I^{AN}}{dx_U^{AN}} = \frac{dq_I^{AN}}{dx_I^{AN}} = -\frac{1}{2} < 0$$

From (6), we learn that a rise in the input supply from either firm $U$ or firm $I$ will increase (decrease) firm $D$'s (firm $I$'s) downstream output. The logic behind this result is as follows. Recall that from (5), a higher input supply from firm $U$ or firm $I$ will decrease the input price. It is followed by a decline in the separated downstream manufacturer's marginal cost, leading to higher downstream output. Consequently, the integrated firm's downstream output falls because of strategic substitutes.

We proceed to the upstream stage, where firm $U$ and firm $I$ compete in quantity. Firm $U$'s profit function is as follows:

(7) $$\pi_U^{AN} = \left(w^{AN} - m\right) x_U^{AN}$$

By using (2.2), (4), (5), and (7), we differentiate $\pi_j^{AN}\left(j = U, I\right)$ with respect to $x_j^{AN}$ and let it equal *zero* to obtain the first-order conditions as follows:[10]

(8.1)
$$\frac{d\pi_U^{AN}}{dx_U^{AN}} = \overbrace{\frac{\partial \pi_U^{AN}}{\partial w^{AN}} \frac{\partial w^{AN}}{\partial x_U^{AN}}}^{\text{input price effect } (-)} + \overbrace{\frac{\partial \pi_U^{AN}}{\partial x_U^{AN}}}^{\text{direct effect } (+)} = \left(x_U^{AN}\right)\left(-\frac{3}{2}\right) + \left(w^{AN} - m\right) = \frac{1}{2} - m - c - 3x_U^{AN} - \frac{3}{2} x_I^{AN} = 0$$

(8.2)
$$\frac{d\pi_I^{AN}}{dx_I^{AN}} = \overbrace{\frac{\partial \pi_I^{AN}}{\partial q_D^{AN}} \frac{dq_D^{AN}}{dx_I^{AN}}}^{\text{strategic effect } (-)} + \overbrace{\frac{\partial \pi_I^{AN}}{\partial w^{AN}} \frac{\partial w^{AN}}{\partial x_I^{AN}}}^{\text{input price effect } (-)} + \overbrace{\frac{\partial \pi_I^{AN}}{\partial x_I^{AN}}}^{\text{direct effect } (+)} = \left(-q_I^{AN}\right)(1) + \left(x_I^{AN}\right)\left(-\frac{3}{2}\right) + \left(w^{AN}\right) = -c - x_U^{AN} - \frac{5}{2} x_I^{AN} < 0$$

We find, from (8.1), that firm $U$'s intermediate good quantity has two effects on its profit. The first term on the right-hand side of this equation is denoted as the *input price effect*. This effect shows that a decrease in firm $U$'s input supply increases the input price for firm $D$, and such a rise in the input price causes

[10] Note that the effect of $x_I^{AN}$ on $\pi_I^{AN}$ through $q_I^{AN}$ vanishes due to the envelop theorem.

a higher profit for the separated upstream firm. Thus, the input price effect is negative. On the contrary, the second term in (8.1), labeled as the *direct effect*, is positive. It is because a fall in firm *U*'s quantity of the intermediate good directly decreases its profit. Accordingly, the reaction function of the separated upstream firm can be obtained by letting the sum of the two effects equal *zero*.

Similarly, the input price effect and the direct effect of firm *I*'s input supply on its profit also appear in the first derivative of $\pi_I^{AN}$ with respect to $x_I^{AN}$ captured by the second and third terms on the right-hand side of (8.2), respectively. Furthermore, Eq. (8.2) introduces a new term, which is referred to as the *strategic effect*. The direct implication of this effect is that a fall in firm *I*'s input supply will increase the input price for its downstream rival. A higher input price will raise firm *D*'s marginal cost, which will subsequently reduce its output. However, the decrease in firm *D*'s output will raise the integrated firm's profit by increasing its downstream output due to strategic substitutes. Hence, the strategic effect is negative.

As shown in (8.2), the first derivative of firm *I*'s input supply on its profit is always negative since the positive direct effect is outweighed by the remaining negative effects. Thus, the integrated firm's optimal decision is not to supply the intermediate good to its downstream rival, i.e., $x_I^{AN} = 0.$ The intuition behind this result is as follows. Recall the assumption that firm *I* is more efficient than firm *D* in producing the final good. In this scenario, the vertically integrated firm has no incentive to supply the intermediate good to the separated downstream manufacturer, forcing firm *D* to purchase the intermediate good from the less efficient input supplier *U,* thereby increasing firm *D's* marginal cost. Therefore, firm *D*'s output shrinks while firm *I* increases its downstream output through strategic substitutes. From firm *I*'s perspective, the extra profit from the downstream market outweighs the foregone revenue in its upstream potential input supply.

Based on the above discussion, we establish:

**Proposition 1:** *In the absence of an exclusive contract between the separated firms, the vertically integrated firm has no incentive to supply the intermediate good to its downstream rival if the rival is less efficient in producing the final good.*

This result differs from the conventional wisdom in which an efficient input supplier has no incentive to give up its profit from selling the intermediate good. However, by introducing a vertically integrated firm that is efficient in both upstream and downstream markets, we can prove that the integrated firm has no incentive to earn profit from supplying input to its downstream rival.

Based on the result derived in Proposition 1, it is abundantly apparent that the separated firms are indifferent on whether to sign the exclusive contract or not since firm *I*'s decision is independent of the separated firms' contract status. Therefore, we conclude with the following proposition:

**Proposition 2:** *Suppose the separated downstream manufacturer is less efficient than the vertically integrated firm in producing the final good. The separated firms are indifferent between signing and not signing the exclusive contract.*

Posner (1976) and Bork (1978) suggest that an inefficient seller cannot be a sole supplier by offering an exclusive contract to a rational buyer. However, in this section, we prove that an inefficient separated input supplier will always solely sell the intermediate good to an inefficient separated downstream manufacturer in the presence of a vertically integrated rival, regardless of the exclusivity status.

## 4. Regime B

This section considers the case where the separated downstream firm is more efficient than the vertically integrated firm in producing the final good, i.e., $c_D \leq c_I$. We follow the assumption laid down in Section 2, that $c_D = 0$, $c_I = c$. Further, we invoke the following assumptions for the analysis of this regime:

**Assumption 1:** $c < \frac{5}{7}$. This assumption guarantees that the final good producers can both survive in the downstream market.

**Assumption 2:** $m < \frac{1}{2} + \frac{c}{2}$. This assumption ensures that firms $U$ and $D$ produce positive quantities of the intermediate and final goods when they sign an exclusive contract.

### 4.1. Non-exclusivity

Suppose the separated downstream manufacturer rejects the exclusive contract from the separated upstream input supplier. In this case, the vertically integrated firm can join the upstream competition to supply the intermediate good to the separated downstream firm. Again, we solve this subgame by backward induction, starting from the downstream stage, wherein firm $D$ and firm $I$ maximize profit functions as follows:

(9.1) $$\pi_D^{BN} = \left(p^{BN} - w^{BN}\right) q_D^{BN}$$

(9.2) $$\pi_I^{BN} = \left(p^{BN} - c\right) q_I^{BN} + w^{BN} x_I^{BN}$$

where the superscript *"BN"* denotes variables associated with the non-exclusivity case in Regime B.

Differentiating (9) with respect to the downstream outputs and letting them equal *zero* yield the first-order conditions as:

(10.1)
$$\frac{\partial \pi_D^{BN}}{\partial q_D^{BN}} = 1 - 2q_D^{BN} - q_I^{BN} - w^{BN} = 0$$

(10.2)
$$\frac{\partial \pi_I^{BN}}{\partial q_I^{BN}} = 1 - q_D^{BN} - 2q_I^{BN} - c = 0$$

Solving (10.1) and (10.2) simultaneously yields:

(11.1)
$$q_D^{BN} = \frac{1}{3}\left(1 + c - 2w^{BN}\right)$$

(11.2)
$$q_I^{BN} = \frac{1}{3}\left(1 - 2c + w^{BN}\right)$$

Note that $q_D = x_U + x_I$. We obtain firm *D*'s derived demand of the intermediate good by (11.1) as:

(12)
$$w^{BN} = \frac{1}{2} + \frac{c}{2} - \frac{3}{2}\left(x_U^{BN} + x_I^{BN}\right)$$

We proceed to the upstream stage, where the separated input supplier and the vertically integrated firm compete to supply the intermediate good to manufacturer *D*. Firm *U*'s profit function can be expressed as follows:

(13)
$$\pi_U^{BN} = \left(w^{BN} - m\right)x_U^{BN}$$

By using (9.2), (11), (12), (13), and differentiating $\pi_j^{BN}\left(j = U, I\right)$ with respect to $x_j^{BN}$, then letting it equal *zero*, we obtain the first-order conditions as follows:[11]

(14.1)
$$\frac{d\pi_U^{BN}}{dx_U^{BN}} = \overbrace{\frac{\partial \pi_U^{BN}}{\partial w^{BN}}\frac{\partial w^{BN}}{\partial x_U^{BN}}}^{\text{input price effect }(-)} + \overbrace{\frac{\partial \pi_U^{BN}}{\partial x_U^{BN}}}^{\text{direct effect }(+)} = x_U^{BN}\left(-\frac{3}{2}\right) + \left(w^{BN} - m\right) = \frac{1}{2} - m + \frac{c}{2} - 3x_U^{BN} - \frac{3}{2}x_I^{BN} = 0$$

[11] The effect of $x_I^{BN}$ on $\pi_I^{BN}$ through $q_I^{BN}$ vanishes due to the envelope theorem.

(14.2)

$$\frac{d\pi_I^{BN}}{dx_I^{BN}} = \overbrace{\frac{\partial \pi_I^{BN}}{\partial q_D^{BN}} \frac{dq_D^{BN}}{dx_I^{BN}}}^{\text{strategic effect }(-)} + \overbrace{\frac{\partial \pi_I^{BN}}{\partial w^{BN}} \frac{\partial w^{BN}}{\partial x_I^{BN}}}^{\text{input price effect }(-)} + \overbrace{\frac{\partial \pi_I^{BN}}{\partial x_I^{BN}}}^{\text{direct effect }(+)} = \left(-q_I^{BN}\right)(1) + \left(x_I^{BN}\right)\left(-\frac{3}{2}\right) + \left(w^{BN}\right) = c - x_U^{BN} - \frac{5}{2}x_I^{BN} = 0$$

We learn from (14) that the effects of $x_j^{BN}\left(j=U,I\right)$ on $\pi_j^{BN}$ are similar to those in (8). However, Eq. (14.2) differs from (8.2) in that the strategic and input price effects do not always outweigh the direct effect. It is because the vertically integrated firm *I* is now less efficient than the rival firm *D* in the downstream market. Therefore, firm *I* focuses more on its upstream profit if its upstream cost advantage is high enough. In this scenario, firm *I* will raise its upstream output to compete with its upstream rival to earn higher upstream profit. Moreover, when firm *I* increases its input supply to firm *D*, its downstream rival's marginal cost reduces due to a decrease in the input price. Ultimately, firm *D*'s downstream output becomes higher, and then firm *I* can earn more upstream profit by supplying the intermediate good to its downstream rival.

Solving (14.1) and (14.2) simultaneously yields the interior solutions of $x_U^{BN}$ and $x_I^{BN}$ as:

(15.1) $$x_U^{BN} = \frac{5}{24} - \frac{c}{24} - \frac{5m}{12}$$

(15.2) $$x_I^{BN} = -\frac{1}{12} + \frac{5c}{12} + \frac{m}{6}$$

It follows from (15) that firm *U* and firm *I* will joint supply the intermediate good to manufacturer *D* if $\frac{1}{2} - \frac{5c}{2} < m < \frac{1}{2} - \frac{c}{10}$. However, if $m \leq \frac{1}{2} - \frac{5c}{2}$, firm *U* will be the sole input supplier to manufacturer *D*, i.e., $x_I^{BN} = 0$. On the contrary, the vertically integrated firm will be the sole input supplier to its downstream rival, i.e., $x_U^{BN} = 0$, if $m \geq \frac{1}{2} - \frac{c}{10}$.[12] The equilibrium outcomes in the non-exclusivity case are reported in Table 1 hereunder.

[12] We calculate from (15) that both $x_U^{BN}$ and $x_I^{BN}$ are positive when $\frac{1}{2} - \frac{5c}{2} < m < \frac{1}{2} - \frac{c}{10}$. When $m \leq \frac{1}{2} - \frac{5c}{2}$, $x_I^{BN} \leq 0$, and when $m \geq \frac{1}{2} - \frac{c}{10}$, $x_U^{BN} \leq 0$.

TABLE 1
THE EQUILIBRIUM OUTCOMES IN THE NON-EXCLUSIVITY CASE IN REGIME B

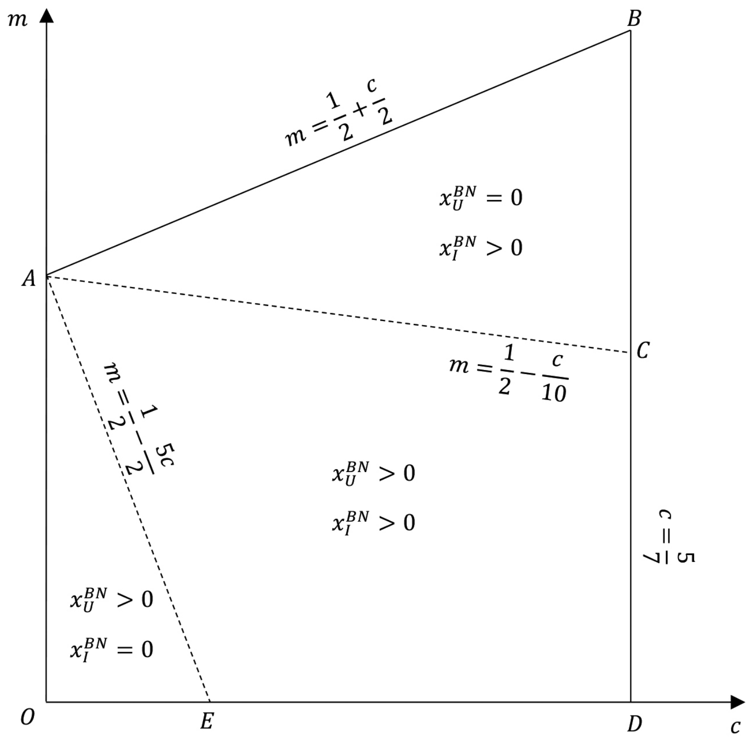
| | $m \leq \frac{1}{2} - \frac{5c}{2}$ | $\frac{1}{2} - \frac{5c}{2} < m < \frac{1}{2} - \frac{c}{10}$ | $m \geq \frac{1}{2} - \frac{c}{10}$ |
|---|---|---|---|
| $x_U^{BN}$ | $\frac{1}{6} + \frac{c}{6} - \frac{m}{3}$ | $\frac{5}{24} - \frac{c}{24} - \frac{5m}{12}$ | 0 |
| $x_I^{BN}$ | 0 | $-\frac{1}{12} + \frac{5c}{12} + \frac{m}{6}$ | $\frac{2c}{5}$ |
| $q_D^{BN}$ | $\frac{1}{6} + \frac{c}{6} - \frac{m}{3}$ | $\frac{1}{8} + \frac{3c}{8} - \frac{m}{4}$ | $\frac{2c}{5}$ |
| $q_I^{BN}$ | $\frac{5}{12} - \frac{7c}{12} + \frac{m}{6}$ | $\frac{7}{16} - \frac{11c}{16} + \frac{m}{8}$ | $\frac{1}{2} - \frac{7c}{10}$ |
| $w^{BN}$ | $\frac{1}{4} + \frac{c}{4} + \frac{m}{2}$ | $\frac{5}{16} - \frac{c}{16} + \frac{3m}{8}$ | $\frac{1}{2} - \frac{c}{10}$ |
| $\pi_D^{BN}$ | $\left(\frac{1}{6} + \frac{c}{6} - \frac{m}{3}\right)^2$ | $\left(\frac{1}{8} + \frac{3c}{8} - \frac{m}{4}\right)^2$ | $\left(\frac{2c}{5}\right)^2$ |
| $\pi_U^{BN}$ | $\frac{3}{2}\left(\frac{1}{6} + \frac{c}{6} - \frac{m}{3}\right)^2$ | $\frac{3}{2}\left(\frac{5}{24} - \frac{c}{24} - \frac{5m}{12}\right)^2$ | 0 |
| $\pi_I^{BN}$ | $\left(\frac{5}{12} - \frac{7c}{12} + \frac{m}{6}\right)^2$ | $\left(\frac{7}{16} - \frac{11c}{16} + \frac{m}{8}\right)^2 + \left(\frac{5}{16} - \frac{c}{16} + \frac{3m}{8}\right)\left(-\frac{1}{12} + \frac{5c}{12} + \frac{m}{6}\right)$ | $\frac{1}{4} - \frac{c}{2} + \frac{9c^2}{20}$ |

We depict Figure 2 to visually illustrate the impact of the cost differentials, i.e., $m$ and $c$, on the upstream market competition in the non-exclusivity case.

Here, the vertical line BD denotes the restriction in Assumption 1, in which our feasible area is on the left-hand side of the line $\left(c < \frac{5}{7}\right)$. Line AB indicates the restriction in Assumption 2, where the feasible area is beneath the line $\left(m < \frac{1}{2} + \frac{c}{2}\right)$. In addition, line AC (AE) represents the equality $m = \frac{1}{2} - \frac{c}{10}$ $\left(m = \frac{1}{2} - \frac{5c}{2}\right)$. According to Table 1, area OAE (ABC) is linked to the case where firm *U* (firm *I*) is the sole input supplier to manufacturer *D*. Otherwise, area ACDE depicts the scenario when the separated downstream firm purchases the intermediate good from both suppliers.

The intuition behind this result is as follows. Given the downstream cost differential ($c$), a sufficiently low upstream cost differential ($m$) indicates that the vertically integrated firm is not efficient enough relative to the separated upstream firm. It follows that firm *I*'s potential profit from supplying input to its

FIGURE 2
THE UPSTREAM COMPETITION IN THE NON-EXCLUSIVITY CASE IN REGIME B




downstream rival is low. In this scenario, the foregone profit from the upstream market is more than compensated by the extra benefit attained in the final good market when firm *D* is supplied only by the less efficient upstream firm. Next, if the upstream cost differential is high enough, the separated upstream firm is too inefficient, forcing it to shut down its production. Finally, if the upstream cost differential is medium, neither firm *U* nor firm *I* is too inefficient such that none of them is deterred from supplying the intermediate good to firm *D*.

Based on the preceding discussion, we establish the following proposition:

**Proposition 3:** *Suppose the separated downstream manufacturer is more efficient than the vertically integrated firm in producing the final good. Given the downstream cost differential, the upstream market outcomes in the absence of the exclusive contract between the separated firms will be one of the following three cases:*

*(i)* *If the upstream cost differential is low enough, i.e.,* $m \le \frac{1}{2} - \frac{5c}{2}$, *the separated upstream firm becomes the sole input supplier of the separated downstream manufacturer.*

*(ii)* *If the upstream cost differential is high enough, i.e.,* $m \ge \frac{1}{2} - \frac{c}{10}$, *the vertically integrated firm becomes the sole input supplier of the separated downstream manufacturer.*

*(iii)* *If the upstream cost differential is in an intermediate range, i.e.,* $\frac{1}{2} - \frac{5c}{2} < m < \frac{1}{2} - \frac{c}{10}$, *the separated upstream firm and the vertically integrated firm will joint supply the intermediate good to the separated downstream manufacturer.*

## 4.2. Exclusivity

We proceed to the case in which manufacturer $D$ accepts the exclusive contract from supplier $U$. It follows that the vertically integrated firm is effectively deterred from supplying the intermediate good to its downstream rival. By referring to Table 1, the separated firms' respective equilibrium profits under exclusivity are obtained as follows:[13]

(16.1) $$\pi_D^{BE} = \left(\frac{1}{6} + \frac{c}{6} - \frac{m}{3}\right)^2 + F^{BE}$$

(16.2) $$\pi_U^{BE} = \frac{3}{2}\left(\frac{1}{6} + \frac{c}{6} - \frac{m}{3}\right)^2 - F^{BE}$$

where the superscript "*BE*" is associated with variables under exclusivity in Regime B.

## 4.3. Contract decision

We first analyze the contract decision when $m \le \frac{1}{2} - \frac{5c}{2}$. In this interval, the operating profits of the respective firms are the same either when supplier $U$ and manufacturer $D$ sign or do not sign an exclusive contract. Recall that that the vertically integrated firm has no incentive to supply the intermediate good to its downstream rival in both scenarios. It follows that the optimal fixed payment supplier $U$ needs to deliver to manufacturer $D$ is *zero*, i.e., $F^{BE} = 0$, and

[13] The firms' operating profits are the same as those in the non-exclusivity case when $m \le \frac{1}{2} - \frac{5c}{2}$ since firm $I$ will not supply its intermediate good to its downstream rival if the separated firms do not sign the contract.

the separated firms are indifferent between signing or not signing that contract. The intuition behind Proposition 3 applies to this result.

Following Kitamura *et al.* (2018), the separated firms will sign the exclusive contract if their joint profit post-contract is no less than that in the absence of exclusivity, i.e., $\pi_U^{BE} + \pi_D^{BE} \geq \pi_U^{BN} + \pi_D^{BN}$. When $m \geq \frac{1}{2} - \frac{c}{10}$, we derive the difference in the separated firms' joint profits between exclusivity and non-exclusivity cases by referring to (16) and Table 1 as follows:[14]

$$(17) \qquad \left(\pi_U^{BE} + \pi_D^{BE}\right) - \left(\pi_U^{BN} + \pi_D^{BN}\right) = \frac{5}{2}\left(\frac{1}{6} + \frac{c}{6} - \frac{m}{3}\right)^2 - \left(\frac{2c}{5}\right)^2 < 0$$

We find, from (17), that the exclusive contract cannot be signed by the separated firms. The economic intuition behind this result is as follows. When $m \geq \frac{1}{2} - \frac{c}{10}$, the separated upstream firm is sufficiently inefficient in producing the intermediate good. In this case, it cannot earn enough extra profit post-contract to compensate the separated downstream firm. Thus, exclusivity cannot appear in equilibrium in this interval.

Finally, we discuss the contract decision when $\frac{1}{2} - \frac{5c}{2} < m < \frac{1}{2} - \frac{c}{10}$. From (16) and Table 1, we derive the separated firms' joint profit difference as follows:

$$(18) \qquad \left(\pi_U^{BE} + \pi_D^{BE}\right) - \left(\pi_U^{BN} + \pi_D^{BN}\right) = \left(-\frac{1}{24} + \frac{5c}{24} + \frac{m}{12}\right)\left(\frac{13}{48} - \frac{17c}{48} - \frac{13m}{24}\right)$$

The first term on the right-hand side of (18) is positive since $m > \frac{1}{2} - \frac{5c}{2}$. Thus, the overall sign of this equation depends on the second term only. We therefore obtain:[15]

$$(19) \qquad \left(\pi_U^{BE} + \pi_D^{BE}\right) - \left(\pi_U^{BN} + \pi_D^{BN}\right) \gtreqless 0 \text{ if } m \lesseqgtr \frac{1}{2} - \frac{17c}{26}$$

14 We can rewrite the joint profit difference as $\left[\frac{\sqrt{10}}{2}\left(\frac{1}{6} + \frac{c}{6} - \frac{m}{3}\right) + \left(\frac{2c}{5}\right)\right]\left[\frac{\sqrt{10}}{2}\left(\frac{1}{6} + \frac{c}{6} - \frac{m}{3}\right) - \left(\frac{2c}{5}\right)\right]$. The former term $\frac{\sqrt{10}}{2}\left(\frac{1}{6} + \frac{c}{6} - \frac{m}{3}\right) + \left(\frac{2c}{5}\right)$ is positive because of Assumption 2, while the latter, $\frac{\sqrt{10}}{2}\left(\frac{1}{6} + \frac{c}{6} - \frac{m}{3}\right) - \left(\frac{2c}{5}\right)$, can be rewritten as $\frac{\sqrt{10}}{6}\left(\frac{1}{2} + \left(\frac{1}{2} - \frac{6\sqrt{10}}{25}\right)c - m\right)$. We then obtain $\frac{\sqrt{10}}{6}\left(\frac{1}{2} + \left(\frac{1}{2} - \frac{6\sqrt{10}}{25}\right)c - m\right) \leq \frac{\sqrt{10}}{6}\left(\frac{1}{2} - \frac{c}{10} - m\right) \leq 0$ since $m \geq \frac{1}{2} - \frac{c}{10}$.

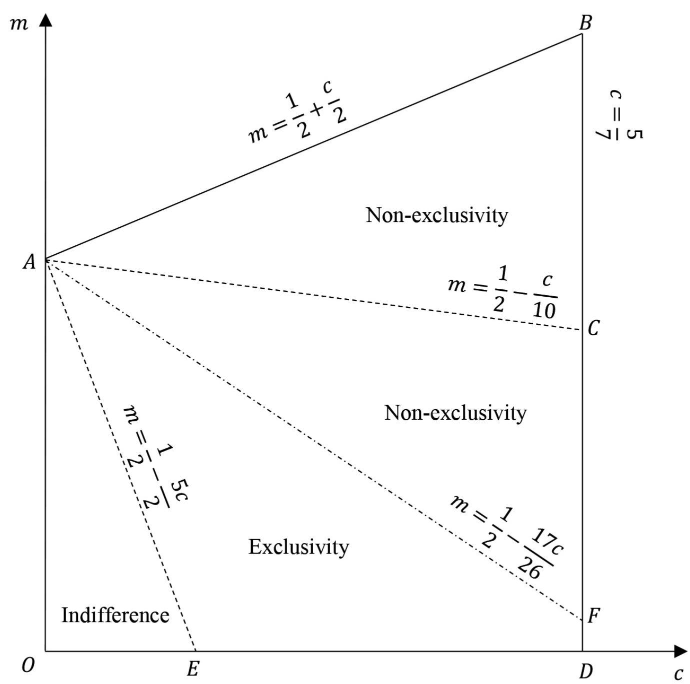
15 The sign of the second term on the right-hand side of (18) is positive, equal to *zero*, or negative when $m$ is less than, equal to, or greater than $\frac{1}{2} - \frac{17c}{26}$.

We find from (19) and the currently considered interval that if $\frac{1}{2}-\frac{5c}{2}<m\leq\frac{1}{2}-\frac{17c}{26}$, the separated firms are willing to sign the exclusive contract, while the reverse occurs otherwise. These results can be explained as follows. When the upstream cost differential satisfies $\frac{1}{2}-\frac{5c}{2}<m\leq\frac{1}{2}-\frac{17c}{26}$, the separated upstream firm is not sufficiently inefficient in producing the intermediate good. On the one hand, given this condition, the integrated firm still has an incentive to provide input for firm *D* in the non-exclusivity case, leading to a small profit for firm *U*. On the other hand, since firm *U* is not too inefficient, signing the contract creates a large enough extra profit. As a result, the separated firms' joint profit post-contract becomes higher such that the contract will be signed.

Next, if $\frac{1}{2}-\frac{17c}{26}\leq m<\frac{1}{2}-\frac{c}{10}$, the economic intuition of the case when $m\geq\frac{1}{2}-\frac{c}{10}$ carries over to this case such that the non-exclusivity result will appear in equilibrium.

Premised on the preceding analysis, we use Figure 3 to illustrate the cost differentials' impact on the separated firms' exclusive contract decision.

FIGURE 3
THE SEPARATED FIRMS' CONTRACT DECISIONS IN REGIME B



In Figure 3, the exclusive contract occurs in area AEDF, the non-exclusivity equilibrium counterpart takes place in area ABF, and it is indifferent between exclusivity and non-exclusivity in area OAE. We summarize the results in the following proposition:

**Proposition 4.** *Suppose the separated downstream manufacturer is more efficient than the vertically integrated firm in producing the final good. Given the downstream cost differential, the separated firms' contract decision will be one of the following three cases:*

*(i) If the upstream cost differential is relatively low, i.e.,* $m \leq \frac{1}{2} - \frac{5c}{2}$*, the separated firms will be indifferent between signing or not signing the contract.*

*(ii) If the upstream cost differential is medium, i.e.,* $\frac{1}{2} - \frac{5c}{2} < m \leq \frac{1}{2} - \frac{17c}{26}$*, the exclusivity equilibrium occurs.*

*(iii) If the upstream cost differential is relatively high, i.e.,* $m \geq \frac{1}{2} - \frac{17c}{26}$*, the non-exclusivity will appear in a unique equilibrium.*

Proposition 4 differs from the Chicago School's classic argument, concluding that an exclusivity equilibrium can never occur if the seller is inefficient. However, by introducing a vertically integrated rival with an inefficient downstream sector, we are able to show that the exclusive contract can be signed as a unique choice if the upstream cost differential is medium.[16]

## 5. Welfare Analysis

This section discusses the effect of exclusive dealing on consumer surplus and social welfare. Recall that the equilibria in the non-exclusivity and exclusivity cases are identical in Regime A and when $m \leq \frac{1}{2} - \frac{5c}{2}$ in Regime B. Therefore, the presence of an exclusive contract between firm $U$ and firm $D$ will not change the values of consumer surplus and social welfare under these circumstances.

[16] We find, from Propositions 2 and 4, that if the downstream cost differential is zero in both regimes, i.e., firm $D$ and firm $I$ are equally efficient in producing the final good, the separated firms are indifferent on whether to sign the exclusive contract or not. It is different from the result derived by Fumagalli and Motta (2006). Their paper shows that the exclusive agreements from an inefficient incumbent to two equally efficient downstream buyers are only signed when the buyers do not compete, and the incumbent pays zero reimbursements. The difference between ours and theirs is based on the competition modes in the vertically related markets and the impacts of the integrated rival's trading behaviors.

We proceed to discuss the two cases where $\frac{1}{2}-\frac{5c}{2}<m<\frac{1}{2}-\frac{c}{10}$ and $m\geq\frac{1}{2}-\frac{c}{10}$ in Regime B. It should be noted that the consumer surplus and social welfare functions are defined as follows:[17]

(20.1) $$CS=\int p(Q)dQ-pQ=\frac{1}{2}Q^2$$

(20.2) $$W=\pi_U+\pi_D+\pi_I+CS$$

By referring to Table 1 and (20), we derive that:[18]

(21.1) $$Q^{BE}-Q^{BN}=\begin{cases}\frac{1}{48}-\frac{5c}{48}-\frac{m}{24}<0 \ \textit{when} \ \frac{1}{2}-\frac{5c}{2}<m<\frac{1}{2}-\frac{c}{10}\\ \frac{1}{12}-\frac{7c}{60}-\frac{m}{6}<0 \ \textit{when} \ m\geq\frac{1}{2}-\frac{c}{10}\end{cases}$$

(21.2)
$$W^{BE}-W^{BN}=\begin{cases}-\frac{(131c+206m+41)(5c+2m-1)}{4608}<0 \quad \textit{when} \ \frac{1}{2}-\frac{5c}{2}<m<\frac{1}{2}-\frac{c}{10}\\ \frac{11}{288}+\frac{43c}{720}-\frac{17m}{72}-\frac{1141c^2}{7200}-\frac{29cm}{72}+\frac{23m^2}{72}<0 \ \textit{when} \ m\geq\frac{1}{2}-\frac{c}{10}\end{cases}$$

From the above discussion and (21), we find that in both regimes, the consumer surplus represented by the total downstream output and the social welfare post-contract will not be improved. Thus, we conclude this result by the following proposition.

**Proposition 5.** *An exclusive contract between two separated firms in the presence of a vertically integrated rival will never increase consumer surplus and social welfare.*

This result is in line with conventional wisdom, in which an exclusive contract reduces the degree of competition among sellers, leading to higher prices, lower consumer surplus, and lower social welfare.

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17 The consumer surplus function $CS=\frac{1}{2}Q^2$ is followed by the linear demand $p(Q)=1-Q$.

18 Please see Appendix B for the proof that $W^{BE}-W^{BN}=\frac{11}{288}+\frac{43c}{720}-\frac{17m}{72}-\frac{1141c^2}{7200}-\frac{29cm}{72}+\frac{23m^2}{72}<0$ when $m\geq\frac{1}{2}-\frac{c}{10}$.

## 6. Concluding Remarks

Chicago School's classic argument on exclusive dealing has prompted controversy among scholars. This paper reexamines whether this argument is still valid in a successive Cournot model. We, therefore, consider a three-firm model in which a separated upstream input supplier offers an exclusive contract to a separated downstream manufacturer to prevent a vertically integrated firm from supplying the input to the downstream party. Meanwhile, the separated downstream manufacturer competes against the vertically integrated firm in the downstream market.

Three main results have been derived in the paper. First, the separated firms are indifferent on whether to sign the exclusive contract or not if the downstream party is less efficient than the integrated firm in producing the final good. Second, the separated firms with an efficient downstream party are indifferent between signing or not signing, willing to sign, and not willing to sign the exclusive contract if the upstream cost differential is relatively low, medium, and high, respectively. Third, signing such an exclusive contract does not increase consumer surplus and social welfare.

Our results are specific to the successive Cournot model, in which the upstream quantity competition is not widespread in the context of exclusive dealing. It would be interesting for future research to conduct a similar analysis involving upstream price competition. Moreover, it will be an appealing challenge for future research to adopt a per-unit discount or a mixed reimbursement to replace the assumption of lump-sum reimbursement in the exclusive contract when the sellers compete in quantity.

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## Appendix A

This Appendix aims to show that the result in Regime A is robust for a general demand function. Let us denote the inverse demand function as:

(A.1) $$p = p(Q),\ p' < 0$$

In the non-exclusivity case, manufacturer *D*'s and firm *I*'s profit functions are the same as those in (2). By differentiating $\pi_i^{AN}\ (i = D, I)$ with respect to $q_i^{AN}$ and letting it equal *zero*, we obtain the first-order conditions of the downstream stage as follows:

(A.2.1) $$\frac{\partial \pi_D^{AN}}{\partial q_D^{AN}} = \left(p^{AN}\right)' q_D^{AN} + p^{AN} - c_D - w^{AN} = 0$$

(A.2.2) $$\frac{\partial \pi_I^{AN}}{\partial q_I^{AN}} = \left(p^{AN}\right)' q_I^{AN} + p^{AN} - c_I = 0$$

The second-order and stability conditions require:

(A.3.1) $$\frac{\partial^2 \pi_D^{AN}}{\partial \left(q_D^{AN}\right)^2} = 2\left(p^{AN}\right)' + \left(p^{AN}\right)'' q_D^{AN} < 0$$

(A.3.2) $$\frac{\partial^2 \pi_I^{AN}}{\partial \left(q_I^{AN}\right)^2} = 2\left(p^{AN}\right)' + \left(p^{AN}\right)'' q_I^{AN} < 0$$

(A.3.3) $$\Delta^{AN} = \left[\frac{\partial^2 \pi_D^{AN}}{\partial \left(q_D^{AN}\right)^2}\right] \times \left[\frac{\partial^2 \pi_I^{AN}}{\partial \left(q_I^{AN}\right)^2}\right] - \left[\frac{\partial^2 \pi_D^{AN}}{\partial q_D^{AN}\, \partial q_I^{AN}}\right] \times \left[\frac{\partial^2 \pi_I^{AN}}{\partial q_I^{AN}\, \partial q_D^{AN}}\right] > 0$$

where $\frac{\partial^2 \pi_D^{AN}}{\partial q_D^{AN}\, \partial q_I^{AN}} = \left(p^{AN}\right)' + \left(p^{AN}\right)'' q_D^{AN} < 0$ and $\frac{\partial^2 \pi_I^{AN}}{\partial q_I^{AN}\, \partial q_D^{AN}} = \left(p^{AN}\right)' + \left(p^{AN}\right)'' q_I^{AN} < 0$.[19]

[19] The last two expressions are assumed to ensure that manufacturer *D*'s and firm *I*'s downstream marginal revenue curves are steeper than the final good demand curve. See Brander and Spencer (1985), Dixit (1986), and Hwang and Mai (1991).

Totally differentiating (A.2.1) and (A.2.2) yields:

(A.4.1) $$\frac{dq_D^{AN}}{dw^{AN}} = \frac{\left[2\left(p^{AN}\right)' + \left(p^{AN}\right)'' q_I^{AN}\right]}{\Delta^{AN}} < 0$$

(A.4.2) $$\frac{dq_I^{AN}}{dw^{AN}} = -\frac{\left[\left(p^{AN}\right)' + \left(p^{AN}\right)'' q_I^{AN}\right]}{\Delta^{AN}} > 0$$

It is apparent from (A.4) that a hike in the input price causes a fall in the separated downstream manufacturer's output while increasing firm *I*'s downstream output. It is because an increase in $w^{AN}$ raises manufacturer *D*'s marginal cost. As a result, $q_D^{AN}$ decreases. By strategic substitutes, firm *I* will produce more in the final good market.

Note that one unit of input is sufficient to produce one unit of output, i.e., $q_D = x_U + x_I$. Let $w^{AN} = w^{AN}\left(x_U, x_I\right)$ be firm *D*'s derived demand of the intermediate good. By (A.4.1) and $q_D^{AN} = x_U^{AN} + x_I^{AN}$, we obtain:

(A.5) $$\frac{\partial w^{AN}}{\partial\left(x_U^{AN} + x_I^{AN}\right)} = \frac{\Delta^{AN}}{\left(2\left(p^{AN}\right)' + \left(p^{AN}\right)'' q_I^{AN}\right)} < 0$$

By (A.4) and (A.5), we obtain:

(A.6.1) $$\frac{dq_D^{AN}}{dx_U^{AN}} = \frac{dq_D^{AN}}{dx_I^{AN}} = 1 > 0$$

(A.6.2) $$\frac{dq_I^{AN}}{dx_U^{AN}} = \frac{dq_I^{AN}}{dx_I^{AN}} = -\frac{\left[\left(p^{AN}\right)' + \left(p^{AN}\right)'' q_I^{AN}\right]}{\left[2\left(p^{AN}\right)' + \left(p^{AN}\right)'' q_I^{AN}\right]} < 0$$

In the upstream stage, input supplier *U*, which maximizes the profit function as in (7), competes against firm *I* in a quantity fashion. By referring to (2.2), (7), (A.2), (A.5), and (A.6.1), the first-order conditions are derived as follows:[20]

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[20] In (A.7.2), the effect of $x_I^{AN}$ on $\pi_I^{AN}$ through $q_I^{AN}$ vanishes due to the envelope theorem. Moreover, we derive from (2.2), (A.2), (A.5), and (A.6.1) that the strategic effect equals $\left(p^{AN}\right)' q_I^{AN} = c_I - p^{AN} < 0,$ the input price effect equals $x_I^{AN}\left[\frac{\Delta^{AN}}{\left(2\left(p^{AN}\right)' + \left(p^{AN}\right)'' q_I^{AN}\right)}\right] < 0,$ and the direct equals $w^{AN} = \left(p^{AN}\right)' q_D^{AN} + p^{AN} - c_D > 0.$ The strategic effect outweighs the

(A.7.1)

$$\frac{d\pi_U^{AN}}{dx_U^{AN}} = \overbrace{\left(\frac{\partial \pi_U^{AN}}{\partial w^{AN}}\right)\left(\frac{\partial w^{AN}}{\partial x_U^{AN}}\right)}^{\text{input price effect }(-)} + \overbrace{\frac{\partial \pi_U^{AN}}{\partial x_U^{AN}}}^{\text{direct effect }(+)} = x_U^{AN}\left[\frac{\Delta^{AN}}{\left(2\left(p^{AN}\right)' + \left(p^{AN}\right)'' q_I^{AN}\right)}\right] + \left(w^{AN} - m\right) = 0$$

(A.7.2)

$$\frac{d\pi_I^{AN}}{dx_I^{AN}} = \overbrace{\left(\frac{\partial \pi_I^{AN}}{\partial q_D^{AN}}\right)\left(\frac{dq_D^{AN}}{dx_I^{AN}}\right)}^{\text{strategic effect }(-)} + \overbrace{\left(\frac{\partial \pi_I^{AN}}{\partial w^{AN}}\right)\left(\frac{\partial w^{AN}}{\partial x_I^{AN}}\right)}^{\text{input price effect }(-)} + \overbrace{\frac{\partial \pi_I^{AN}}{\partial x_I^{AN}}}^{\text{direct effect }(+)} = \left(p^{AN}\right)' q_D^{AN} + c_I - c_D + x_I^{AN}\left[\frac{\Delta^{AN}}{\left(2\left(p^{AN}\right)' + \left(p^{AN}\right)'' q_I^{AN}\right)}\right] < 0$$

Since $\frac{d\pi_I^{AN}}{dx_I^{AN}} < 0,$ firm *I* will not supply its intermediate good to manufacturer *D* in the non-exclusivity case. The result in Regime A is robust for a general demand function accordingly.

direct effect since the summation of the two is as $\left(p^{AN}\right)' q_D^{AN} + c_I - c_D < 0.$ In addition, the input price effect is also negative. As a result, $\frac{d\pi_I^{AN}}{dx_I^{AN}} < 0.$

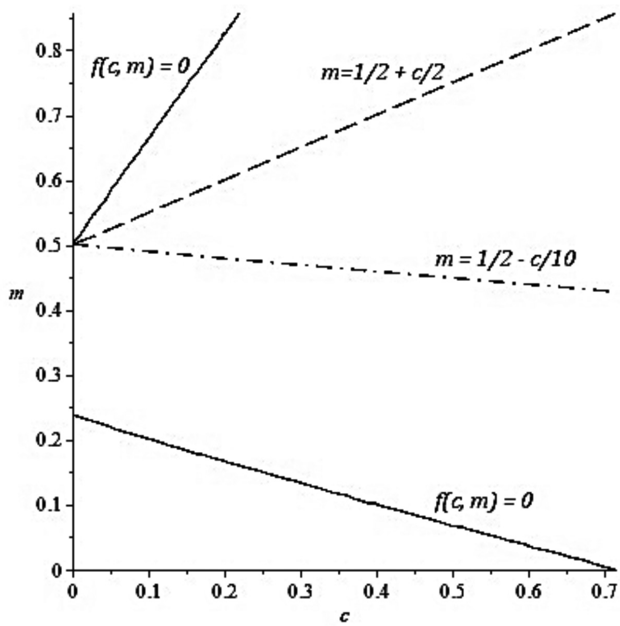
## Appendix B

This Appendix proves that the welfare difference between exclusivity and non-exclusivity cases in Regime B is negative when $m \geq \frac{1}{2} - \frac{c}{10}$. Let *f*(*c, m*) denote the function of this welfare difference derived in (21.2), i.e., $f(c,m) = \frac{11}{288} + \frac{43c}{720} - \frac{17m}{72} - \frac{1141c^2}{7200} - \frac{29cm}{72} + \frac{23m^2}{72}$.

We employ the following figure (Figure B.1) to determine the sign of *f*(*c, m*) when $m \geq \frac{1}{2} - \frac{c}{10}$. It should be noted that the horizontal (vertical) axis is for the downstream (upstream) cost differential. In addition, the solid curve represents *f*(*c, m*) = 0. The condition for this case and the two assumptions mentioned at the beginning of Regime B require that the feasible area is between the dash line $m = \frac{1}{2} + \frac{c}{2}$ and the dash-dot line $m = \frac{1}{2} - \frac{c}{10}$ with $c < \frac{5}{7}$. Since the feasible area is inside the solid curve, all the points of *c* and *m* located inside this area result in the same sign of *f*(*c, m*). Taking (*c, m*) = (0.6, 0.6) as an example yields *f*(0.6, 0.6) < 0. It follows that *f*(*c, m*) < 0 when $m \geq \frac{1}{2} - \frac{c}{10}$.

FIGURE B.1

A PLOT OF $f(c,m) = 0$ WHEN $m \geq \frac{1}{2} - \frac{c}{10}$ IN REGIME B



# A new look at the pollution halo hypothesis: The role of environmental policy stringency*

## *Una nueva mirada a la hipótesis del halo de contaminación: El papel del rigor de la política ambiental*

Hale Akbulut**
Ahmet Burçin Yereli***

**Abstract**

*The effect of Foreign Direct Investments (FDIs) on greenhouse gas (GHG) emissions, has attracted the attention of researchers in recent years. However, the indirect effects of environmental policies in the process were not sufficiently considered. This study uses a panel threshold methodology to examine the non-linear impact of environmental policy stringency on the relationship between FDIs and GHG emissions in 25 OECD countries. Our results show a negative relationship between FDIs and GHG emissions if the countries have environmental policy stringency index above a threshold level of (2.22). The results are also supported by the fixed effects model, which indicates a threshold effect of (2.88). The threshold effect is mostly due to the stringency of nonmarket-based environmental policies.*

Key words: *Climate change, environmental taxes, public policy.*

JEL Classification: *Q50, Q53, Q58.*

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**Resumen**

*El efecto de las Inversiones Extranjeras Directas (IED) sobre las emisiones de gas de efecto invernadero (GEI) ha llamado la atención de los investigadores en los últimos años. Sin embargo, los efectos indirectos de las políticas ambientales en el proceso no fueron suficientemente considerados. Este estudio utiliza una metodología de umbral de panel para examinar el impacto no lineal del rigor de la política ambiental en la relación entre las IED y las emisiones de GEI en 25 países de la OCDE. Nuestros resultados muestran una relación negativa entre las IED y las emisiones de GEI si los países tienen un índice de rigor de la política ambiental por encima de un nivel de umbral de (2.22). Los resultados también están respaldados por el modelo de efectos fijos, que indica un efecto de umbral de (2.88). El efecto de umbral se debe principalmente a la rigurosidad de las políticas ambientales no basadas en el mercado.*

Palabras clave: *Cambio climático, impuestos ambientales, política pública.*

Clasificación JEL: *Q50, Q53, Q58.*

## 1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) reports that global warming is one of the most critical problems of our age that concerns both current and future generations. While combating climate change is determined as one of the Sustainable Development Goals (SDGs), the Paris Agreement, which entered into force in November 2016, aims to limit the average global temperature rise to 2°C above pre-industrial levels. Based on the widespread view that greenhouse gas (GHG) emissions from non-renewable energy sources are one of the leading causes of climate change, it is essential to eliminate these emissions through different policies. Although many factors affect GHG emissions, empirical analyses of economic variables' effects have only been made in recent years. In the literature, foreign direct investment (FDI) inflows draw attention as an important economic factor affecting this process.

FDIs are seen as an important tool in ensuring economic growth and employment. Therefore, host countries are trying to attract FDIs to their countries with different strategies. There is essentially no consensus on the impact of FDI inflows on the GHG emissions in the host country, and the debate is based on two main arguments. The first argument was developed by Walter and Ugelow (1979) and Pethig (1976) and called the Pollution Haven Hypothesis (PHAH). This view argues that FDIs, particularly from pollution-intensive industries, tend toward countries with less environmental stringency, thereby increasing the level of pollution in the host country. The second argument, called the Pollution Halo Hypothesis (PHH), argues that FDIs from more developed countries help improve environmental standards in developing countries due to high production standards and clean technology transfer. Both findings support the PHAH (e.g., Blanco *et al.*, 2013; Kivyiro and Arminen, 2014; Gokmenoglu and Taspinar, 2016; Bae *et al.*, 2017; Hanif *et al.*, 2019) and support PHH (e.g. Pao and Tsai, 2011; Kivyiro and Arminen, 2014; Hao and Liu, 2015; Mert and Boluk, 2016; Rafindadi *et al.*, 2018; Balsalobre-Lorente *et al.*, 2019; Mert and Caglar, 2020; Neves *et al.*, 2020).

Although attention has been drawn to the role of environmental policies in the effect of FDI on GHG emissions[1], it has been observed that this relationship has neither been analysed in detail nor empirically tested. However, the strictness of environmental policies implemented in host countries can impact the decisions about what type of FDI will be directed to the relevant country[2]. And this effect may differ depending on the type of policy implemented.

OECD considers environmental policies under three headings: market-based policies, nonmarket-based policies, and technology support policies. Market-based approaches try to eliminate negative externality by changing price signals. Emission tax and marketable permit system are among the most widely used market-based policies. Nonmarket-based policies impose direct controls on pollutants while removing negative externalities. The command-and-control system directly limiting emissions is an excellent example of non-market-based policy instruments. Technology support policies include upstream support such as low-carbon R&D expenditures and adoption support about solar and wind-based energy systems.

In general, FDI inflows are expected to positively impact environmental quality in economies with sufficiently stringent environmental policies. In market-based policies, this effect will work through corrected price signals. As Nobel Prize-winning economist Nordhaus (2013: 19) points out, for policies to combat climate change to be effective, the market prices of GHG emissions must increase. Such an increase in prices will serve four different targets. First, it will signal to consumers which goods and services are pollution-intensive, thus ensuring that they are consumed less. Second, it will show producers which inputs are less pollution-intensive, enabling them to be used more in the production process. Third, it will encourage entrepreneurs and investment bankers to make production technologies more environmentally friendly. Finally, the GHG price lowers the amount of information one needs to know to do all this. The positive effect of the corrective tax policy on regulating price signals may ensure that the efficiency of FDIs comes to the fore. Thus, in countries with sufficiently strict market-based environmental regulations, FDI inflows are relatively likely to serve ecological quality. On the other hand, in nonmarket-based policies, there will be a direct impact that is considered in the decision-making process

1 The fact that some countries lower their environmental regulations to attract FDI creates a separate factor that triggers environmental degradation.

2 Weak environmental policies in the host countries may give the high-income economies a comparative advantage in pollution-intensive goods (Sapkota & Bastola, 2017: 206).

of investments. Therefore, foreign investments that do not meet the defined standards will not be directed to the host country. Countries with sufficiently stringent standards will tend to attract clean investments. In the case of technology support programs, the government bears the costs, so foreign investments can be expected to have a negative impact on the environment in countries where the support is not sufficient. In sum, in addition to the direct effects of reducing pollution, environmental policies can also be considered to have positive effects on environmental quality by serving to attract clean foreign investments.

Based on these discussions, this study aims to test the relationship between FDI inflows and GHG emissions, considering the moderating role of environmental regulations. In this context, the main hypothesis of the study was determined as follows:

$H_0$: In economies where, environmental policy stringency is above a certain threshold, FDI inflows have a negative effect on GHG emissions.

$H_1$: The stringency of environmental policies does not affect the relationship between FDI inflows and GHG emissions.

To test these hypotheses, we wanted to benefit from a large dataset, so we preferred to focus on OECD countries. The OECD countries generally consist of developed countries and their GHG emissions are 9.15 tonnes per capita as of 2019. Australia, Canada and the US have the highest emission values with 24.14, 20.70 and 17.54 tonnes per capita, respectively. And, these values are well above the world average of 6.45 tonnes per capita (OurWorldInData, 2022). Therefore, it is noteworthy to examine the effects on GHG emissions in the OECD countries.

It is expected that the findings obtained from this study will contribute to the literature in some respects. Firstly, the study will contribute to creating policy recommendations for reducing GHG emissions in the sample countries and will reveal that the pollution halo hypothesis will become more likely if any policy is implemented. Secondly, we test the relationship in the panel framework. In this way, we benefit from the advantage of the increased number of observations and include the country-specific effects. Thirdly, we use updated environmental policy stringency index of OECD which is a comprehensive measure of environmental policies and thereby, we provide substantial information by using recent data obtained from new methodology. We also had the opportunity to compare the effects of different types of policies: market-based, nonmarket-based and technology support policies. And last, we check our findings by comparing them with the findings obtained from fixed effects regressions.

The rest of the paper is organised as follows. Section 2 presents a literature review. Section 3 presents the methodology. Section 4 sets out the data and description. Section 5 presents empirical analysis, results, and their discussion. Section 6 concludes the paper and offers policy recommendations.

## 2. Literature Review

Although economies are trying to attract FDI inflows to their countries, the impact of these investments on the environmental quality of the host country is uncertain. In studies examining how FDIs will affect GHG emissions, it is observed that the discussions are divided into two basic views. According to the PHAH, multinational enterprises gain a cost advantage by directing their pollution-intensive industries to countries with weak environmental regulations, thus increasing the volume of pollution in the host country. According to the PHH, multinational companies transfer high production standards and clean technologies, thereby reduce the volume of pollution in the host country.

There are many studies in the literature supporting the PHAH. It is noteworthy that these studies have addressed quite different countries and groups of countries: e.g., Asian countries (Hanif *et al.* 2019), BRIC (Pao and Tsai, 2011), China (Zhou *et al.*, 2018), developed and developing countries (Essandoh *et al.*, 2020; Singhania and Saini, 2021) Latin American countries (Blanco *et al.*, 2013; Sabkota and Bastola, 2017), OECD countries (Caetano *et al.*, 2022), PIIGS countries (Balsalobre-Lorente *et al.* 2022), Sub-Saharan African countries (Kivyiro and Arminen, 2014), and Post-Soviet countries (Bae *et al.*, 2017).

Similarly, there are also studies supporting the PHH. However, it is noteworthy that these studies mostly dealt with the Asian sample: e.g., China (Zhang and Zou, 2016; Sung *et al.* 2018), Korea (Hille *et al.* 2019), and Southeast Asian countries (Zhu *et al.*, 2016). Accordingly, it can be argued that the foreign investments directed to the Asian countries under consideration have effects on reducing emissions by supporting environmentally friendly production technologies instead of increasing carbon emissions. There also studies supporting PHH by considering non-Asian countries: e.g., BRIC (Pao and Tsai, 2011) and Sub-Saharan countries (Kivyiro and Arminen, 2014; Opoku *et al.*, 2021). Table 1 summarizes these studies.

Nevertheless, studies given in Table 1 have set out from the assumption of a linear relationship between the variables in question while testing the effects of FDIs on environmental quality. However, FDIs can have non-linear impacts on GHG emissions. These effects may occur through FDIs themselves or third variables. Among the studies in which the square and cube of FDIs were included in the analysis, Pazienza *et al.* (2019) focused on 30 OECD economies. In the study using fixed-effects and random-effects models, the effect of FDIs in the manufacturing sector on carbon emissions was found to be positive. At the same time, the coefficient of the square of the variable was found to be negative. In other words, FDIs increase carbon emissions, but this increase is gradually decreasing. Another study considering the nonlinear relationship belongs to Sarkodie and Strazov (2019). The FDI variable with its square and cube was included in the analysis for five developing countries, including Asian countries such as China and Indonesia. According to the findings of the study, while the FDI variable and its cube have a positive relationship with carbon emissions, the relationship between the square of the variable and carbon emissions is negative.

TABLE 1
A SUMMARY OF RELEVANT STUDIES

| Study | Sample | Methodology | Supporting Hypothesis |
|---|---|---|---|
| Pao & Tsai (2011) | BRIC (1992-2007) | PECM (Panel) | PHH and PHAH |
| Blanco *et al.* (2013) | 18 Latin American Countries (1980-2007) | Granger Causality (Panel) | PHAH |
| Kivyiro & Arminen (2014) | 6 Sub-Saharan African Countries (1971-2006) | ARDL (Time Series) | PHAH-in 6 countries<br>PHH-in DRC and S. Africa |
| Zhang & Zou (2016) | China (3 regions) (1995-2010) | Fixed-effects, GLS (Panel) | PHH |
| Zhu *et al.* (2016) | 5 Southeast Asian Countries (1981-2011) | Quantile Regression (Panel) | PHH |
| Bae *et al.* (2017) | 115 Post-Soviet Countries (2000-2011) | GMM (Panel) | PHAH |
| Sabkota & Bastola (2017) | 14 Latin American Countries (1980-2014) | Fixed-effects, Random effects (Panel) | PHAH |
| Sung *et al.* (2018) | China (28 subsectors) (2002-2015) | GMM (Panel) | PHH |
| Zhou *et al.* (2018) | China (285 cities) (2003-2015) | GMM (Panel) | PHAH |
| Hanif *et al.* (2019) | 15 Asian Countries (1990-2013) | ARDL (Panel) | PHAH |
| Hille *et al.* (2019) | Korea (16 provinces) (2000-2011) | Simultaneous equations (Panel) | PHH |
| Essandoh *et al.* (2020) | 52 countries (1991-2014) | ARDL (Panel) | PHAH in developing countries<br>PHH in developed countries |
| Opoku *et al.* (2021) | 22 Sub-Saharan Countries (1995-2014) | GMM (Panel) | PHH |
| Singhania & Saini (2021) | 21 countries with high carbon emissions (1990-2016) | GMM (Panel) | PHAH |
| Balsalobre-Lorente *et al.* (2022) | PIIGS (1990-2019) | Dynamic OLS (Panel) | PHAH |
| Caetano *et al.* (2022) | 15 OECD Countries (2005-2018) | ARDL (Panel) | PHAH |

While considering the nonlinear relationship between FDI and emissions, some studies handle the effect of a third variable on the process. The first of these studies belongs to Liobikiene and Butkus (2019). The authors examined the interaction with the third variables by including the product of FDI and industrial sector value-added, efficiency in energy use, and renewable energy consumption variables in the analysis with the data of 147 countries for the period 1990-2012. However, the analysis findings were statistically insignificant for the coefficients related to the interaction terms. A later study by Xie *et al.* (2020) examined the impact of FDIs on emissions through the economic growth channel. It has been confirmed that FDIs increase emissions in developing countries, but this effect turns negative through the economic growth channel.

To summarise, few studies consider the effects of third variables in testing the relationship between FDIs and emissions. Although, there are many recent studies in the literature emphasising the impact of environmental policies on emissions (e.g. Wang & Shao, 2019; Ahmed, 2020; Neves *et al.*, 2020; Wang *et al.*, 2020; Wolde-Rufael & Weldemeskel, 2020, 2021; Zhang *et al.*, 2020), the role of environmental policies on the relationship between FDIs and emissions are not taken into account. However, strict environmental policies can have an impact on production costs by requiring certain equipment, decreasing waste disposal capacity, and prohibiting certain factor inputs or outputs (Xing and Kolstad, 2002). Therefore, they can also have an impact on companies' investment decisions. As Copeland and Taylor (2004) stated, large-scale enterprises with the capacity to invest directly may prefer to direct their investments towards countries with less strict environmental policies that offer cost advantages by considering ecological costs while making investment decisions. List and Co (2000) and List *et al.* (2003) also confirmed that heterogenous regulations across regions alter the choices regarding FDIs.

Based on the discussions, the strictness of the environmental policies implemented in the host country will have an important role in the ecological effects of foreign capital directed to the country. In other words, it is expected that foreign capital to be required to countries with sufficient strictness in environmental regulations will be relatively environment-friendly and have a reducing effect rather than increasing pollution. Examining the hypothesis above with a sample based on OECD countries and supporting the discussion with empirical findings constitute the primary motivation for this study.

## 3. Methodology

There are some reasons for choosing the panel threshold regression model of Hansen (1999) as the methodology in the study. First, the method in question eliminates the multicollinearity problem that may arise when the variables' squares, cubes, or multiplications are used in the non-linear analysis. Secondly, a specific threshold value will be found for the variable considered as the threshold variable due to the analysis. Thus, concrete policy recommendations can be made depending on whether it is below or above the threshold value for each country. In addition, since the method is based on panel data, the number of observations and the degree of independence will increase accordingly, making the estimation results more reliable.

A single-threshold model of Hansen (1999) that tests whether there are regime-switching effects can be constructed as follows:

(1)
$$y_{it} = \mu_i + \alpha X_{it} + \beta FDI_{it} + e_{it}\ ,\ e_{it} \sim iid\left(0,\sigma^2\right)$$
$$y_{it} = \begin{cases} \mu_i + \alpha X_{it} + \beta_1 FDI_{it} + e_{it}, P_{it} \le \lambda \\ \mu_i + \alpha X_{it} + \beta_2 FDI_{it} + e_{it}, P_{it} > \lambda \end{cases}$$
$$\alpha = \left(\alpha_1,\ \alpha_2,\ \alpha_3,\ \alpha_4\right)'$$
$$e_{it} \approx N\left(0,\sigma^2\right)$$

where $P_{it}$ indicates relevant environmental policy stringency as the threshold variable, $\lambda$ indicates threshold value, $FDI_{it}$ indicates FDI variable, $X_{it}$ indicates explanatory variables other than FDI, $\mu_i$ indicates fixed effects and $e_{it}$ indicates error term.

Equation (1) can be written as equation (2) or (3) if I(.) denotes an indicator function:

(2)
$$y_{it} = \mu_i + \alpha X_{it} + \beta_1 FDI_{it} I\left(P_{it} \le \lambda\right) + \beta_2 FDI_t I\left(P_{it} > \lambda\right) + e_{it}$$
$$y_{it} = \mu_i + \alpha' X_{it} + \beta' FDI_{it}\left(\lambda\right) + e_{it} \beta = \left(\beta_1, \beta_2\right)'$$
$$y_{it} = \mu_i + \left[\alpha', \beta'\right] \begin{bmatrix} X_{it} \\ FDI_{it}\left(\lambda\right) \end{bmatrix} + e_{it}$$

(3)
$$y_{it} = \mu_i + \theta' h_{it}\left(\lambda\right) + e_{it}$$
$$FDI_{it}\left(\lambda\right) = \begin{bmatrix} FDI_{it} I\left(P_{it} \le \lambda\right) \\ FDI_{it} I\left(P_{it} > \lambda\right) \end{bmatrix},$$

where $\theta = \left(\alpha', \beta'\right)'$ and $h_{it} = \left(X_{it}{}', FDI_{it}\left(\lambda\right)'\right)'$.

Accordingly, the regression divides the observations into two regimes depending on whether the threshold variable ($P_{it}$) is smaller or larger than the threshold ($\lambda$). Differing regression slopes distinguish the regimes $\left(\beta_1, \beta_2\right)$.

Taking averages of equation (2) over the time index will give:

(4)
$$\overline{y}_i = \mu_i + \theta' \overline{h}_i\left(\lambda\right) + \overline{e}_i,$$

where:

$$\overline{y}_i = T^{-1}\sum\nolimits_{t=1}^{T} y_{it},\ h_i = T^{-1}\sum\nolimits_{t=1}^{T} \overline{h}_{it},\ \overline{e}_i = T^{-1}\sum\nolimits_{t=1}^{T} e_{it}$$

Taking the difference between equations (2) and (4) yields

$$y_{it}^* = \theta' h_{it}^*(\lambda) + e_{it}^* \tag{5}$$

where:

$$y_{it}^* = y_{it} - \bar{y}_i \ , h_{it}^*(\lambda) = h_{it}(\lambda) - \bar{h}_i(\lambda), e_{it}^* = e_{it} - \bar{e}_i.$$

If

$$y_i^* = \begin{bmatrix} y_{i2}^* \\ . \\ . \\ . \\ y_{iT}^* \end{bmatrix}, h_i^*(\gamma) = \begin{bmatrix} h_{i2}^*(\lambda) \\ . \\ . \\ . \\ h_{iT}^*(\lambda) \end{bmatrix}, e_i^* = \begin{bmatrix} e_{i2}^* \\ . \\ . \\ . \\ e_{iT}^* \end{bmatrix}, \text{ and}$$

$$Y^* = \begin{bmatrix} y_1^* \\ . \\ . \\ . \\ y_n^* \end{bmatrix}, H^*(\lambda) = \begin{bmatrix} h_1^*(\lambda) \\ . \\ . \\ . \\ h_{it}^*(\lambda) \end{bmatrix}, e^* = \begin{bmatrix} e_1^* \\ . \\ . \\ . \\ e_n^* \end{bmatrix};$$

Equation (5) can be re-written as follows:

$$Y_{it}^* = \theta' H_{it}^*(\lambda) + e_{it}{}^* \tag{6}$$

The slope coefficient will be calculated with the OLS estimator as follows:

$$\hat{\theta}(\lambda) = \left(H^*(\lambda)' H^*(\lambda)\right)^{-1} H^*(\lambda)' Y^* \tag{7}$$

The residual vector will be as in equation (8):

$$\hat{e}^*(\lambda) = Y^* - H(\lambda)\hat{\theta}(\lambda) \tag{8}$$

The sum of squared errors will be as in equation (9):

$$SSE_1(\lambda) = \hat{e}^*(\lambda)\hat{e}^*(\lambda)' = Y^{*'}(I - H^*(\lambda)'\left(H^*(\lambda)' H^*(\lambda)\right)^{-1} H^*(\lambda)')Y^* \tag{9}$$

In this case, λ; can be calculated by minimizing the concentrated sum of squared errors. Therefore, the least-square estimator is:

(10) $$\hat{\lambda} = \underset{\lambda}{\operatorname{argmin}} \, SSE_1(\lambda)$$

When calculating the slope coefficient and the residual vector based on λ, the estimator of the residual variance will be as follows $\left(\widehat{\theta} = \hat{\theta}(\lambda),\, \hat{e}^* = \hat{e}^*(\lambda)\right)$:

(11) $$\hat{\sigma}^2 = \frac{1}{n(T-1)} \hat{e}^{*\prime} \hat{e}^* = \frac{1}{n(T-1)} SSE_1\left(\hat{\lambda}\right)$$

Here n is the number of countries in the sample, where T represents the number of years. Finally, it is necessary to test whether the threshold effect is statistically significant. By testing the null hypothesis that the coefficients are equal to each other, if the probability value is below the critical value, the null hypothesis is rejected, and it is concluded that the threshold effect is statistically significant.

## 4. Data and description

### 4.1. Dependent Variable: *ghg*

In the literature, previous studies used different GHGs such as $CO_x$, $NO_x$, $SO_x$, and $PM_x$ (e.g. Narayan and Narayan, 2010; Luo *et al.*, 2014; Hao and Liu, 2016; Wang *et al.*, 2016; Sinha and Bhattacharya, 2016; Aye and Edoja, 2017; Wei *et al.*, 2018; Zhang *et al.*, 2018; Hasmi and Alam, 2019; Ouyang *et al.*, 2019; Neves *et al.*, 2020; Demiral *et al.*, 2021). However, we used GHG emissions as a whole, which are seen as the main cause of climate change, as the dependent variable. The fact that the current environmental policies are directed towards different GHG emissions also played role in our choice. The relevant data is extracted from OECD (2022) database. The *ghg* variable measures GHG emissions in tonnes per capita.

### 4.2. Regime-Dependent Variable: *fdi*

FDI inflow is an economic variable that is thought to significantly affect GHG emissions (e.g. Blanco *et al.*, 2013; Gokmenoglu and Taspinar, 2016; Bae *et al.*, 2017; Balsalobre-Lorente *et al.*, 2022; Caetano *et al.*, 2022). The *fdi* variable measures FDI net inflows (% of GDP). The relevant data is extracted from World Bank WDI (2022) database.

### 4.3. Threshold Variables: *eps, meps, nmeps, tsp*

In the next section, the impact of FDI inflows on GHG emissions will be tested by considering the role of environmental policies in the process. Botta and Kozluk (2014) pioneered the creation of a comprehensive index of environmental policy stringency. This index published by the OECD has been used in some recent studies (e.g. Ahmed & Ahmed, 2018; Ahmed, 2020; Demiral *et al.*, 2021; Ouyang *et al.*, 2019; Wolde-Rufael & Weldemeskel, 2020, 2021; Zhang *et al.*, 2020). Utilising selected policy tools on climate and air pollution, the index is considered the implicit or explicit cost of polluting or environmentally harmful behaviour.[3] The index ranges from 0 (not stringent) to 6 (highest degree of stringency) and shows relatively high and significant correlations with its alternatives used in the literature (Botta & Kozluk, 2014). Since the index is created based on a dual distinction between market-based and non-market-based policies, it also allows to empirically test the effects of different policies.

Later, Kruse *et al.* (2022) have developed this index by handling with a triple distinction to include technology support policies (*tsp*) in addition to market-based (*meps*) and nonmarket-based (*nmeps*) environmental policies. Accordingly, market-based policies consist of certificates and taxes, while nonmarket-based policies consist of emission limits. Technology support policies include clean R&D expenditures and support for adaptation to solar and wind-based energy systems.

With the new methodology, the previous index data were also recalculated and the data set was expanded to include the year 2020. Thus, in our study, data from 25 OECD countries (Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Japan, Korea, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkiye, United Kingdom and United States) were used for the 1998-2020 period, considering the maximum data availability. The effects of each of the three policy types are examined separately.

### 4.4. Control Variables: *gdppc, primen, poplr, ren*

We used GDP per capita (*gdppc*), primary energy consumption per capita (*primen*), population in the largest city (*poplr*), the share of renewable energy consumption in total energy consumption (*ren*) as the control variables. The data of *gdppc* and *poplr* variables were used in the logarithmic form. These variables are frequently used in the literature as determinants of GHG emissions. It is expected that increases in population and primary energy consumption will increase GHG emissions, while increases in the renewable energy use will decrease. How GDP per capita will affect is controversial in the literature. Detailed descriptions of all variables used in the analysis are reported in Table 2, and Table A1 in Appendix 1 shows descriptive statistics of all the variables in the model.

[3] Detailed information about the index is available in the study of Botta and Kozluk (2014).

TABLE 2
DESCRIPTION AND SOURCES

| Variable | Definition | Source |
|---|---|---|
| *ghg* | GHG emissions (tonnes/capita) | OECD.stat (2022) |
| *gdppc* | GDP per capita (constant 2015 USD) | World Bank, WDI (2022) |
| *primen* | Primary energy consumption per capita (kWh/person) | Our World in Data, GCP (2022) |
| *poplr* | Population in the largest city (% of urban population) | World Bank, WDI (2022) |
| *ren* | Renewable energy consumption (% of total final energy consumption) | World Bank, WDI (2022) |
| *fdi* | Foreign direct investments, net inflows (% of GDP) | World Bank, WDI (2022) |
| *eps* | EPS index | OECD.stat (2022) |
| *meps* | EPS index (market-based policies) | OECD.stat (2022) |
| *nmeps* | EPS index (nonmarket-based policies) | OECD.stat (2022) |
| *tsp* | EPS index (technology support policies) | OECD.stat (2022) |

## 5. Empirical analysis

In the first step, we tested for cross-sectional dependency of residuals to choose appropriate panel unit root test. We benefited from three different tests: Breusch-Pagan (1980) Lagrange Multiplier (LM) test, the Pesaran, Ullah, and Yamagata (2008), bias-adjusted LM test, and the Pesaran (2004) Cross-Sectional Dependence (CD) test. The results of the tests are given in Table 3.

The null hypothesis of no covariance between the residuals of cross-sections have been rejected in all models according to LM and the CD tests. Therefore, in the next stage, all variables were tested for stationarity using the second-generation panel unit root test of the Cross-Sectionally Augmented Dickey-Fuller (CADF) test of Pesaran (2007). This test gives more robust results than the first-generation unit root tests in case of cross-sectional dependence. The results

TABLE 3
RESIDUAL CROSS-SECTIONAL DEPENDENCE

| | LM | | LM Adj. | | LM CD | |
|---|---|---|---|---|---|---|
| Policy Variable | Stat. | p-value | Stat. | p-value | Stat. | p-value |
| *eps* | 397 | 0.0001 | 1.85 | 0.0643 | 5.944 | 0.0000 |
| *meps* | 367.4 | 0.0047 | -0.1892 | 0.8499 | 5.711 | 0.0000 |
| *nmeps* | 405.6 | 0.0000 | 2.856 | 0.0043 | 5.954 | 0.0000 |
| *tsp* | 404.6 | 0.0001 | 5.954 | 0.0100 | 5.769 | 0.0000 |

TABLE 4
PESARAN (2007) CADF UNIT ROOT TEST RESULTS

| | | Z(t-bar) | | p-value | |
|---|---|---|---|---|---|
| | | Without trend | With trend | Without trend | With trend |
| *ghg* | level | -1.888 | -2.391 | 0.030 | 0.008 |
| | 1st diff. | -11.548 | -9.621 | 0.000 | 0.000 |
| *gdppc* | level | -0.275 | 0.574 | 0.391 | 0.717 |
| | 1st diff. | -3.600 | -1.485 | 0.000 | 0.069 |
| *primen* | level | -2.622 | -3.141 | 0.004 | 0.001 |
| | 1st diff. | -11.591 | -9.503 | 0.000 | 0.000 |
| *poplr* | level | 1.190 | -5.501 | 0.883 | 0.000 |
| | 1st diff. | -6.521 | -4.201 | 0.000 | 0.000 |
| *ren* | level | -1.107 | 0.002 | 0.134 | 0.501 |
| | 1st diff. | -8.458 | -7.797 | 0.000 | 0.000 |
| *fdi* | level | -2.947 | -0.522 | 0.002 | 0.301 |
| | 1st diff. | -11.632 | -9.937 | 0.000 | 0.000 |
| *eps* | level | -3.756 | -3.090 | 0.000 | 0.001 |
| | 1st diff. | -10.130 | -7.276 | 0.000 | 0.000 |
| *meps* | level | -2.345 | -0.131 | 0.010 | 0.448 |
| | 1st diff. | -7.985 | -6.388 | 0.000 | 0.000 |
| *nmeps* | level | -3.126 | -3.325 | 0.001 | 0.000 |
| | 1st diff. | -10.125 | -6.739 | 0.000 | 0.000 |
| *tsp* | level | -4.974 | -2.817 | 0.000 | 0.002 |
| | 1st diff. | -9.832 | -7.253 | 0.000 | 0.000 |

***, **, and * denote statistically significance at 1%, 5%, and 10% levels, respectively.

are displayed in Table 4. The results show that the *gdppc* and *ren* variables are not stationary at the level. For this reason, we took the first differences of them and re-tested for stationarity. The new variables, which we named *dgdppc* and *dren*, were stationary due to the panel stationarity test. Stationary variables are used in the following panel threshold analyses.

We constituted four different models using different policy variables:

$$\text{M1}: ghg_{it} = \mu_i + \alpha_1 dgdppc_{it} + \alpha_2 primen_{it} + \alpha_3 poplr_{it} + \alpha_4 dren_{it} + \beta_1 FDI_{it} I\left(eps_{it} \leq \lambda\right) + \beta_2 FDI_t I\left(eps_{it} > \lambda\right) + e_{it}$$

$$\text{M2}: ghg_{it} = \mu_i + \alpha_1 dgdppc_{it} + \alpha_2 primen_{it} + \alpha_3 poplr_{it} + \alpha_4 dren_{it} + \beta_1 FDI_{it} I\left(meps_{it} \leq \lambda\right) + \beta_2 FDI_t I\left(meps_{it} > \lambda\right) + e_{it}$$

$$\text{M3}: ghg_{it} = \mu_i + \alpha_1 dgdppc_{it} + \alpha_2 primen_{it} + \alpha_3 poplr_{it} + \alpha_4 dren_{it} + \beta_1 FDI_{it} I\left(nmeps_{it} \leq \lambda\right) + \beta_2 FDI_t I\left(nmeps_{it} > \lambda\right) + e_{it}$$

$$\text{M4}: ghg_{it} = \mu_i + \alpha_1 dgdppc_{it} + \alpha_2 primen_{it} + \alpha_3 poplr_{it} + \alpha_4 dren_{it} +$$
$$\beta_1 FDI_{it} I\left(tsp_{it} \leq \lambda\right) + \beta_2 FDI_t I\left(tsp_{it} > \lambda\right) + e_{it}$$

Each model tests the threshold effect of one of the policy variables. Table 5 shows the results of the threshold tests.

According to Table 5, environmental policy stringency has a threshold effect at a 1% significance level. Therefore, the stringency of environmental policies has been observed to affect the relationship between FDIs and GHG emissions. The threshold value of (2.22) divides the observations into two regimes depending on whether the *eps* variable is smaller or larger than the threshold. In addition, it was observed that *meps* and *tsp* did not have a threshold effect at the 5% significance level, while *nmeps* had a threshold effect. The threshold value of (5.00) divides the observations into two regimes in which FDI has a different effect on GHG emissions. In the low-regime countries that have *nmeps* lower than or equal to (5.00), FDIs increase GHG emissions. On the other hand, in the high-regime countries that have *nmeps* value higher that (5.00), FDIs decrease GHG emissions. The estimated coefficients are given in Table 6.

As Table 6 shows, GDP per capita has a positive significant effect on the level of GHG emissions. Fossil fuels are still the most common source of energy in many of the countries in the sample. Therefore, economic growth and income increase can cause polluting effects. In this context, it can be deduced that

TABLE 5

TESTING THE THRESHOLD EFFECTS OF ENVIRONMENTAL POLICY ON GHG EMISSIONS

| Model | Threshold effects | F-stats | P-values | Critical Values | | | Threshold Values | 95% Confidence Interval |
|---|---|---|---|---|---|---|---|---|
| | | | | 1% | 5% | 10% | | |
| M1 | Single threshold | 35.10*** | 0.0033 | 31.7113 | 23.2079 | 19.5476 | 2.2222 | 1.9306-2.2500 |
| M2 | Single threshold | 10.50 | 0.2067 | 46.8715 | 20.9993 | 14.7540 | 2.3333 | 2.0833-2.500 |
| M3 | Single threshold | 30.84** | 0.0367 | 35.3468 | 26.8535 | 23.5404 | 5.0000 | 3.7500-5.2500 |
| M4 | Single threshold | 20.99* | 0.0900 | 36.6505 | 26.7731 | 19.9326 | 1.500 | 0.0000-1.7500 |

Note: (1) Three hundred bootstrap replications are employed for each bootstrap test.
(2) No evidence of second threshold effects was found in any model.
(3) ***, ** and * denote those variables are statistically significant at 1%, 5% and 10% respectively.

TABLE 6
THRESHOLD REGRESSIONS FOR THE STRINGENCY OF ENVIRONMENTAL POLICIES

| Dependent variable: *ghg* | M1 | M2 | M3 | M4 |
|---|---|---|---|---|
| Threshold variable | *eps* | *meps* | *nmeps* | *tsp* |
| *dgdppc* | 4.8844***<br>(1.6048) | 5.9344***<br>(1.6927) | 5.0828***<br>(1.5745) | 5.1870***<br>(1.6146) |
| *primen* | 0.0003***<br>(0.0001) | 0.0003***<br>(0.0001) | 0.0003***<br>(0.0001) | 0.0002***<br>(0.0001) |
| *poplr* | -0.3869<br>(3.2460) | -0.5528<br>(3.3980) | -0.1968<br>(3.2867) | -0.5899<br>(3.3854) |
| *dren* | -0.0965***<br>(0.0281) | -0.1067***<br>(0.0293) | -0.1151***<br>(0.0299) | -0.1017***<br>(0.0277) |
| *fdi((p≤λ)* | 0.0457***<br>(0.0125) | 0.0028<br>(0.0047) | 0.0290**<br>(0.0113) | 0.0346**<br>(0.0123) |
| *fdi(p>λ)* | -0.0034<br>(0.0029) | -0.0361*<br>(0.0176) | -0.0074**<br>(0.0035) | -0.0039<br>(0.0030) |
| *c* | -0.6005<br>(9.9284) | -0.4767<br>(10.3707) | -1.1934<br>(10.0671) | 0.0299<br>(10.3406) |
| R-square | 0.7358 | 0.7230 | 0.7346 | 0.7298 |
| F-stat. | 41.10 | 34.47 | 37.42 | 40.56 |
| F-prob. | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

Note: (1) Three hundred bootstrap replications are employed for each bootstrap test.
(2) ***, ** and * denote those variables are statistically significant at 1%, 5% and 10% respectively.
(3) White heteroscedasticity consistent standard errors are in parentheses.
(4) Residuals are stationary according to Pesaran (2007) CADF test (Z(t-bar) value is -3.565).

sample countries are in the ascending part of the environmental Kuznets curve. Primary energy consumption was found to be significant in all models and it has an increasing effect on GHG emissions in line with expectations. Similarly, the increase in the share of renewable energy consumption has a decreasing effect on GHG emissions. This finding is consistent with the work of Bae *et al.* (2017) and Balsalobre-Lorente *et al.* (2022), who draws attention to the importance of using alternative energy sources.

When we focus on the policy variables, according to the results presented in Table 5 and Table 6, the *eps* index has a threshold effect on the FDI-GHG emissions nexus at the 5% significance level. This effect is mainly due to *nmeps*. Accordingly, if the stringency of nonmarket-based environmental policies is under a certain threshold level (5.00 from Table 5), there is a positive relationship between FDIs and GHG emissions. However, if the stringency of nonmarket-based environmental policies is above (5.00), there is a negative relationship between FDIs and GHG emissions. This finding confirms that the pollution halo hypothesis will be valid if sufficiently strict environmental policies are applied in the sample under consideration.

### 5.1. Robustness Analysis: Fixed-Effects Regression

In the last step, we used fixed effects regression to check the robustness of our previous analyses.

Table 7 summarizes the results obtained from fixed effect regressions with Driscoll-Kraay standard errors which gives robust results in case of heteroscedasticity, autocorrelation and cross-sectional dependence. Each column presents the findings from the model using a different policy variable. Accordingly, *fdi* has a positive effect on the GHG emissions in first three models. However, the interaction terms with *eps*, *meps* and *nmeps* has a moderating role on the level of emissions. More importantly, the coefficients of the interaction terms in which

TABLE 7
FIXED EFFECT REGRESSION RESULTS

| Dependent variable: *ghg* | M1 | M2 | M3 | M4 |
|---|---|---|---|---|
| policy variable (*p*) | *eps* | *meps* | *nmeps* | *tsp* |
| *dgdppc* | 5.2793* | 5.7867** | 4.9968* | 5.6618** |
| | (2.5751) | (2.6117) | (2.5206) | (2.6368) |
| *primen* | 0.0003*** | 0.0003*** | 0.0002*** | 0.0003*** |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| *poplr* | -0.3969 | -0.6265 | -0.3172 | -0.4651 |
| | (1.0948) | (1.0727) | (1.1056) | (1.0983) |
| *dren* | -0.0964** | -0.1043*** | -0.0988** | -0.1035*** |
| | (0.0354) | (0.0354) | (0.0356) | (0.0351) |
| *fdi* | 0.0634*** | 0.0196** | 0.0695*** | 0.0140 |
| | (0.0161) | (0.0077) | (0.0225) | (0.0122) |
| *fdi*p* | -0.0220*** | -0.0166*** | -0.0136*** | -0.0057 |
| | (0.0055) | (0.0051) | (0.0039) | (0.0046) |
| *c* | -0.6079 | -0.2114 | -0.7804 | -0.6210 |
| | (2.3109) | (2.2970) | (2.3597) | (2.3213) |
| Num. of Obs. | 550 | 550 | 550 | 550 |
| F-stat. | 331.19 | 382.01 | 743.32 | 283.77 |
| R-square | 0.7306 | 0.7222 | 0.7332 | 0.7211 |

Note: (1) ***, ** and * denote those variables are statistically significant at 1%, 5% and 10% respectively.
(2) Driscoll-Kraay consistent standard errors are in parentheses.
(3) The models were estimated with random effects regressions. As the results of the Hausman tests, fixed effects models were preferred.

the *eps* and *nmeps* variables are used (2.88 and 5.11, respectively) provide estimates very close to the findings obtained from the Hansen panel threshold method (2.22 and 5.00, respectively).

Thus, nonmarket-based environmental policy stringency in particular plays an important role in the FDI-GHG emissions nexus. While policy stringency has direct effects on reducing emissions, it also has indirect effects, supporting pollution halo hypothesis.

## 6. Conclusions

Analysing the effects of FDI on the environment would guide policymakers make critical decisions on FDI inflows. As Sapkota and Bastola (2017) suggest, if the effect of FDI on the environment is positive, then the current policy on FDI would be appropriate. However, the conditions under which FDI inflows reduce pollution may depend on currently implemented environmental policies. The findings in this study showed that if the stringency of environmental policy is above a certain threshold value (2.88 and 2.22 according to fixed-effects and panel threshold regressions, respectively), FDIs will reduce GHG emissions. Moreover, the threshold effect is mainly due to nonmarket-based policy stringency. Accordingly, in the low-regime countries that have *nmeps* lower than or equal to the threshold value (5.11 and 5.00 according to fixed-effects and panel threshold regressions, respectively), FDI inflows increase GHG emissions. On the other hand, in the high-regime countries that have *nmeps* value higher than the threshold value, FDI inflows decrease GHG emissions.

Non-market environmental policies have direct impacts in the decision-making process of investments. Enterprises that do not meet the standards set by the host countries will direct their investments to countries with weaker environmental regulations as they will avoid incurring additional costs. Changing production technologies, especially moving to cleaner technologies, is often costly. For this reason, the standards in the host countries play a decisive role when making decisions about where FDIs will be directed. On the other hand, investments that meet the standards set by the host countries are clean investments that already include advanced production technologies. Therefore, they contribute to the transfer of clean technologies to the host country and positively affect the environmental quality.

Of the countries in our sample, none of the countries has a nonmarket-based policy stringency above threshold value during the whole sample period. However, 18 out of 25 countries (Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Korea, Netherlands, Poland, Slovak Republic, Spain, Sweden and United Kingdom) have a nonmarket-based policy stringency value higher than (5.00) in 2015 and beyond. Thus, foreign investment entering the country has gained a pollution-reducing nature in recent years, as nonmarket-based environmental policies are sufficiently stringent in these countries. On the other hand, in three of the sample countries (Australia, Norway, and Turkiye), nonmarket-based policy stringency is always below 5 for the period under consideration. Therefore, foreign investments directed to these countries do not contribute to the reduction of pollution. Thus, these countries need to tighten up their environmental regulations.

Additionally, it is worth noting that, fixed effects regression results also indicate a significant threshold effect for market-based environmental policy stringency, which is approximately (0.09). The difference in the findings is perhaps attributable to the multicollinearity problem caused by the interaction term in the fixed effects model. However, it should be kept in mind that market-based policies remain relatively weak in the sample countries (See Figure A1 in Appendix 2) and may limit the polluting effects of FDIs if implemented sufficiently stringent in the future. Future studies can obtain more reliable results with the development of the data set and the use of different methods.

As a result, environmental policies have indirect effects that reduce pollution caused by FDI inflows, as well as direct effects of reducing pollution originating from domestic production. Therefore, policy makers can benefit from environmental policies to avoid the polluting effects of FDI inflows. When environmental policies are implemented stringently enough, they can make the pollution halo hypothesis more likely through the transfer of clean technologies and production techniques. Thus, FDIs deemed necessary for economic growth also serve the environmental quality of the host country. However, these recommendations focus on only one aspect of the fight against climate change. It is also necessary for the government to implement policies to raise awareness about the importance of climate change and to support the expansion of domestic production with environment-friendly technologies.

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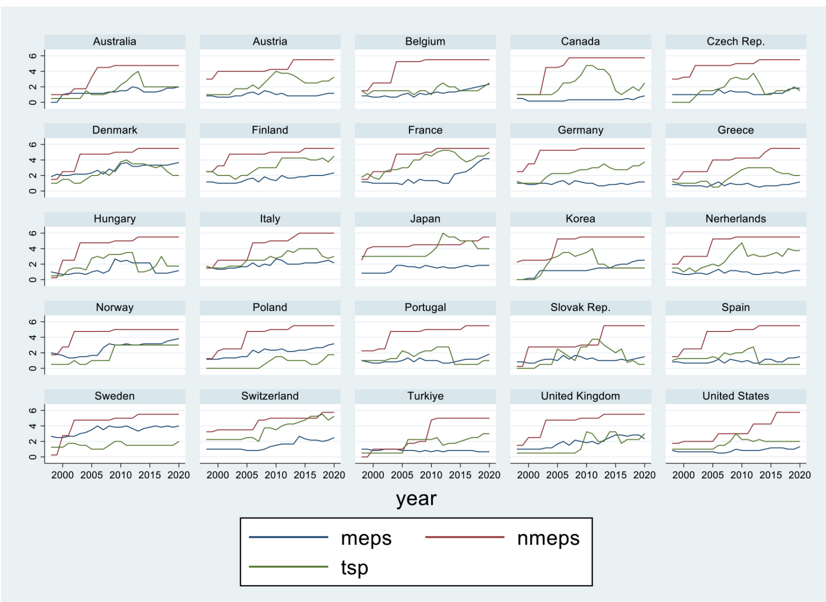
## Appendix A1

TABLE A1
SUMMARY STATISTICS

| Variables | | Obs. | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|---|
| ghg | 1 | 575 | 11.4249 | 4.9144 | 4.294 | 26.011 |
| gdppc | 2 | 575 | 10.3290 | 0.6074 | 8.7121 | 11.3898 |
| primen | 3 | 575 | 52122.25 | 24028.67 | 12238.71 | 129020 |
| poplr | 4 | 575 | 20.7017 | 9.7316 | 5.4125 | 49.0051 |
| ren | 4 | 575 | 16.2261 | 13.9238 | 0.69 | 62.37 |
| fdi | 5 | 575 | 4.2787 | 10.1839 | -40.0811 | 109.3306 |
| eps | 6 | 575 | 2.6167 | 0.8895 | 0.3611 | 4.8889 |
| meps | 7 | 575 | 1.4432 | 0.8489 | 0 | 4.1667 |
| nmeps | 8 | 575 | 4.3087 | 1.4180 | 0 | 6 |
| tsp | 9 | 575 | 2.0983 | 1.2393 | 0 | 6 |

## Appendix A2

FIGURE A1
THE ENVIRONMENTAL POLICY STRINGENCY IN SELECTED OECD COUNTRIES




Source:The figure was created by the authors using OECD data and STATA software.

# Decline in values of degrees and recent evolution of wage inequality: Evidence from Chile*

*Disminución en el valor de los títulos y la evolución reciente de la desigualdad salarial: Evidencia de Chile*

Yoshimichi Murakami**
Tomokazu Nomura***

**Abstract**

*Using data from nationally and regionally representative household surveys, we analyze the association between the changes in coefficients of dummy variables for higher education degrees in the wage equation and evolution of wage inequality in Chile from 2013-2017. Employing a decomposition method using unconditional quantile regressions, we find that a significant decline in the coefficients of professional degrees, especially from new private universities, with a larger magnitude at upper quantiles, is associated with a substantial reduction in wage inequality. The results are robust to the correction for sample selection bias and control for workers' occupation and firm size categories.*

Key words: *Higher education, wage inequality.*

JEL Classification: *I23, I24, I26, J31.*

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## Resumen

*Usamos datos de encuestas de hogares para analizar la asociación entre cambios en los retornos a la educación superior en ecuaciones de salarios y la evolución de la desigualdad salarial en Chile entre 2013 y 2017. Empleamos un método de descomposición con la regresión de cuantiles incondicionales y encontramos que una caída significativa en el retorno a títulos profesionales, especialmente de universidades privadas nuevas, se asocia con reducciones substanciales en la desigualdad salarial. Los resultados son robustos a correcciones por sesgo de selección e inclusión de controles por ocupación y tamaño de empresa.*



Palabras clave: *Educación superior, desigualdad salarial.*

Clasificación JEL: *I23, I24, I26, J31.*


## 1. Introduction

Over the past three decades, Latin American countries (LACs) have experienced rapid expansion in higher education. The average gross enrollment rate in higher education for 16 LACs increased from 18.8% in 1990 to 57.0% in 2017.[1] Such educational expansion is likely associated with wage inequality through changes in the proportion of educated workers and the return to education (Knight & Sabot, 1983).[2] Returns to higher education and income inequality slightly increased in LACs during the 1990s. By contrast, the returns to higher education and income inequality sharply decreased since the 2000s (Gasparini *et al.*, 2011; Figures 9 and 10 of Rodríguez-Castelán *et al.*, 2016: 16-17).

The observed reduction in returns to higher education in LACs since the 2000s, which contrasts with the region's previous trend, is a crucial area of research. A possible reason for the reduction in the returns to higher education is an increase in the share of educated workers, which decreases wage inequality as long as the return to education is negatively correlated with educational attainment (Coady & Dizioli, 2018; Murakami & Nomura, 2020). However, the observed reduction in returns to higher education exceeded what the quantity expansion of educated

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1 The 16 countries are Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, México, Nicaragua, Panamá, Paraguay, Perú, Uruguay, and Venezuela. We sourced the data from CEPALSTAT of the Economic Commission for Latin America and the Caribbean (ECLAC). (https://statistics.cepal.org/portal/cepalstat/index.html?lang=es, accessed on June 21, 2022).

2 In the literature, the term "returns to higher education" does not necessarily mean the causal effect of higher education on wages. In our study, recognizing that the distinction between a causal effect and correlation is crucial, we use the term "coefficients of higher education" instead.

workers predicts in several LACs (Messina & Silva, 2018). Moreover, the decline in the returns to higher education was not homogenous across different types of degrees and degree-granting institutions (Camacho *et al.*, 2016 for Colombia; González-Velosa *et al.*, 2015 for Chile and Colombia).

Considered among the most successful LACs regarding economic growth as well as far-reaching economic and institutional reforms, Chile, nonetheless, has a similarly high level of income inequality as other LACs and presents an ideal case for analyzing the association between recent changes in returns to degrees and the evolution of wage inequality. Before the reform in 1980, higher education in Chile consisted of two state universities and six private universities, which offered five-year programs leading to college degrees (Brunner, 1993; Cox, 1996). The higher education reform deregulated the country's standards for establishments and diversified its system. Accordingly, many new private universities and non-university higher education institutions have been established with minimum requirements (Brunner, 1993; Cox, 1996). The latter comprise Professional Institutes (*Institutos Profesionales*, IPs), which provide four-year programs leading to professional degrees (*títulos profesionales*), and Technical Training Centers (*Centros de Formación Técnica*, CFTs), which provide two-year vocational programs leading to technical degrees (*títulos técnicos de nivel superior*). Meanwhile, only universities continue to offer five-year programs leading to professional and college degrees (*licenciaturas*) and allow graduates to enroll in post-graduate schools (Brunner, 1993; Cox, 1996; Espinoza & González, 2013). Moreover, universities in Chile are distinguished into (1) traditional universities, known as the Council of Rectors of Chilean Universities (*Consejo de Rectores de las Universidades Chilenas*, CRUCH), which consist of state and private universities that existed before the 1980 reform and those derived from them and (2) new private universities founded after 1980 (Cox, 1996; Espinoza & González, 2013).

Based on these diversified higher education systems, Montoya *et al.* (2017) and Rodríguez *et al.* (2016) precisely estimate the returns to those different types of higher education degrees (i.e., technical, professional, and college degrees) by addressing the endogeneity issue due to unobserved abilities. González-Velosa *et al.* (2015) find that technical and professional degrees' returns are substantially heterogeneous across degree-granting institutions. However, since those studies estimate the returns to degrees in a particular year, they do not analyze their evolution over time. Moreover, the association between the changes in returns to degrees and wage inequality evolution is beyond the scope of their analyses.

Therefore, based on the data from nationally and regionally representative household surveys, this study aims to analyze the association between the changes in the coefficients of dummy variables for higher education degrees in the wage equation and the evolution of wage inequality in Chile from 2013 to 2017. For this purpose, this study takes advantage of a method proposed by Firpo *et al.* (2009). By this method, we can extend the Oaxaca-Blinder (O-B) decomposition (Blinder, 1973; Oaxaca, 1973) and decompose changes in distributional statistics beyond the mean (e.g., quantiles) into a part attributable to the changes in the workforce's average characteristics (e.g., an increase in the share of workers with higher education) and a part attributable to the changes in the characteristics' coefficients (e.g., a decrease in the coefficients of higher education degrees).

By employing this method, Fernández and Messina (2018) and Murakami and Nomura (2020) find that a decrease in education premiums, with a larger magnitude at upper quantiles, had a prominent role in decreasing wage inequality among full-time employed workers in Chile from 1990 to 2013 and 2000 to 2013, respectively.

However, Fernández and Messina (2018), who use only years of schooling as the variable indicating educational achievements, do not account for any heterogeneous returns to different types of degrees. Moreover, they include only potential experience (and their quadric terms) and a female dummy as control variables. Therefore, the estimated returns to education may contain bias due to omitted variables, and the contribution of the changes in education premiums to the reduction in wage inequality is likely to be overestimated. Although Murakami and Nomura (2020) find a significant difference between returns to technical and professional degrees, they do not consider within-degree heterogeneity associated with degree-granting institutions. Furthermore, both studies do not deal with any potential bias in the estimated returns to education associated with the non-random selection of full-time employed workers.

Consequently, a novel contribution of this study to the literature is identifying the association between changes in the coefficients of different types of degrees and the recent evolution of wage inequality in Chile after including appropriate control variables. We reveal that a significant decrease in the coefficients of professional degrees, especially from new private universities, with a larger magnitude at upper quantiles, is associated with a substantial reduction in wage inequality. Furthermore, we verify that the findings are robust to the correction for the sample selection bias, the control for workers' occupation and firm size categories, and the choice of the analysis period.

This paper is organized as follows. Section 2 explains the data employed in the analysis and presents the descriptive statistics. Section 3 presents the empirical specifications and explains the decomposition method using unconditional quantile regressions. Section 4 presents the estimation results. Section 5 performs several robustness checks, and the final section concludes the paper and provides some policy implications.

## 2. Data and descriptive statistics

The data used for the analysis were sourced from the 2013 and 2017 Socioeconomic Characterization Surveys (*Encuesta de Caracterización Socioeconómica Nacional*, CASEN).[3] The CASEN survey is a cross-sectional

3 We sourced the data from the Ministry of Social Development and Family of Chile (http://observatorio.ministeriodesarrollosocial.gob.cl/encuesta-casen-2013 and http://observatorio.

household survey conducted every two or three years by the Ministry of Social Development of Chile, collaborating with the National Institute of Statistics (*Instituto Nacional de Estadísticas*, INE) and the Microdata Center of the Department of Economics at the University of Chile.[4] The survey's objectives are to measure the socioeconomic characteristics of households and provide necessary information to design and evaluate the country's social policies. Thus, the survey provides detailed information on demographic characteristics, education, employment, sources of income, health, and housing. The survey covered 66,725 and 70,948 households and 218,491 and 216,439 individuals in 2013 and 2017, respectively. The survey provides non-response adjusted expansion weights.[5] Using the weights, the sample represents the country at national, regional, and urban/rural levels (Ministerio de Desarrollo Social, 2015). The expansion weights are used for all estimations in this study.

In this study, we define wages as regular monetary earnings from a principal occupation, deflated by the national consumer price index (December 2008 = 1).[6] Thus, the defined wages do not include non-regular wages from a principal occupation, such as overtime wages, commissions, tips, bonuses, or any additional income from a principal occupation, such as housing, transportation, and education allowances. Since the data on income variables had already been corrected and adjusted for non-response and missing income values, we do not apply further data-cleaning, including dropping outliers, to the data on wages.

The sample is limited to full-time (more than 35 hours per week) male and female employed workers aged 24 to 50 years. We limit the sample to those up to 50 years old (i.e., born in 1962 or later) because they enrolled in higher education after the 1980 reform. We exclude self-employed workers, part-time workers, and military personnel because their income or wages are likely to be determined differently from the wages of full-time workers. Since this limitation may lead to potential selection bias in the estimated coefficients of degrees, we try to correct this bias using the seminal Heckman two-step procedure (Heckman, 1979) in Section 5.1.

ministeriodesarrollosocial.gob.cl/encuesta-casen-2017, accessed on October 3, 2015, and October 4, 2019, respectively). Although the data from CASEN 2020 survey are also available, the survey does not report the educational institution from which individuals obtained their final degree.

4 The former has been responsible for the sampling design and elaboration of expansion weights, while the latter has contracted to implement field surveys and data processing (Ministerio de Desarrollo Social, 2015).

5 According to Chumacero *et al.* (2011), we use the term "expansion weights." The original term of the survey is *factor de expansión* ("expansion factor" in English).

6 We sourced the data from the Central Bank of Chile (http://www.bcentral.cl/estadisticas-economicas/series-indicadores/index_p.htm and https://si3.bcentral.cl/Siete/en, accessed on January 1, 2015, and December 22, 2020, respectively).

The CASEN 2013 and 2017 surveys report the educational institution from which individuals obtained their final degree for those who attended higher education.[7] Meanwhile, the category of a college degree has been incorporated into the category of a professional degree. Therefore, the available degree types for our analysis are technical, professional, and post-graduate degrees, while the available institution types are CFTs, IPs, new private universities, and traditional universities. While universities can offer the above three types of degrees, IPs can offer only technical and professional degrees, and CFTs can offer only technical degrees. In this study, we set a separate category for those who did not complete a given program and thus did not obtain a degree, irrespective of the type of institution that they attended. To minimize any missing observations, we also set a category for those who did not know the type of institution they attended or did not respond to the question. The resulting degree-institution type combinations are listed in Table 1.

Table 1 presents the descriptive statistics of variables used for our wage equation presented in Section 3. We find that the reduction in wage inequality, which was observed during the 2000s as reported by Fernández and Messina (2018), Murakami and Nomura (2020), and Parro and Reyes (2017), persisted from 2013 to 2017. The log hourly wage gap between the 90th and 10th quantiles decreased from 1.552 to 1.409. The gap between the 90th and 50th quantiles decreased from 1.054 to 0.982. We further find that workers with higher educations, including those who did not complete a given program, increased from 34.2% in 2013 to 42.7% in 2017. Although the share of any type of higher education degrees and institutions has increased, the increase is especially evident in workers with professional degrees. We further find an increase in the share of female employment among full-time wage workers in this period.

Figure 1 shows the estimated wage distribution for each workers' group classified by educational achievements in 2013 and 2017. While the share of workers with professional degrees earning wages above the 90th percentile of the overall wage distribution declined, those earning below the 50th percentile increased. As a result, the wage distribution in 2017 is more symmetric. Similarly, while the share of workers with technical degrees earning wages above the 50th percentile of the overall wage distribution declined, those earning below the 50th percentile increased. Thus, the wage distribution of workers with technical degrees became more right-skewed in 2017. The findings indicate that the share of higher wage earners has declined among workers with both professional and technical degrees.

---

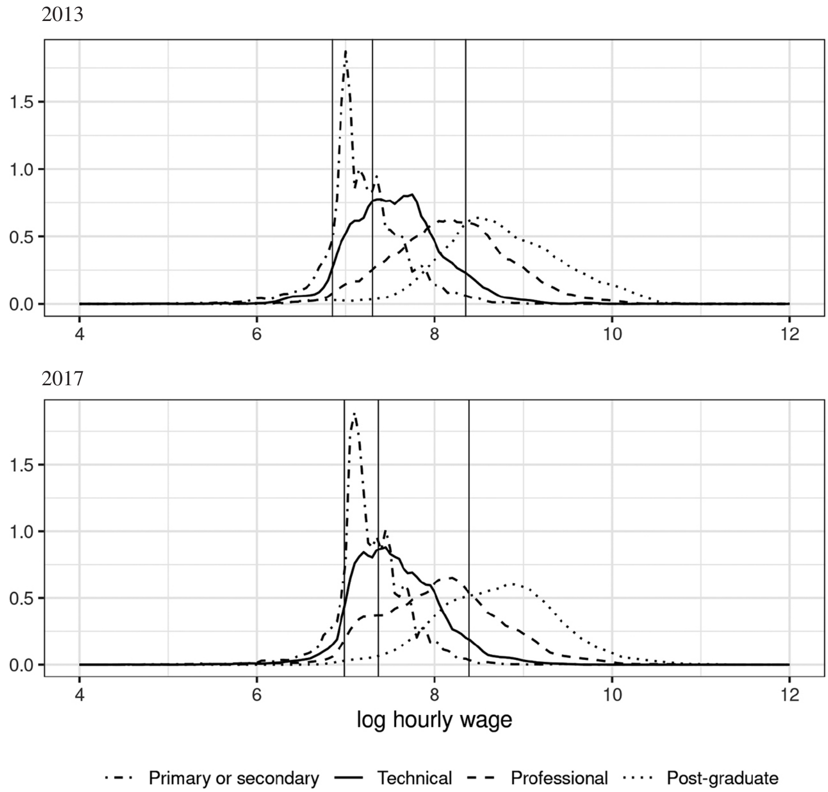
7 Although the CASEN 2017 survey reports a more disaggregated classification of the degree-granting institution, we have aggregated some categories such that the results correspond with the categories in the 2013 survey.

TABLE 1
DESCRIPTIVE STATISTICS OF THE VARIABLES IN 2013 AND 2017

| | 2013 | 2017 |
|---|---|---|
| Observations | 35,626 | 35,543 |
| Log hourly wage | | |
| Mean | 7.481 | 7.570 |
| Q10 | 6.878 | 7.017 |
| Q50 | 7.375 | 7.444 |
| Q90 | 8.430 | 8.426 |
| Primary education or less | 0.143 | 0.109 |
| Secondary education | 0.515 | 0.465 |
| Scientific-Humanistic school | 0.373 | 0.346 |
| Technical-Vocational school | 0.142 | 0.118 |
| Higher education | 0.342 | 0.427 |
| Technical degree | 0.120 | 0.143 |
| CFT | 0.032 | 0.028 |
| IP | 0.059 | 0.070 |
| New private university | 0.004 | 0.009 |
| Traditional university | 0.002 | 0.005 |
| Does not know/No response | 0.004 | 0.006 |
| Incomplete | 0.020 | 0.024 |
| Professional degree | 0.203 | 0.255 |
| IP | 0.014 | 0.027 |
| New private university | 0.061 | 0.075 |
| Traditional university | 0.087 | 0.111 |
| Does not know/No response | 0.009 | 0.007 |
| Incomplete | 0.031 | 0.036 |
| Post-graduate degree | 0.019 | 0.029 |
| New private university | 0.005 | 0.008 |
| Traditional university | 0.011 | 0.017 |
| Does not know/No response | 0.001 | 0.001 |
| Incomplete | 0.002 | 0.003 |
| Experience | 18.658 | 17.521 |
| Male | 0.588 | 0.558 |
| Head of the household | 0.475 | 0.455 |
| Married | 0.355 | 0.293 |
| Formal | 0.903 | 0.904 |
| Urban | 0.895 | 0.897 |

Note: Q10, Q50, and Q90 represent the 10th, 50th, and 90th unconditional quantiles of log hourly wages, respectively. CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales)*.
Source: Authors' calculations based on data from the CASEN 2013 and 2017 surveys.

FIGURE 1
THE ESTIMATED LOG HOURLY WAGE DISTRIBUTION IN 2013 AND 2017, CLASSIFIED BY EDUCATIONAL ACHIEVEMENTS




Note: The vertical lines show the 10th, 50th, and 90th quantiles of the overall wage distribution for each year.
Source: Authors' calculations based on data from the CASEN 2013 and 2017 surveys

## 3. Empirical specification

### 3.1. Wage equation

To analyze the association between educational achievements and individual wages, we separately estimate the wage equation for 2013 and 2017. Given that recent studies find within-degree heterogeneity in returns to degrees in Chile (González-Velosa *et al.*, 2015; Rodríguez *et al.*, 2016), we consider that the returns to higher education are heterogeneous across different types of degrees and degree-granting institutions (i.e., CFTs, IPs, new private universities, and traditional universities). Thus, we include dummy variables indicating an individual's final educational achievement (i.e., the degree obtained) interacted with dummy variables indicating the educational institution granting the degrees in the wage equation.

We estimate the following wage equation for each year, $t = 2013$ and 2017, separately:

$$\ln w_{it} = \sum_{jt}\sum_{kt}\rho_{jkt} I\left(degree_{it} = j \ and \ institution_{it} = k\right) + \mathbf{Z}_{it}^{'}\delta_t + \varepsilon_{it}, \quad (1)$$

where $w_{it}$ represents hourly wages. $I(\cdot)$ is the indicator function taking a value of 1 if the condition is satisfied and 0, otherwise. The subscript $i$ indicates individual, $j$ type of higher education degree, and $k$ type of degree-granting institution. $\rho_{jkt}$ is the coefficient of the dummy variable for higher education degree given the type of degree and degree-granting institution and what we are focusing on in this study. $\mathbf{Z}_{it}$ represents other control variables which may affect the wage, and $\varepsilon_{ijt}$ is an error term.

The vector of control variables $\mathbf{Z}_{it}$ includes years of potential labor experience (age – years of schooling – 6) and its squared term divided by 100. The vector also includes dummy variables for male workers, heads of household, married workers, workers with written employment contracts, and workers living in urban areas. Industry dummies (classified at the two-digit level of the International Standard Industrial Classification (ISIC) Revision 3) and region dummies are also included in the vector of control variables. Since we evaluate the coefficients of higher education degrees relative to secondary education, a dummy variable indicating whether the individual's educational achievement is primary education or less is also included.

The surveys report a worker's occupation at the four-digit level of the International Standard Classification of Occupations (ISCO)-88. However, we do not include the variable in the wage equation in our main analysis because we consider that the coefficients of higher education degrees include the increasing opportunities for higher-paying occupations rather than the coefficients within a given occupation. However, as a robustness check, we show the results controlling for the occupational categories in Sections 5.3 and 5.4.

### 3.2. Decomposition of the wage distribution

To analyze the association between the changes in the coefficients of higher education degrees and the evolution of wage inequality, we decompose the evolution of wage distribution from 2013 to 2017 into changes attributable to changes in explanatory variables (i.e., composition effect) and the coefficients of explanatory variables (i.e., wage structure effect). For this purpose, we employ the method proposed by Firpo *et al.* (2009) of estimating unconditional quantile regressions, which allows the O-B decomposition at any unconditional quantiles. A clear advantage of the method is that it allows for the subdivision of the overall composition and wage structure effects into the contribution of each explanatory variable (Fortin *et al.*, 2011). The O-B decomposition was initially used for the decomposition based on the average between two groups over the same period. However, the extended O-B decomposition, based on the method by Firpo *et al.* (2009), is widely used to analyze the changes in wage distribution between two periods, particularly to analyze the association between educational expansion and the evolution of wage inequality (Firpo *et al.*, 2018).[8]

The key idea of this method is to replace the observed value of a dependent variable with an estimated value of the re-centered influence function (RIF) and regress the RIF value on the covariates (unconditional quantile regression). The RIF value at the $\tau$-th unconditional quantile of the dependent variable ln $w_{it}$ is given by:

$$\text{(2)} \qquad \text{RIF}\left(\ln w_{it},\, q_t^{\tau}\right) = q_t^{\tau} + \frac{\tau_t - I\left\{\ln w_{it} \le q_t^{\tau}\right\}}{f_{\ln w_{it}}\left(q_t^{\tau}\right)},$$

where $q_t^{\tau}$ is the $\tau$-th unconditional quantile of the dependent variable, and $\ln w_{it}$. $I(\cdot)$ is an indicator function taking a value of 1 if the condition is satisfied and 0, otherwise. $f_{\ln w_{it}}\left(q_t^{\tau}\right)$ is the density of $\ln w_{it}$ evaluated at $q_t^{\tau}$. Since the expectation of RIF at the $\tau$-th unconditional quantile is equal to the variable's $\tau$-th unconditional quantile and the law of iterated expectations applies in the case of RIF values, the estimated coefficients of the unconditional quantile regression indicate a marginal effect on $\hat{q}_t^{\tau}$ (see Note 5 and equation (4) of Firpo *et al.*, 2009: 954, 957):

$$\text{(3)} \qquad \hat{q}_t^{\tau} = \text{E}\left[\widehat{\text{RIF}}\left(\ln w_{it},\, q_t^{\tau}\right)\right] = \text{E}\left[\text{E}\left(\widehat{\text{RIF}}\left(\ln w_{it},\, q_t^{\tau}\right)|\boldsymbol{X}_{it}\right)\right] = \bar{\boldsymbol{X}}_{it}^{'}\hat{\beta}_t^{\tau},$$

where $\boldsymbol{X}_{it}$ is a vector of all explanatory variables in equation (1). The bar over the term denotes the mean. $\hat{\beta}_t^{\tau}$ is a vector of the estimated coefficients of the unconditional quantile regression at the $\tau$-th quantile.

Thus, we can write the equivalent of the O-B decomposition for any unconditional quantile as equation (35) of Fortin *et al.* (2011: 78). That is, by adding and subtracting the counterfactual wage quantile for 2017 $\hat{q}_{2017c}^{\tau} = \bar{\boldsymbol{X}}_{2017}^{'}\hat{\beta}_{2013}^{\tau}$, which would prevail if individuals in 2017 would have been paid under the wage structure in 2013, the change in the wage distribution between 2013 and 2017 at the $\tau$-th quantile is decomposed as follows:

[8] Other examples are Fernández and Messina (2018) for Argentina, Brazil, and Chile; Murakami and Nomura (2020) for Chile; Sámano-Robles (2018) for 18 LACs; Seneviratne (2019) for Sri Lanka; and Yang and Gao (2018) for China.

$$
\begin{aligned}
\hat{q}^{\tau}_{2017} - \hat{q}^{\tau}_{2013} &= \left(\hat{q}^{\tau}_{2017c} - \hat{q}^{\tau}_{2013}\right) + \left(\hat{q}^{\tau}_{2017} - \hat{q}^{\tau}_{2017c}\right) \\
&= \left(\bar{\boldsymbol{X}}^{'}_{2017}\hat{\beta}^{\tau}_{2013} - \bar{\boldsymbol{X}}^{'}_{2013}\hat{\beta}^{\tau}_{2013}) + (\bar{\boldsymbol{X}}^{'}_{2017}\hat{\beta}^{\tau}_{2017} - \bar{\boldsymbol{X}}^{'}_{2017}\hat{\beta}^{\tau}_{2013}\right) \\
&= \left(\bar{\boldsymbol{X}}^{'}_{2017} - \bar{\boldsymbol{X}}^{'}_{2013}\right)\hat{\beta}^{\tau}_{2013} + \bar{\boldsymbol{X}}^{'}_{2017}\left(\hat{\beta}^{\tau}_{2017} - \hat{\beta}^{\tau}_{2013}\right).
\end{aligned} \tag{4}
$$

In equation (4), the first term on the last line of the right-hand side represents the composition effect, which captures the change in log hourly wages at the $\tau$ -th quantile attributable to changes in the average individuals' characteristics, holding the coefficients of individuals constant at the values in 2013. The second term represents the wage structure effect, which captures the change attributable to the changes in the coefficients of explanatory variables, holding the characteristics of individuals fixed at the average of 2017.[9]

Finally, based on the result of equation (4), we can decompose the evolution of wage inequality measured by the difference between the upper quantile $U$ and lower quantile $L$ $\left(\text{let } \tau \in \{U, L\}\right)$ from 2013 to 2017 as follows (see equation 3.3 of Fernández & Messina, 2018: 560):

$$
\begin{aligned}
&(\hat{q}^{U}_{2017} - \hat{q}^{L}_{2017}) - (\hat{q}^{U}_{2013} - \hat{q}^{L}_{2013}) \\
&= \left(\bar{\boldsymbol{X}}^{'}_{2017}\hat{\beta}^{U}_{2017} - \bar{\boldsymbol{X}}^{'}_{2013}\hat{\beta}^{U}_{2013}\right) - \left(\bar{\boldsymbol{X}}^{'}_{2017}\hat{\beta}^{L}_{2017} - \bar{\boldsymbol{X}}^{'}_{2013}\hat{\beta}^{L}_{2013}\right) \\
&= \left(\bar{\boldsymbol{X}}^{'}_{2017} - \bar{\boldsymbol{X}}^{'}_{2013}\right)\left(\hat{\beta}^{U}_{2013} - \hat{\beta}^{L}_{2013}\right) + \bar{\boldsymbol{X}}^{'}_{2017}\left[\left(\hat{\beta}^{U}_{2017} - \hat{\beta}^{U}_{2013}\right) - \left(\hat{\beta}^{L}_{2017} - \hat{\beta}^{L}_{2013}\right)\right].
\end{aligned} \tag{5}
$$

The first term on the last line of the right-hand side of equation (5) represents the difference in the composition effects between the upper and lower quantiles, and the second term represents the difference in the wage structure effects between the upper and lower quantiles. Following previous studies analyzing LACs, including Fernández and Messina (2018), we choose $U$ as the 90th quantile and $L$ as the 50th and 10th quantiles. This choice is based on the findings that income inequality in Chile is fundamentally due to the significant inequality between the wealthiest 10 percent and the rest of the population, while the country's inequality among the rest is relatively small (Núñez & Gutiérrez, 2004).

---

[9] Thus, the O-B decomposition assumes that the counterfactual wages of a group or period can be constructed based on the observed wage structure of the reference group or period. For example, we assume that the counterfactual wage distribution in 2017, which would prevail if the workers were paid on the same basis as in 2013, can be calculated based on the observed wage structure in 2013 (see assumption 3 of Fortin *et al.*, 2011: 16-17). However, it is natural that the wage structure may change because of the compositional changes. Therefore, the assumption is a significant limitation inherent in the O-B decomposition (see Fortin *et al.*, 2011: 3). Overcoming this limitation is beyond the scope of this study.

## 4. Estimation results

Table 2 reports the estimation results of the mean and unconditional quantile regressions for the selected quantiles in 2013 and 2017, respectively (Table S.1 in the Supplemental file provides those for other quantiles). The coefficients of higher education (relative to secondary education) are heterogeneous across different types of degrees and degree-granting institutions. Expectedly, the coefficients of professional degrees are substantially higher than those of technical degrees, supporting the findings of studies analyzing previous periods in Chile (e.g., González-Velosa *et al.*, 2015; Murakami & Nomura, 2020; Puentes, 2000; Rodríguez *et al.*, 2016; Urzúa, 2017). The types of degree-granting institutions significantly matter in the case of professional degrees: the estimated coefficients indicate that the workers with professional degrees from traditional universities earned 1.063 log points (189.6%) more than high school graduates on average in 2013, whereas those with professional degrees from new private universities earned 0.914 log points (149.5%) more than high school graduates on average in the year.[10] The gap further widened from 40.1% in 2013 to 68.1% in 2017. Additionally, we find that the coefficients of higher education, especially technical education, are substantially lower when workers did not complete the given program and thus did not obtain a degree. In general, the coefficients of higher education degrees decreased from 2013 to 2017. However, the trend is heterogeneous across the different quantiles as well as the types of degrees and degree-granting institutions, as discussed in greater detail below.

Subsequently, we discuss the decomposition results. Table 3 reports the detailed decomposition results of each explanatory variable at the selected quantiles (see Table S.2 in the Supplemental file for other quantiles). The results are visually summarized in Figures 2-4. Figure 2 shows overall wage changes at quantiles from the 5th to 95th and their decomposition into the composition and wage structure effects. Figure 3 decomposes the overall composition and wage structure effects into the contribution of four groups of explanatory variables (education, experience, gender, and all other variables). Further, Figure 4 reports the detailed composition and wage structure effects of our main interest variables, the higher education degrees. Finally, Table 4 reports each variable's contribution of the difference in the composition and wage structure effects between the selected quantiles to the evolution of wage inequality, as presented by equation (5).

Figure 2 shows that the composition effect almost monotonically increases when moving from the lower to upper quantiles. By contrast, the opposite trend is observed in the wage structure effect (though there are some fluctuations between quantiles): the former effect is 0.014 and 0.125 log points at the 10th and 90th quantiles, respectively, whereas the latter effect is 0.125 and -0.129 log points at the 10th and 90th quantiles, respectively (see Table 3). As a whole,

[10] The calculations are based on exp (1.063) – 1 and exp (0.914) – 1.

the overall wage increases are particularly considerable at the lower parts of the distribution (e.g., 0.139 log point at the 10th quantile), whereas they are negative at the upper parts of the distribution (e.g., -0.004 log point at the 90th quantile), thereby indicating the reduction in wage inequality from 2013 to 2017. Additionally, we find that the wage changes are relatively similar in the middle of the distribution (between the 25th and 80th quantiles) except for the 30th and 55th quantiles. Thus, this observed trend of wage changes during the analysis period justifies using the log wage gap between the upper (90th quantile) and lower (10th quantile) ends of the distribution as our inequality measure.

Figure 3 and Table 3 show that the composition effects of higher education increased wages, particularly at the upper quantiles, whereas the wage structure effects of higher education decreased wages, particularly at the upper quantiles. Therefore, as shown in Table 1, the findings show that the increase in the relative supply of workers with higher education is associated with increasing wage inequality, whereas the decrease in the coefficients of higher education is associated with decreasing inequality. The finding concurs with those of Fernández and Messina (2018) and Murakami and Nomura (2020). As reported in Table 4, the difference between the wage structure effect of higher education at the 90th and 10th quantiles is -0.119, accounting for 83.4% of the decrease in the 90-10 log wage gap. Together with Figure 2, the findings indicate that the increase in the relative supply of workers with higher education was accompanied by the decline in the returns to their skills. Moreover, the demand for those skills failed to keep pace with the increase in the relative supply.

A novel contribution of this study is the finding that the wage structure effects of higher education are substantially heterogeneous across the types of degrees and degree-granting institutions. We find that the wage structure effects of professional degrees significantly decreased wages at the upper quantiles (see Figure 4 and Table 3). Given the degree-institution type combinations, professional degrees from new private universities contribute most significantly to the reduction in wage inequality. The decreases in the coefficients of this degree account for 34.0% of the total decrease in the 90-10 log wage gap (see Table 4). The coefficients of post-graduate degrees show a similar trend but to a lesser extent. Conversely, the coefficients of technical degrees are relatively stable from 2013 to 2017 (see Figure 4 and Table 3). Since the new private universities require more extended enrollment periods and higher annual tuition costs than IPs and CFTs, technical degrees are likely to be an alternative to professional degrees, especially for those who cannot gain admittance to traditional universities. Finally, we find that other explanatory variables, such as gender, do not account for the observed reduction in wage inequality because the changes in the male coefficient are similar among the different quantiles (see Figure 4 and Table 3). In summary, the significant decline in the coefficients of professional degrees, especially from new private universities, is primarily associated with the observed reduction in wage inequality from 2013 to 2017.

We consider that the increase in the relative supply of workers with higher education degrees is insufficient to account for the entire decline in the coefficients

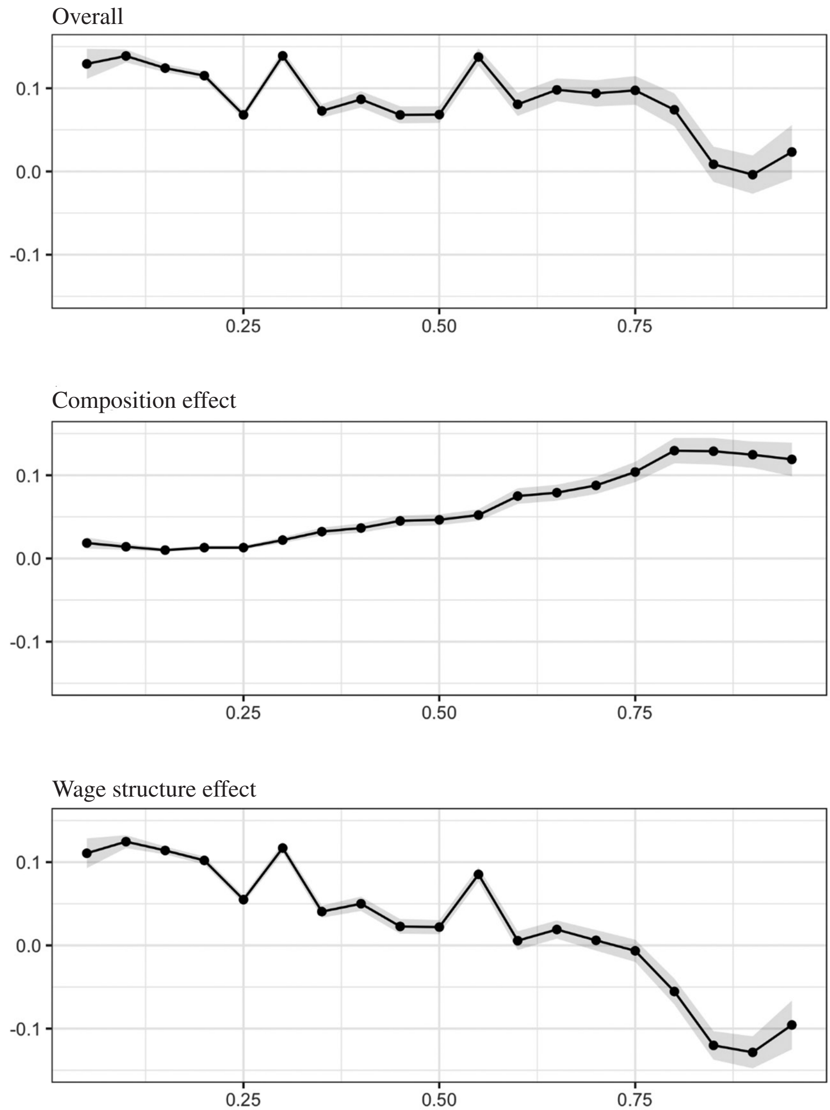
TABLE 2
ESTIMATION RESULTS OF THE MEAN AND UNCONDITIONAL QUANTILE REGRESSIONS FOR LOG HOURLY WAGES IN 2013 AND 2017

| | 2013 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Primary | -0.141*** | -0.136*** | -0.180*** | -0.024 | -0.117*** | -0.075*** | -0.169*** | -0.019 |
| | (0.009) | (0.023) | (0.020) | (0.020) | (0.009) | (0.012) | (0.014) | (0.015) |
| Technical degree | | | | | | | | |
| CFT | 0.282*** | 0.079*** | 0.387*** | 0.230*** | 0.252*** | 0.055*** | 0.281*** | 0.208*** |
| | (0.014) | (0.031) | (0.036) | (0.056) | (0.015) | (0.014) | (0.029) | (0.049) |
| IP | 0.336*** | 0.119*** | 0.400*** | 0.249*** | 0.279*** | 0.058*** | 0.331*** | 0.202*** |
| | (0.011) | (0.016) | (0.037) | (0.056) | (0.010) | (0.010) | (0.029) | (0.041) |
| New private university | 0.401*** | 0.106*** | 0.443*** | 0.542** | 0.217*** | 0.064* | 0.205** | 0.322*** |
| | (0.039) | (0.035) | (0.062) | (0.254) | (0.026) | (0.037) | (0.097) | (0.091) |
| Traditional university | 0.497*** | 0.115** | 0.610*** | 0.847** | 0.433*** | 0.103*** | 0.509*** | 0.416*** |
| | (0.061) | (0.049) | (0.074) | (0.373) | (0.032) | (0.018) | (0.048) | (0.117) |
| Does not know/No response | 0.322*** | 0.168*** | 0.320*** | 0.400*** | 0.181*** | 0.057* | 0.235*** | 0.052 |
| | (0.040) | (0.035) | (0.064) | (0.154) | (0.032) | (0.031) | (0.053) | (0.071) |
| Incomplete | 0.118*** | 0.015 | 0.244*** | -0.032 | 0.155*** | 0.019 | 0.219*** | 0.131*** |
| | (0.018) | (0.056) | (0.047) | (0.055) | (0.016) | (0.020) | (0.029) | (0.043) |
| Professional degree | | | | | | | | |
| IP | 0.700*** | 0.109*** | 0.646*** | 1.235*** | 0.587*** | 0.086*** | 0.564*** | 0.943*** |
| | (0.021) | (0.023) | (0.035) | (0.184) | (0.015) | (0.012) | (0.030) | (0.112) |
| New private university | 0.914*** | 0.110*** | 0.687*** | 1.936*** | 0.693*** | 0.081*** | 0.554*** | 1.259*** |
| | (0.011) | (0.015) | (0.028) | (0.175) | (0.010) | (0.015) | (0.039) | (0.129) |
| Traditional university | 1.063*** | 0.149*** | 0.738*** | 2.441*** | 0.986*** | 0.105*** | 0.708*** | 2.019*** |
| | (0.010) | (0.014) | (0.027) | (0.159) | (0.009) | (0.008) | (0.025) | (0.145) |
| Does not know/No response | 0.807*** | 0.160*** | 0.710*** | 1.391*** | 0.780*** | 0.130*** | 0.664*** | 1.311*** |
| | (0.027) | (0.016) | (0.039) | (0.221) | (0.030) | (0.011) | (0.037) | (0.175) |
| Incomplete | 0.432*** | 0.062*** | 0.435*** | 0.685*** | 0.301*** | 0.053*** | 0.303*** | 0.444*** |
| | (0.015) | (0.023) | (0.034) | (0.168) | (0.013) | (0.012) | (0.029) | (0.075) |

| | 2013 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Post-graduate degree | | | | | | | | |
| New private university | 1.349*** | 0.012 | 0.655*** | 3.230*** | 1.362*** | 0.111*** | 0.734*** | 3.343*** |
| | (0.036) | (0.080) | (0.068) | (0.378) | (0.028) | (0.013) | (0.035) | (0.329) |
| Traditional university | 1.430*** | 0.133*** | 0.720*** | 3.981*** | 1.370*** | 0.101*** | 0.707*** | 3.381*** |
| | (0.024) | (0.016) | (0.035) | (0.295) | (0.019) | (0.009) | (0.028) | (0.297) |
| Does not know/No response | 1.277*** | 0.161*** | 0.714*** | 2.979*** | 0.922*** | 0.100*** | 0.562*** | 1.521** |
| | (0.080) | (0.035) | (0.084) | (0.664) | (0.080) | (0.019) | (0.146) | (0.772) |
| Incomplete | 1.253*** | 0.156*** | 0.689*** | 2.720*** | 1.027*** | 0.111*** | 0.739*** | 2.249*** |
| | (0.053) | (0.031) | (0.053) | (0.569) | (0.043) | (0.011) | (0.038) | (0.386) |
| Experience | 0.019*** | 0.000 | 0.007*** | 0.045*** | 0.025*** | 0.001 | 0.012*** | 0.061*** |
| | (0.001) | (0.003) | (0.003) | (0.012) | (0.001) | (0.001) | (0.002) | (0.008) |
| Experience-squared | -0.042*** | -0.004 | -0.015** | -0.104*** | -0.055*** | -0.003 | -0.024*** | -0.137*** |
| | (0.003) | (0.007) | (0.007) | (0.027) | (0.003) | (0.004) | (0.005) | (0.017) |
| Male | 0.132*** | 0.079*** | 0.158*** | 0.164*** | 0.107*** | 0.042*** | 0.122*** | 0.126*** |
| | (0.006) | (0.013) | (0.014) | (0.036) | (0.006) | (0.007) | (0.011) | (0.026) |
| Head of the household | 0.104*** | 0.001 | 0.074*** | 0.256*** | 0.093*** | 0.010 | 0.094*** | 0.166*** |
| | (0.005) | (0.012) | (0.012) | (0.031) | (0.005) | (0.006) | (0.012) | (0.028) |
| Married | 0.074*** | 0.031*** | 0.088*** | 0.053* | 0.100*** | 0.007 | 0.075*** | 0.227*** |
| | (0.006) | (0.010) | (0.013) | (0.031) | (0.006) | (0.006) | (0.010) | (0.031) |
| Formal | 0.223*** | 0.370*** | 0.177*** | 0.011 | 0.188*** | 0.207*** | 0.127*** | 0.045 |
| | (0.009) | (0.031) | (0.016) | (0.060) | (0.008) | (0.016) | (0.018) | (0.028) |
| Urban | 0.040*** | 0.025 | 0.065*** | -0.007 | 0.026*** | 0.027*** | 0.046*** | -0.050** |
| | (0.009) | (0.020) | (0.013) | (0.019) | (0.009) | (0.009) | (0.011) | (0.025) |
| Constant | 6.654*** | 6.414*** | 6.661*** | 7.492*** | 6.734*** | 6.708*** | 6.757*** | 7.370*** |
| | (0.018) | (0.048) | (0.038) | (0.154) | (0.018) | (0.026) | (0.038) | (0.092) |
| Observations | 35,626 | 35,626 | 35,626 | 35,626 | 35,543 | 35,543 | 35,543 | 35,543 |
| *R*-squared | 0.534 | 0.111 | 0.350 | 0.364 | 0.513 | 0.094 | 0.323 | 0.350 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). Numbers in parentheses represent standard errors. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively. The standard errors of the unconditional quantile regressions are calculated via bootstrap with 500 replications. Industry dummies and region dummies are also included.

FIGURE 2
THE DECOMPOSITION OF OVERALL WAGE CHANGES INTO COMPOSITION AND WAGE STRUCTURE EFFECTS




Note: Shaded areas show 95% confidence intervals.
Source: Authors' calculations based on data from the CASEN 2013 and 2017 surveys.

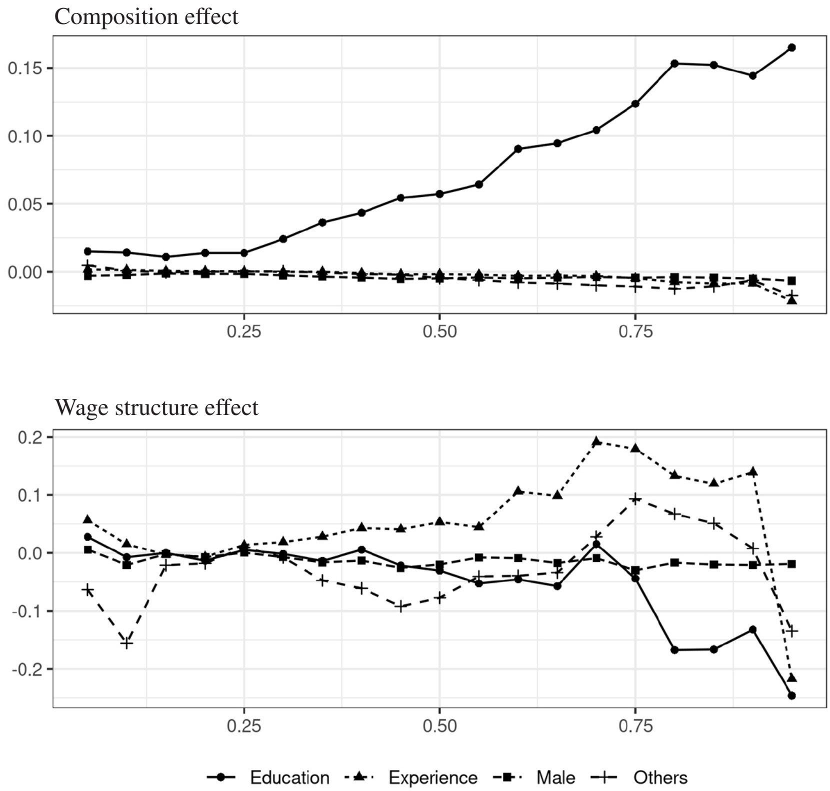
TABLE 3
DECOMPOSITION OF WAGE CHANGES FROM 2013 TO 2017 INTO COMPOSITION AND WAGE STRUCTURE EFFECTS OF EACH EXPLANATORY VARIABLE

| | Composition effect | | | | Wage structure effect | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Overall | 0.0595*** | 0.0140*** | 0.0464*** | 0.1246*** | 0.0297*** | 0.1247*** | 0.0220*** | -0.1285*** |
| | (0.0039) | (0.0019) | (0.0033) | (0.0080) | (0.0035) | (0.0039) | (0.0043) | (0.0098) |
| Primary | 0.0048*** | 0.0047*** | 0.0062*** | 0.0008 | 0.0026* | 0.0066*** | 0.0012 | 0.0006 |
| | (0.0005) | (0.0005) | (0.0006) | (0.0008) | (0.0014) | (0.0015) | (0.0017) | (0.0038) |
| Higher education | 0.0677*** | 0.0096*** | 0.0512*** | 0.1434*** | -0.0418*** | -0.0140*** | -0.0317*** | -0.1329*** |
| | (0.0032) | (0.0010) | (0.0024) | (0.0075) | (0.0037) | (0.0041) | (0.0046) | (0.0103) |
| Technical degree | 0.0078*** | 0.0024*** | 0.0093*** | 0.0085*** | -0.0068*** | -0.0059*** | -0.0116*** | -0.0062 |
| | (0.0009) | (0.0005) | (0.0011) | (0.0013) | (0.0016) | (0.0018) | (0.0020) | (0.0045) |
| CFT | -0.0012*** | -0.0003*** | -0.0017*** | -0.0010*** | -0.0008 | -0.0007 | -0.0030*** | -0.0006 |
| | (0.0004) | (0.0001) | (0.0005) | (0.0003) | (0.0006) | (0.0006) | (0.0007) | (0.0016) |
| IP | 0.0039*** | 0.0014*** | 0.0047*** | 0.0029*** | -0.0041*** | -0.0043*** | -0.0049*** | -0.0033 |
| | (0.0006) | (0.0003) | (0.0008) | (0.0006) | (0.0010) | (0.0012) | (0.0013) | (0.0029) |
| New private university | 0.0020*** | 0.0005** | 0.0022*** | 0.0027*** | -0.0016*** | -0.0004 | -0.0021*** | -0.0020* |
| | (0.0003) | (0.0003) | (0.0004) | (0.0006) | (0.0004) | (0.0005) | (0.0005) | (0.0012) |
| Traditional university | 0.0019*** | 0.0004 | 0.0024*** | 0.0033*** | -0.0004 | -0.0001 | -0.0006 | -0.0024** |
| | (0.0003) | (0.0003) | (0.0004) | (0.0008) | (0.0004) | (0.0005) | (0.0005) | (0.0011) |
| Does not know/No response | 0.0006*** | 0.0003** | 0.0006*** | 0.0008** | -0.0008*** | -0.0006* | -0.0005 | -0.0019** |
| | (0.0002) | (0.0001) | (0.0002) | (0.0003) | (0.0003) | (0.0003) | (0.0004) | (0.0008) |
| Incomplete | 0.0005*** | 0.0001 | 0.0011*** | -0.0001 | 0.0009 | 0.0001 | -0.0006 | 0.0040** |
| | (0.0002) | (0.0001) | (0.0003) | (0.0002) | (0.0006) | (0.0007) | (0.0007) | (0.0016) |
| Professional degree | 0.0466*** | 0.0063*** | 0.0353*** | 0.0999*** | -0.0330*** | -0.0081*** | -0.0204*** | -0.1146*** |
| | (0.0029) | (0.0007) | (0.0022) | (0.0065) | (0.0026) | (0.0029) | (0.0032) | (0.0072) |
| IP | 0.0085*** | 0.0013*** | 0.0079*** | 0.0151*** | -0.0030*** | -0.0006 | -0.0022** | -0.0078*** |
| | (0.0008) | (0.0004) | (0.0008) | (0.0015) | (0.0007) | (0.0008) | (0.0009) | (0.0019) |
| New private university | 0.0128*** | 0.0015*** | 0.0096*** | 0.0271*** | -0.0166*** | -0.0021* | -0.0100*** | -0.0507*** |
| | (0.0017) | (0.0003) | (0.0013) | (0.0037) | (0.0012) | (0.0013) | (0.0014) | (0.0033) |
| Traditional university | 0.0253*** | 0.0035*** | 0.0176*** | 0.0581*** | -0.0086*** | -0.0049*** | -0.0033* | -0.0470*** |
| | (0.0024) | (0.0005) | (0.0017) | (0.0055) | (0.0015) | (0.0017) | (0.0018) | (0.0041) |
| Does not know/No response | -0.0019*** | -0.0004*** | -0.0017*** | -0.0032*** | -0.0002 | -0.0002 | -0.0003 | -0.0005 |
| | (0.0005) | (0.0001) | (0.0005) | (0.0009) | (0.0003) | (0.0003) | (0.0003) | (0.0007) |

| | Composition effect | | | | Wage structure effect | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Incomplete | 0.0018*** | 0.0003** | 0.0019*** | 0.0029*** | -0.0047*** | -0.0003 | -0.0047*** | -0.0086*** |
| | (0.0006) | (0.0001) | (0.0006) | (0.0009) | (0.0007) | (0.0008) | (0.0009) | (0.0019) |
| Post-graduate degree | 0.0134*** | 0.0009*** | 0.0067*** | 0.0350*** | -0.0019*** | 0.0000 | 0.0004 | -0.0121*** |
| | (0.0016) | (0.0003) | (0.0008) | (0.0042) | (0.0007) | (0.0008) | (0.0009) | (0.0020) |
| New private university | 0.0040*** | 0.0000 | 0.0019*** | 0.0096*** | 0.0001 | 0.0008* | 0.0006 | 0.0009 |
| | (0.0008) | (0.0001) | (0.0004) | (0.0019) | (0.0004) | (0.0004) | (0.0004) | (0.0010) |
| Traditional university | 0.0082*** | 0.0008*** | 0.0041*** | 0.0229*** | -0.0010* | -0.0005 | -0.0002 | -0.0103*** |
| | (0.0013) | (0.0002) | (0.0007) | (0.0036) | (0.0005) | (0.0006) | (0.0006) | (0.0015) |
| Does not know/No response | -0.0001 | -0.0000 | -0.0000 | -0.0002 | -0.0003*** | -0.0001 | -0.0001 | -0.0013*** |
| | (0.0003) | (0.0000) | (0.0002) | (0.0007) | (0.0001) | (0.0001) | (0.0001) | (0.0004) |
| Incomplete | 0.0013** | 0.0002* | 0.0007** | 0.0027** | -0.0007*** | -0.0001 | 0.0002 | -0.0015** |
| | (0.0005) | (0.0001) | (0.0003) | (0.0011) | (0.0002) | (0.0002) | (0.0003) | (0.0006) |
| Experience | -0.0213*** | -0.0002 | -0.0077*** | -0.0515*** | 0.1134*** | 0.0132 | 0.0918** | 0.2666*** |
| | (0.0019) | (0.0018) | (0.0017) | (0.0049) | (0.0292) | (0.0324) | (0.0358) | (0.0807) |
| Experience-squared | 0.0175*** | 0.0015 | 0.0060*** | 0.0430*** | -0.0508*** | 0.0017 | -0.0385* | -0.1271*** |
| | (0.0017) | (0.0016) | (0.0016) | (0.0045) | (0.0166) | (0.0183) | (0.0203) | (0.0458) |
| Male | -0.0040*** | -0.0024*** | -0.0048*** | -0.0049*** | -0.0139*** | -0.0207*** | -0.0198*** | -0.0209* |
| | (0.0005) | (0.0004) | (0.0006) | (0.0008) | (0.0045) | (0.0051) | (0.0056) | (0.0126) |
| Demographic dummies | -0.0067*** | -0.0019*** | -0.0069*** | -0.0083*** | 0.0026 | -0.0027 | 0.0053 | 0.0100 |
| | (0.0006) | (0.0005) | (0.0006) | (0.0014) | (0.0039) | (0.0043) | (0.0048) | (0.0108) |
| Industry dummies | 0.0000 | 0.0021** | 0.0013 | -0.0008 | -0.0331** | -0.0264 | -0.0334* | -0.0280 |
| | (0.0010) | (0.0009) | (0.0011) | (0.0024) | (0.0145) | (0.0161) | (0.0178) | (0.0401) |
| Formal | 0.0002 | 0.0004 | 0.0002 | 0.0000 | -0.0317*** | -0.1469*** | -0.0453*** | 0.0311 |
| | (0.0005) | (0.0008) | (0.0004) | (0.0000) | (0.0108) | (0.0120) | (0.0133) | (0.0299) |
| Region dummies | 0.0010 | 0.0002 | 0.0006 | 0.0029** | 0.0149*** | 0.0186*** | 0.0136*** | 0.0340*** |
| | (0.0007) | (0.0005) | (0.0007) | (0.0012) | (0.0040) | (0.0045) | (0.0049) | (0.0111) |
| Urban | 0.0001 | 0.0001 | 0.0002 | -0.0000 | -0.0128 | 0.0017 | -0.0174 | -0.0393 |
| | (0.0001) | (0.0001) | (0.0002) | (0.0001) | (0.0114) | (0.0127) | (0.0140) | (0.0316) |
| Constant | | | | | 0.0802*** | 0.2935*** | 0.0964*** | -0.1225* |
| | | | | | (0.0251) | (0.0277) | (0.0307) | (0.0691) |
| Observations | 71,169 | 71,169 | 71,169 | 71,169 | 71,169 | 71,169 | 71,169 | 71,169 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales)*. Numbers in parentheses represent standard errors. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

FIGURE 3
THE DECOMPOSITION OF THE OVERALL COMPOSITION AND WAGE STRUCTURE EFFECTS INTO FOUR GROUPS OF EXPLANATORY VARIABLES

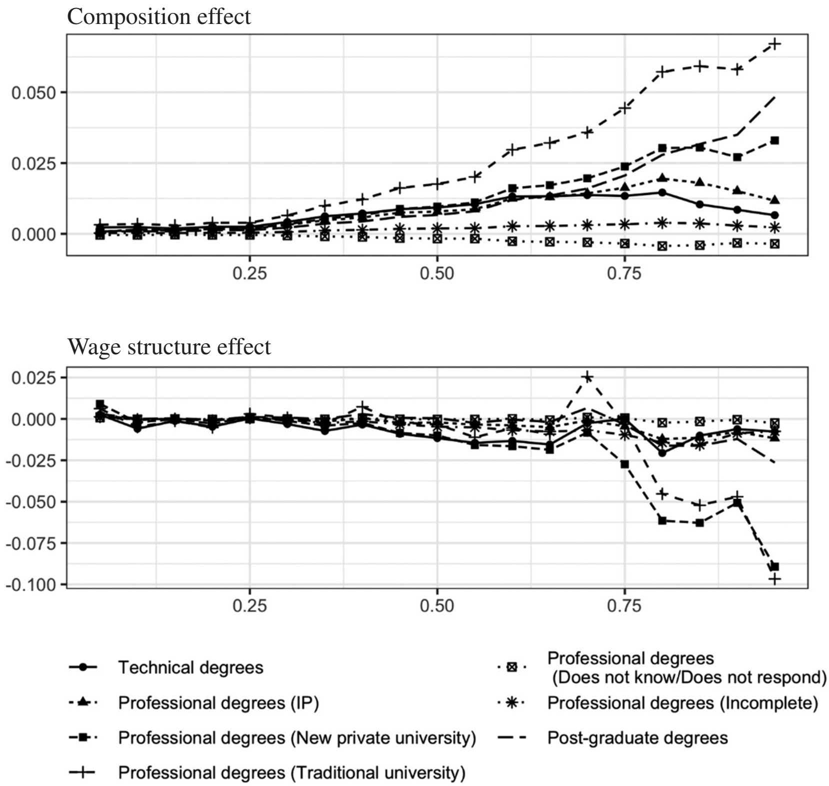



Note: "Education" is the sum of dummies on educational achievements; "Experience" is the sum of years of potential labor experience and its squared term; "Male" is the dummy for male workers; "Others" is the sum of all other explanatory variables except for the constant term.
Source: Authors' calculations based on data from the CASEN 2013 and 2017 surveys.

of higher education degrees. For example, Murakami (2014) finds the estimated coefficient of the relative supply of college-educated workers to be -0.1652 (i.e., the inverse of the elasticity of substitution between college-educated and unskilled workers) in Chile for the previous period.[11] This estimate predicts that the observed increase in the share of workers with higher education (from 0.342 in 2013 to 0.427 in 2017, see Table 1) leads to a 0.059 log point decrease in the coefficient of higher education. Thus, the actual 0.098 log point decrease in the

11 Note that Table 4.1 of Gasparini *et al.* (2011: 32) provides similar estimation results from 16 LACs.

FIGURE 4
THE DETAILED COMPOSITION AND WAGE STRUCTURE EFFECTS OF HIGHER EDUCATION DEGREES




Note: IP, Professional Institutes (*Institutos Profesionales*). The wage structure effects of technical and post-graduate degrees are not disaggregated into degree-granting institutions. The degree-granting institutions of professional degrees are represented in parentheses.
Source: Authors' calculations based on data from the CASEN 2013 and 2017 surveys.

coefficient is more significant than predicted.[12] Moreover, the quantitative change may not account for the decline in the coefficients of particular types of degrees.

Thus, we discuss several possible reasons for the observed decline in the coefficients of professional degrees, particularly at the upper quantiles. First, in addition to the expansion and diversification of higher education explained

[12] Note that the increase in the log of the relative share of workers with higher education from 2013 to 2017 (i.e., log (0.427/ (1 – 0.427)) – log (0.342/ (1 – 0.342)) = 0.357) multiplied by the estimated coefficient -0.1652 yields the value -0.059. Furthermore, the wage structure effect of overall higher education, -0.042 (see Table 3), divided by the share of workers with higher education in 2017 (0.427), yields the value -0.098.

TABLE 4
CONTRIBUTION OF THE DIFFERENCE IN THE COMPOSITION AND WAGE STRUCTURE EFFECTS BETWEEN SELECTED QUANTILES TO THE EVOLUTION OF WAGE INEQUALITY FROM 2013 TO 2017

| | All workers | | | |
|---|---|---|---|---|
| | Q90-Q10 | | Q90-Q50 | |
| 2013 | 1.5516 | | 1.0544 | |
| 2017 | 1.4090 | | 0.9822 | |
| Overall difference | -0.1426 | | -0.0722 | |
| Total composition effect | 0.1106 | -77.53% | 0.0783 | -108.36% |
| Primary education or less | -0.0038 | 2.68% | -0.0053 | 7.38% |
| Higher education | 0.1338 | -93.78% | 0.0922 | -127.60% |
| Technical degree | 0.0061 | -4.25% | -0.0008 | 1.09% |
| CFT | -0.0006 | 0.45% | 0.0007 | -0.93% |
| IP | 0.0015 | -1.06% | -0.0018 | 2.44% |
| New private university | 0.0021 | -1.50% | 0.0005 | -0.67% |
| Traditional university | 0.0028 | -1.99% | 0.0009 | -1.27% |
| Does not know/No response | 0.0004 | -0.31% | 0.0002 | -0.21% |
| Incomplete | -0.0002 | 0.15% | -0.0012 | 1.73% |
| Professional degree | 0.0936 | -65.66% | 0.0647 | -89.56% |
| IP | 0.0138 | -9.64% | 0.0072 | -9.97% |
| New private university | 0.0255 | -17.89% | 0.0175 | -24.17% |
| Traditional university | 0.0546 | -38.27% | 0.0406 | -56.15% |
| Does not know/No response | -0.0029 | 2.02% | -0.0016 | 2.20% |
| Incomplete | 0.0027 | -1.87% | 0.0011 | -1.48% |
| Post-graduate degree | 0.0340 | -23.87% | 0.0283 | -39.13% |
| New private university | 0.0095 | -6.68% | 0.0076 | -10.56% |
| Traditional university | 0.0221 | -15.52% | 0.0188 | -25.97% |
| Does not know/No response | -0.0002 | 0.13% | -0.0002 | 0.21% |
| Incomplete | 0.0026 | -1.80% | 0.0020 | -2.81% |
| Experience | -0.0513 | 35.95% | -0.0438 | 60.62% |
| Experience-squared | 0.0416 | -29.13% | 0.0370 | -51.24% |
| Male | -0.0026 | 1.79% | -0.0002 | 0.25% |
| Demographic dummies | -0.0064 | 4.48% | -0.0014 | 1.99% |
| Industry dummies | -0.0028 | 2.00% | -0.0021 | 2.85% |
| Formal | -0.0004 | 0.25% | -0.0002 | 0.23% |
| Region dummies | 0.0026 | -1.84% | 0.0022 | -3.11% |
| Urban | -0.0001 | 0.06% | -0.0002 | 0.27% |
| Total wage structure effect | -0.2532 | 177.53% | -0.1505 | 208.36% |
| Primary education or less | -0.0060 | 4.19% | -0.0006 | 0.79% |
| Higher education | -0.1189 | 83.36% | -0.1013 | 140.19% |
| Technical degree | -0.0003 | 0.20% | 0.0054 | -7.52% |
| CFT | 0.0001 | -0.05% | 0.0024 | -3.33% |
| IP | 0.0010 | -0.68% | 0.0016 | -2.16% |
| New private university | -0.0016 | 1.12% | 0.0002 | -0.22% |
| Traditional university | -0.0023 | 1.61% | -0.0018 | 2.51% |
| Does not know/No response | -0.0013 | 0.93% | -0.0015 | 2.04% |
| Incomplete | 0.0039 | -2.72% | 0.0046 | -6.36% |
| Professional degree | -0.1064 | 74.62% | -0.0941 | 130.31% |
| IP | -0.0072 | 5.04% | -0.0056 | 7.76% |

| | All workers | | | |
|---|---|---|---|---|
| | Q90-Q10 | | Q90-Q50 | |
| New private university | -0.0485 | 34.03% | -0.0407 | 56.34% |
| Traditional university | -0.0421 | 29.53% | -0.0437 | 60.51% |
| Does not know/No response | -0.0003 | 0.23% | -0.0002 | 0.31% |
| Incomplete | -0.0082 | 5.78% | -0.0039 | 5.38% |
| Post-graduate degree | -0.0122 | 8.54% | -0.0126 | 17.40% |
| New private university | 0.0001 | -0.08% | 0.0003 | -0.38% |
| Traditional university | -0.0097 | 6.81% | -0.0100 | 13.90% |
| Does not know/No response | -0.0012 | 0.87% | -0.0012 | 1.60% |
| Incomplete | -0.0013 | 0.94% | -0.0016 | 2.28% |
| Experience | 0.2534 | -177.67% | 0.1748 | -242.08% |
| Experience-squared | -0.1288 | 90.32% | -0.0886 | 122.69% |
| Male | -0.0002 | 0.14% | -0.0011 | 1.46% |
| Demographic dummies | 0.0127 | -8.88% | 0.0047 | -6.54% |
| Industry dummies | -0.0017 | 1.16% | 0.0054 | -7.47% |
| Formal | 0.1780 | -124.77% | 0.0764 | -105.77% |
| Region dummies | 0.0154 | -10.79% | 0.0204 | -28.20% |
| Urban | -0.0410 | 28.74% | -0.0218 | 30.23% |
| Constant | -0.4161 | 291.72% | -0.2189 | 303.07% |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). % indicates the contribution of the respective variables to the evolution of wage inequality between the selected quantiles.

in the Introduction section, the expansion of financial aid from the government in the form of scholarships and loan programs since the mid-2000s has led to a rapid increase in the enrollment in higher education in Chile (Bucarey, 2018; Hastings *et al.*, 2016; Rojas *et al.*, 2016).[13] If sorting into higher education existed, students facing higher returns to education were more likely to enroll in higher education. Thus, the rapid increase in enrollment could have meant the enrollment of students facing lower returns in recent periods. Second, although Chile introduced a quality assurance system based on accreditation processes (Cox, 1996; Espinoza & González, 2013), the quality of the institutions and programs of new private universities has been frequently questioned in comparison with those of traditional universities (Rodríguez *et al.*, 2016). Moreover, until recently, higher education institutions in Chile had not disclosed information regarding the employment prospects and earnings of their graduates

[13] In 2006, Chile introduced a new loan program for students of all accredited higher education institutions, the State Guaranteed Loan (*Crédito con Aval del Estado*, CAE), in addition to the existing loan program only for students of traditional universities, the University Credit Solidarity Fund (*Fondo Solidario de Crédito Universitario*, FSCU) (OECD, 2017). Following the introduction of the CAE, the number of beneficiaries rapidly increased from approximately 21,300 in 2006 to 369,300 in 2015 (MINEDUC, 2017: 143). Simultaneously, total enrollment in higher education increased from approximately 619,000 to 1,233,000 (MINEDUC, 2017: 135-136).

with different careers and degrees (Rodríguez *et al.*, 2016).[14] Thus, it would be possible that some students enrolled in low-quality institutions and programs because of the lack of information. Third, the demand for highly skilled workers might have stagnated recently. In the United States (US), while the employment for highly skilled workers increased in the 1980s and 1990s, it stagnated in the 2000s (Acemoglu & Autor 2011). Gallego (2012) finds that the evolution of the demand for skilled workers in Chile correlated with that in the US from 1960 to 2000, mainly through the international diffusion of technologies. Thus, it is plausible that the demand for highly skilled workers has stagnated in Chile since the 2000s. The explanation is also compatible with Fernández and Messina (2018) and Murakami and Nomura (2020), who find that the returns to higher education declined in Chile in the 2000s.

If the first and second explanations were the main factors, the coefficients of professional degrees should have declined in the lower quantiles. However, we found that the coefficients of professional degrees declined, particularly at the upper quantiles. Therefore, the third explanation is the most plausible for our finding.

## 5. Robustness checks

### 5.1. Selection-bias corrections

The limitation of our sample to full-time employed workers may lead to biased estimates in the coefficients of degrees, particularly for females, since a larger share of females in this study are non-participants. That is, the female participation share (share of participants to the sum of participants and non-participants) is 0.488 (14,316 out of 29,366) in 2013 and 0.545 (15,396 out of 28,256) in 2017, whereas the male participation share is 0.868 (21,301 out of 24,553) in 2013 and 0.843 (20,135 out of 23,885) in 2017 (see Tables S.8 to S.10 in the Supplemental file).[15] Since educated individuals are more likely to become full-time employed workers (see Contreras *et al.*, 2011 for the case of Chile), this non-random selection can lead to underestimating the coefficients of degrees. If this selectivity bias changes over time, our decomposition results can also suffer from the bias. Thus, following Seneviratne (2019), we apply the

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[14] Currently, we know such information from the Ministry of Education in Chile (http://www.mifuturo.cl/).

[15] Due to very few observations of male post-graduates who did not know their degree-granting institutions nor respond to this question, we cannot estimate the coefficient for this category of the Probit selection equation (A-1) in 2013. Therefore, we exclude the workers of this category in both 2013 and 2017 in advance. Due to this exclusion, the number of observations of male participants decreased from 21,310 to 21,301 in 2013 and from 20,147 to 20,135 in 2017, respectively.

seminal Heckman two-step approach to our decomposition analysis to address this issue.

The processes are as follows (see the Appendix for more detail). First, we estimate the Probit selection equation from which each year's selectivity-correction term (inverse Mills ratio) is estimated for each year. Second, including the correction term, we estimate the wage equation for each year. Since an exclusion restriction variable (the number of children under the age of six years in a given household) is likely to be associated with the participation differently between genders, we separately estimate the selection and wage equations for males and females. Finally, following Neuman and Oaxaca (2004), we decompose all explanatory variables, including the correction term, into the composition and wage structure effects.

We find that workers with higher education degrees are more likely to become full-time employed workers (see Table S.8 in the Supplemental file), as expected, and the coefficients on the correction term are positive at the mean and the 90th quantile for both males and females in 2013 and 2017 (see Tables S.9 and S.10 in the Supplemental file). Thus, the coefficients of degrees estimated without the sample selection correction term tend to be underestimated for males and females in both years (see Tables S.3 and S.4 in the Supplemental file for the estimation results of the wage equation without the correction term for males and females, respectively). However, for females, the decline in the coefficients of professional degrees, with a larger magnitude at the 90th quantile, is robust to the inclusion of the correction term (see Table S.10 in the Supplemental file). Moreover, the decline is strongly associated with the reduction in wage inequality: it accounts for 164.0% of the reduction in the 90-10 log wage gap (see Table A.1). For males, an opposite trend is observed in professional degrees from IPs and traditional universities. However, we again confirm the robust decline in the coefficient of professional degrees from new private universities, with a larger magnitude at the 90th quantile (see Table S.9 in the Supplemental file). The decline accounts for 10.4% of the reduction in the 90-10 log wage gap (see Table A.1).

### 5.2. Different analysis period

To confirm that the observed decline in the coefficients of professional degrees and its association with the reduction in wage inequality are robust to the choice of the analysis period and continuous trend, it is helpful to include the data from the CASEN 2015 survey in our analysis. Considering that the educational characteristics of the workforce in 2015 are relatively similar to those in 2013 (see Table S.11 in the Supplemental file), we additionally perform the decomposition analysis from 2015 to 2017. Since the 90-50 log wage gap is stable in this period, we only show the contribution to the reduction in the 90-10 log wage gap in Table A.2.

As observed in the analysis period from 2013 to 2017, we find that the coefficients of professional degrees from new private universities declined from 2015 to 2017, with a larger magnitude at the 90th quantile (see Table S.13 in the Supplemental file). The decline is associated with the reduction in wage inequality and accounts for 23.6% of the reduction in the 90-10 log wage gap in this period (see Table A.2). Thus, the observed decline in the coefficients of degrees and its association with the reduction in wage inequality are robust trends.

### 5.3. Occupation control

Our next robustness check is to include workers' occupation categories in the wage equation. We find that the inclusion of occupation dummies (the reference category is elementary occupations) provides remarkably similar estimation results in the wage equation (see Table S.14 in the Supplemental file) and the decomposition analysis (see Table S.15 in the Supplemental file). The magnitudes of the contributions of higher education degrees to the reduction in wage inequality are also quite similar; the decline in the coefficients of professional degrees accounts for 76.3% of the reduction in the 90-10 log wage gap (see Table A.3), which is comparable to the previous result of 74.6% (see Table 4). In other words, the correlation between final education achievements and occupation choices was stable from 2013 to 2017.

### 5.4. Control for firm characteristics

Finally, we check that the findings are robust to the inclusion of characteristics of firms that employ the workers. Note that we have already controlled for workers' industry affiliations in all estimations as variables related to the labor-demand side. In addition, we have controlled for occupation categories in Section 5.3. Since the household surveys provide the data on firm size categories based on the number of workers employed, we use them as the variables representing firm characteristics (the reference category is firms with five workers or less). Firm size is usually considered a proxy for firm productivity (e.g., Bustos, 2011; Infante and Sunkel, 2009). Thus, the variables are likely to be positively correlated with wages. However, we cannot compare the data on firm size in 2013 and 2017 because the questions about firm size in the 2013 and 2017 surveys are different.[16] Consequently, we use the data from the 2015 and 2017 surveys for this robustness check. We dropped the observations which reported unawareness of the firm size in the country.

We find that the firm size distributions are quite stable from 2015 to 2017 (see Table S.16 in the Supplemental file). Thus, we do not find significant changes

[16] The CASEN 2013 survey asked about both firm size in the establishment and firm size in the country, whereas the CASEN 2015 and 2017 surveys asked only about the firm size in the country. The two separate questions in the 2013 survey might have led to a substantial part of respondents not reporting them. Nearly a quarter of the workers in the sample reported that they did not know the firm size in the country in the 2013 survey, whereas only about 10% of the workers reported that they did not know it in the 2015 and 2017 surveys.

in firm characteristics from this variable. Expectedly, we find that employment in larger firms is associated with higher wages in both years (see Table S.17 in the Supplemental file). However, the observed decline in the coefficient of professional degrees from new private universities, with a larger magnitude at the 90th quantile, is robust to the inclusion of the firm size dummies (see Tables S.17 and S.18 in the Supplemental file). The decline accounts for 22.7% of the reduction in the 90-10 log wage gap (see Table A.4), which is comparable to the previous result (without controlling for the occupation and firm size categories in Section 5.2) of 23.6% (see Table A.2).

## 6. Concluding remarks

After increasing the returns to higher education degrees and wage inequality in the 1990s, LACs have experienced a significant reduction in both since the early 2000s. Considering that the recent decline in the returns to higher education degrees may not be homogenous across different types of degrees and degree-granting institutions, an empirical analysis to identify the association between the changes in coefficients of dummy variables for different types of degrees and the recent evolution of wage inequality is highly required. In this context, Chile presents a fascinating case study because its higher education has experienced significant expansion and diversification.

Thus, this study analyzed the association between the changes in the coefficients of degrees and the evolution of wage inequality in Chile from 2013 to 2017 using data from nationally and regionally representative household surveys. For this purpose, this study takes advantage of a method proposed by Firpo *et al.* (2009), which allowed us to decompose wage changes at any unconditional quantile into composition and wage structure effects. As observed in the previous period in Chile (e.g., Fernández and Messina, 2018; Murakami & Nomura, 2020), we found that the coefficients of higher education degrees continuously decreased in general, with a larger magnitude at the upper quantiles, associated with the reduction in wage inequality among full-time employed workers during this period. However, we found that the coefficients of degrees declined heterogeneously across the types of degrees (i.e., technical, professional, and post-graduate degrees) and degree-granting institutions. We found that the coefficients of professional degrees, especially from new private universities, remarkably declined, which is associated with a substantial part of the reduction in wage inequality. Since the coefficients of professional degrees declined particularly at the upper quantiles, the decline was likely related to the stagnant demand for highly skilled workers in recent periods. Finally, we verified that the findings are robust to the selection of full-time employed workers, the control for workers' occupation and firm size categories, and the choice of the analysis period.

Responding to the widespread protests against the country's higher education policies in 2011, Michelle Bachelet pledged to make higher education tuition-free for all students in her presidential campaign in 2013 (Bucarey, 2018). The second Bachelet government took office in 2014 and introduced a tuition-free college policy in 2016. We cannot evaluate the effects of this policy change from the data from the CASEN 2017 survey. However, based on the findings of this study, we provide some implications for the tuition-free college policy. On the one hand, we expect an increase in the private returns to higher education owing to the reduction in the cost of higher education will induce a further increase in enrollment. Thus, increasing the relative supply of workers with higher education will decrease their wage premiums, decreasing wage inequality between workers with higher education and those with less education.

On the other hand, the tuition-free college policy does not require students to meet academic standards, unlike the existing scholarships and loan programs (Delisle & Bernasconi, 2018). Thus, the tuition-free college policy will likely allow students with even lower returns to higher education, increasing wage inequality among college graduates. Therefore, the effects of the tuition-free college policy on overall wage inequality will depend on the magnitude of the two effects.

Finally, we note that although we controlled for selection bias and as many observable variables as possible, we still cannot interpret our results as direct causal effects of changes in the coefficients of degrees on the reduction in wage inequality because we did not address the endogeneity issue due to individuals' unobserved abilities and skills before enrolling in higher education institutions. Such an analysis is beyond the scope of this study; however, especially from a policy perspective, it is an interesting subject for future research.

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## Appendix: The detailed process of the decomposition with correction for selection bias

First, we estimate a Probit selection equation for the sample of potential wage earners aged between 24 and 50 years, including unemployed and non-labor force participants, except those who reported that their reasons for not seeking employment were enrolling in school, illness or disability, or receiving pensions. The independent variables in the participation equation include all of the explanatory variables in the wage equation except for the current work description (i.e., the industry affiliation and employment contract). We also include the following exclusion restrictions: (1) the sum of an individual's total non-labor income (assets income and transfer income) and income of other family members (in million pesos) and (2) the number of children under the age of six years in the household. Since an individual with a higher non-labor income generally has a higher reservation wage, the individual is less likely to be a full-time worker, regardless of gender.

The number of children under the age of six is likely to be associated with participation differently for each gender. If males tend to be the primary earners in the household and females tend to have more responsibility for childcare, the number of children is likely to correlate positively with full-time labor participation for males but negatively for females. Contreras *et al.* (2011) find a positive correlation between the number of young children and labor participation for males and a negative correlation for females in Chile. Considering this gender difference in the exclusion restriction variable, we separately estimate the following selection equation for males and females (see Table S.8 in the Supplemental file for the estimation results):

$$L_{it} = I\left\{ \boldsymbol{H}_{it}^{'}\gamma_t + u_{it} > 0 \right\} \tag{A-1}$$

where $L_{it}$ is a binary variable, taking a value of 1 if an individual $i$ becomes a full-time employed worker and 0, otherwise. $H$ is a vector of explanatory variables that determine the full-time labor participation. $u_{it}$ is an error term (note that the variance of the error term $\sigma_{ut}$ is normalized to 1).

The estimation results of the Probit selection equation show that the marital status and the number of children are positively correlated with the full-time labor participation for males, whereas they are negatively correlated for females, as expected. The coefficient of total non-labor income is negative for both males and females but not significant (see Table S.8 in the Supplemental file).

Second, we include the estimated inverse Mills ratio (the selectivity-correction term), $\hat{\lambda}_{it} = \dfrac{\phi\left(\boldsymbol{H}_{it}^{'}\hat{\gamma}_t\right)}{\boldsymbol{\Phi}\left(\boldsymbol{H}_{it}^{'}\hat{\gamma}_t\right)}$, (where $\phi(\cdot)$ and $\boldsymbol{\Phi}(\cdot)$ are the density and cumulative distribution functions of the standard normal distribution, respectively) as an additional variable in the wage equation (1):

(A-2) $$\ln\left(w_{it}\right)=\boldsymbol{X}_{it}^{'}\beta_t+\theta_t\hat{\lambda}_{it}+\varepsilon_{it}$$

where $\theta_t=\text{cov}\left(\sigma_{\varepsilon t},\,\sigma_{ut}\right)=\sigma_{\varepsilon ut}$ . In the case of adding the correction term, we estimate the wage equation separately for males and females (see Tables S.9 and S.10 in the Supplemental file for estimation results for males and females, respectively).

Finally, following Neuman and Oaxaca (2004), we decompose the effect of explanatory variables, including the correction term, into the composition and wage structure effect. To apply the O-B decomposition to the correction term, we construct the following counterfactual values of the inverse Mills ratios for 2017, where individuals in 2017 would have faced the same coefficients of the selection equation faced by individuals in 2013:

(A-3) $$\hat{\lambda}_{i2017c}=\frac{\phi\left(\boldsymbol{H}_{i2017}^{'}\hat{\gamma}_{2013}\right)}{\Phi\left(\boldsymbol{H}_{i2017}^{'}\hat{\gamma}_{2013}\right)}$$

Using the mean value of the counterfactual inverse Mills ratio, $\bar{\lambda}_{2017c}$, we can decompose the change in the mean value of the correction term between $t$ = 2013 and $t$ = 2017 as follows (see equation (8) of Neuman and Oaxaca, 2004: 6):

(A-4) $$\begin{aligned}&\hat{\theta}_{2017}\bar{\lambda}_{2017}-\hat{\theta}_{2013}\bar{\lambda}_{2013}=\hat{\theta}_{2013}\left(\bar{\lambda}_{2017c}-\bar{\lambda}_{2013}\right)+\hat{\theta}_{2013}\left(\bar{\lambda}_{2017}-\bar{\lambda}_{2017c}\right)\\&+\left(\hat{\theta}_{2017}-\hat{\theta}_{2013}\right)\bar{\lambda}_{2017}\\&=\hat{\theta}_{2013}\left(\bar{\lambda}_{2017c}-\bar{\lambda}_{2013}\right)+\ \hat{\theta}_{2017}\bar{\lambda}_{2017}-\hat{\theta}_{2013}\bar{\lambda}_{2017c}.\end{aligned}$$

The first term in the first line of the right-hand side of the equation (A-4) represents the log wage change attributable to changes in the explanatory variables that determine the selection probability (we refer to the composition effect of the inverse Mills ratio). The last two terms represent the log wage change attributable to changes in the coefficients of explanatory variables in the selection equation and the change in the covariance between the selection equation error term and the wage equation error term (we refer to the wage structure effect of the inverse Mills ratio).

Therefore, based on equation (A-4), we can propose the following extension of the decomposition of the wage change from 2013 to 2017 at the $\tau$ -th unconditional quantile expressed in equation (4) as follows (see equations (12) and (14) of Neuman and Oaxaca, 2004: 7-8 for the case of mean regression):

(A-5) $$\begin{aligned}&\hat{q}_{2017}^{\tau}-\hat{q}_{2013}^{\tau}=\left(\bar{\boldsymbol{X}}_{2017}^{'}-\bar{\boldsymbol{X}}_{2013}^{'}\right)\hat{\beta}_{2013}^{\tau}+\hat{\theta}_{2013}^{\tau}\left(\bar{\lambda}_{2017c}-\bar{\lambda}_{2013}\right)\\&+\bar{\boldsymbol{X}}_{2017}^{'}\left(\hat{\beta}_{2017}^{\tau}-\hat{\beta}_{2013}^{\tau}\right)+\hat{\theta}_{2017}^{\tau}\bar{\lambda}_{2017}-\hat{\theta}_{2013}^{\tau}\bar{\lambda}_{2017c}.\end{aligned}$$

The decomposition analysis with the sample selection correction term reveals that the negative wage structure effect of the correction term, which is driven by the decline in the covariance between the selection equation error term and the wage equation error term at the 90th quantile (see Tables S.9 and S.10 in the Supplemental file), is strongly associated with the reduction in wage inequality for both males and females (see Table A.1). However, the composition effect of the correction term is associated with increasing and decreasing wage inequality for males and females, respectively (see Table A.1).

TABLE A.1

CONTRIBUTION OF THE DIFFERENCE IN THE COMPOSITION AND WAGE STRUCTURE EFFECTS BETWEEN SELECTED QUANTILES TO THE EVOLUTION OF WAGE INEQUALITY FROM 2013 TO 2017 FOR MALES AND FEMALES, WITH THE SELECTIVITY-CORRECTION TERM

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Q90-Q10 | | Q90-Q50 | | Q90-Q10 | | Q90-Q50 | |
| 2013 | 1.5907 | | 1.0676 | | 1.5455 | | 1.0913 | |
| 2017 | 1.4926 | | 1.0100 | | 1.4391 | | 1.0494 | |
| Overall difference | -0.0981 | | -0.0576 | | -0.1064 | | -0.0419 | |
| Total composition effect | 0.1013 | -103.27% | 0.0783 | -135.97% | 0.1085 | -101.91% | 0.0556 | -132.83% |
| Primary education or less | 0.0003 | -0.33% | -0.0036 | 6.29% | 0.0014 | -1.33% | 0.0014 | -3.34% |
| Higher education | 0.1347 | -137.29% | 0.1062 | -184.44% | 0.1450 | -136.26% | 0.0974 | -232.57% |
| Technical degree | 0.0087 | -8.87% | 0.0032 | -5.53% | 0.0033 | -3.13% | -0.0035 | 8.29% |
| CFT | 0.0000 | 0.01% | -0.0002 | 0.27% | -0.0044 | 4.16% | 0.0001 | -0.14% |
| IP | 0.0021 | -2.19% | 0.0006 | -1.08% | 0.0046 | -4.30% | -0.0003 | 0.72% |
| New private university | 0.0026 | -2.65% | 0.0017 | -2.87% | 0.0004 | -0.34% | -0.0022 | 5.32% |
| Traditional university | 0.0013 | -1.30% | -0.0001 | 0.24% | 0.0038 | -3.60% | 0.0018 | -4.34% |
| Does not know/No response | 0.0023 | -2.30% | 0.0013 | -2.20% | 0.0000 | 0.00% | 0.0000 | 0.09% |
| Incomplete | 0.0004 | -0.45% | -0.0001 | 0.10% | -0.0010 | 0.95% | -0.0028 | 6.62% |
| Professional degree | 0.0935 | -95.31% | 0.0740 | -128.53% | 0.1031 | -96.88% | 0.0697 | -166.37% |
| IP | 0.0157 | -16.02% | 0.0110 | -19.06% | 0.0162 | -15.24% | 0.0088 | -20.92% |
| New private university | 0.0253 | -25.82% | 0.0202 | -35.08% | 0.0289 | -27.14% | 0.0194 | -46.43% |
| Traditional university | 0.0521 | -53.06% | 0.0437 | -75.87% | 0.0598 | -56.20% | 0.0424 | -101.36% |
| Does not know/No response | -0.0050 | 5.12% | -0.0039 | 6.75% | -0.0021 | 2.00% | -0.0011 | 2.53% |
| Incomplete | 0.0054 | -5.54% | 0.0030 | -5.26% | 0.0003 | -0.30% | 0.0001 | -0.19% |
| Post-graduate degree | 0.0325 | -33.12% | 0.0290 | -50.38% | 0.0386 | -36.26% | 0.0312 | -74.48% |
| New private university | 0.0077 | -7.85% | 0.0067 | -11.69% | 0.0138 | -12.97% | 0.0109 | -26.13% |
| Traditional university | 0.0246 | -25.10% | 0.0222 | -38.50% | 0.0227 | -21.34% | 0.0189 | -45.14% |
| Does not know/No response | | | | | -0.0027 | 2.53% | -0.0022 | 5.30% |
| Incomplete | 0.0002 | -0.17% | 0.0001 | -0.19% | 0.0048 | -4.48% | 0.0036 | -8.51% |
| Experience | -0.1077 | 109.75% | -0.1032 | 179.10% | -0.0445 | 41.81% | -0.0358 | 85.53% |
| Experience-squared | 0.0919 | -93.69% | 0.0886 | -153.80% | 0.0305 | -28.66% | 0.0248 | -59.17% |

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Q90-Q10 | | Q90-Q50 | | Q90-Q10 | | Q90-Q50 | |
| Demographic dummies | -0.0388 | 39.57% | -0.0306 | 53.13% | 0.0250 | -23.50% | 0.0217 | -51.74% |
| Industry dummies | -0.0003 | 0.26% | -0.0002 | 0.27% | 0.0008 | -0.80% | 0.0002 | -0.43% |
| Formal | 0.0002 | -0.17% | 0.0004 | -0.69% | -0.0074 | 6.93% | -0.0099 | 23.72% |
| Region dummies | 0.0011 | -1.10% | 0.0010 | -1.71% | 0.0054 | -5.03% | 0.0040 | -9.48% |
| Urban | -0.0009 | 0.96% | -0.0014 | 2.36% | -0.0007 | 0.64% | -0.0009 | 2.05% |
| Inverse Mills ratio | 0.0208 | -21.22% | 0.0210 | -36.49% | -0.0471 | 44.29% | -0.0471 | 112.59% |
| Total wage structure effect | -0.1995 | 203.27% | -0.1359 | 235.97% | -0.2149 | 201.91% | -0.0975 | 232.83% |
| Primary education or less | -0.0070 | 7.10% | -0.0052 | 8.96% | 0.0092 | -8.68% | 0.0110 | -26.20% |
| Higher education | 0.0321 | -32.67% | 0.0343 | -59.61% | -0.2135 | 200.60% | -0.1874 | 447.58% |
| Technical degree | -0.0087 | 8.83% | -0.0040 | 7.00% | -0.0132 | 12.44% | -0.0085 | 20.28% |
| CFT | 0.0036 | -3.65% | 0.0040 | -6.92% | -0.0055 | 5.16% | -0.0017 | 4.00% |
| IP | -0.0045 | 4.63% | -0.0031 | 5.31% | -0.0116 | 10.86% | -0.0154 | 36.82% |
| New private university | -0.0024 | 2.46% | -0.0010 | 1.68% | 0.0020 | -1.85% | 0.0044 | -10.51% |
| Traditional university | 0.0006 | -0.57% | 0.0005 | -0.80% | -0.0049 | 4.60% | -0.0039 | 9.34% |
| Does not know/No response | -0.0043 | 4.35% | -0.0033 | 5.65% | 0.0013 | -1.18% | 0.0008 | -1.92% |
| Incomplete | -0.0016 | 1.61% | -0.0012 | 2.07% | 0.0055 | -5.15% | 0.0073 | -17.45% |
| Professional degree | 0.0146 | -14.91% | 0.0140 | -24.25% | -0.1745 | 164.00% | -0.1533 | 366.24% |
| IP | 0.0048 | -4.94% | 0.0048 | -8.25% | -0.0184 | 17.25% | -0.0156 | 37.27% |
| New private university | -0.0102 | 10.37% | -0.0096 | 16.68% | -0.0785 | 73.77% | -0.0650 | 155.21% |
| Traditional university | 0.0286 | -29.11% | 0.0211 | -36.55% | -0.0697 | 65.48% | -0.0692 | 165.23% |
| Does not know/No response | -0.0004 | 0.43% | -0.0006 | 0.97% | -0.0004 | 0.33% | -0.0002 | 0.53% |
| Incomplete | -0.0082 | 8.35% | -0.0017 | 2.91% | -0.0076 | 7.16% | -0.0033 | 8.00% |
| Post-graduate degree | 0.0261 | -26.58% | 0.0244 | -42.36% | -0.0257 | 24.17% | -0.0256 | 61.07% |
| New private university | 0.0079 | -8.07% | 0.0078 | -13.53% | -0.0073 | 6.81% | -0.0069 | 16.59% |
| Traditional university | 0.0150 | -15.24% | 0.0134 | -23.25% | -0.0172 | 16.12% | -0.0168 | 40.13% |
| Does not know/No response | | | | | -0.0008 | 0.73% | -0.0007 | 1.76% |
| Incomplete | 0.0032 | -3.27% | 0.0032 | -5.58% | -0.0005 | 0.50% | -0.0011 | 2.59% |
| Experience | 0.0966 | -98.43% | -0.0342 | 59.34% | 0.2181 | -204.92% | 0.1361 | -324.99% |
| Experience-squared | -0.0742 | 75.65% | -0.0203 | 35.16% | -0.1228 | 115.35% | -0.0816 | 194.81% |
| Demographic dummies | 0.1070 | -108.99% | 0.0732 | -127.06% | 0.0146 | -13.71% | 0.0299 | -71.46% |

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Q90-Q10 | | Q90-Q50 | | Q90-Q10 | | Q90-Q50 | |
| Industry dummies | -0.0392 | 40.00% | -0.0218 | 37.77% | 0.1924 | -180.74% | 0.0183 | -43.65% |
| Formal | -0.0628 | 63.97% | -0.0523 | 90.84% | 0.1493 | -140.30% | 0.0874 | -208.76% |
| Region dummies | 0.0235 | -23.91% | 0.0184 | -31.92% | 0.0302 | -28.33% | 0.0224 | -53.43% |
| Urban | -0.0036 | 3.65% | 0.0198 | -34.32% | -0.1458 | 137.00% | -0.1651 | 394.28% |
| Constant | -0.1902 | 193.88% | -0.0271 | 46.98% | -0.0520 | 48.89% | 0.3307 | -789.93% |
| Inverse Mills ratio | -0.0815 | 83.03% | -0.1209 | 209.82% | -0.2945 | 276.74% | -0.2992 | 714.57% |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). % indicates the contribution of the respective variable to the evolution of wage inequality between the selected quantiles.

TABLE A.2

CONTRIBUTION OF THE DIFFERENCE IN THE COMPOSITION AND WAGE STRUCTURE EFFECTS BETWEEN SELECTED QUANTILES TO THE EVOLUTION OF WAGE INEQUALITY FROM 2015 TO 2017

| | All workers | |
|---|---|---|
| | Q90-Q10 | |
| 2015 | 1.4789 | |
| 2017 | 1.4090 | |
| Overall difference | -0.0699 | |
| Total composition effect | 0.0543 | -77.62% |
| Primary education or less | -0.0009 | 1.30% |
| Higher education | 0.0731 | -104.58% |
| Technical degree | 0.0021 | -2.95% |
| CFT | -0.0011 | 1.53% |
| IP | 0.0017 | -2.40% |
| New private university | 0.0008 | -1.10% |
| Traditional university | 0.0009 | -1.27% |
| Does not know/No response | -0.0002 | 0.28% |
| Incomplete | 0.0000 | 0.01% |
| Professional degree | 0.0473 | -67.70% |
| IP | 0.0033 | -4.71% |
| New private university | -0.0024 | 3.50% |
| Traditional university | 0.0423 | -60.49% |
| Does not know/No response | 0.0028 | -4.04% |
| Incomplete | 0.0014 | -1.96% |
| Post-graduate degree | 0.0237 | -33.92% |
| New private university | 0.0033 | -4.65% |
| Traditional university | 0.0198 | -28.33% |
| Does not know/No response | 0.0023 | -3.36% |
| Incomplete | -0.0017 | 2.42% |
| Experience | -0.0301 | 43.10% |
| Experience-squared | 0.0252 | -36.11% |
| Male | -0.0009 | 1.22% |
| Demographic dummies | -0.0086 | 12.36% |
| Industry dummies | -0.0062 | 8.92% |
| Formal | 0.0018 | -2.53% |
| Region dummies | 0.0010 | -1.42% |
| Urban | -0.0001 | 0.10% |
| Total wage structure effect | -0.1242 | 177.62% |
| Primary education or less | -0.0003 | 0.38% |
| Higher education | -0.0174 | 24.85% |
| Technical degree | -0.0049 | 6.99% |
| CFT | -0.0015 | 2.13% |
| IP | -0.0070 | 10.01% |
| New private university | 0.0004 | -0.52% |
| Traditional university | -0.0001 | 0.12% |
| Does not know/No response | 0.0003 | -0.37% |
| Incomplete | 0.0031 | -4.37% |
| Professional degree | -0.0096 | 13.69% |
| IP | 0.0002 | -0.29% |

| | All workers | |
|---|---|---|
| | Q90-Q10 | |
| New private university | -0.0165 | 23.64% |
| Traditional university | 0.0024 | -3.38% |
| Does not know/No response | 0.0030 | -4.36% |
| Incomplete | 0.0014 | -1.93% |
| Post-graduate degree | -0.0029 | 4.17% |
| New private university | 0.0049 | -6.96% |
| Traditional university | -0.0037 | 5.36% |
| Does not know/No response | -0.0018 | 2.58% |
| Incomplete | -0.0022 | 3.19% |
| Experience | 0.2893 | -413.72% |
| Experience-squared | -0.1421 | 203.26% |
| Male | 0.0098 | -14.05% |
| Demographic dummies | -0.0179 | 25.60% |
| Industry dummies | -0.0310 | 44.33% |
| Formal | 0.1592 | -227.72% |
| Region dummies | -0.0403 | 57.64% |
| Urban | -0.0539 | 77.04% |
| Constant | -0.2797 | 400.02% |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales)*. % indicates the contribution of the respective variable to the evolution of wage inequality between the selected quantiles.

TABLE A.3

CONTRIBUTION OF THE DIFFERENCE IN THE COMPOSITION AND WAGE STRUCTURE EFFECTS BETWEEN SELECTED QUANTILES TO THE EVOLUTION OF WAGE INEQUALITY FROM 2013 TO 2017, WITH OCCUPATION DUMMIES

| | All workers | | | |
|---|---|---|---|---|
| | Q90-Q10 | | Q90-Q50 | |
| 2013 | 1.5516 | | 1.0544 | |
| 2017 | 1.4090 | | 0.9822 | |
| Overall difference | -0.1426 | | -0.0722 | |
| Total composition effect | 0.1010 | -70.79% | 0.0756 | -104.62% |
| Primary education or less | -0.0037 | 2.58% | -0.0044 | 6.12% |
| Higher education | 0.0846 | -59.34% | 0.0586 | -81.16% |
| Technical degree | 0.0013 | -0.94% | -0.0033 | 4.54% |
| CFT | 0.0001 | -0.04% | 0.0010 | -1.38% |
| IP | -0.0008 | 0.58% | -0.0030 | 4.16% |
| New private university | 0.0008 | -0.53% | -0.0003 | 0.45% |
| Traditional university | 0.0020 | -1.42% | 0.0006 | -0.81% |
| Does not know/No response | 0.0001 | -0.07% | 0.0000 | 0.02% |
| Incomplete | -0.0008 | 0.55% | -0.0015 | 2.11% |
| Professional degree | 0.0580 | -40.66% | 0.0399 | -55.27% |
| IP | 0.0068 | -4.78% | 0.0025 | -3.48% |
| New private university | 0.0152 | -10.66% | 0.0102 | -14.14% |
| Traditional university | 0.0358 | -25.08% | 0.0274 | -37.88% |
| Does not know/No response | -0.0012 | 0.87% | -0.0004 | 0.62% |
| Incomplete | 0.0014 | -1.01% | 0.0003 | -0.39% |
| Post-graduate degree | 0.0253 | -17.74% | 0.0220 | -30.42% |
| New private university | 0.0068 | -4.80% | 0.0057 | -7.87% |
| Traditional university | 0.0170 | -11.91% | 0.0151 | -20.86% |
| Does not know/No response | -0.0001 | 0.09% | -0.0001 | 0.15% |
| Incomplete | 0.0016 | -1.12% | 0.0013 | -1.84% |
| Experience | -0.0492 | 34.47% | -0.0417 | 57.70% |
| Experience-squared | 0.0389 | -27.30% | 0.0350 | -48.39% |
| Male | -0.0024 | 1.70% | -0.0002 | 0.28% |
| Demographic dummies | -0.0058 | 4.07% | -0.0015 | 2.01% |
| Occupation dummies | 0.0463 | -32.47% | 0.0362 | -50.09% |
| Industry dummies | -0.0098 | 6.84% | -0.0082 | 11.38% |
| Formal | -0.0004 | 0.25% | -0.0002 | 0.22% |
| Region dummies | 0.0023 | -1.63% | 0.0021 | -2.89% |
| Urban | -0.0001 | 0.06% | -0.0002 | 0.22% |
| Total wage structure effect | -0.2436 | 170.79% | -0.1478 | 204.62% |
| Primary education or less | -0.0059 | 4.16% | -0.0007 | 0.94% |
| Higher education | -0.1223 | 85.75% | -0.0818 | 113.24% |
| Technical degree | 0.0026 | -1.80% | 0.0129 | -17.92% |
| CFT | 0.0010 | -0.73% | 0.0043 | -5.94% |
| IP | 0.0009 | -0.65% | 0.0048 | -6.70% |
| New private university | -0.0007 | 0.52% | 0.0009 | -1.23% |
| Traditional university | -0.0024 | 1.67% | -0.0017 | 2.40% |
| Does not know/No response | -0.0010 | 0.68% | -0.0010 | 1.39% |
| Incomplete | 0.0047 | -3.29% | 0.0057 | -7.85% |
| Professional degree | -0.1088 | 76.26% | -0.0810 | 112.12% |

| | All workers | | | |
|---|---|---|---|---|
| | Q90-Q10 | | Q90-Q50 | |
| IP | -0.0069 | 4.86% | -0.0037 | 5.06% |
| New private university | -0.0431 | 30.20% | -0.0327 | 45.26% |
| Traditional university | -0.0512 | 35.89% | -0.0426 | 58.95% |
| Does not know/No response | -0.0002 | 0.12% | 0.0004 | -0.50% |
| Incomplete | -0.0074 | 5.20% | -0.0024 | 3.35% |
| Post-graduate degree | -0.0161 | 11.28% | -0.0137 | 19.04% |
| New private university | -0.0008 | 0.56% | 0.0001 | -0.10% |
| Traditional university | -0.0126 | 8.85% | -0.0112 | 15.49% |
| Does not know/No response | -0.0011 | 0.80% | -0.0011 | 1.46% |
| Incomplete | -0.0015 | 1.07% | -0.0016 | 2.18% |
| Experience | 0.1402 | -98.29% | 0.1030 | -142.63% |
| Experience-squared | -0.0786 | 55.11% | -0.0582 | 80.53% |
| Male | 0.0141 | -9.86% | 0.0073 | -10.13% |
| Demographic dummies | 0.0074 | -5.22% | 0.0027 | -3.70% |
| Occupation dummies | -0.0118 | 8.26% | -0.0457 | 63.22% |
| Industry dummies | 0.0397 | -27.87% | 0.0475 | -65.72% |
| Formal | 0.1739 | -121.92% | 0.0710 | -98.25% |
| Region dummies | 0.0166 | -11.62% | 0.0231 | -32.01% |
| Urban | -0.0353 | 24.74% | -0.0252 | 34.94% |
| Constant | -0.3816 | 267.56% | -0.1908 | 264.18% |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). % indicates the contribution of the respective variable to the evolution of wage inequality between the selected quantiles.

TABLE A.4
CONTRIBUTION OF THE DIFFERENCE IN THE COMPOSITION AND WAGE STRUCTURE EFFECTS BETWEEN SELECTED QUANTILES TO THE EVOLUTION OF WAGE INEQUALITY FROM 2015 TO 2017, WITH OCCUPATION AND FIRM SIZE DUMMIES

| | All workers | |
|---|---|---|
| | Q90-Q10 | |
| 2015 | 1.5120 | |
| 2017 | 1.4730 | |
| Overall difference | -0.0391 | |
| Total composition effect | 0.0583 | -149.04% |
| Primary education or less | -0.0011 | 2.78% |
| Higher education | 0.0519 | -132.89% |
| Technical degree | 0.0012 | -3.06% |
| CFT | -0.0003 | 0.83% |
| IP | 0.0010 | -2.67% |
| New private university | 0.0003 | -0.78% |
| Traditional university | 0.0005 | -1.23% |
| Does not know/No response | -0.0003 | 0.88% |
| Incomplete | 0.0000 | -0.10% |
| Professional degree | 0.0308 | -78.87% |
| IP | 0.0016 | -4.04% |
| New private university | -0.0003 | 0.85% |
| Traditional university | 0.0282 | -72.23% |
| Does not know/No response | 0.0007 | -1.81% |
| Incomplete | 0.0006 | -1.64% |
| Post-graduate degree | 0.0199 | -50.95% |
| New private university | 0.0030 | -7.78% |
| Traditional university | 0.0165 | -42.30% |
| Does not know/No response | 0.0014 | -3.52% |
| Incomplete | -0.0010 | 2.65% |
| Experience | -0.0316 | 80.96% |
| Experience-squared | 0.0267 | -68.34% |
| Male | -0.0010 | 2.57% |
| Demographic dummies | -0.0072 | 18.42% |
| Occupation dummies | 0.0252 | -64.35% |
| Firm size dummies | 0.0023 | -5.76% |
| Industry dummies | -0.0097 | 24.80% |
| Formal | 0.0011 | -2.90% |
| Region dummies | 0.0018 | -4.63% |
| Urban | -0.0001 | 0.30% |
| Total wage structure effect | -0.0974 | 249.04% |
| Primary education or less | -0.0008 | 1.98% |
| Higher education | -0.0017 | 4.30% |
| Technical degree | -0.0147 | 37.61% |
| CFT | -0.0015 | 3.85% |
| IP | -0.0160 | 40.96% |
| New private university | 0.0003 | -0.76% |
| Traditional university | 0.0000 | 0.03% |
| Does not know/No response | -0.0002 | 0.55% |

| | All workers | |
|---|---|---|
| | Q90-Q10 | |
| Incomplete | 0.0027 | -7.02% |
| Professional degree | 0.0067 | -17.14% |
| IP | 0.0008 | -2.08% |
| New private university | -0.0089 | 22.70% |
| Traditional university | 0.0124 | -31.70% |
| Does not know/No response | 0.0018 | -4.60% |
| Incomplete | 0.0006 | -1.46% |
| Post-graduate degree | 0.0063 | -16.17% |
| New private university | 0.0077 | -19.74% |
| Traditional university | 0.0019 | -4.95% |
| Does not know/No response | -0.0012 | 3.12% |
| Incomplete | -0.0021 | 5.40% |
| Experience | 0.3643 | -931.93% |
| Experience-squared | -0.1822 | 466.15% |
| Male | 0.0254 | -64.95% |
| Demographic dummies | 0.0294 | -75.19% |
| Occupation dummies | 0.1448 | -370.53% |
| Firm size dummies | 0.0281 | -71.97% |
| Industry dummies | -0.1196 | 305.90% |
| Formal | 0.2021 | -516.87% |
| Region dummies | -0.0528 | 135.08% |
| Urban | -0.0377 | 96.34% |
| Constant | -0.4967 | 1270.73% |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales)*. % indicates the contribution of the respective variable to the evolution of wage inequality between the selected quantiles.

# SUPPLEMENTAL FILE:
## Decline in values of degrees and recent evolution of wage inequality: Evidence from Chile

### TABLE S.1
ESTIMATION RESULTS OF THE UNCONDITIONAL QUANTILE REGRESSIONS FOR LOG HOURLY WAGES FOR OTHER QUANTILES IN 2013 AND 2017

| | 2013 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Q25 | Q35 | Q65 | Q75 | Q25 | Q35 | Q65 | Q75 |
| Primary | -0.082*** | -0.186*** | -0.159*** | -0.147*** | -0.100*** | -0.146*** | -0.147*** | -0.119*** |
| | (0.012) | (0.020) | (0.023) | (0.021) | (0.011) | (0.016) | (0.016) | (0.020) |
| Technical degree | | | | | | | | |
| CFT | 0.103*** | 0.286*** | 0.499*** | 0.383*** | 0.110*** | 0.217*** | 0.398*** | 0.489*** |
| | (0.014) | (0.027) | (0.058) | (0.061) | (0.013) | (0.023) | (0.041) | (0.055) |
| IP | 0.110*** | 0.282*** | 0.614*** | 0.548*** | 0.120*** | 0.235*** | 0.469*** | 0.547*** |
| | (0.013) | (0.025) | (0.057) | (0.067) | (0.010) | (0.019) | (0.046) | (0.060) |
| New private university | 0.119*** | 0.306*** | 0.646*** | 0.765*** | -0.039 | 0.055 | 0.355*** | 0.338*** |
| | (0.020) | (0.041) | (0.132) | (0.168) | (0.092) | (0.103) | (0.093) | (0.081) |
| Traditional university | 0.156*** | 0.382*** | 0.842*** | 0.819*** | 0.173*** | 0.342*** | 0.730*** | 0.851*** |
| | (0.021) | (0.052) | (0.169) | (0.208) | (0.017) | (0.033) | (0.079) | (0.118) |
| Does not know/No response | 0.130*** | 0.327*** | 0.393*** | 0.413*** | 0.124*** | 0.216*** | 0.274*** | 0.461*** |
| | (0.025) | (0.043) | (0.091) | (0.115) | (0.024) | (0.036) | (0.073) | (0.110) |
| Incomplete | 0.040 | 0.109** | 0.236*** | 0.215** | 0.069*** | 0.151*** | 0.291*** | 0.239*** |
| | (0.027) | (0.045) | (0.076) | (0.090) | (0.016) | (0.024) | (0.040) | (0.045) |
| Professional degree | | | | | | | | |
| IP | 0.140*** | 0.395*** | 1.063*** | 1.334*** | 0.173*** | 0.335*** | 0.877*** | 1.166*** |
| | (0.012) | (0.024) | (0.063) | (0.098) | (0.011) | (0.025) | (0.052) | (0.076) |
| New private university | 0.137*** | 0.382*** | 1.230*** | 1.704*** | 0.153*** | 0.327*** | 0.980*** | 1.337*** |
| | (0.009) | (0.020) | (0.055) | (0.087) | (0.015) | (0.027) | (0.056) | (0.068) |
| Traditional university | 0.162*** | 0.415*** | 1.348*** | 1.863*** | 0.189*** | 0.391*** | 1.265*** | 1.835*** |
| | (0.008) | (0.019) | (0.045) | (0.080) | (0.009) | (0.025) | (0.047) | (0.056) |
| Does not know/No response | 0.164*** | 0.391*** | 1.214*** | 1.454*** | 0.188*** | 0.354*** | 1.110*** | 1.533*** |
| | (0.010) | (0.031) | (0.092) | (0.144) | (0.014) | (0.031) | (0.064) | (0.103) |
| Incomplete | 0.094*** | 0.275*** | 0.655*** | 0.802*** | 0.107*** | 0.208*** | 0.440*** | 0.533*** |
| | (0.012) | (0.024) | (0.056) | (0.086) | (0.012) | (0.023) | (0.043) | (0.052) |

| | 2013 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Q25 | Q35 | Q65 | Q75 | Q25 | Q35 | Q65 | Q75 |
| Post-graduate degree | | | | | | | | |
| New private university | 0.086** | 0.313*** | 1.357*** | 2.030*** | 0.186*** | 0.393*** | 1.360*** | 1.983*** |
| | (0.037) | (0.058) | (0.096) | (0.155) | (0.013) | (0.028) | (0.065) | (0.100) |
| Traditional university | 0.149*** | 0.391*** | 1.429*** | 2.208*** | 0.168*** | 0.360*** | 1.356*** | 2.086*** |
| | (0.009) | (0.023) | (0.058) | (0.099) | (0.011) | (0.025) | (0.051) | (0.069) |
| Does not know/No response | 0.172*** | 0.389*** | 1.416*** | 2.212*** | 0.153*** | 0.316*** | 0.794*** | 1.330*** |
| | (0.022) | (0.069) | (0.119) | (0.183) | (0.041) | (0.076) | (0.290) | (0.433) |
| Incomplete | 0.153*** | 0.404*** | 1.393*** | 2.074*** | 0.181*** | 0.386*** | 1.341*** | 2.026*** |
| | (0.018) | (0.036) | (0.078) | (0.131) | (0.019) | (0.035) | (0.076) | (0.104) |
| Experience | 0.002* | 0.005** | 0.012*** | 0.016*** | 0.003*** | 0.007*** | 0.022*** | 0.036*** |
| | (0.001) | (0.002) | (0.003) | (0.005) | (0.001) | (0.002) | (0.003) | (0.004) |
| Experience-squared | -0.007** | -0.013** | -0.028*** | -0.034*** | -0.008*** | -0.018*** | -0.045*** | -0.078*** |
| | (0.003) | (0.006) | (0.008) | (0.012) | (0.003) | (0.004) | (0.007) | (0.009) |
| Male | 0.050*** | 0.118*** | 0.141*** | 0.145*** | 0.051*** | 0.089*** | 0.110*** | 0.092*** |
| | (0.008) | (0.013) | (0.018) | (0.022) | (0.006) | (0.009) | (0.015) | (0.023) |
| Head of the household | 0.018*** | 0.052*** | 0.119*** | 0.134*** | 0.034*** | 0.071*** | 0.122*** | 0.161*** |
| | (0.007) | (0.012) | (0.017) | (0.023) | (0.005) | (0.009) | (0.016) | (0.019) |
| Married | 0.014** | 0.050*** | 0.086*** | 0.089*** | 0.029*** | 0.049*** | 0.118*** | 0.146*** |
| | (0.007) | (0.011) | (0.016) | (0.020) | (0.005) | (0.007) | (0.013) | (0.019) |
| Formal | 0.171*** | 0.165*** | 0.146*** | 0.087*** | 0.123*** | 0.153*** | 0.128*** | 0.140*** |
| | (0.013) | (0.021) | (0.019) | (0.020) | (0.012) | (0.017) | (0.017) | (0.023) |
| Urban | 0.018* | 0.084*** | 0.064*** | 0.047*** | 0.030*** | 0.044*** | 0.042*** | 0.037** |
| | (0.010) | (0.017) | (0.015) | (0.017) | (0.008) | (0.009) | (0.012) | (0.017) |
| Constant | 6.775*** | 6.585*** | 6.754*** | 6.989*** | 6.800*** | 6.675*** | 6.784*** | 6.784*** |
| | (0.022) | (0.044) | (0.048) | (0.064) | (0.021) | (0.032) | (0.049) | (0.052) |
| Observations | 35,626 | 35,626 | 35,626 | 35,626 | 35,543 | 35,543 | 35,543 | 35,543 |
| *R*-squared | 0.158 | 0.265 | 0.411 | 0.443 | 0.184 | 0.248 | 0.408 | 0.442 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). Numbers in parentheses represent bootstrapped standard errors (500 replications). ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively. Industry dummies and region dummies are also included.

TABLE S.2
DECOMPOSITION OF WAGE CHANGES FROM 2013 TO 2017 AT OTHER QUANTILES INTO COMPOSITION AND WAGE STRUCTURE EFFECTS OF EACH EXPLANATORY VARIABLE

| | Composition effect | | | | Wage structure effect | | | |
|---|---|---|---|---|---|---|---|---|
| | Q25 | Q35 | Q65 | Q75 | Q25 | Q35 | Q65 | Q75 |
| Overall | 0.0130*** | 0.0322*** | 0.0790*** | 0.1039*** | 0.0550*** | 0.0406*** | 0.0191*** | -0.0065 |
| | (0.0012) | (0.0024) | (0.0049) | (0.0062) | (0.0025) | (0.0037) | (0.0056) | (0.0068) |
| Primary | 0.0028*** | 0.0064*** | 0.0054*** | 0.0050*** | -0.0019** | 0.0043*** | 0.0013 | 0.0030 |
| | (0.0003) | (0.0006) | (0.0006) | (0.0007) | (0.0010) | (0.0014) | (0.0021) | (0.0026) |
| Higher education degrees | 0.0112*** | 0.0300*** | 0.0890*** | 0.1185*** | 0.0073*** | -0.0183*** | -0.0586*** | -0.0473*** |
| | (0.0007) | (0.0015) | (0.0041) | (0.0056) | (0.0026) | (0.0039) | (0.0058) | (0.0072) |
| Technical degree | 0.0025*** | 0.0062*** | 0.0133*** | 0.0134*** | 0.0003 | -0.0073*** | -0.0155*** | 0.0001 |
| | (0.0004) | (0.0008) | (0.0015) | (0.0014) | (0.0012) | (0.0017) | (0.0026) | (0.0031) |
| CFT | -0.0004*** | -0.0012*** | -0.0021*** | -0.0016*** | 0.0002 | -0.0019*** | -0.0028*** | 0.0030*** |
| | (0.0001) | (0.0004) | (0.0006) | (0.0005) | (0.0004) | (0.0006) | (0.0009) | (0.0011) |
| IP | 0.0013*** | 0.0033*** | 0.0072*** | 0.0064*** | 0.0007 | -0.0033*** | -0.0102*** | -0.0001 |
| | (0.0002) | (0.0005) | (0.0011) | (0.0010) | (0.0007) | (0.0011) | (0.0016) | (0.0020) |
| New private university | 0.0006*** | 0.0015*** | 0.0032*** | 0.0037*** | -0.0014*** | -0.0022*** | -0.0026*** | -0.0038*** |
| | (0.0002) | (0.0003) | (0.0005) | (0.0006) | (0.0003) | (0.0005) | (0.0007) | (0.0008) |
| Traditional university | 0.0006*** | 0.0015*** | 0.0033*** | 0.0032*** | 0.0001 | -0.0002 | -0.0006 | 0.0002 |
| | (0.0002) | (0.0003) | (0.0005) | (0.0006) | (0.0003) | (0.0004) | (0.0006) | (0.0007) |
| Does not know/No response | 0.0002*** | 0.0006*** | 0.0008*** | 0.0008*** | -0.0000 | -0.0006** | -0.0007 | 0.0003 |
| | (0.0001) | (0.0002) | (0.0002) | (0.0003) | (0.0002) | (0.0003) | (0.0005) | (0.0006) |
| Incomplete | 0.0002** | 0.0005*** | 0.0011*** | 0.0010*** | 0.0007* | 0.0010* | 0.0013 | 0.0006 |
| | (0.0001) | (0.0001) | (0.0003) | (0.0003) | (0.0004) | (0.0006) | (0.0009) | (0.0011) |
| Professional degree | 0.0075*** | 0.0203*** | 0.0622*** | 0.0845*** | 0.0058*** | -0.0110*** | -0.0411*** | -0.0441*** |
| | (0.0006) | (0.0013) | (0.0039) | (0.0053) | (0.0018) | (0.0027) | (0.0041) | (0.0050) |
| IP | 0.0017*** | 0.0048*** | 0.0130*** | 0.0163*** | 0.0009* | -0.0016** | -0.0050*** | -0.0045*** |
| | (0.0002) | (0.0005) | (0.0012) | (0.0015) | (0.0005) | (0.0007) | (0.0011) | (0.0013) |
| New private university | 0.0019*** | 0.0053*** | 0.0172*** | 0.0238*** | 0.0012 | -0.0041*** | -0.0187*** | -0.0274*** |
| | (0.0003) | (0.0007) | (0.0023) | (0.0032) | (0.0008) | (0.0012) | (0.0018) | (0.0023) |
| Traditional university | 0.0039*** | 0.0099*** | 0.0321*** | 0.0444*** | 0.0030*** | -0.0027* | -0.0092*** | -0.0031 |
| | (0.0004) | (0.0010) | (0.0030) | (0.0042) | (0.0010) | (0.0015) | (0.0023) | (0.0028) |
| Does not know/No response | -0.0004*** | -0.0009*** | -0.0028*** | -0.0034*** | 0.0002 | -0.0002 | -0.0007* | 0.0005 |
| | (0.0001) | (0.0003) | (0.0008) | (0.0010) | (0.0002) | (0.0003) | (0.0004) | (0.0005) |

| | Composition effect | | | | Wage structure effect | | | |
|---|---|---|---|---|---|---|---|---|
| | Q25 | Q35 | Q65 | Q75 | Q25 | Q35 | Q65 | Q75 |
| Incomplete | 0.0004*** | 0.0012*** | 0.0028*** | 0.0034*** | 0.0005 | -0.0024*** | -0.0076*** | -0.0096*** |
| | (0.0001) | (0.0004) | (0.0009) | (0.0011) | (0.0005) | (0.0007) | (0.0011) | (0.0014) |
| Post-graduate degree | 0.0013*** | 0.0036*** | 0.0135*** | 0.0206*** | 0.0012** | -0.0000 | -0.0019* | -0.0034** |
| | (0.0002) | (0.0005) | (0.0016) | (0.0025) | (0.0005) | (0.0007) | (0.0011) | (0.0013) |
| New private university | 0.0003*** | 0.0009*** | 0.0040*** | 0.0060*** | 0.0008*** | 0.0006* | 0.0000 | -0.0004 |
| | (0.0001) | (0.0002) | (0.0008) | (0.0012) | (0.0003) | (0.0004) | (0.0006) | (0.0007) |
| Traditional university | 0.0009*** | 0.0022*** | 0.0082*** | 0.0127*** | 0.0003 | -0.0005 | -0.0012 | -0.0021** |
| | (0.0002) | (0.0004) | (0.0013) | (0.0020) | (0.0004) | (0.0006) | (0.0008) | (0.0010) |
| Does not know/No response | -0.0000 | -0.0000 | -0.0001 | -0.0001 | -0.0000 | -0.0001 | -0.0005*** | -0.0008*** |
| | (0.0000) | (0.0001) | (0.0003) | (0.0005) | (0.0001) | (0.0001) | (0.0002) | (0.0002) |
| Incomplete | 0.0002** | 0.0004** | 0.0014** | 0.0021** | 0.0001 | -0.0001 | -0.0002 | -0.0002 |
| | (0.0001) | (0.0002) | (0.0005) | (0.0008) | (0.0002) | (0.0002) | (0.0003) | (0.0004) |
| Experience | -0.0026*** | -0.0055*** | -0.0142*** | -0.0185*** | 0.0181 | 0.0461 | 0.1674*** | 0.3527*** |
| | (0.0010) | (0.0015) | (0.0023) | (0.0028) | (0.0208) | (0.0306) | (0.0459) | (0.0562) |
| Experience-squared | 0.0030*** | 0.0055*** | 0.0114*** | 0.0139*** | -0.0042 | -0.0180 | -0.0691*** | -0.1732*** |
| | (0.0009) | (0.0014) | (0.0021) | (0.0025) | (0.0118) | (0.0174) | (0.0260) | (0.0319) |
| Male | -0.0015*** | -0.0036*** | -0.0043*** | -0.0044*** | 0.0005 | -0.0162*** | -0.0174** | -0.0299*** |
| | (0.0002) | (0.0005) | (0.0006) | (0.0006) | (0.0032) | (0.0048) | (0.0071) | (0.0087) |
| Demographic dummies | -0.0012*** | -0.0041*** | -0.0077*** | -0.0081*** | 0.0116*** | 0.0086** | 0.0103* | 0.0292*** |
| | (0.0003) | (0.0005) | (0.0008) | (0.0009) | (0.0028) | (0.0041) | (0.0061) | (0.0075) |
| Industry dummies | 0.0009* | 0.0021** | -0.0017 | -0.0038** | 0.0402*** | -0.0258* | -0.0203 | 0.0036 |
| | (0.0005) | (0.0010) | (0.0014) | (0.0015) | (0.0103) | (0.0152) | (0.0228) | (0.0279) |
| Formal | 0.0002 | 0.0002 | 0.0001 | 0.0001 | -0.0431*** | -0.0109 | -0.0165 | 0.0474** |
| | (0.0004) | (0.0004) | (0.0003) | (0.0002) | (0.0077) | (0.0113) | (0.0170) | (0.0208) |
| Region dummies | 0.0003 | 0.0010 | 0.0006 | 0.0010 | -0.0102*** | 0.0173*** | 0.0122* | 0.0218*** |
| | (0.0003) | (0.0006) | (0.0006) | (0.0008) | (0.0029) | (0.0042) | (0.0063) | (0.0077) |
| Urban | 0.0000 | 0.0002 | 0.0002 | 0.0001 | 0.0111 | -0.0367*** | -0.0196 | -0.0087 |
| | (0.0000) | (0.0002) | (0.0002) | (0.0001) | (0.0081) | (0.0120) | (0.0180) | (0.0220) |
| Constant | | | | | 0.0256 | 0.0901*** | 0.0293 | -0.2052*** |
| | | | | | (0.0178) | (0.0262) | (0.0394) | (0.0482) |
| Observations | 71,169 | 71,169 | 71,169 | 71,169 | 71,169 | 71,169 | 71,169 | 71,169 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). Numbers in parentheses represent standard errors. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

TABLE S.3
ESTIMATION RESULTS OF THE MEAN AND UNCONDITIONAL QUANTILE REGRESSIONS FOR LOG HOURLY WAGES FOR MALES IN 2013 AND 2017

| | 2013 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Primary | -0.156*** | -0.104*** | -0.199*** | -0.013 | -0.139*** | -0.086*** | -0.183*** | -0.026 |
| | (0.011) | (0.019) | (0.026) | (0.023) | (0.012) | (0.017) | (0.019) | (0.024) |
| Technical degree | | | | | | | | |
| CFT | 0.277*** | 0.089*** | 0.364*** | 0.226** | 0.279*** | 0.065*** | 0.318*** | 0.142 |
| | (0.023) | (0.016) | (0.049) | (0.093) | (0.022) | (0.017) | (0.038) | (0.088) |
| IP | 0.357*** | 0.096*** | 0.346*** | 0.327*** | 0.302*** | 0.081*** | 0.305*** | 0.370*** |
| | (0.016) | (0.014) | (0.052) | (0.088) | (0.015) | (0.015) | (0.032) | (0.067) |
| New private university | 0.442*** | 0.039 | 0.407*** | 1.075** | 0.240*** | 0.047 | 0.163* | 0.634*** |
| | (0.059) | (0.052) | (0.081) | (0.509) | (0.043) | (0.065) | (0.090) | (0.222) |
| Traditional university | 0.341*** | 0.047 | 0.387*** | 0.521* | 0.480*** | 0.115*** | 0.481*** | 0.575** |
| | (0.101) | (0.079) | (0.124) | (0.287) | (0.045) | (0.020) | (0.056) | (0.234) |
| Does not know/No response | 0.410*** | 0.051 | 0.367*** | 0.616** | 0.219*** | 0.097*** | 0.230*** | 0.008 |
| | (0.064) | (0.045) | (0.077) | (0.300) | (0.043) | (0.018) | (0.075) | (0.105) |
| Incomplete | 0.072*** | -0.060 | 0.127** | 0.054 | 0.171*** | 0.035 | 0.213*** | 0.216*** |
| | (0.024) | (0.061) | (0.061) | (0.085) | (0.022) | (0.023) | (0.042) | (0.080) |
| Professional degree | | | | | | | | |
| IP | 0.664*** | 0.098*** | 0.497*** | 1.300*** | 0.583*** | 0.066*** | 0.464*** | 1.543*** |
| | (0.030) | (0.018) | (0.044) | (0.253) | (0.021) | (0.018) | (0.037) | (0.208) |
| New private university | 0.891*** | 0.084*** | 0.501*** | 2.107*** | 0.687*** | 0.060** | 0.462*** | 1.897*** |
| | (0.016) | (0.015) | (0.044) | (0.243) | (0.015) | (0.027) | (0.044) | (0.190) |
| Traditional university | 1.073*** | 0.107*** | 0.529*** | 2.684*** | 1.026*** | 0.099*** | 0.598*** | 3.006*** |
| | (0.014) | (0.013) | (0.041) | (0.309) | (0.012) | (0.011) | (0.030) | (0.217) |
| Does not know/No response | 0.758*** | 0.108*** | 0.500*** | 1.806*** | 0.772*** | 0.100*** | 0.522*** | 1.787*** |
| | (0.038) | (0.016) | (0.058) | (0.350) | (0.046) | (0.021) | (0.050) | (0.310) |
| Incomplete | 0.456*** | 0.063*** | 0.386*** | 0.824*** | 0.306*** | 0.088*** | 0.252*** | 0.656*** |
| | (0.019) | (0.019) | (0.038) | (0.225) | (0.017) | (0.016) | (0.040) | (0.116) |

| | 2013 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Post-graduate degree | | | | | | | | |
| New private university | 1.323*** | -0.074 | 0.407*** | 3.533*** | 1.408*** | 0.090*** | 0.589*** | 5.076*** |
| | (0.048) | (0.104) | (0.102) | (0.557) | (0.040) | (0.015) | (0.038) | (0.580) |
| Traditional university | 1.441*** | 0.081*** | 0.508*** | 4.160*** | 1.450*** | 0.095*** | 0.597*** | 5.082*** |
| | (0.032) | (0.014) | (0.050) | (0.436) | (0.026) | (0.013) | (0.036) | (0.403) |
| Incomplete | 1.228*** | 0.101*** | 0.573*** | 2.890*** | 1.026*** | 0.108*** | 0.584*** | 2.762*** |
| | (0.068) | (0.037) | (0.069) | (0.810) | (0.064) | (0.019) | (0.063) | (0.666) |
| Experience | 0.021*** | 0.001 | 0.005 | 0.073*** | 0.026*** | 0.001 | 0.010*** | 0.079*** |
| | (0.002) | (0.003) | (0.004) | (0.013) | (0.002) | (0.002) | (0.003) | (0.011) |
| Experience-squared | -0.046*** | -0.003 | -0.010 | -0.163*** | -0.056*** | -0.002 | -0.019*** | -0.179*** |
| | (0.004) | (0.006) | (0.010) | (0.028) | (0.004) | (0.004) | (0.007) | (0.024) |
| Head of the household | 0.153*** | 0.049*** | 0.123*** | 0.253*** | 0.124*** | 0.024** | 0.130*** | 0.308*** |
| | (0.008) | (0.012) | (0.020) | (0.052) | (0.007) | (0.009) | (0.013) | (0.044) |
| Married | 0.045*** | 0.009 | 0.065*** | 0.020 | 0.084*** | 0.012 | 0.058*** | 0.243*** |
| | (0.008) | (0.011) | (0.019) | (0.047) | (0.008) | (0.010) | (0.013) | (0.052) |
| Formal | 0.215*** | 0.232*** | 0.187*** | 0.117* | 0.183*** | 0.222*** | 0.158*** | 0.067** |
| | (0.011) | (0.027) | (0.025) | (0.064) | (0.011) | (0.031) | (0.023) | (0.034) |
| Urban | 0.039*** | 0.026 | 0.080*** | -0.023 | 0.038*** | 0.024** | 0.056*** | -0.063 |
| | (0.012) | (0.016) | (0.016) | (0.022) | (0.012) | (0.011) | (0.014) | (0.039) |
| Constant | 6.745*** | 6.587*** | 6.841*** | 7.227*** | 6.818*** | 6.726*** | 6.885*** | 7.116*** |
| | (0.023) | (0.042) | (0.051) | (0.149) | (0.023) | (0.042) | (0.045) | (0.126) |
| Observations | 21,301 | 21,301 | 21,301 | 21,301 | 20,135 | 20,135 | 20,135 | 20,135 |
| *R*-squared | 0.514 | 0.093 | 0.301 | 0.402 | 0.511 | 0.091 | 0.285 | 0.378 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). Numbers in parentheses represent standard errors. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively. The standard errors of the unconditional quantile regressions are calculated via bootstrap with 500 replications. Industry dummies and region dummies are also included.

TABLE S.4

ESTIMATION RESULTS OF THE MEAN AND UNCONDITIONAL QUANTILE REGRESSIONS FOR LOG HOURLY WAGES FOR FEMALES IN 2013 AND 2017

| | 2013 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Primary | -0.107*** | -0.170*** | -0.172*** | -0.005 | -0.073*** | -0.085*** | -0.105*** | 0.016 |
| | (0.014) | (0.060) | (0.028) | (0.024) | (0.015) | (0.030) | (0.033) | (0.023) |
| Technical degree | | | | | | | | |
| CFT | 0.280*** | 0.057 | 0.433*** | 0.162** | 0.221*** | 0.053** | 0.317*** | 0.168*** |
| | (0.018) | (0.059) | (0.055) | (0.069) | (0.020) | (0.026) | (0.051) | (0.055) |
| IP | 0.307*** | 0.163*** | 0.448*** | 0.183*** | 0.254*** | 0.064*** | 0.390*** | 0.105** |
| | (0.015) | (0.026) | (0.055) | (0.062) | (0.014) | (0.018) | (0.041) | (0.042) |
| New private university | 0.360*** | 0.175*** | 0.512*** | 0.017 | 0.181*** | 0.090** | 0.235 | 0.140 |
| | (0.050) | (0.052) | (0.084) | (0.145) | (0.032) | (0.039) | (0.158) | (0.085) |
| Traditional university | 0.588*** | 0.176*** | 0.758*** | 0.947* | 0.379*** | 0.112*** | 0.523*** | 0.292** |
| | (0.074) | (0.046) | (0.070) | (0.492) | (0.046) | (0.040) | (0.070) | (0.116) |
| Does not know/No response | 0.267*** | 0.254*** | 0.445*** | 0.044 | 0.141*** | -0.001 | 0.271*** | 0.117 |
| | (0.050) | (0.043) | (0.108) | (0.075) | (0.048) | (0.079) | (0.072) | (0.097) |
| Incomplete | 0.175*** | 0.104* | 0.357*** | -0.132** | 0.129*** | 0.014 | 0.196*** | 0.023 |
| | (0.027) | (0.054) | (0.072) | (0.052) | (0.023) | (0.041) | (0.043) | (0.049) |
| Professional degree | | | | | | | | |
| IP | 0.721*** | 0.104** | 0.709*** | 1.152*** | 0.582*** | 0.131*** | 0.640*** | 0.715*** |
| | (0.029) | (0.049) | (0.053) | (0.240) | (0.022) | (0.018) | (0.049) | (0.115) |
| New private university | 0.925*** | 0.125*** | 0.774*** | 1.731*** | 0.695*** | 0.134*** | 0.629*** | 1.111*** |
| | (0.016) | (0.027) | (0.050) | (0.183) | (0.014) | (0.018) | (0.068) | (0.103) |
| Traditional university | 1.041*** | 0.201*** | 0.850*** | 2.062*** | 0.944*** | 0.140*** | 0.783*** | 1.713*** |
| | (0.014) | (0.019) | (0.048) | (0.163) | (0.012) | (0.015) | (0.046) | (0.098) |
| Does not know/No response | 0.835*** | 0.218*** | 0.819*** | 1.046*** | 0.781*** | 0.168*** | 0.750*** | 1.219*** |
| | (0.037) | (0.033) | (0.059) | (0.256) | (0.039) | (0.018) | (0.057) | (0.203) |
| Incomplete | 0.377*** | 0.052 | 0.497*** | 0.517*** | 0.295*** | 0.044* | 0.346*** | 0.349*** |
| | (0.022) | (0.056) | (0.054) | (0.162) | (0.021) | (0.025) | (0.045) | (0.088) |

| | 2013 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Post-graduate degree | | | | | | | | |
| New private university | 1.375*** | 0.173*** | 0.861*** | 3.110*** | 1.317*** | 0.184*** | 0.835*** | 2.545*** |
| | (0.052) | (0.037) | (0.056) | (0.418) | (0.038) | (0.031) | (0.051) | (0.304) |
| Traditional university | 1.380*** | 0.199*** | 0.861*** | 3.573*** | 1.288*** | 0.157*** | 0.794*** | 2.916*** |
| | (0.035) | (0.031) | (0.053) | (0.373) | (0.029) | (0.017) | (0.048) | (0.212) |
| Does not know/No response | 1.215*** | 0.274*** | 0.812*** | 2.892*** | 0.812*** | 0.191*** | 0.608* | 0.938 |
| | (0.103) | (0.050) | (0.143) | (0.813) | (0.188) | (0.049) | (0.347) | (1.027) |
| Incomplete | 1.333*** | 0.278*** | 0.838*** | 2.376*** | 1.028*** | 0.146*** | 0.839*** | 2.045*** |
| | (0.085) | (0.073) | (0.087) | (0.709) | (0.057) | (0.019) | (0.052) | (0.416) |
| Experience | 0.017*** | 0.002 | 0.011*** | 0.033*** | 0.025*** | 0.002 | 0.016*** | 0.058*** |
| | (0.002) | (0.004) | (0.003) | (0.010) | (0.002) | (0.002) | (0.003) | (0.008) |
| Experience-squared | -0.040*** | -0.010 | -0.028*** | -0.072*** | -0.055*** | -0.006 | -0.035*** | -0.130*** |
| | (0.005) | (0.013) | (0.009) | (0.023) | (0.005) | (0.007) | (0.009) | (0.019) |
| Head of the household | 0.033*** | -0.074*** | 0.037* | 0.138*** | 0.051*** | -0.012 | 0.052*** | 0.083** |
| | (0.008) | (0.022) | (0.021) | (0.044) | (0.008) | (0.010) | (0.020) | (0.034) |
| Married | 0.061*** | -0.002 | 0.047** | 0.077* | 0.093*** | 0.006 | 0.060*** | 0.270*** |
| | (0.009) | (0.020) | (0.019) | (0.045) | (0.009) | (0.011) | (0.015) | (0.040) |
| Formal | 0.241*** | 0.573*** | 0.185*** | 0.077** | 0.194*** | 0.302*** | 0.105*** | 0.020 |
| | (0.013) | (0.064) | (0.023) | (0.032) | (0.013) | (0.034) | (0.031) | (0.051) |
| Urban | 0.052*** | 0.064* | 0.039** | 0.021 | 0.018 | 0.045** | 0.040*** | -0.062 |
| | (0.015) | (0.039) | (0.019) | (0.040) | (0.014) | (0.018) | (0.015) | (0.039) |
| Constant | 6.682*** | 6.062*** | 6.648*** | 7.705*** | 6.744*** | 6.514*** | 6.725*** | 7.568*** |
| | (0.028) | (0.103) | (0.050) | (0.119) | (0.027) | (0.054) | (0.050) | (0.107) |
| Observations | 14,316 | 14,316 | 14,316 | 14,316 | 15,396 | 15,396 | 15,396 | 15,396 |
| *R*-squared | 0.566 | 0.152 | 0.401 | 0.340 | 0.521 | 0.124 | 0.359 | 0.319 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). Numbers in parentheses represent standard errors. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively. The standard errors of the unconditional quantile regressions are calculated via bootstrap with 500 replications. Industry dummies and region dummies are also included.

# TABLE S.5

DECOMPOSITION OF WAGE CHANGES FROM 2013 TO 2017 INTO COMPOSITION AND WAGE STRUCTURE EFFECTS OF EACH EXPLANATORY VARIABLE FOR MALES

| | Composition effect | | | | Wage structure effect | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Overall | 0.0485*** | 0.0070*** | 0.0300*** | 0.1100*** | 0.0274*** | 0.1059*** | 0.0424*** | -0.0953*** |
| | (0.0051) | (0.0018) | (0.0039) | (0.0111) | (0.0048) | (0.0043) | (0.0056) | (0.0149) |
| Primary | 0.0066*** | 0.0044*** | 0.0084*** | 0.0006 | 0.0023 | 0.0024 | 0.0021 | -0.0017 |
| | (0.0007) | (0.0006) | (0.0009) | (0.0012) | (0.0020) | (0.0018) | (0.0024) | (0.0064) |
| Higher education | 0.0588*** | 0.0057*** | 0.0343*** | 0.1360*** | -0.0273*** | 0.0007 | -0.0024 | 0.0407*** |
| | (0.0040) | (0.0009) | (0.0023) | (0.0101) | (0.0045) | (0.0040) | (0.0053) | (0.0139) |
| Technical degree | 0.0063*** | 0.0009* | 0.0064*** | 0.0091*** | -0.0022 | 0.0015 | -0.0030 | -0.0015 |
| | (0.0011) | (0.0005) | (0.0012) | (0.0018) | (0.0019) | (0.0017) | (0.0023) | (0.0060) |
| CFT | 0.0001 | 0.0000 | 0.0002 | 0.0001 | 0.0000 | -0.0006 | -0.0011 | -0.0019 |
| | (0.0004) | (0.0001) | (0.0005) | (0.0003) | (0.0007) | (0.0006) | (0.0009) | (0.0023) |
| IP | 0.0022*** | 0.0006** | 0.0021*** | 0.0020*** | -0.0030** | -0.0008 | -0.0023 | 0.0024 |
| | (0.0008) | (0.0002) | (0.0008) | (0.0008) | (0.0012) | (0.0011) | (0.0014) | (0.0037) |
| New private university | 0.0011*** | 0.0001 | 0.0010*** | 0.0028*** | -0.0012*** | 0.0000 | -0.0014*** | -0.0025** |
| | (0.0003) | (0.0001) | (0.0003) | (0.0008) | (0.0004) | (0.0004) | (0.0005) | (0.0013) |
| Traditional university | 0.0014*** | 0.0002 | 0.0016*** | 0.0022* | 0.0007 | 0.0004 | 0.0005 | 0.0003 |
| | (0.0005) | (0.0004) | (0.0005) | (0.0011) | (0.0006) | (0.0005) | (0.0007) | (0.0016) |
| Does not know/No response | 0.0013*** | 0.0002 | 0.0012*** | 0.0019*** | -0.0011** | 0.0003 | -0.0008 | -0.0035*** |
| | (0.0003) | (0.0002) | (0.0003) | (0.0007) | (0.0005) | (0.0004) | (0.0005) | (0.0014) |
| Incomplete | 0.0002 | -0.0002 | 0.0003* | 0.0001 | 0.0023*** | 0.0022*** | 0.0020** | 0.0038 |
| | (0.0001) | (0.0001) | (0.0002) | (0.0002) | (0.0008) | (0.0007) | (0.0009) | (0.0023) |
| Professional degree | 0.0413*** | 0.0045*** | 0.0240*** | 0.0955*** | -0.0253*** | -0.0022 | -0.0021 | 0.0161 |
| | (0.0036) | (0.0007) | (0.0021) | (0.0088) | (0.0032) | (0.0028) | (0.0038) | (0.0098) |
| IP | 0.0079*** | 0.0012*** | 0.0059*** | 0.0155*** | -0.0020** | -0.0008 | -0.0008 | 0.0060** |
| | (0.0010) | (0.0004) | (0.0008) | (0.0020) | (0.0009) | (0.0008) | (0.0011) | (0.0027) |
| New private university | 0.0110*** | 0.0010*** | 0.0062*** | 0.0259*** | -0.0129*** | -0.0015 | -0.0025 | -0.0133*** |
| | (0.0020) | (0.0003) | (0.0012) | (0.0048) | (0.0014) | (0.0012) | (0.0016) | (0.0043) |
| Traditional university | 0.0213*** | 0.0021*** | 0.0105*** | 0.0532*** | -0.0044** | -0.0008 | 0.0065*** | 0.0303*** |
| | (0.0029) | (0.0004) | (0.0015) | (0.0074) | (0.0018) | (0.0016) | (0.0021) | (0.0055) |

| | Composition effect | | | | Wage structure effect | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Does not know/No response | -0.0022*** | -0.0003** | -0.0014*** | -0.0052*** | 0.0001 | -0.0000 | 0.0001 | -0.0001 |
| | (0.0006) | (0.0001) | (0.0004) | (0.0014) | (0.0003) | (0.0003) | (0.0004) | (0.0010) |
| Incomplete | 0.0034*** | 0.0005*** | 0.0029*** | 0.0061*** | -0.0060*** | 0.0010 | -0.0054*** | -0.0067** |
| | (0.0009) | (0.0002) | (0.0007) | (0.0016) | (0.0010) | (0.0009) | (0.0012) | (0.0032) |
| Post-graduate degree | 0.0111*** | 0.0003 | 0.0038*** | 0.0314*** | 0.0002 | 0.0014* | 0.0028*** | 0.0260*** |
| | (0.0020) | (0.0002) | (0.0008) | (0.0057) | (0.0009) | (0.0008) | (0.0011) | (0.0030) |
| New private university | 0.0027*** | -0.0001 | 0.0008** | 0.0071*** | 0.0006 | 0.0011*** | 0.0012** | 0.0105*** |
| | (0.0010) | (0.0001) | (0.0003) | (0.0027) | (0.0004) | (0.0004) | (0.0005) | (0.0016) |
| Traditional university | 0.0083*** | 0.0005** | 0.0029*** | 0.0240*** | 0.0001 | 0.0002 | 0.0015* | 0.0158*** |
| | (0.0017) | (0.0002) | (0.0006) | (0.0049) | (0.0007) | (0.0006) | (0.0008) | (0.0023) |
| Incomplete | 0.0001 | 0.0000 | 0.0001 | 0.0003 | -0.0005** | 0.0000 | 0.0000 | -0.0003 |
| | (0.0006) | (0.0000) | (0.0003) | (0.0014) | (0.0002) | (0.0002) | (0.0003) | (0.0007) |
| Experience | -0.0260*** | -0.0013 | -0.0060** | -0.0885*** | 0.0866** | -0.0078 | 0.0944* | 0.1098 |
| | (0.0028) | (0.0019) | (0.0024) | (0.0084) | (0.0410) | (0.0365) | (0.0483) | (0.1283) |
| Experience-squared | 0.0218*** | 0.0012 | 0.0047** | 0.0769*** | -0.0397* | 0.0021 | -0.0370 | -0.0635 |
| | (0.0025) | (0.0018) | (0.0023) | (0.0077) | (0.0230) | (0.0204) | (0.0271) | (0.0724) |
| Demographic dummies | -0.0121*** | -0.0034*** | -0.0119*** | -0.0159*** | -0.0031 | -0.0119** | 0.0013 | 0.1024*** |
| | (0.0010) | (0.0006) | (0.0010) | (0.0020) | (0.0055) | (0.0049) | (0.0065) | (0.0173) |
| Industry dummies | -0.0015 | -0.0002 | -0.0004 | 0.0001 | -0.0576*** | -0.0288* | -0.0393* | -0.0946 |
| | (0.0014) | (0.0009) | (0.0015) | (0.0030) | (0.0183) | (0.0163) | (0.0216) | (0.0576) |
| Formal | 0.0005 | 0.0005 | 0.0004 | 0.0003 | -0.0283** | -0.0086 | -0.0261 | -0.0454 |
| | (0.0006) | (0.0007) | (0.0006) | (0.0004) | (0.0141) | (0.0126) | (0.0167) | (0.0443) |
| Region dummies | 0.0002 | -0.0002 | -0.0001 | 0.0008 | 0.0231*** | 0.0194*** | 0.0270*** | 0.0033 |
| | (0.0009) | (0.0006) | (0.0009) | (0.0014) | (0.0056) | (0.0050) | (0.0067) | (0.0177) |
| Urban | 0.0003** | 0.0002* | 0.0006** | -0.0002 | -0.0011 | -0.0014 | -0.0212 | -0.0351 |
| | (0.0002) | (0.0001) | (0.0003) | (0.0003) | (0.0146) | (0.0130) | (0.0173) | (0.0458) |
| Constant | | | | | 0.0727** | 0.1398*** | 0.0435 | -0.1112 |
| | | | | | (0.0321) | (0.0285) | (0.0378) | (0.1008) |
| Observations | 41,436 | 41,436 | 41,436 | 41,436 | 41,436 | 41,436 | 41,436 | 41,436 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). Numbers in parentheses represent standard errors. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

TABLE S.6
DECOMPOSITION OF WAGE CHANGES FROM 2013 TO 2017 INTO COMPOSITION AND WAGE STRUCTURE EFFECTS OF EACH EXPLANATORY VARIABLE FOR FEMALES

| | Composition effect | | | | Wage structure effect | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Overall | 0.0760*** | 0.0212*** | 0.0741*** | 0.1304*** | 0.0381*** | 0.1476*** | 0.0302*** | -0.0681*** |
| | (0.0060) | (0.0042) | (0.0056) | (0.0114) | (0.0053) | (0.0075) | (0.0067) | (0.0147) |
| Primary | 0.0021*** | 0.0034*** | 0.0034*** | 0.0001 | 0.0029 | 0.0072*** | 0.0057** | 0.0018 |
| | (0.0005) | (0.0008) | (0.0007) | (0.0008) | (0.0018) | (0.0025) | (0.0023) | (0.0049) |
| Higher education | 0.0724*** | 0.0152*** | 0.0628*** | 0.1328*** | -0.0561*** | -0.0224** | -0.0499*** | -0.1410*** |
| | (0.0051) | (0.0020) | (0.0043) | (0.0107) | (0.0063) | (0.0089) | (0.0080) | (0.0175) |
| Technical degree | 0.0080*** | 0.0048*** | 0.0116*** | 0.0037* | -0.0122*** | -0.0142*** | -0.0193*** | -0.0046 |
| | (0.0014) | (0.0012) | (0.0021) | (0.0020) | (0.0028) | (0.0040) | (0.0035) | (0.0077) |
| CFT | -0.0033*** | -0.0007* | -0.0052*** | -0.0019*** | -0.0020** | -0.0001 | -0.0040*** | 0.0002 |
| | (0.0007) | (0.0004) | (0.0010) | (0.0007) | (0.0009) | (0.0013) | (0.0012) | (0.0026) |
| IP | 0.0053*** | 0.0028*** | 0.0077*** | 0.0031*** | -0.0047*** | -0.0089*** | -0.0052** | -0.0070 |
| | (0.0010) | (0.0007) | (0.0015) | (0.0009) | (0.0018) | (0.0026) | (0.0023) | (0.0050) |
| New private university | 0.0028*** | 0.0013** | 0.0039*** | 0.0001 | -0.0023*** | -0.0011 | -0.0036*** | 0.0016 |
| | (0.0006) | (0.0007) | (0.0008) | (0.0011) | (0.0008) | (0.0012) | (0.0010) | (0.0022) |
| Traditional university | 0.0020*** | 0.0006 | 0.0026*** | 0.0033*** | -0.0012** | -0.0004 | -0.0014** | -0.0038** |
| | (0.0005) | (0.0005) | (0.0007) | (0.0010) | (0.0005) | (0.0008) | (0.0007) | (0.0015) |
| Does not know/No response | 0.0000 | 0.0000 | 0.0001 | 0.0000 | -0.0007* | -0.0014** | -0.0009* | 0.0004 |
| | (0.0002) | (0.0002) | (0.0004) | (0.0000) | (0.0004) | (0.0006) | (0.0005) | (0.0010) |
| Incomplete | 0.0012*** | 0.0007** | 0.0025*** | -0.0009 | -0.0012 | -0.0023* | -0.0042*** | 0.0040 |
| | (0.0004) | (0.0004) | (0.0007) | (0.0006) | (0.0009) | (0.0013) | (0.0012) | (0.0025) |
| Professional degree | 0.0489*** | 0.0081*** | 0.0416*** | 0.0930*** | -0.0404*** | -0.0071 | -0.0291*** | -0.1181*** |
| | (0.0048) | (0.0014) | (0.0041) | (0.0092) | (0.0043) | (0.0061) | (0.0054) | (0.0120) |
| IP | 0.0089*** | 0.0013** | 0.0087*** | 0.0142*** | -0.0041*** | 0.0008 | -0.0020 | -0.0128*** |
| | (0.0013) | (0.0006) | (0.0013) | (0.0022) | (0.0011) | (0.0016) | (0.0014) | (0.0030) |
| New private university | 0.0135*** | 0.0018*** | 0.0113*** | 0.0252*** | -0.0205*** | 0.0008 | -0.0130*** | -0.0554*** |
| | (0.0030) | (0.0006) | (0.0025) | (0.0055) | (0.0020) | (0.0027) | (0.0024) | (0.0054) |
| Traditional university | 0.0279*** | 0.0054*** | 0.0228*** | 0.0552*** | -0.0129*** | -0.0080** | -0.0090*** | -0.0464*** |
| | (0.0039) | (0.0010) | (0.0032) | (0.0078) | (0.0025) | (0.0035) | (0.0031) | (0.0069) |
| Does not know/No response | -0.0015 | -0.0004 | -0.0015 | -0.0019 | -0.0005 | -0.0004 | -0.0006 | 0.0015 |
| | (0.0009) | (0.0003) | (0.0009) | (0.0012) | (0.0005) | (0.0006) | (0.0006) | (0.0013) |

| | Composition effect | | | | Wage structure effect | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Incomplete | 0.0002 | 0.0000 | 0.0003 | 0.0003 | -0.0025*** | -0.0003 | -0.0045*** | -0.0050* |
| | (0.0007) | (0.0001) | (0.0010) | (0.0010) | (0.0009) | (0.0013) | (0.0012) | (0.0026) |
| Post-graduate degree | 0.0155*** | 0.0022*** | 0.0096*** | 0.0361*** | -0.0035*** | -0.0012 | -0.0014 | -0.0183*** |
| | (0.0025) | (0.0007) | (0.0016) | (0.0060) | (0.0011) | (0.0016) | (0.0014) | (0.0032) |
| New private university | 0.0057*** | 0.0007* | 0.0036*** | 0.0129*** | -0.0005 | 0.0001 | -0.0002 | -0.0051*** |
| | (0.0013) | (0.0004) | (0.0009) | (0.0031) | (0.0006) | (0.0009) | (0.0008) | (0.0017) |
| Traditional university | 0.0080*** | 0.0011*** | 0.0050*** | 0.0206*** | -0.0016** | -0.0007 | -0.0011 | -0.0112*** |
| | (0.0019) | (0.0004) | (0.0012) | (0.0049) | (0.0008) | (0.0011) | (0.0010) | (0.0023) |
| Does not know/No response | -0.0011*** | -0.0002 | -0.0007** | -0.0025** | -0.0001 | -0.0000 | -0.0001 | -0.0007* |
| | (0.0004) | (0.0002) | (0.0003) | (0.0010) | (0.0001) | (0.0001) | (0.0001) | (0.0004) |
| Incomplete | 0.0029*** | 0.0006* | 0.0018*** | 0.0051*** | -0.0012*** | -0.0005 | 0.0000 | -0.0013 |
| | (0.0008) | (0.0004) | (0.0006) | (0.0016) | (0.0004) | (0.0006) | (0.0005) | (0.0011) |
| Experience | -0.0163*** | -0.0022 | -0.0109*** | -0.0315*** | 0.1332*** | -0.0030 | 0.0777 | 0.4319*** |
| | (0.0025) | (0.0029) | (0.0025) | (0.0059) | (0.0417) | (0.0590) | (0.0529) | (0.1156) |
| Experience-squared | 0.0127*** | 0.0030 | 0.0087*** | 0.0227*** | -0.0555** | 0.0126 | -0.0281 | -0.2173*** |
| | (0.0022) | (0.0024) | (0.0022) | (0.0050) | (0.0240) | (0.0337) | (0.0304) | (0.0665) |
| Demographic dummies | -0.0007 | -0.0034*** | -0.0000 | 0.0035** | 0.0143** | 0.0243*** | 0.0088 | 0.0283* |
| | (0.0005) | (0.0008) | (0.0006) | (0.0014) | (0.0059) | (0.0084) | (0.0075) | (0.0163) |
| Industry dummies | 0.0050*** | 0.0062*** | 0.0087*** | -0.0011 | 0.0065 | -0.0713** | -0.0095 | 0.0818 |
| | (0.0016) | (0.0018) | (0.0018) | (0.0042) | (0.0238) | (0.0338) | (0.0302) | (0.0660) |
| Formal | -0.0004 | -0.0010 | -0.0003 | -0.0001 | -0.0429** | -0.2467*** | -0.0726*** | -0.0517 |
| | (0.0008) | (0.0019) | (0.0006) | (0.0003) | (0.0169) | (0.0240) | (0.0215) | (0.0469) |
| Region dummies | 0.0017* | 0.0005 | 0.0018 | 0.0042** | 0.0045 | 0.0121 | 0.0202*** | 0.0118 |
| | (0.0010) | (0.0009) | (0.0012) | (0.0018) | (0.0057) | (0.0080) | (0.0072) | (0.0158) |
| Urban | -0.0004* | -0.0004* | -0.0003 | -0.0001 | -0.0305* | -0.0174 | 0.0008 | -0.0760 |
| | (0.0002) | (0.0003) | (0.0002) | (0.0003) | (0.0184) | (0.0262) | (0.0233) | (0.0510) |
| Constant | | | | | 0.0617 | 0.4521*** | 0.0769 | -0.1376 |
| | | | | | (0.0384) | (0.0543) | (0.0487) | (0.1065) |
| Observations | 29,712 | 29,712 | 29,712 | 29,712 | 29,712 | 29,712 | 29,712 | 29,712 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). Numbers in parentheses represent standard errors. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

TABLE S.7
CONTRIBUTION OF THE DIFFERENCE IN THE COMPOSITION AND WAGE STRUCTURE EFFECTS BETWEEN SELECTED QUANTILES TO THE EVOLUTION OF WAGE INEQUALITY FROM 2013 TO 2017 FOR MALES AND FEMALES

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Q90–Q10 | | Q90–Q50 | | Q90–Q10 | | Q90–Q50 | |
| 2013 | 1.5907 | | 1.0676 | | 1.5455 | | 1.0913 | |
| 2017 | 1.4926 | | 1.0100 | | 1.4391 | | 1.0494 | |
| Overall difference | -0.0981 | | -0.0576 | | -0.1064 | | -0.0419 | |
| Total composition effect | 0.1031 | -105.03% | 0.0801 | -138.98% | 0.1092 | -102.61% | 0.0564 | -134.61% |
| Primary education or less | -0.0038 | 3.89% | -0.0078 | 13.55% | -0.0033 | 3.11% | -0.0033 | 7.95% |
| Higher education | 0.1303 | -132.77% | 0.1018 | -176.65% | 0.1176 | -110.49% | 0.0699 | -167.04% |
| Technical degree | 0.0082 | -8.35% | 0.0027 | -4.64% | -0.0011 | 1.06% | -0.0079 | 18.94% |
| CFT | 0.0001 | -0.07% | -0.0001 | 0.12% | -0.0012 | 1.17% | 0.0032 | -7.74% |
| IP | 0.0014 | -1.44% | -0.0001 | 0.20% | 0.0003 | -0.31% | -0.0045 | 10.86% |
| New private university | 0.0027 | -2.72% | 0.0017 | -2.98% | -0.0012 | 1.14% | -0.0038 | 9.09% |
| Traditional university | 0.0020 | -2.00% | 0.0006 | -0.96% | 0.0027 | -2.51% | 0.0007 | -1.56% |
| Does not know/No response | 0.0018 | -1.82% | 0.0008 | -1.36% | 0.0000 | 0.04% | -0.0001 | 0.17% |
| Incomplete | 0.0003 | -0.31% | -0.0002 | 0.34% | -0.0016 | 1.54% | -0.0034 | 8.11% |
| Professional degree | 0.0910 | -92.72% | 0.0715 | -124.07% | 0.0849 | -79.73% | 0.0514 | -122.77% |
| IP | 0.0143 | -14.60% | 0.0096 | -16.63% | 0.0129 | -12.13% | 0.0055 | -13.02% |
| New private university | 0.0249 | -25.34% | 0.0197 | -34.26% | 0.0234 | -21.95% | 0.0139 | -33.23% |
| Traditional university | 0.0510 | -52.02% | 0.0427 | -74.10% | 0.0498 | -46.80% | 0.0324 | -77.46% |
| Does not know/No response | -0.0049 | 5.01% | -0.0038 | 6.56% | -0.0015 | 1.39% | -0.0004 | 0.97% |
| Incomplete | 0.0057 | -5.76% | 0.0033 | -5.65% | 0.0003 | -0.24% | 0.0000 | -0.03% |
| Post-graduate degree | 0.0311 | -31.70% | 0.0276 | -47.94% | 0.0339 | -31.83% | 0.0265 | -63.21% |
| New private university | 0.0073 | -7.41% | 0.0063 | -10.95% | 0.0122 | -11.47% | 0.0093 | -22.32% |
| Traditional university | 0.0235 | -23.96% | 0.0210 | -36.53% | 0.0194 | -18.26% | 0.0156 | -37.31% |
| Does not know/No response | | | | | -0.0023 | 2.15% | -0.0018 | 4.35% |
| Incomplete | 0.0003 | -0.33% | 0.0003 | -0.46% | 0.0045 | -4.26% | 0.0033 | -7.93% |
| Experience | -0.0873 | 88.93% | -0.0826 | 143.31% | -0.0294 | 27.59% | -0.0207 | 49.37% |
| Experience-squared | 0.0757 | -77.13% | 0.0722 | -125.32% | 0.0197 | -18.54% | 0.0140 | -33.44% |
| Demographic dummies | -0.0125 | 12.70% | -0.0040 | 6.92% | 0.0069 | -6.50% | 0.0036 | -8.54% |
| Industry dummies | 0.0003 | -0.33% | 0.0006 | -0.97% | -0.0072 | 6.81% | -0.0098 | 23.40% |

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Q90–Q10 | | Q90–Q50 | | Q90–Q10 | | Q90–Q50 | |
| Formal | -0.0003 | 0.27% | -0.0002 | 0.28% | 0.0009 | -0.81% | 0.0002 | -0.45% |
| Region dummies | 0.0010 | -0.98% | 0.0009 | -1.50% | 0.0037 | -3.49% | 0.0023 | -5.57% |
| Urban | -0.0004 | 0.39% | -0.0008 | 1.39% | 0.0003 | -0.28% | 0.0001 | -0.29% |
| Total wage structure effect | -0.2012 | 205.03% | -0.1377 | 238.98% | -0.2156 | 202.61% | -0.0982 | 234.61% |
| Primary education or less | -0.0040 | 4.10% | -0.0038 | 6.55% | -0.0055 | 5.16% | -0.0039 | 9.31% |
| Higher education | 0.0400 | -40.74% | 0.0430 | -74.65% | -0.1186 | 111.43% | -0.0911 | 217.56% |
| Technical degree | -0.0030 | 3.07% | 0.0015 | -2.61% | 0.0096 | -8.99% | 0.0147 | -35.17% |
| CFT | -0.0014 | 1.39% | -0.0009 | 1.51% | 0.0003 | -0.32% | 0.0042 | -10.14% |
| IP | 0.0032 | -3.28% | 0.0047 | -8.09% | 0.0019 | -1.78% | -0.0018 | 4.19% |
| New private university | -0.0026 | 2.62% | -0.0011 | 1.95% | 0.0027 | -2.52% | 0.0052 | -12.33% |
| Traditional university | -0.0001 | 0.08% | -0.0002 | 0.36% | -0.0035 | 3.25% | -0.0025 | 5.87% |
| Does not know/No response | -0.0038 | 3.84% | -0.0027 | 4.71% | 0.0018 | -1.66% | 0.0013 | -3.18% |
| Incomplete | 0.0016 | -1.58% | 0.0018 | -3.06% | 0.0063 | -5.96% | 0.0082 | -19.59% |
| Professional degree | 0.0183 | -18.69% | 0.0183 | -31.70% | -0.1110 | 104.29% | -0.0889 | 212.39% |
| IP | 0.0068 | -6.92% | 0.0068 | -11.82% | -0.0136 | 12.74% | -0.0107 | 25.63% |
| New private university | -0.0118 | 12.03% | -0.0108 | 18.81% | -0.0562 | 52.80% | -0.0424 | 101.22% |
| Traditional university | 0.0311 | -31.73% | 0.0239 | -41.45% | -0.0383 | 36.03% | -0.0374 | 89.28% |
| Does not know/No response | -0.0001 | 0.06% | -0.0002 | 0.36% | 0.0019 | -1.77% | 0.0020 | -4.87% |
| Incomplete | -0.0077 | 7.87% | -0.0014 | 2.39% | -0.0048 | 4.48% | -0.0005 | 1.13% |
| Post-graduate degree | 0.0246 | -25.12% | 0.0232 | -40.34% | -0.0172 | 16.13% | -0.0169 | 40.34% |
| New private university | 0.0094 | -9.60% | 0.0093 | -16.14% | -0.0052 | 4.92% | -0.0049 | 11.69% |
| Traditional university | 0.0156 | -15.86% | 0.0143 | -24.81% | -0.0105 | 9.86% | -0.0101 | 24.05% |
| Does not know/No response | | | | | -0.0006 | 0.61% | -0.0006 | 1.45% |
| Incomplete | -0.0003 | 0.35% | -0.0003 | 0.61% | -0.0008 | 0.74% | -0.0013 | 3.15% |
| Experience | 0.1176 | -119.84% | 0.0154 | -26.72% | 0.4349 | -408.65% | 0.3542 | -845.92% |
| Experience-squared | -0.0656 | 66.87% | -0.0265 | 46.02% | -0.2299 | 216.05% | -0.1893 | 452.07% |
| Demographic dummies | 0.1143 | -116.50% | 0.1011 | -175.55% | 0.0040 | -3.71% | 0.0194 | -46.37% |
| Industry dummies | -0.0658 | 67.08% | -0.0553 | 95.96% | 0.1532 | -143.90% | 0.0913 | -218.12% |
| Formal | -0.0369 | 37.57% | -0.0193 | 33.56% | 0.1950 | -183.20% | 0.0209 | -50.03% |
| Region dummies | -0.0161 | 16.41% | -0.0237 | 41.14% | -0.0003 | 0.26% | -0.0085 | 20.21% |
| Urban | -0.0337 | 34.29% | -0.0139 | 24.09% | -0.0586 | 55.06% | -0.0768 | 183.38% |
| Constant | -0.2510 | 255.76% | -0.1547 | 268.59% | -0.5898 | 554.12% | -0.2146 | 512.52% |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). % indicates the contribution of the respective variables to the evolution of wage inequality between the selected quantiles.

TABLE S.8
ESTIMATION RESULTS OF SELECTION EQUATION FOR MALES AND FEMALES IN 2013 AND 2017

| | Males | | Females | |
|---|---|---|---|---|
| Explanatory variables | 2013 | 2017 | 2013 | 2017 |
| Primary | -0.188*** | -0.266*** | -0.405*** | -0.289*** |
| | (0.055) | (0.045) | (0.038) | (0.035) |
| Technical degree | | | | |
| CFT | -0.229 | 0.145 | 0.566*** | 0.542*** |
| | (0.185) | (0.094) | (0.079) | (0.067) |
| IP | 0.248** | -0.026 | 0.567*** | 0.545*** |
| | (0.100) | (0.189) | (0.074) | (0.044) |
| New private university | -0.006 | 0.033 | 0.440 | 0.970*** |
| | (0.225) | (0.232) | (0.280) | (0.228) |
| Traditional university | -0.239 | -0.057 | 0.811*** | 0.511*** |
| | (0.279) | (0.141) | (0.252) | (0.124) |
| Does not know/No response | 0.294 | 0.167 | 0.425** | 0.449*** |
| | (0.192) | (0.158) | (0.166) | (0.119) |
| Incomplete | 0.109 | -0.145* | 0.145* | 0.292*** |
| | (0.105) | (0.086) | (0.085) | (0.065) |
| Professional degree | | | | |
| IP | 0.245 | 0.112 | 0.568*** | 0.584*** |
| | (0.161) | (0.093) | (0.135) | (0.097) |
| New private university | 0.098 | 0.176** | 0.898*** | 0.759*** |
| | (0.080) | (0.081) | (0.080) | (0.055) |
| Traditional university | 0.130* | 0.101* | 0.881*** | 0.824*** |
| | (0.075) | (0.060) | (0.107) | (0.045) |
| Does not know/No response | 0.092 | -0.033 | 0.816*** | 0.563*** |
| | (0.160) | (0.145) | (0.165) | (0.146) |
| Incomplete | -0.033 | -0.054 | 0.279*** | 0.179*** |
| | (0.101) | (0.075) | (0.085) | (0.064) |
| Post-graduate degree | | | | |
| New private university | 0.732** | 0.024 | 0.907*** | 1.126*** |
| | (0.300) | (0.331) | (0.309) | (0.162) |
| Traditional university | 0.526** | 0.555** | 1.807*** | 1.296*** |
| | (0.216) | (0.220) | (0.209) | (0.156) |
| Does not know/No response | | | 1.363*** | 0.383 |
| | | | (0.381) | (0.488) |
| Incomplete | -1.384** | 0.176 | 0.226 | 1.245*** |
| | (0.609) | (0.248) | (0.422) | (0.209) |
| Experience | 0.027*** | 0.028*** | 0.036*** | 0.020*** |
| | (0.008) | (0.009) | (0.010) | (0.006) |
| Experience-squared | -0.051*** | -0.059*** | -0.089*** | -0.052*** |
| | (0.020) | (0.018) | (0.022) | (0.014) |
| Head of the household | 0.510*** | 0.591*** | 0.403*** | 0.428*** |
| | (0.046) | (0.035) | (0.039) | (0.037) |
| Married | 0.172*** | 0.253*** | -0.536*** | -0.403*** |
| | (0.050) | (0.039) | (0.034) | (0.024) |
| Urban | -0.127*** | -0.073* | 0.263*** | 0.244*** |
| | (0.045) | (0.041) | (0.032) | (0.032) |

| | Males | | Females | |
|---|---|---|---|---|
| Explanatory variables | 2013 | 2017 | 2013 | 2017 |
| Non-labor income | -0.008 | -0.022 | -0.023 | -0.007 |
| | (0.026) | (0.017) | (0.017) | (0.008) |
| Numbers of children | 0.081** | 0.171*** | -0.215*** | -0.240*** |
| | (0.033) | (0.029) | (0.021) | (0.021) |
| Constant | 0.777*** | 0.563*** | -0.189 | -0.098 |
| | (0.104) | (0.102) | (0.124) | (0.066) |
| Observations | 24,553 | 23,885 | 29,366 | 28,256 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). Numbers in parentheses represent standard errors. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

TABLE S.9
ESTIMATION RESULTS OF THE MEAN AND UNCONDITIONAL QUANTILE REGRESSIONS FOR LOG HOURLY WAGES FOR MALES IN 2013 AND 2017, WITH THE SELECTIVITY CORRECTION TERM

| | 2013 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Primary | -0.187*** | -0.104*** | -0.198*** | -0.112*** | -0.178*** | -0.102*** | -0.210*** | -0.164*** |
| | (0.013) | (0.025) | (0.031) | (0.038) | (0.013) | (0.017) | (0.023) | (0.042) |
| Technical degree | | | | | | | | |
| CFT | 0.227*** | 0.089*** | 0.365*** | 0.067 | 0.296*** | 0.072*** | 0.330*** | 0.204** |
| | (0.025) | (0.024) | (0.053) | (0.107) | (0.022) | (0.018) | (0.038) | (0.091) |
| IP | 0.395*** | 0.096*** | 0.345*** | 0.447*** | 0.295*** | 0.078*** | 0.301*** | 0.348*** |
| | (0.018) | (0.021) | (0.052) | (0.104) | (0.015) | (0.014) | (0.032) | (0.067) |
| New private university | 0.434*** | 0.039 | 0.408*** | 1.050** | 0.240*** | 0.047 | 0.163* | 0.636*** |
| | (0.059) | (0.052) | (0.081) | (0.508) | (0.043) | (0.065) | (0.090) | (0.223) |
| Traditional university | 0.288*** | 0.047 | 0.389*** | 0.355 | 0.466*** | 0.109*** | 0.471*** | 0.526** |
| | (0.101) | (0.083) | (0.126) | (0.296) | (0.045) | (0.020) | (0.056) | (0.233) |
| Does not know/No response | 0.458*** | 0.050 | 0.365*** | 0.767** | 0.240*** | 0.106*** | 0.245*** | 0.081 |
| | (0.065) | (0.049) | (0.078) | (0.302) | (0.043) | (0.019) | (0.075) | (0.109) |
| Incomplete | 0.087*** | -0.060 | 0.126** | 0.104 | 0.144*** | 0.024 | 0.194*** | 0.120 |
| | (0.024) | (0.061) | (0.061) | (0.090) | (0.022) | (0.024) | (0.042) | (0.079) |
| Professional degree | | | | | | | | |
| IP | 0.700*** | 0.098*** | 0.495*** | 1.416*** | 0.595*** | 0.071*** | 0.472*** | 1.586*** |
| | (0.031) | (0.022) | (0.044) | (0.260) | (0.021) | (0.018) | (0.038) | (0.209) |
| New private university | 0.903*** | 0.084*** | 0.501*** | 2.145*** | 0.708*** | 0.068** | 0.476*** | 1.969*** |
| | (0.017) | (0.016) | (0.043) | (0.246) | (0.015) | (0.028) | (0.045) | (0.195) |
| Traditional university | 1.089*** | 0.107*** | 0.529*** | 2.735*** | 1.034*** | 0.102*** | 0.603*** | 3.033*** |
| | (0.015) | (0.014) | (0.040) | (0.313) | (0.012) | (0.011) | (0.031) | (0.218) |
| Does not know/No response | 0.769*** | 0.107*** | 0.499*** | 1.843*** | 0.761*** | 0.096*** | 0.514*** | 1.747*** |
| | (0.038) | (0.016) | (0.058) | (0.351) | (0.046) | (0.021) | (0.049) | (0.309) |
| Incomplete | 0.447*** | 0.063*** | 0.387*** | 0.794*** | 0.292*** | 0.082*** | 0.243*** | 0.609*** |
| | (0.019) | (0.020) | (0.039) | (0.223) | (0.017) | (0.015) | (0.039) | (0.116) |

| | 2013 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Post-graduate degree | | | | | | | | |
| New private university | 1.389*** | -0.074 | 0.404*** | 3.742*** | 1.404*** | 0.089*** | 0.586*** | 5.065*** |
| | (0.050) | (0.108) | (0.109) | (0.579) | (0.040) | (0.015) | (0.038) | (0.578) |
| Traditional university | 1.503*** | 0.081*** | 0.506*** | 4.355*** | 1.502*** | 0.117*** | 0.633*** | 5.262*** |
| | (0.034) | (0.026) | (0.052) | (0.455) | (0.027) | (0.018) | (0.041) | (0.409) |
| Incomplete | 0.806*** | 0.103 | 0.588*** | 1.552* | 1.048*** | 0.117*** | 0.599*** | 2.838*** |
| | (0.112) | (0.152) | (0.204) | (0.926) | (0.064) | (0.020) | (0.064) | (0.663) |
| Experience | 0.027*** | 0.001 | 0.005 | 0.089*** | 0.031*** | 0.003 | 0.014*** | 0.097*** |
| | (0.002) | (0.003) | (0.004) | (0.014) | (0.002) | (0.002) | (0.003) | (0.012) |
| Experience-squared | -0.057*** | -0.003 | -0.010 | -0.198*** | -0.068*** | -0.007 | -0.027*** | -0.220*** |
| | (0.005) | (0.007) | (0.011) | (0.031) | (0.004) | (0.005) | (0.007) | (0.026) |
| Head of the household | 0.257*** | 0.048 | 0.119** | 0.583*** | 0.223*** | 0.064*** | 0.198*** | 0.652*** |
| | (0.023) | (0.042) | (0.051) | (0.121) | (0.017) | (0.019) | (0.032) | (0.104) |
| Married | 0.077*** | 0.009 | 0.064** | 0.119* | 0.123*** | 0.028** | 0.085*** | 0.380*** |
| | (0.010) | (0.015) | (0.026) | (0.064) | (0.010) | (0.014) | (0.019) | (0.061) |
| Formal | 0.216*** | 0.232*** | 0.187*** | 0.120* | 0.184*** | 0.222*** | 0.158*** | 0.067** |
| | (0.011) | (0.027) | (0.025) | (0.064) | (0.011) | (0.031) | (0.023) | (0.034) |
| Urban | 0.017 | 0.026 | 0.080*** | -0.094*** | 0.026** | 0.020* | 0.047*** | -0.104** |
| | (0.013) | (0.019) | (0.020) | (0.035) | (0.012) | (0.012) | (0.014) | (0.041) |
| Inverse Mills ratio | 0.621*** | -0.004 | -0.022 | 1.971*** | 0.485*** | 0.197** | 0.334** | 1.683*** |
| | (0.131) | (0.224) | (0.268) | (0.661) | (0.078) | (0.092) | (0.143) | (0.398) |
| Constant | 6.521*** | 6.588*** | 6.849*** | 6.515*** | 6.605*** | 6.640*** | 6.738*** | 6.377*** |
| | (0.053) | (0.100) | (0.100) | (0.298) | (0.041) | (0.064) | (0.080) | (0.235) |
| Observations | 21,301 | 21,301 | 21,301 | 21,301 | 20,135 | 20,135 | 20,135 | 20,135 |
| *R*-squared | 0.515 | 0.093 | 0.301 | 0.403 | 0.512 | 0.092 | 0.285 | 0.379 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). Numbers in parentheses represent standard errors. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively. The standard errors of the unconditional quantile regressions are calculated via bootstrap with 500 replications. Industry dummies and region dummies are also included.

TABLE S.10

ESTIMATION RESULTS OF THE MEAN AND UNCONDITIONAL QUANTILE REGRESSIONS FOR LOG HOURLY WAGES FOR FEMALES IN 2013 AND 2017, WITH THE SELECTIVITY CORRECTION TERM

| | 2013 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Primary | -0.139*** | -0.157** | -0.158*** | -0.228*** | -0.083*** | -0.068** | -0.089** | -0.031 |
| | (0.018) | (0.076) | (0.038) | (0.061) | (0.017) | (0.031) | (0.042) | (0.040) |
| Technical degree | | | | | | | | |
| CFT | 0.317*** | 0.042 | 0.418*** | 0.414*** | 0.236*** | 0.027 | 0.292*** | 0.239*** |
| | (0.022) | (0.064) | (0.064) | (0.099) | (0.023) | (0.032) | (0.058) | (0.075) |
| IP | 0.342*** | 0.150*** | 0.434*** | 0.417*** | 0.270*** | 0.038 | 0.366*** | 0.176*** |
| | (0.019) | (0.041) | (0.067) | (0.093) | (0.018) | (0.025) | (0.054) | (0.066) |
| New private university | 0.388*** | 0.163*** | 0.500*** | 0.211 | 0.204*** | 0.049 | 0.198 | 0.249** |
| | (0.051) | (0.058) | (0.087) | (0.157) | (0.037) | (0.046) | (0.170) | (0.113) |
| Traditional university | 0.635*** | 0.157** | 0.739*** | 1.263** | 0.393*** | 0.088** | 0.501*** | 0.358*** |
| | (0.076) | (0.065) | (0.079) | (0.512) | (0.048) | (0.042) | (0.079) | (0.124) |
| Does not know/No response | 0.292*** | 0.244*** | 0.435*** | 0.215** | 0.154*** | -0.024 | 0.250*** | 0.179* |
| | (0.051) | (0.051) | (0.109) | (0.087) | (0.049) | (0.080) | (0.081) | (0.107) |
| Incomplete | 0.188*** | 0.099* | 0.352*** | -0.047 | 0.137*** | -0.001 | 0.182*** | 0.064 |
| | (0.027) | (0.055) | (0.073) | (0.052) | (0.024) | (0.041) | (0.048) | (0.056) |
| Professional degree | | | | | | | | |
| IP | 0.758*** | 0.089 | 0.694*** | 1.405*** | 0.598*** | 0.103*** | 0.614*** | 0.790*** |
| | (0.031) | (0.057) | (0.062) | (0.251) | (0.025) | (0.024) | (0.064) | (0.127) |
| New private university | 0.977*** | 0.104* | 0.753*** | 2.090*** | 0.715*** | 0.099*** | 0.597*** | 1.205*** |
| | (0.024) | (0.053) | (0.068) | (0.222) | (0.021) | (0.028) | (0.094) | (0.131) |
| Traditional university | 1.093*** | 0.180*** | 0.829*** | 2.415*** | 0.965*** | 0.103*** | 0.748*** | 1.814*** |
| | (0.022) | (0.052) | (0.068) | (0.205) | (0.021) | (0.027) | (0.070) | (0.128) |
| Does not know/No response | 0.885*** | 0.198*** | 0.798*** | 1.389*** | 0.796*** | 0.141*** | 0.725*** | 1.290*** |
| | (0.040) | (0.055) | (0.074) | (0.269) | (0.041) | (0.023) | (0.071) | (0.208) |
| Incomplete | 0.395*** | 0.045 | 0.490*** | 0.640*** | 0.301*** | 0.034 | 0.337*** | 0.375*** |
| | (0.023) | (0.057) | (0.056) | (0.168) | (0.022) | (0.025) | (0.048) | (0.091) |

| | 2013 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Post-graduate degree | | | | | | | | |
| New private university | 1.428*** | 0.151** | 0.839*** | 3.473*** | 1.342*** | 0.140*** | 0.795*** | 2.664*** |
| | (0.055) | (0.062) | (0.073) | (0.435) | (0.043) | (0.040) | (0.078) | (0.316) |
| Traditional university | 1.459*** | 0.167** | 0.829*** | 4.110*** | 1.315*** | 0.108*** | 0.749*** | 3.046*** |
| | (0.044) | (0.082) | (0.084) | (0.418) | (0.036) | (0.033) | (0.082) | (0.232) |
| Does not know/No response | 1.277*** | 0.248*** | 0.787*** | 3.321*** | 0.825*** | 0.169*** | 0.588* | 0.997 |
| | (0.106) | (0.075) | (0.154) | (0.811) | (0.189) | (0.049) | (0.350) | (1.022) |
| Incomplete | 1.348*** | 0.272*** | 0.831*** | 2.481*** | 1.055*** | 0.098*** | 0.796*** | 2.172*** |
| | (0.085) | (0.073) | (0.088) | (0.704) | (0.061) | (0.034) | (0.084) | (0.419) |
| Experience | 0.019*** | 0.001 | 0.010*** | 0.047*** | 0.025*** | 0.001 | 0.015*** | 0.060*** |
| | (0.002) | (0.004) | (0.004) | (0.012) | (0.002) | (0.002) | (0.004) | (0.009) |
| Experience-squared | -0.045*** | -0.008 | -0.026** | -0.105*** | -0.056*** | -0.005 | -0.034*** | -0.134*** |
| | (0.005) | (0.013) | (0.010) | (0.027) | (0.005) | (0.007) | (0.009) | (0.019) |
| Head of the household | 0.057*** | -0.084*** | 0.027 | 0.302*** | 0.061*** | -0.031** | 0.035 | 0.133** |
| | (0.012) | (0.029) | (0.029) | (0.069) | (0.012) | (0.015) | (0.033) | (0.054) |
| Married | 0.024 | 0.013 | 0.062* | -0.179* | 0.081*** | 0.027* | 0.079*** | 0.214*** |
| | (0.016) | (0.038) | (0.033) | (0.091) | (0.013) | (0.016) | (0.026) | (0.059) |
| Formal | 0.241*** | 0.573*** | 0.185*** | 0.082** | 0.194*** | 0.302*** | 0.105*** | 0.022 |
| | (0.013) | (0.064) | (0.023) | (0.033) | (0.013) | (0.034) | (0.031) | (0.052) |
| Urban | 0.071*** | 0.056 | 0.031 | 0.156*** | 0.026* | 0.032* | 0.028 | -0.027 |
| | (0.016) | (0.040) | (0.024) | (0.052) | (0.015) | (0.019) | (0.019) | (0.046) |
| Inverse Mills ratio | 0.115*** | -0.047 | -0.047 | 0.787*** | 0.050 | -0.088 | -0.080 | 0.234 |
| | (0.039) | (0.105) | (0.086) | (0.213) | (0.039) | (0.054) | (0.094) | (0.149) |
| Constant | 6.566*** | 6.110*** | 6.696*** | 6.908*** | 6.696*** | 6.598*** | 6.802*** | 7.344*** |
| | (0.048) | (0.142) | (0.105) | (0.264) | (0.046) | (0.068) | (0.110) | (0.191) |
| Observations | 14,316 | 14,316 | 14,316 | 14,316 | 15,396 | 15,396 | 15,396 | 15,396 |
| *R*-squared | 0.566 | 0.152 | 0.402 | 0.343 | 0.521 | 0.124 | 0.359 | 0.319 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). Numbers in parentheses represent standard errors. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively. The standard errors of the unconditional quantile regressions are calculated via bootstrap with 500 replications. Industry dummies and region dummies are also included.

TABLE S.11
DESCRIPTIVE STATISTICS OF THE VARIABLES IN 2015

| | 2015 |
|---|---|
| Observations | 44,608 |
| Log hourly wage | |
| Mean | 7.533 |
| Q10 | 6.936 |
| Q50 | 7.435 |
| Q90 | 8.415 |
| Primary education or less | 0.124 |
| Secondary education | 0.501 |
| Scientific-Humanistic school | 0.367 |
| Technical-Vocational school | 0.134 |
| Higher education | 0.375 |
| Technical degree | 0.131 |
| CFT | 0.033 |
| IP | 0.063 |
| New private university | 0.005 |
| Traditional university | 0.003 |
| Does not know/No response | 0.002 |
| Incomplete | 0.024 |
| Professional degree | 0.222 |
| IP | 0.023 |
| New private university | 0.077 |
| Traditional university | 0.089 |
| Does not know/No response | 0.003 |
| Incomplete | 0.032 |
| Post-graduate degree | 0.022 |
| New private university | 0.007 |
| Traditional university | 0.011 |
| Does not know/No response | 0.000 |
| Incomplete | 0.004 |
| Experience | 18.221 |
| Male | 0.571 |
| Head of the household | 0.467 |
| Married | 0.333 |
| Formal | 0.909 |
| Urban | 0.894 |

Note: Q10, Q50, and Q90 represent the 10th, 50th, and 90th unconditional quantiles of log hourly wages, respectively. CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*).
Source: Authors' calculations based on data from the CASEN 2015 survey.

TABLE S.12
ESTIMATION RESULTS OF THE MEAN AND UNCONDITIONAL QUANTILE REGRESSIONS FOR LOG HOURLY WAGES IN 2015

| | 2015 | | | |
|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 |
| Primary | -0.141*** | -0.108*** | -0.204*** | -0.049*** |
| | (0.008) | (0.017) | (0.015) | (0.014) |
| Technical degree | | | | |
| CFT | 0.316*** | 0.138*** | 0.427*** | 0.344*** |
| | (0.012) | (0.020) | (0.027) | (0.060) |
| IP | 0.353*** | 0.147*** | 0.464*** | 0.390*** |
| | (0.009) | (0.016) | (0.025) | (0.051) |
| New private university | 0.402*** | 0.138*** | 0.502*** | 0.355*** |
| | (0.029) | (0.035) | (0.052) | (0.107) |
| Traditional university | 0.458*** | 0.157*** | 0.501*** | 0.485*** |
| | (0.040) | (0.035) | (0.064) | (0.168) |
| Does not know/No response | 0.320*** | 0.155*** | 0.446*** | 0.104 |
| | (0.048) | (0.045) | (0.086) | (0.131) |
| Incomplete | 0.170*** | 0.081*** | 0.271*** | 0.067* |
| | (0.014) | (0.024) | (0.035) | (0.040) |
| Professional degree | | | | |
| IP | 0.646*** | 0.163*** | 0.681*** | 1.013*** |
| | (0.015) | (0.025) | (0.031) | (0.115) |
| New private university | 0.881*** | 0.188*** | 0.799*** | 1.587*** |
| | (0.009) | (0.017) | (0.024) | (0.134) |
| Traditional university | 1.042*** | 0.219*** | 0.862*** | 2.112*** |
| | (0.008) | (0.017) | (0.021) | (0.150) |
| Does not know/No response | 0.660*** | 0.208*** | 0.699*** | 0.922*** |
| | (0.041) | (0.040) | (0.080) | (0.241) |
| Incomplete | 0.330*** | 0.083*** | 0.372*** | 0.436*** |
| | (0.012) | (0.031) | (0.036) | (0.070) |
| Post-graduate degree | | | | |
| New private university | 1.225*** | 0.190*** | 0.847*** | 2.799*** |
| | (0.026) | (0.022) | (0.029) | (0.308) |
| Traditional university | 1.541*** | 0.191*** | 0.833*** | 3.690*** |
| | (0.020) | (0.019) | (0.024) | (0.252) |
| Does not know/No response | 1.386*** | 0.275*** | 0.887*** | 3.737*** |
| | (0.145) | (0.062) | (0.081) | (0.916) |
| Incomplete | 1.310*** | 0.093 | 0.758*** | 2.937*** |
| | (0.034) | (0.106) | (0.088) | (0.438) |
| Experience | 0.022*** | 0.003 | 0.012*** | 0.046*** |
| | (0.001) | (0.002) | (0.002) | (0.007) |
| Experience-squared | -0.048*** | -0.006 | -0.024*** | -0.103*** |
| | (0.003) | (0.005) | (0.005) | (0.016) |
| Male | 0.120*** | 0.071*** | 0.145*** | 0.138*** |
| | (0.005) | (0.011) | (0.011) | (0.025) |
| Head of the household | 0.097*** | -0.001 | 0.093*** | 0.241*** |
| | (0.004) | (0.009) | (0.010) | (0.023) |
| Married | 0.098*** | 0.021** | 0.092*** | 0.169*** |
| | (0.005) | (0.009) | (0.011) | (0.026) |
| Formal | 0.215*** | 0.373*** | 0.204*** | 0.035 |
| | (0.008) | (0.034) | (0.015) | (0.023) |
| Urban | 0.012 | 0.004 | 0.033*** | -0.013 |
| | (0.008) | (0.013) | (0.012) | (0.017) |
| Constant | 6.705*** | 6.456*** | 6.664*** | 7.398*** |
| | (0.015) | (0.053) | (0.032) | (0.109) |
| Observations | 44,608 | 44,608 | 44,608 | 44,608 |
| *R*-squared | 0.531 | 0.102 | 0.338 | 0.346 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). Numbers in parentheses represent standard errors. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively. The standard errors of the unconditional quantile regressions are calculated via bootstrap with 500 replications. Industry dummies and region dummies are also included.

TABLE S.13

DECOMPOSITION OF WAGE CHANGES FROM 2013 TO 2015 INTO COMPOSITION AND WAGE STRUCTURE EFFECTS OF EACH EXPLANATORY VARIABLE

| | Composition effect | | | | Wage structure effect | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Overall | 0.0341*** | 0.0077*** | 0.0299*** | 0.0620*** | 0.0032 | 0.0728*** | -0.0208*** | -0.0514*** |
| | (0.0035) | (0.0016) | (0.0033) | (0.0065) | (0.0032) | (0.0035) | (0.0042) | (0.0087) |
| Primary | 0.0022*** | 0.0017*** | 0.0031*** | 0.0007** | 0.0026** | 0.0035** | 0.0038** | 0.0033 |
| | (0.0003) | (0.0003) | (0.0005) | (0.0003) | (0.0013) | (0.0014) | (0.0017) | (0.0035) |
| Higher education | 0.0433*** | 0.0096*** | 0.0365*** | 0.0827*** | -0.0352*** | -0.0382*** | -0.0631*** | -0.0555*** |
| | (0.0030) | (0.0008) | (0.0025) | (0.0062) | (0.0034) | (0.0038) | (0.0045) | (0.0092) |
| Technical degree | 0.0047*** | 0.0018*** | 0.0059*** | 0.0039*** | -0.0100*** | -0.0116*** | -0.0185*** | -0.0165*** |
| | (0.0008) | (0.0005) | (0.0011) | (0.0011) | (0.0015) | (0.0016) | (0.0019) | (0.0040) |
| CFT | -0.0016*** | -0.0007*** | -0.0022*** | -0.0018*** | -0.0018*** | -0.0023*** | -0.0041*** | -0.0038*** |
| | (0.0004) | (0.0002) | (0.0005) | (0.0005) | (0.0005) | (0.0006) | (0.0007) | (0.0014) |
| IP | 0.0024*** | 0.0010*** | 0.0032*** | 0.0027*** | -0.0052*** | -0.0062*** | -0.0094*** | -0.0132*** |
| | (0.0006) | (0.0003) | (0.0008) | (0.0007) | (0.0010) | (0.0010) | (0.0012) | (0.0026) |
| New private university | 0.0014*** | 0.0005*** | 0.0018*** | 0.0013*** | -0.0016*** | -0.0007* | -0.0026*** | -0.0003 |
| | (0.0003) | (0.0002) | (0.0003) | (0.0003) | (0.0004) | (0.0004) | (0.0005) | (0.0009) |
| Traditional university | 0.0012*** | 0.0004*** | 0.0014*** | 0.0013*** | -0.0001 | -0.0003 | 0.0000 | -0.0004 |
| | (0.0002) | (0.0002) | (0.0003) | (0.0004) | (0.0003) | (0.0003) | (0.0004) | (0.0008) |
| Does not know/No response | 0.0012*** | 0.0006** | 0.0017*** | 0.0004 | -0.0008** | -0.0005 | -0.0012*** | -0.0003 |
| | (0.0002) | (0.0002) | (0.0003) | (0.0005) | (0.0003) | (0.0004) | (0.0004) | (0.0009) |
| Incomplete | 0.0001 | 0.0000 | 0.0001 | 0.0000 | -0.0004 | -0.0015*** | -0.0013* | 0.0016 |
| | (0.0002) | (0.0001) | (0.0003) | (0.0001) | (0.0005) | (0.0006) | (0.0007) | (0.0014) |
| Professional degree | 0.0281*** | 0.0063*** | 0.0247*** | 0.0537*** | -0.0221*** | -0.0243*** | -0.0412*** | -0.0339*** |
| | (0.0027) | (0.0007) | (0.0024) | (0.0052) | (0.0024) | (0.0026) | (0.0031) | (0.0064) |
| IP | 0.0025*** | 0.0006*** | 0.0026*** | 0.0039*** | -0.0016*** | -0.0021*** | -0.0031*** | -0.0019 |
| | (0.0007) | (0.0002) | (0.0008) | (0.0011) | (0.0006) | (0.0006) | (0.0007) | (0.0015) |
| New private university | -0.0015 | -0.0003 | -0.0014 | -0.0028 | -0.0141*** | -0.0080*** | -0.0184*** | -0.0246*** |
| | (0.0017) | (0.0004) | (0.0015) | (0.0030) | (0.0010) | (0.0011) | (0.0014) | (0.0028) |
| Traditional university | 0.0233*** | 0.0049*** | 0.0193*** | 0.0472*** | -0.0062*** | -0.0127*** | -0.0170*** | -0.0103*** |
| | (0.0022) | (0.0005) | (0.0019) | (0.0046) | (0.0014) | (0.0015) | (0.0018) | (0.0036) |
| Does not know/No response | 0.0026*** | 0.0008*** | 0.0028*** | 0.0036*** | 0.0008** | -0.0005 | -0.0002 | 0.0025*** |
| | (0.0004) | (0.0002) | (0.0004) | (0.0006) | (0.0003) | (0.0004) | (0.0004) | (0.0009) |

| | Composition effect | | | | Wage structure effect | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Incomplete | 0.0013*** | 0.0003*** | 0.0014*** | 0.0017*** | -0.0010 | -0.0011 | -0.0025*** | 0.0003 |
| | (0.0004) | (0.0001) | (0.0005) | (0.0006) | (0.0006) | (0.0007) | (0.0008) | (0.0017) |
| Post-graduate degree | 0.0104*** | 0.0014*** | 0.0059*** | 0.0252*** | -0.0032*** | -0.0022*** | -0.0034*** | -0.0052*** |
| | (0.0016) | (0.0003) | (0.0010) | (0.0038) | (0.0007) | (0.0007) | (0.0008) | (0.0018) |
| New private university | 0.0015** | 0.0002* | 0.0011** | 0.0035** | 0.0011*** | -0.0006* | -0.0009** | 0.0042*** |
| | (0.0007) | (0.0001) | (0.0005) | (0.0017) | (0.0003) | (0.0003) | (0.0004) | (0.0008) |
| Traditional university | 0.0087*** | 0.0011*** | 0.0047*** | 0.0209*** | -0.0029*** | -0.0015*** | -0.0021*** | -0.0053*** |
| | (0.0013) | (0.0002) | (0.0007) | (0.0032) | (0.0005) | (0.0005) | (0.0006) | (0.0013) |
| Does not know/No response | 0.0009*** | 0.0002 | 0.0006*** | 0.0025*** | -0.0004** | -0.0002 | -0.0003 | -0.0020*** |
| | (0.0003) | (0.0001) | (0.0002) | (0.0007) | (0.0002) | (0.0002) | (0.0002) | (0.0005) |
| Incomplete | -0.0008 | -0.0001 | -0.0005 | -0.0017 | -0.0009*** | 0.0001 | -0.0001 | -0.0022*** |
| | (0.0005) | (0.0000) | (0.0003) | (0.0012) | (0.0002) | (0.0002) | (0.0002) | (0.0005) |
| Experience | -0.0155*** | -0.0022** | -0.0082*** | -0.0323*** | 0.0536** | -0.0389 | 0.0040 | 0.2504*** |
| | (0.0016) | (0.0010) | (0.0013) | (0.0036) | (0.0271) | (0.0296) | (0.0352) | (0.0731) |
| Experience-squared | 0.0125*** | 0.0017* | 0.0063*** | 0.0269*** | -0.0277* | 0.0129 | -0.0013 | -0.1292*** |
| | (0.0014) | (0.0009) | (0.0011) | (0.0032) | (0.0156) | (0.0170) | (0.0202) | (0.0420) |
| Male | -0.0015*** | -0.0009*** | -0.0019*** | -0.0018*** | -0.0071* | -0.0165*** | -0.0127** | -0.0066 |
| | (0.0004) | (0.0003) | (0.0005) | (0.0005) | (0.0042) | (0.0046) | (0.0054) | (0.0112) |
| Demographic dummies | -0.0050*** | -0.0008*** | -0.0047*** | -0.0095*** | -0.0014 | 0.0009 | -0.0046 | -0.0170* |
| | (0.0005) | (0.0003) | (0.0005) | (0.0012) | (0.0036) | (0.0040) | (0.0047) | (0.0098) |
| Industry dummies | -0.0013 | 0.0005 | -0.0007 | -0.0058*** | -0.0038 | 0.0073 | -0.0040 | -0.0237 |
| | (0.0008) | (0.0006) | (0.0009) | (0.0018) | (0.0134) | (0.0146) | (0.0174) | (0.0362) |
| Formal | -0.0011** | -0.0020** | -0.0011** | -0.0002 | -0.0240** | -0.1503*** | -0.0696*** | 0.0090 |
| | (0.0004) | (0.0008) | (0.0004) | (0.0001) | (0.0101) | (0.0111) | (0.0132) | (0.0273) |
| Region dummies | 0.0006 | 0.0002 | 0.0004 | 0.0012 | 0.0039 | 0.0193*** | 0.0219*** | -0.0210** |
| | (0.0006) | (0.0005) | (0.0007) | (0.0008) | (0.0037) | (0.0041) | (0.0048) | (0.0100) |
| Urban | 0.0000 | 0.0000 | 0.0001 | -0.0001 | 0.0127 | 0.0206* | 0.0117 | -0.0332 |
| | (0.0000) | (0.0000) | (0.0001) | (0.0001) | (0.0105) | (0.0115) | (0.0137) | (0.0284) |
| Constant | | | | | 0.0297 | 0.2519*** | 0.0931*** | -0.0278 |
| | | | | | (0.0234) | (0.0255) | (0.0303) | (0.0629) |
| Observations | 80,151 | 80,151 | 80,151 | 80,151 | 80,151 | 80,151 | 80,151 | 80,151 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). Numbers in parentheses represent standard errors. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

TABLE S.14
ESTIMATION RESULTS OF THE MEAN AND UNCONDITIONAL QUANTILE REGRESSIONS FOR LOG HOURLY WAGES IN 2013 AND 2017, WITH OCCUPATION DUMMIES

| | 2013 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Primary | -0.117*** | -0.123*** | -0.145*** | -0.016 | -0.094*** | -0.065*** | -0.135*** | -0.012 |
| | (0.008) | (0.022) | (0.019) | (0.018) | (0.009) | (0.013) | (0.015) | (0.015) |
| Technical degree | | | | | | | | |
| CFT | 0.151*** | 0.037 | 0.257*** | 0.023 | 0.123*** | 0.029* | 0.133*** | 0.052 |
| | (0.014) | (0.031) | (0.033) | (0.062) | (0.014) | (0.015) | (0.027) | (0.041) |
| IP | 0.192*** | 0.077*** | 0.264*** | 0.007 | 0.114*** | 0.028*** | 0.160*** | -0.029 |
| | (0.011) | (0.016) | (0.034) | (0.058) | (0.010) | (0.011) | (0.022) | (0.056) |
| New private university | 0.225*** | 0.067* | 0.287*** | 0.221 | 0.088*** | 0.045 | 0.082 | 0.116 |
| | (0.038) | (0.037) | (0.067) | (0.256) | (0.024) | (0.041) | (0.081) | (0.095) |
| Traditional university | 0.324*** | 0.059 | 0.431*** | 0.583 | 0.258*** | 0.073*** | 0.327*** | 0.163 |
| | (0.059) | (0.047) | (0.072) | (0.380) | (0.030) | (0.020) | (0.048) | (0.109) |
| Does not know/No response | 0.191*** | 0.131*** | 0.193*** | 0.187 | 0.063** | 0.031 | 0.098** | -0.088 |
| | (0.039) | (0.037) | (0.065) | (0.139) | (0.030) | (0.033) | (0.049) | (0.061) |
| Incomplete | 0.029* | -0.008 | 0.158*** | -0.181*** | 0.071*** | 0.003 | 0.128*** | 0.022 |
| | (0.017) | (0.057) | (0.046) | (0.058) | (0.015) | (0.020) | (0.029) | (0.038) |
| Professional degree | | | | | | | | |
| IP | 0.386*** | 0.049** | 0.402*** | 0.607*** | 0.256*** | 0.044*** | 0.275*** | 0.343*** |
| | (0.021) | (0.024) | (0.035) | (0.179) | (0.015) | (0.014) | (0.027) | (0.090) |
| New private university | 0.530*** | 0.048** | 0.405*** | 1.136*** | 0.329*** | 0.041** | 0.258*** | 0.552*** |
| | (0.014) | (0.019) | (0.030) | (0.156) | (0.011) | (0.020) | (0.035) | (0.085) |
| Traditional university | 0.651*** | 0.082*** | 0.435*** | 1.584*** | 0.514*** | 0.053*** | 0.329*** | 1.095*** |
| | (0.013) | (0.019) | (0.027) | (0.170) | (0.011) | (0.013) | (0.023) | (0.100) |
| Does not know/No response | 0.436*** | 0.097*** | 0.437*** | 0.627*** | 0.393*** | 0.083*** | 0.339*** | 0.585*** |
| | (0.027) | (0.020) | (0.039) | (0.198) | (0.028) | (0.013) | (0.034) | (0.166) |
| Incomplete | 0.261*** | 0.024 | 0.295*** | 0.362** | 0.140*** | 0.031** | 0.162*** | 0.160*** |
| | (0.014) | (0.024) | (0.031) | (0.158) | (0.013) | (0.013) | (0.028) | (0.056) |
| Post-graduate degree | | | | | | | | |
| New private university | 0.890*** | -0.058 | 0.334*** | 2.253*** | 0.836*** | 0.058*** | 0.338*** | 2.266*** |
| | (0.036) | (0.089) | (0.068) | (0.341) | (0.027) | (0.017) | (0.034) | (0.273) |

| | 2013 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Traditional university | 0.977*** | 0.065*** | 0.399*** | 3.018*** | 0.821*** | 0.046*** | 0.296*** | 2.261*** |
| | (0.025) | (0.019) | (0.034) | (0.278) | (0.020) | (0.014) | (0.026) | (0.230) |
| Does not know/No response | 0.822*** | 0.099*** | 0.405*** | 1.999*** | 0.501*** | 0.054** | 0.262* | 0.663 |
| | (0.078) | (0.037) | (0.081) | (0.586) | (0.075) | (0.021) | (0.159) | (0.514) |
| Incomplete | 0.768*** | 0.085*** | 0.357*** | 1.687*** | 0.499*** | 0.057*** | 0.345*** | 1.175*** |
| | (0.052) | (0.032) | (0.052) | (0.522) | (0.040) | (0.016) | (0.036) | (0.366) |
| Experience | 0.018*** | 0.000 | 0.007*** | 0.043*** | 0.021*** | 0.000 | 0.009*** | 0.052*** |
| | (0.001) | (0.003) | (0.002) | (0.012) | (0.001) | (0.001) | (0.002) | (0.006) |
| Experience-squared | -0.039*** | -0.003 | -0.012* | -0.097*** | -0.044*** | -0.002 | -0.017*** | -0.116*** |
| | (0.003) | (0.007) | (0.006) | (0.027) | (0.003) | (0.004) | (0.005) | (0.015) |
| Male | 0.133*** | 0.083*** | 0.157*** | 0.164*** | 0.119*** | 0.043*** | 0.129*** | 0.149*** |
| | (0.006) | (0.014) | (0.013) | (0.038) | (0.005) | (0.007) | (0.012) | (0.030) |
| Head of the household | 0.100*** | 0.001 | 0.071*** | 0.248*** | 0.082*** | 0.008 | 0.084*** | 0.149*** |
| | (0.005) | (0.012) | (0.012) | (0.032) | (0.005) | (0.006) | (0.010) | (0.030) |
| Married | 0.065*** | 0.028*** | 0.076*** | 0.043 | 0.085*** | 0.004 | 0.058*** | 0.210*** |
| | (0.005) | (0.011) | (0.012) | (0.030) | (0.005) | (0.006) | (0.009) | (0.031) |
| Occupation categories | | | | | | | | |
| Managers | 0.855*** | 0.145*** | 0.597*** | 1.646*** | 1.043*** | 0.121*** | 0.682*** | 2.162*** |
| | (0.022) | (0.027) | (0.042) | (0.245) | (0.020) | (0.014) | (0.042) | (0.347) |
| Professionals | 0.631*** | 0.143*** | 0.569*** | 1.088*** | 0.727*** | 0.121*** | 0.687*** | 1.211*** |
| | (0.014) | (0.024) | (0.032) | (0.156) | (0.012) | (0.014) | (0.027) | (0.106) |
| Technicians and associate professionals | 0.414*** | 0.133*** | 0.474*** | 0.536*** | 0.391*** | 0.110*** | 0.521*** | 0.315*** |
| | (0.012) | (0.021) | (0.030) | (0.078) | (0.010) | (0.012) | (0.023) | (0.049) |
| Clerks | 0.196*** | 0.163*** | 0.329*** | -0.031 | 0.162*** | 0.091*** | 0.271*** | -0.036 |
| | (0.010) | (0.021) | (0.029) | (0.031) | (0.009) | (0.011) | (0.020) | (0.024) |
| Service and sales workers | 0.128*** | -0.004 | 0.125*** | 0.182*** | 0.123*** | 0.039*** | 0.143*** | 0.132*** |
| | (0.010) | (0.027) | (0.023) | (0.033) | (0.009) | (0.013) | (0.024) | (0.027) |
| Skilled agricultural and fishery workers | 0.085*** | 0.082** | 0.091*** | -0.010 | 0.071*** | 0.036 | 0.154*** | -0.038 |
| | (0.015) | (0.042) | (0.022) | (0.019) | (0.020) | (0.023) | (0.030) | (0.033) |
| Craft and related trades workers | 0.139*** | 0.077*** | 0.245*** | -0.015 | 0.125*** | 0.081*** | 0.275*** | -0.095*** |
| | (0.010) | (0.024) | (0.026) | (0.041) | (0.009) | (0.011) | (0.020) | (0.027) |

| | 2013 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Plant and machine operators and assemblers | 0.153*** | 0.080*** | 0.299*** | -0.070** | 0.132*** | 0.079*** | 0.256*** | -0.101*** |
| | (0.011) | (0.025) | (0.025) | (0.031) | (0.010) | (0.012) | (0.021) | (0.027) |
| Formal | 0.208*** | 0.360*** | 0.158*** | -0.000 | 0.178*** | 0.204*** | 0.115*** | 0.036 |
| | (0.008) | (0.030) | (0.016) | (0.061) | (0.008) | (0.015) | (0.018) | (0.028) |
| Urban | 0.030*** | 0.020 | 0.048*** | -0.011 | 0.026*** | 0.026*** | 0.043*** | -0.044* |
| | (0.009) | (0.018) | (0.013) | (0.020) | (0.008) | (0.009) | (0.010) | (0.023) |
| Constant | 6.591*** | 6.368*** | 6.571*** | 7.489*** | 6.720*** | 6.690*** | 6.703*** | 7.430*** |
| | (0.018) | (0.047) | (0.039) | (0.161) | (0.017) | (0.025) | (0.037) | (0.084) |
| Observations | 35,626 | 35,626 | 35,626 | 35,626 | 35,543 | 35,543 | 35,543 | 35,543 |
| *R*-squared | 0.566 | 0.118 | 0.379 | 0.388 | 0.577 | 0.100 | 0.374 | 0.399 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). Numbers in parentheses represent standard errors. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively. The standard errors of the unconditional quantile regressions are calculated via bootstrap with 500 replications. Industry dummies and region dummies are also included.

# TABLE S.15
## DECOMPOSITION OF WAGE CHANGES FROM 2013 TO 2017 INTO COMPOSITION AND WAGE STRUCTURE EFFECTS OF EACH EXPLANATORY VARIABLE, WITH OCCUPATION DUMMIES

| | Composition effect | | | | Wage structure effect | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Overall | 0.0466*** | 0.0083*** | 0.0337*** | 0.1092*** | 0.0426*** | 0.1305*** | 0.0347*** | -0.1131*** |
| | (0.0040) | (0.0020) | (0.0035) | (0.0083) | (0.0034) | (0.0040) | (0.0042) | (0.0096) |
| Primary | 0.0040*** | 0.0042*** | 0.0050*** | 0.0005 | 0.0026** | 0.0063*** | 0.0011 | 0.0004 |
| | (0.0004) | (0.0005) | (0.0005) | (0.0008) | (0.0013) | (0.0015) | (0.0016) | (0.0037) |
| Higher education | 0.0411*** | 0.0049*** | 0.0309*** | 0.0895*** | -0.0501*** | -0.0074 | -0.0479*** | -0.1297*** |
| | (0.0021) | (0.0012) | (0.0017) | (0.0054) | (0.0048) | (0.0058) | (0.0060) | (0.0137) |
| Technical degree | 0.0044*** | 0.0015*** | 0.0061*** | 0.0029*** | -0.0076*** | -0.0041** | -0.0145*** | -0.0016 |
| | (0.0006) | (0.0005) | (0.0008) | (0.0011) | (0.0017) | (0.0020) | (0.0021) | (0.0047) |
| CFT | -0.0006*** | -0.0002* | -0.0011*** | -0.0001 | -0.0008 | -0.0002 | -0.0035*** | 0.0008 |
| | (0.0002) | (0.0001) | (0.0003) | (0.0002) | (0.0006) | (0.0006) | (0.0007) | (0.0016) |
| IP | 0.0022*** | 0.0009*** | 0.0031*** | 0.0001 | -0.0055*** | -0.0035*** | -0.0074*** | -0.0025 |
| | (0.0004) | (0.0002) | (0.0005) | (0.0004) | (0.0011) | (0.0012) | (0.0013) | (0.0030) |
| New private university | 0.0011*** | 0.0003 | 0.0014*** | 0.0011** | -0.0012*** | -0.0002 | -0.0018*** | -0.0009 |
| | (0.0002) | (0.0003) | (0.0003) | (0.0005) | (0.0004) | (0.0005) | (0.0005) | (0.0011) |
| Traditional university | 0.0013*** | 0.0002 | 0.0017*** | 0.0023*** | -0.0004 | 0.0001 | -0.0006 | -0.0023** |
| | (0.0003) | (0.0003) | (0.0003) | (0.0007) | (0.0004) | (0.0005) | (0.0005) | (0.0010) |
| Does not know/No response | 0.0004*** | 0.0003** | 0.0004*** | 0.0004 | -0.0007** | -0.0006* | -0.0005 | -0.0015* |
| | (0.0001) | (0.0001) | (0.0001) | (0.0002) | (0.0003) | (0.0003) | (0.0003) | (0.0008) |
| Incomplete | 0.0001 | -0.0000 | 0.0007*** | -0.0008*** | 0.0010* | 0.0003 | -0.0007 | 0.0049*** |
| | (0.0001) | (0.0001) | (0.0002) | (0.0003) | (0.0006) | (0.0007) | (0.0007) | (0.0016) |
| Professional degree | 0.0277*** | 0.0031*** | 0.0212*** | 0.0611*** | -0.0383*** | -0.0037 | -0.0315*** | -0.1125*** |
| | (0.0018) | (0.0008) | (0.0015) | (0.0043) | (0.0035) | (0.0042) | (0.0044) | (0.0100) |
| IP | 0.0047*** | 0.0006* | 0.0049*** | 0.0074*** | -0.0035*** | -0.0001 | -0.0034*** | -0.0070*** |
| | (0.0005) | (0.0004) | (0.0005) | (0.0010) | (0.0007) | (0.0008) | (0.0009) | (0.0020) |
| New private university | 0.0074*** | 0.0007** | 0.0057*** | 0.0159*** | -0.0150*** | -0.0006 | -0.0109*** | -0.0436*** |
| | (0.0010) | (0.0003) | (0.0008) | (0.0022) | (0.0014) | (0.0016) | (0.0017) | (0.0039) |
| Traditional university | 0.0155*** | 0.0019*** | 0.0104*** | 0.0377*** | -0.0152*** | -0.0032 | -0.0118*** | -0.0544*** |
| | (0.0015) | (0.0005) | (0.0011) | (0.0037) | (0.0019) | (0.0023) | (0.0024) | (0.0055) |
| Does not know/No response | -0.0010*** | -0.0002** | -0.0010*** | -0.0015*** | -0.0003 | -0.0001 | -0.0006** | -0.0003 |
| | (0.0003) | (0.0001) | (0.0003) | (0.0004) | (0.0003) | (0.0003) | (0.0003) | (0.0007) |

| | Composition effect | | | | Wage structure effect | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Incomplete | 0.0011*** | 0.0001 | 0.0013*** | 0.0015*** | -0.0043*** | 0.0003 | -0.0047*** | -0.0072*** |
| | (0.0004) | (0.0001) | (0.0004) | (0.0005) | (0.0007) | (0.0008) | (0.0009) | (0.0019) |
| Post-graduate degree | 0.0090*** | 0.0003 | 0.0036*** | 0.0256*** | -0.0042*** | 0.0004 | -0.0019** | -0.0156*** |
| | (0.0011) | (0.0003) | (0.0005) | (0.0031) | (0.0008) | (0.0009) | (0.0010) | (0.0022) |
| New private university | 0.0026*** | -0.0002 | 0.0010*** | 0.0067*** | -0.0004 | 0.0009** | 0.0000 | 0.0001 |
| | (0.0005) | (0.0001) | (0.0002) | (0.0014) | (0.0004) | (0.0004) | (0.0004) | (0.0010) |
| Traditional university | 0.0056*** | 0.0004* | 0.0023*** | 0.0174*** | -0.0027*** | -0.0003 | -0.0018** | -0.0130*** |
| | (0.0009) | (0.0002) | (0.0004) | (0.0027) | (0.0006) | (0.0007) | (0.0007) | (0.0016) |
| Does not know/No response | -0.0001 | -0.0000 | -0.0000 | -0.0001 | -0.0003*** | -0.0000 | -0.0001 | -0.0012*** |
| | (0.0002) | (0.0000) | (0.0001) | (0.0005) | (0.0001) | (0.0001) | (0.0001) | (0.0003) |
| Incomplete | 0.0008** | 0.0001 | 0.0004** | 0.0017** | -0.0008*** | -0.0001 | -0.0000 | -0.0016*** |
| | (0.0003) | (0.0001) | (0.0002) | (0.0007) | (0.0002) | (0.0003) | (0.0003) | (0.0006) |
| Experience | -0.0204*** | -0.0000 | -0.0075*** | -0.0492*** | 0.0529* | 0.0072 | 0.0444 | 0.1474* |
| | (0.0018) | (0.0018) | (0.0017) | (0.0048) | (0.0278) | (0.0324) | (0.0348) | (0.0786) |
| Experience-squared | 0.0160*** | 0.0012 | 0.0052*** | 0.0401*** | -0.0232 | 0.0042 | -0.0162 | -0.0744* |
| | (0.0016) | (0.0016) | (0.0015) | (0.0043) | (0.0158) | (0.0183) | (0.0197) | (0.0446) |
| Male | -0.0040*** | -0.0025*** | -0.0047*** | -0.0049*** | -0.0077* | -0.0223*** | -0.0156*** | -0.0083 |
| | (0.0005) | (0.0004) | (0.0006) | (0.0008) | (0.0045) | (0.0052) | (0.0056) | (0.0127) |
| Demographic dummies | -0.0060*** | -0.0018*** | -0.0061*** | -0.0076*** | -0.0021 | -0.0039 | 0.0009 | 0.0035 |
| | (0.0006) | (0.0005) | (0.0006) | (0.0014) | (0.0037) | (0.0043) | (0.0046) | (0.0105) |
| Occupation dummies | 0.0170*** | -0.0005 | 0.0096*** | 0.0458*** | 0.0085 | -0.0087 | 0.0252** | -0.0205 |
| | (0.0018) | (0.0010) | (0.0017) | (0.0037) | (0.0089) | (0.0105) | (0.0111) | (0.0251) |
| Industry dummies | -0.0022** | 0.0022** | 0.0007 | -0.0075*** | -0.0497*** | -0.0488*** | -0.0565*** | -0.0090 |
| | (0.0010) | (0.0009) | (0.0010) | (0.0026) | (0.0149) | (0.0175) | (0.0187) | (0.0423) |
| Formal | 0.0002 | 0.0004 | 0.0002 | -0.0000 | -0.0277*** | -0.1414*** | -0.0385*** | 0.0325 |
| | (0.0005) | (0.0008) | (0.0003) | (0.0000) | (0.0103) | (0.0120) | (0.0129) | (0.0291) |
| Region dummies | 0.0008 | 0.0002 | 0.0004 | 0.0025** | 0.0135*** | 0.0175*** | 0.0109** | 0.0341*** |
| | (0.0006) | (0.0005) | (0.0006) | (0.0011) | (0.0038) | (0.0045) | (0.0048) | (0.0108) |
| Urban | 0.0001 | 0.0001 | 0.0001 | -0.0000 | -0.0033 | 0.0054 | -0.0046 | -0.0299 |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0109) | (0.0127) | (0.0136) | (0.0308) |
| Constant | | | | | 0.1289*** | 0.3223*** | 0.1315*** | -0.0593 |
| | | | | | (0.0246) | (0.0287) | (0.0307) | (0.0695) |
| Observations | 71,169 | 71,169 | 71,169 | 71,169 | 71,169 | 71,169 | 71,169 | 71,169 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). Numbers in parentheses represent standard errors. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

TABLE S.16
FIRM SIZE DISTRIBUTIONS IN 2015 AND 2017

| Firm size categories | 2015 | 2017 |
|---|---|---|
| 200 workers or more | 0.344 | 0.365 |
| 50-199 workers | 0.203 | 0.196 |
| 10-49 workers | 0.242 | 0.232 |
| 6-9 workers | 0.076 | 0.079 |
| 5 workers or less | 0.134 | 0.127 |

Source: Authors' calculations based on data from the CASEN 2015 and 2017 surveys.

## TABLE S.17
ESTIMATION RESULTS OF THE MEAN AND UNCONDITIONAL QUANTILE REGRESSIONS FOR LOG HOURLY WAGES IN 2015 AND 2017, WITH OCCUPATION AND FIRM SIZE DUMMIES

| | 2015 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Primary | -0.110*** | -0.092*** | -0.166*** | -0.023* | -0.083*** | -0.058*** | -0.132*** | 0.004 |
| | (0.008) | (0.018) | (0.015) | (0.013) | (0.010) | (0.013) | (0.016) | (0.018) |
| Technical degree | | | | | | | | |
| CFT | 0.201*** | 0.087*** | 0.282*** | 0.156*** | 0.105*** | 0.026* | 0.117*** | 0.044 |
| | (0.013) | (0.020) | (0.028) | (0.049) | (0.015) | (0.016) | (0.030) | (0.053) |
| IP | 0.231*** | 0.093*** | 0.311*** | 0.238*** | 0.101*** | 0.021* | 0.142*** | -0.056 |
| | (0.010) | (0.015) | (0.026) | (0.050) | (0.011) | (0.011) | (0.024) | (0.076) |
| New private university | 0.256*** | 0.069* | 0.364*** | 0.147 | 0.085*** | 0.054 | 0.096 | 0.164 |
| | (0.029) | (0.040) | (0.052) | (0.100) | (0.026) | (0.041) | (0.081) | (0.113) |
| Traditional university | 0.307*** | 0.099*** | 0.306*** | 0.289* | 0.245*** | 0.073*** | 0.318*** | 0.260** |
| | (0.040) | (0.032) | (0.069) | (0.164) | (0.033) | (0.020) | (0.055) | (0.130) |
| Does not know/No response | 0.210*** | 0.102* | 0.322*** | -0.002 | 0.055 | 0.016 | 0.121** | -0.130** |
| | (0.049) | (0.057) | (0.098) | (0.115) | (0.034) | (0.040) | (0.060) | (0.065) |
| Incomplete | 0.093*** | 0.050** | 0.173*** | -0.039 | 0.065*** | -0.002 | 0.119*** | 0.021 |
| | (0.014) | (0.025) | (0.033) | (0.036) | (0.016) | (0.021) | (0.034) | (0.055) |
| Professional degree | | | | | | | | |
| IP | 0.375*** | 0.089*** | 0.411*** | 0.520*** | 0.270*** | 0.048*** | 0.281*** | 0.511*** |
| | (0.016) | (0.025) | (0.033) | (0.103) | (0.017) | (0.015) | (0.033) | (0.119) |
| New private university | 0.540*** | 0.113*** | 0.479*** | 0.878*** | 0.324*** | 0.038* | 0.256*** | 0.689*** |
| | (0.012) | (0.016) | (0.028) | (0.112) | (0.012) | (0.022) | (0.042) | (0.104) |
| Traditional university | 0.681*** | 0.139*** | 0.532*** | 1.288*** | 0.517*** | 0.051*** | 0.330*** | 1.307*** |
| | (0.012) | (0.016) | (0.025) | (0.139) | (0.012) | (0.014) | (0.028) | (0.125) |
| Does not know/No response | 0.397*** | 0.161*** | 0.501*** | 0.365 | 0.421*** | 0.082*** | 0.356*** | 0.589*** |
| | (0.043) | (0.026) | (0.063) | (0.263) | (0.032) | (0.015) | (0.037) | (0.206) |
| Incomplete | 0.197*** | 0.038 | 0.236*** | 0.209*** | 0.141*** | 0.032** | 0.164*** | 0.220*** |
| | (0.013) | (0.034) | (0.033) | (0.060) | (0.014) | (0.014) | (0.031) | (0.066) |

| | 2015 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Post-graduate degree | | | | | | | | |
| New private university | 0.827*** | 0.095*** | 0.478*** | 1.858*** | 0.838*** | 0.055*** | 0.345*** | 2.790*** |
| | (0.029) | (0.019) | (0.032) | (0.274) | (0.029) | (0.019) | (0.036) | (0.371) |
| Traditional university | 1.102*** | 0.110*** | 0.477*** | 2.706*** | 0.808*** | 0.042*** | 0.293*** | 2.741*** |
| | (0.022) | (0.018) | (0.028) | (0.214) | (0.020) | (0.014) | (0.031) | (0.250) |
| Does not know/No response | 1.062*** | 0.218*** | 0.537*** | 2.397** | 0.528*** | 0.049* | 0.295 | 0.758 |
| | (0.151) | (0.064) | (0.087) | (1.015) | (0.084) | (0.028) | (0.204) | (0.602) |
| Incomplete | 0.888*** | -0.008 | 0.397*** | 2.046*** | 0.506*** | 0.055*** | 0.351*** | 1.485*** |
| | (0.035) | (0.111) | (0.097) | (0.366) | (0.042) | (0.016) | (0.042) | (0.412) |
| Experience | 0.022*** | 0.003* | 0.011*** | 0.046*** | 0.021*** | 0.000 | 0.009*** | 0.063*** |
| | (0.001) | (0.002) | (0.002) | (0.007) | (0.001) | (0.002) | (0.002) | (0.008) |
| Experience-squared | -0.047*** | -0.006 | -0.021*** | -0.101*** | -0.044*** | -0.002 | -0.016*** | -0.143*** |
| | (0.003) | (0.005) | (0.006) | (0.016) | (0.003) | (0.004) | (0.006) | (0.017) |
| Male | 0.136*** | 0.083*** | 0.153*** | 0.156*** | 0.120*** | 0.039*** | 0.137*** | 0.158*** |
| | (0.005) | (0.012) | (0.011) | (0.028) | (0.006) | (0.007) | (0.013) | (0.039) |
| Head of the household | 0.087*** | -0.004 | 0.081*** | 0.202*** | 0.081*** | 0.010 | 0.090*** | 0.204*** |
| | (0.005) | (0.009) | (0.010) | (0.021) | (0.005) | (0.007) | (0.011) | (0.032) |
| Married | 0.085*** | 0.018** | 0.072*** | 0.149*** | 0.084*** | 0.008 | 0.056*** | 0.258*** |
| | (0.005) | (0.009) | (0.011) | (0.024) | (0.006) | (0.007) | (0.010) | (0.034) |
| Occupation categories | | | | | | | | |
| Managers | 0.948*** | 0.174*** | 0.593*** | 1.820*** | 1.045*** | 0.124*** | 0.732*** | 2.685*** |
| | (0.020) | (0.025) | (0.033) | (0.164) | (0.021) | (0.015) | (0.048) | (0.405) |
| Professionals | 0.563*** | 0.188*** | 0.642*** | 0.828*** | 0.724*** | 0.117*** | 0.731*** | 1.340*** |
| | (0.013) | (0.023) | (0.029) | (0.117) | (0.012) | (0.015) | (0.034) | (0.116) |
| Technicians and associate professionals | 0.351*** | 0.183*** | 0.507*** | 0.318*** | 0.389*** | 0.107*** | 0.551*** | 0.383*** |
| | (0.010) | (0.022) | (0.025) | (0.044) | (0.011) | (0.013) | (0.028) | (0.051) |
| Clerks | 0.188*** | 0.176*** | 0.354*** | -0.001 | 0.156*** | 0.087*** | 0.284*** | -0.069*** |
| | (0.009) | (0.022) | (0.023) | (0.037) | (0.010) | (0.013) | (0.024) | (0.027) |
| Service and sales workers | 0.149*** | 0.079*** | 0.176*** | 0.193*** | 0.125*** | 0.038** | 0.160*** | 0.163*** |
| | (0.009) | (0.022) | (0.021) | (0.026) | (0.010) | (0.015) | (0.031) | (0.036) |

| | 2015 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Skilled agricultural and fishery workers | 0.041*** | -0.037 | 0.106*** | 0.021 | 0.087*** | 0.041* | 0.186*** | -0.022 |
| | (0.015) | (0.033) | (0.022) | (0.023) | (0.022) | (0.023) | (0.034) | (0.044) |
| Craft and related trades workers | 0.143*** | 0.136*** | 0.308*** | -0.105*** | 0.127*** | 0.083*** | 0.294*** | -0.135*** |
| | (0.009) | (0.020) | (0.023) | (0.026) | (0.011) | (0.013) | (0.024) | (0.034) |
| Plant and machine operators and assemblers | 0.121*** | 0.106*** | 0.297*** | -0.140*** | 0.129*** | 0.076*** | 0.275*** | -0.149*** |
| | (0.010) | (0.022) | (0.022) | (0.024) | (0.011) | (0.013) | (0.026) | (0.032) |
| Firm size categories | | | | | | | | |
| 200 workers or more | 0.145*** | 0.101*** | 0.190*** | 0.155*** | 0.133*** | 0.069*** | 0.122*** | 0.170*** |
| | (0.008) | (0.017) | (0.017) | (0.029) | (0.009) | (0.014) | (0.022) | (0.043) |
| 50-199 workers | 0.115*** | 0.096*** | 0.180*** | 0.057** | 0.094*** | 0.058*** | 0.096*** | -0.002 |
| | (0.009) | (0.019) | (0.018) | (0.027) | (0.010) | (0.015) | (0.027) | (0.045) |
| 10-49 workers | 0.078*** | 0.106*** | 0.153*** | -0.010 | 0.074*** | 0.059*** | 0.112*** | 0.007 |
| | (0.008) | (0.018) | (0.017) | (0.025) | (0.009) | (0.015) | (0.024) | (0.039) |
| 6-9 workers | 0.037*** | 0.072*** | 0.064*** | -0.017 | 0.034*** | 0.061*** | 0.020 | -0.026 |
| | (0.010) | (0.022) | (0.023) | (0.027) | (0.012) | (0.016) | (0.024) | (0.048) |
| Formal | 0.183*** | 0.366*** | 0.156*** | -0.019 | 0.160*** | 0.201*** | 0.087*** | 0.038 |
| | (0.008) | (0.039) | (0.014) | (0.022) | (0.009) | (0.016) | (0.020) | (0.037) |
| Urban | 0.002 | -0.002 | 0.022* | -0.025 | 0.034*** | 0.034*** | 0.047*** | -0.030 |
| | (0.008) | (0.014) | (0.012) | (0.017) | (0.009) | (0.010) | (0.011) | (0.026) |
| Constant | 6.574*** | 6.333*** | 6.446*** | 7.415*** | 6.646*** | 6.639*** | 6.616*** | 7.224*** |
| | (0.017) | (0.064) | (0.038) | (0.104) | (0.019) | (0.031) | (0.044) | (0.106) |
| Observations | 40,147 | 40,147 | 40,147 | 40,147 | 30,279 | 30,279 | 30,279 | 30,279 |
| *R*-squared | 0.575 | 0.117 | 0.375 | 0.375 | 0.588 | 0.105 | 0.385 | 0.390 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). Numbers in parentheses represent standard errors. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively. The standard errors of the unconditional quantile regressions are calculated via bootstrap with 500 replications. Industry dummies and region dummies are also included.

## TABLE S.18
DECOMPOSITION OF WAGE CHANGES FROM 2015 TO 2017 INTO COMPOSITION AND WAGE STRUCTURE EFFECTS OF EACH EXPLANATORY VARIABLE, WITH OCCUPATION AND FIRM SIZE DUMMIES

| | Composition effect | | | | Wage structure effect | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Overall | 0.0338*** | 0.0065*** | 0.0241*** | 0.0648*** | 0.0102*** | 0.0784*** | -0.0066 | -0.0190* |
| | (0.0039) | (0.0018) | (0.0037) | (0.0070) | (0.0033) | (0.0038) | (0.0045) | (0.0102) |
| Primary | 0.0017*** | 0.0014*** | 0.0026*** | 0.0004 | 0.0029** | 0.0036** | 0.0037** | 0.0028 |
| | (0.0003) | (0.0003) | (0.0004) | (0.0003) | (0.0013) | (0.0015) | (0.0018) | (0.0041) |
| Higher education | 0.0318*** | 0.0065*** | 0.0251*** | 0.0584*** | -0.0631*** | -0.0281*** | -0.0743*** | -0.0298** |
| | (0.0022) | (0.0009) | (0.0018) | (0.0045) | (0.0048) | (0.0056) | (0.0065) | (0.0146) |
| Technical degree | 0.0032*** | 0.0011*** | 0.0041*** | 0.0023*** | -0.0155*** | -0.0089*** | -0.0218*** | -0.0236*** |
| | (0.0006) | (0.0004) | (0.0008) | (0.0008) | (0.0017) | (0.0019) | (0.0023) | (0.0051) |
| CFT | -0.0009*** | -0.0004*** | -0.0013*** | -0.0007*** | -0.0028*** | -0.0018*** | -0.0048*** | -0.0033* |
| | (0.0003) | (0.0001) | (0.0004) | (0.0003) | (0.0006) | (0.0006) | (0.0008) | (0.0018) |
| IP | 0.0017*** | 0.0007*** | 0.0022*** | 0.0017*** | -0.0093*** | -0.0051*** | -0.0122*** | -0.0211*** |
| | (0.0005) | (0.0002) | (0.0006) | (0.0005) | (0.0011) | (0.0012) | (0.0014) | (0.0032) |
| New private university | 0.0010*** | 0.0003 | 0.0014*** | 0.0006* | -0.0016*** | -0.0001 | -0.0025*** | 0.0002 |
| | (0.0002) | (0.0002) | (0.0003) | (0.0003) | (0.0004) | (0.0004) | (0.0005) | (0.0011) |
| Traditional university | 0.0008*** | 0.0003* | 0.0008*** | 0.0007** | -0.0003 | -0.0001 | 0.0001 | -0.0002 |
| | (0.0002) | (0.0001) | (0.0002) | (0.0003) | (0.0003) | (0.0003) | (0.0004) | (0.0008) |
| Does not know/No response | 0.0007*** | 0.0003 | 0.0011*** | -0.0000 | -0.0008** | -0.0004 | -0.0010** | -0.0007 |
| | (0.0002) | (0.0002) | (0.0003) | (0.0004) | (0.0003) | (0.0004) | (0.0004) | (0.0009) |
| Incomplete | -0.0000 | -0.0000 | -0.0001 | 0.0000 | -0.0007 | -0.0013** | -0.0013* | 0.0015 |
| | (0.0001) | (0.0001) | (0.0002) | (0.0000) | (0.0005) | (0.0006) | (0.0007) | (0.0016) |
| Professional degree | 0.0200*** | 0.0044*** | 0.0170*** | 0.0352*** | -0.0405*** | -0.0177*** | -0.0477*** | -0.0110 |
| | (0.0019) | (0.0007) | (0.0017) | (0.0035) | (0.0035) | (0.0041) | (0.0048) | (0.0105) |
| IP | 0.0014*** | 0.0003** | 0.0015*** | 0.0019*** | -0.0028*** | -0.0011 | -0.0034*** | -0.0003 |
| | (0.0004) | (0.0001) | (0.0005) | (0.0006) | (0.0006) | (0.0007) | (0.0008) | (0.0019) |
| New private university | -0.0002 | -0.0000 | -0.0002 | -0.0004 | -0.0168*** | -0.0058*** | -0.0173*** | -0.0147*** |
| | (0.0011) | (0.0002) | (0.0010) | (0.0018) | (0.0013) | (0.0015) | (0.0018) | (0.0040) |

| | Composition effect | | | | Wage structure effect | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Traditional university | 0.0167*** | 0.0034*** | 0.0131*** | 0.0316*** | -0.0191*** | -0.0102*** | -0.0235*** | 0.0022 |
| | (0.0016) | (0.0005) | (0.0013) | (0.0031) | (0.0019) | (0.0023) | (0.0027) | (0.0059) |
| Does not know/No response | 0.0014*** | 0.0006** | 0.0017*** | 0.0013*** | 0.0001 | -0.0005 | -0.0009* | 0.0013 |
| | (0.0003) | (0.0002) | (0.0003) | (0.0004) | (0.0003) | (0.0004) | (0.0004) | (0.0009) |
| Incomplete | 0.0007*** | 0.0001* | 0.0009*** | 0.0008** | -0.0020*** | -0.0002 | -0.0025*** | 0.0004 |
| | (0.0003) | (0.0001) | (0.0003) | (0.0003) | (0.0007) | (0.0008) | (0.0009) | (0.0021) |
| Post-graduate degree | 0.0087*** | 0.0010*** | 0.0040*** | 0.0209*** | -0.0071*** | -0.0015* | -0.0048*** | 0.0048** |
| | (0.0013) | (0.0003) | (0.0006) | (0.0030) | (0.0008) | (0.0009) | (0.0011) | (0.0024) |
| New private university | 0.0014*** | 0.0002* | 0.0008*** | 0.0032*** | 0.0001 | -0.0003 | -0.0011** | 0.0074*** |
| | (0.0005) | (0.0001) | (0.0003) | (0.0012) | (0.0003) | (0.0004) | (0.0004) | (0.0011) |
| Traditional university | 0.0070*** | 0.0007*** | 0.0030*** | 0.0172*** | -0.0055*** | -0.0013* | -0.0034*** | 0.0007 |
| | (0.0011) | (0.0002) | (0.0005) | (0.0026) | (0.0006) | (0.0007) | (0.0008) | (0.0017) |
| Does not know/No response | 0.0007*** | 0.0001 | 0.0003** | 0.0015*** | -0.0004*** | -0.0001 | -0.0002 | -0.0014*** |
| | (0.0002) | (0.0001) | (0.0002) | (0.0005) | (0.0002) | (0.0002) | (0.0002) | (0.0005) |
| Incomplete | -0.0004 | 0.0000 | -0.0002 | -0.0010 | -0.0013*** | 0.0002 | -0.0002 | -0.0019*** |
| | (0.0004) | (0.0000) | (0.0002) | (0.0009) | (0.0002) | (0.0002) | (0.0003) | (0.0006) |
| Experience | -0.0165*** | -0.0026** | -0.0085*** | -0.0343*** | -0.0233 | -0.0576* | -0.0464 | 0.3067*** |
| | (0.0017) | (0.0011) | (0.0014) | (0.0038) | (0.0275) | (0.0315) | (0.0373) | (0.0855) |
| Experience-squared | 0.0132*** | 0.0018* | 0.0060*** | 0.0285*** | 0.0091 | 0.0163 | 0.0215 | -0.1659*** |
| | (0.0015) | (0.0011) | (0.0012) | (0.0033) | (0.0158) | (0.0180) | (0.0214) | (0.0491) |
| Male | -0.0019*** | -0.0012*** | -0.0021*** | -0.0022*** | -0.0088** | -0.0244*** | -0.0091 | 0.0010 |
| | (0.0005) | (0.0003) | (0.0006) | (0.0006) | (0.0043) | (0.0049) | (0.0058) | (0.0132) |
| Demographic dummies | -0.0042*** | -0.0007** | -0.0036*** | -0.0079*** | -0.0028 | 0.0039 | -0.0005 | 0.0333*** |
| | (0.0005) | (0.0003) | (0.0005) | (0.0011) | (0.0038) | (0.0043) | (0.0051) | (0.0118) |
| Occupation dummies | 0.0113*** | 0.0014* | 0.0064*** | 0.0266*** | 0.0277*** | -0.0469*** | 0.0118 | 0.0979*** |
| | (0.0016) | (0.0007) | (0.0017) | (0.0031) | (0.0087) | (0.0100) | (0.0118) | (0.0267) |
| Firm size dummies | 0.0015*** | 0.0006** | 0.0013*** | 0.0028*** | -0.0098 | -0.0311*** | -0.0541*** | -0.0030 |
| | (0.0004) | (0.0003) | (0.0005) | (0.0006) | (0.0099) | (0.0113) | (0.0134) | (0.0307) |
| Industry dummies | -0.0037*** | -0.0004 | -0.0035*** | -0.0101*** | -0.0112 | 0.0373** | -0.0163 | -0.0823* |
| | (0.0008) | (0.0006) | (0.0009) | (0.0022) | (0.0149) | (0.0170) | (0.0201) | (0.0461) |

| | Composition effect | | | | Wage structure effect | | | |
|---|---|---|---|---|---|---|---|---|
| Explanatory variables | Mean | Q10 | Q50 | Q90 | Mean | Q10 | Q50 | Q90 |
| Formal | -0.0005 | -0.0011 | -0.0005 | 0.0001 | -0.0210* | -0.1506*** | -0.0624*** | 0.0515 |
| | (0.0004) | (0.0008) | (0.0003) | (0.0001) | (0.0108) | (0.0123) | (0.0146) | (0.0334) |
| Region dummies | 0.0011* | 0.0007 | 0.0008 | 0.0025*** | 0.0105*** | 0.0175*** | 0.0273*** | -0.0353*** |
| | (0.0006) | (0.0005) | (0.0008) | (0.0008) | (0.0037) | (0.0042) | (0.0050) | (0.0115) |
| Urban | 0.0000 | -0.0000 | 0.0001 | -0.0001 | 0.0284*** | 0.0325*** | 0.0225 | -0.0052 |
| | (0.0000) | (0.0001) | (0.0001) | (0.0001) | (0.0108) | (0.0124) | (0.0147) | (0.0337) |
| Constant | | | | | 0.0717*** | 0.3061*** | 0.1695*** | -0.1906** |
| | | | | | (0.0258) | (0.0296) | (0.0350) | (0.0801) |
| Observations | 70,426 | 70,426 | 70,426 | 70,426 | 70,426 | 70,426 | 70,426 | 70,426 |

Note: Q, quantile; CFT, Technical Training Centers (*Centros de Formación Técnica*); IP, Professional Institutes (*Institutos Profesionales*). Numbers in parentheses represent standard errors. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

# On the welfare analysis of external reference pricing and reimbursement policy*

***Análisis de bienestar de precios referenciales externos y política de reembolso***

Van-Chung Dong**
Yan-Shu Lin***
Pei-Cyuan Shih****

**Abstract**

*The co-existence of external referencing pricing (ERP) and reimbursement policy is common in many countries. Thus, this research examines whether or not the imposition of ERP is socially desirable in the presence of reimbursement policy. For direct sales channel, we find that the home social welfare is worse-off with ERP if the home copayment rate is too high. Our main results are robust under indirect sales channel. Moreover, the home social welfare under the pharmacy-purchasing-price (PPP) ERP is larger than that under the ex-factory-price (EFP) ERP if the home copayment rate is high enough. Finally, the profit of brand-name firm under indirect sales channel is higher than that under direct sales channel if the home copayment rate is too high.*

Key words: *Copayment rate, direct and indirect sales channeles, external reference pricing, reimbursement policy.*

JEL Classification: *F10, I11, I18, D42.*

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**Resumen**

*Precios referenciales externos (ERP) y políticas de reembolso coexisten en muchos países. Este documento evalúa si ERP son socialmente deseables en presencia de políticas de reembolso. Para el canal de venta directa, encontramos que el bienestar social del hogar está peor con ERP si la tasa de copago de la vivienda es demasiado alta. Nuestros principales resultados son robustos bajo el canal de ventas indirectas. Además, el bienestar social bajo el precio de compra de farmacia (PPP) es mayor que el del ERP de precio de fábrica (EFP) si la tasa de copago es lo suficientemente alta. Finalmente, el beneficio de la empresa de marca en el canal de ventas indirectas es mayor que el del canal de ventas directas si la tasa de copago es demasiado alta.*

Palabras clave: *Tasa de copago, canales de venta directa e indirecta, precios de referencia externos, política de reembolso.*

Clasificación JEL: *F10, I11, I18, D42.*

## 1. Introduction

External reference pricing (ERP) is the most common tool implemented by many countries to achieve the goal of pharmaceutical cost containment, where drug prices in one or several countries are used as referencing prices to determine drug prices in a given country. Overall, 24 of 30 OECD countries and 20 of 27 EU countries apply ERP to pricing drugs (Dedet, 2016; Vogler *et al.*, 2020). The practice of ERP is also popular in other regions such as the Middle East and South Asia, East Asia, Africa, and South America (Verghese *et al.*, 2019; Vogler *et al.*, 2020). If firms sell directly, ERP is subject to foreign prices. However, if firms serve globally throughout agents, ERP is subject to either wholesale prices or foreign prices, that is so-called ex-factory-price (EFP) or pharmacy-purchasing-price (PPP) ERP, respectively.

From 2018, ERP has received much attention as President Trump's administration proposed to adopt ERP. Supporting this plan, Kang *et al.* (2019) and Mulcahy *et al.* (2021) show that ERP could reduce the U.S. drug expenditure and improve the social welfare. Theoretically, Geng and Saggi (2017, 2020) and Iravani *et al.* (2020) show that a country is always socially desirable with ERP if a producer exports. Similarly, Marinoso *et al.* (2011) indicate that a country is better-off with ERP if its fixed copayment is high. Empirically, Hakonsen *et al.* (2009) indicate that ERP is the most successful method to reduce drug prices in nine EU countries. Salter (2015) and Holtorf *et al.* (2019) find that ERP might enhance the welfare of home countries. Considering the EU region, Vogler *et al.* (2014) suggest that ERP is effective to raise patients' access to drugs and to reduce healthcare expenditure. Disagreeing with arguments, Kanavos *et al.* (2020) criticize that the efficiency of ERP is not clear, especially in the long run, and it may bring some unintended consequences to consumers and public payers. In sum, there is a strong confirmation about the success of ERP, but there still has a debate. In this paper, we investigate whether ERP is a welfare-improving policy, and under what circumstances ERP may not be a socially beneficial policy.

In practice, the co-existence of ERP and reimbursement policy is common in many countries (see Table 1). The reimbursement policy covers some certain expenses to receive healthcare services or medical bills. Motive to implement the reimbursement policy is two-folds: Encouraging pharmaceutical firms to research and develop potential drugs/medicines, and helping consumers to access more drugs (Bruen *et al.*, 2016). In Slovakia, authorities apply ERP to determine reimbursement policy and to manage national expenditure for pharmaceuticals (Albreht *et al.*, 2009). In Italy, ERP is used as a basis to negotiate drug prices and to discuss reimbursement process. Similarly, in Spain and France, ERP is a crucial tool to negotiate prices between authorities and drug manufacturers (Ruggeri and Nolte, 2013; Kanavos *et al.*, 2017). Stargardt and Schreyogg (2007) suggest that countries can use ERP to determine reimbursement prices. Practically, the reimbursement policy can be a fixed copayment, a copayment rate, or a combination (Kanavos *et al.*, 2017; Leopold *et al.*, 2012; Vogler *et al.*, 2018). In this paper, we consider the reimbursement policy as a copayment rate only. Copayment rates are usually set by law, thus they take time to amend (Marinoso *et al.*, 2011). Moreover, copayment rates often vary on drugs. Therefore, we take the copayment rate as given, and our analysis can carry out any possibility of copayment rate.

It is a fact that ERP is not the only instrument to deter the market power of brand-name firms. Introducing generic drugs can achieve the same results. The penetration of generic drugs in market is allowed after patents are expired, that will make brand-name firms behave more aggressively. As a result, generic drugs can improve social welfare (Brekke *et al.*, 2011; Dirnagl and Cocoli, 2016; Geng and Saggi, 2020). Give the above discussions, we therefore incorporate the reimbursement policy and generic producer to figure out how they affect the implementation of ERP.

In pharmaceutical industry, producers commonly distribute drugs throughout either direct or indirect sales channels (Kanavos *et al.*, 2011; Iravani *et al.*, 2020). Under direct sales channel, manufacturers serve foreign markets directly; while under indirect sales channel, they serve globally through foreign agents. In this paper, we examine both distribution channels.

We build a simple two-country model: home country and foreign country. There is a brand-name producer located in the home and potentially serves both countries. In each country, there is a local generic producer. Since the generic drug is off-patent, it can be produced ubiquitously. Practically, generic drugs usually face the difficulties associated to compulsory licenses and documenting processes for exporting. Thus, we assume two generic firms serve locally only.

TABLE 1
PRACTICE OF ERP AND REIMBURSEMENT IN SELECTED COUNTIRES

| Country | ERP | | | | Reimbursement Type | Link |
|---|---|---|---|---|---|---|
| | Scope | Types | Basket size | Revision | | |
| Austria | All medicines | Average | 24 | 6 months | Fixed copayment | Yes |
| Belgium | National positive list | Average | 26 | Launch only | Copayment rate | No |
| Bulgaria | National positive list | Lowest | 10 | 6 months | Copayment rate | Yes |
| Czech | National positive list | Average | 17 | Annually | Copayment rate | Yes |
| Estonia | National positive list | Ceiling | 3 | Annually | Fixed copayment + Copayment rate | Yes |
| France | National positive list | Flooring | 4 | 4-5 years | Fixed copayment + Copayment rate | Yes |
| Greece | National positive list | Average | 22 | 2 years | Fixed copayment + Copayment rate | Yes |
| Latvia | National positive list | Lowest | 27 | 2 years | Fixed copayment + Copayment rate | Yes |
| Portugal | National positive list | Lowest | 3 | Annually | Copayment rate | Yes |
| Romania | All medicines | Lowest | 12 | Annually | Copayment rate | Yes |
| Slovakia | National positive list | Average | 27 | 6 months | Copayment rate | Yes |
| Slovenia | National positive list | Lowest | 3 | 6 months | Copayment rate | No |
| Spain | National positive list | Lowest | 16 | 2 years | Copayment rate | Yes |
| Jordan | All medicines | Average | 16 | 2 years | Copayment rate | Yes/ Critical |
| Lebanon | All medicines | Ceiling | 14 | 5 years | Copayment rate | Yes/ Critical |

Source: Complication from Leopold *et al.* (2012), Kanavos *et al.* (2017), and Vogler *et al.* (2018).

We consider two scenarios that either or not the home government indexes the brand-name drug in an ERP system.

Our findings show that under direct sales channel, the home social welfare can be worse-off with ERP. With ERP, an increase in the home copayment rate creates both negative effects and positive effects on the home social welfare; while without ERP, it is independent of the social welfare. Thus, if the home copayment rate is high enough, the home social welfare is worse-off with ERP. Our main insights are robust under indirect sales channel. Comparatively, the home social welfare (brand-name profit) is better-off with PPP ERP (indirect sales channel) if the home copayment rate is relatively high.

Our model is close to Geng and Saggi (2017, 2020) and Iravani *et al.* (2020), but it is different in several key factors. First, Geng and Saggi (2017, 2020) and

Iravani *et al.* (2020) ignore the role of reimbursement policy. Second, Geng and Saggi (2017, 2020) consider only direct sales channel, while both direct and indirect sales channels are incorporated in our model.

Our model is also related to Marinoso *et al.* (2011), but they consider a fixed copayment, while we investigate a copayment rate. A fixed copayment is inflexible and it does not affect the market price. However, a copayment rate will affect the market price, then indirectly affects ERP. In addition, they focus on consumer surplus only since a drug producer is located in a third country; while we consider the home social welfare including the profits of producers.

The remainder of the paper is structured as follows. Section 2 describes the basic model. Section 3 investigates direct sales channel. Section 4 analyzes indirect sales channel. Section 5 concludes the paper.

## 2. Basic model

We consider a pharmaceutical industry consisting of a brand-name drug and a generic drug in a two-country model: home (H) and foreign (F). A brand-name drug producer is located in country H, and potentially serves both markets. The brand-name drug is on-patent and protected in both countries. Each country has one local generic producer that produces generic drug and serves locally. For simplicity, the marginal production costs of two drugs are normalized to zero.[1]

An individual consumer's utility when she consumes the brand-name drug and generic drug is $u=\theta-p+\gamma p$ and $\tilde{u}=\alpha\theta-\tilde{p}+\gamma\tilde{p}$, respectively. If a consumer does not buy products, utility is zero. We note that the variables with no superscript "*" denote variables in country H, while those with superscript "*" denotes variables in country F. $\theta$ represents the consumer's taste of quality. Two countries are considered as both having a unity continuum of consumers, but the different tastes of quality that are uniformly distributed in interval $\left[0,\bar{\theta}\right]$ in country H and interval [0,1] in country F. $\alpha$ is the effectiveness of generic drug, $0<\alpha<1,$ implying that the brand-name drug is perceived higher quality. For simplicity, we assume that the quality levels of generic drugs in both countries are equal, i.e., $\alpha^*=\alpha$ . $p$ and $\tilde{p}$ are the brand-name and generic prices, respectively. $\gamma\in[0,1)$ is a copayment rate that is paid by authorities, i.e., national health agencies. If $\gamma=0,$ consumers pay full prices. We restrict $\gamma<1$ for two reasons: Ensuring meaningful analysis and avoiding a scenario of wasteful source by oversupplying of drugs. Two countries differ in two main features: Consumers' taste of drug quality, i.e., $\bar{\theta}\geq\bar{\theta}^*=1$ and copayment rates, i.e., $\gamma$ and $\gamma^*$ .

In country H, a marginal consumer $\theta_b$ between buying the brand-name drug or generic drug is $\theta_b=\dfrac{(1-\gamma)(p-\tilde{p})}{1-\alpha}$. A marginal consumer $\theta_g$ between

[1] See Marinoso *et al.* (2011), Geng and Saggi (2017, 2020), and Iravani *et al.* (2020).

buying and not buying the generic drug is $\theta_g = \frac{(1-\gamma)\tilde{p}}{\alpha}$. Thus, demands for the brand-name and generic drugs are $q = \frac{1}{\bar{\theta}}\left(\bar{\theta} - \theta_b\right)$ and $\tilde{q} = \frac{1}{\bar{\theta}}\left(\theta_b - \theta_g\right)$, respectively. Similarly, in country F, demands for the brand-name and generic drugs are obtained as $q^* = 1 - \theta_b^*$ and $\tilde{q}^* = \theta_b^* - \theta_g^*$, where $\theta_b^* = \frac{\left(1-\gamma^*\right)\left(p^* - \tilde{p}^*\right)}{1-\alpha}$ and $\theta_g^* = \frac{\left(1-\gamma^*\right)\tilde{p}^*}{\alpha}$, respectively.

The game structure is as follows. In the first stage, government H imposes ERP where the home brand-name price is regulated to be equal to its foreign price. In the second stage, the brand-name firm decides to serve either country H only or both countries H and F. If he abandons country F, he competes in price with the generic firm in country H only but does not serve the brand-name drug in country F. If he decides to export, he simultaneously competes in price with the generic firms in both markets. With ERP, if the brand-name firm chooses to serve country H only, that is $\pi_H$, serving as his exporting reservation profit. Hereafter, we assume the brand-name firm has an incentive to serve both markets under ERP. To ensure an incentive for government H to impose ERP and the brand-name firm to export under ERP, we have the following assumption:

**Assumption 1:** $\frac{1-\gamma}{1-\gamma^*} \leq \bar{\theta} \leq \frac{3(1-\gamma)}{1-\gamma^*}$.

## 3. Direct sales channel

### 3.1. Without ERP

Under this scenario, the brand-name producer freely serves and competes with the local generic producer in each country. Given that, in the final stage, the brand-name and generic firms maximize the following equation:

$$(1) \qquad \begin{cases} \max\limits_{p,p^*} \Pi = \frac{1}{\bar{\theta}}\left[\bar{\theta} - \frac{(1-\gamma)(p-\tilde{p})}{1-\alpha}\right]p + \left[1 - \frac{\left(1-\gamma^*\right)\left(p^* - \tilde{p}^*\right)}{1-\alpha}\right]p^* \\ \max\limits_{\tilde{p}} \tilde{\pi} = \frac{1}{\bar{\theta}}\left[\frac{(1-\gamma)(p-\tilde{p})}{1-\alpha} - \frac{(1-\gamma)\tilde{p}}{\alpha}\right]\tilde{p} \\ \max\limits_{\tilde{p}^*} \tilde{\pi}^* = \left[\frac{\left(1-\gamma^*\right)\left(p^* - \tilde{p}^*\right)}{1-\alpha} - \frac{\left(1-\gamma^*\right)\tilde{p}^*}{\alpha}\right]\tilde{p}^* \end{cases}$$

It is straightforward to derive the best response functions from the equation (1) as:

$$p(\tilde{p})=\frac{1}{2}\left[\tilde{p}+\frac{(1-\alpha)\bar{\theta}}{1-\gamma}\right],\ p^*\left(\tilde{p}^*\right)=\frac{1}{2}\left(\tilde{p}^*+\frac{1-\alpha}{1-\gamma^*}\right),\ \tilde{p}(p)=\frac{p}{2},\ \tilde{p}^*\left(p^*\right)=\frac{p^*}{2}.$$

The brand-name and generic prices are strategic complements as a change in the brand-name price reinforces a change in the generic price and vice versa.

By solving the maximizing problems in the equation (1), we achieve the equilibrium prices as:

$$p^N=\frac{2\bar{\theta}(1-\alpha)}{(1-\gamma)(4-\alpha)},\quad p^{*N}=\frac{2(1-\alpha)}{\left(1-\gamma^*\right)(4-\alpha)},\quad \tilde{p}^N=\frac{\alpha(1-\alpha)\bar{\theta}}{(1-\gamma)(4-\alpha)},$$
$$\tilde{p}^{*N}=\frac{\alpha(1-\alpha)}{\left(1-\gamma^*\right)(4-\alpha)}.$$

The superscript "*N*" denotes the equilibrium outcomes. Using these prices, we can derive the profits as $\Pi^N$ and $\tilde{\pi}^N$.

The home social welfare is defined by the sum of consumer surplus, profits of brand-name and generic firms, and subtraction of expenditure as:

(2) $$sw^N=cs^N+\Pi^N+\tilde{\pi}^N-E^N,$$

where $E^N=\gamma\left(p^Nq^N+\tilde{p}^N\tilde{q}^N\right)$, $cs^N=\frac{1}{\bar{\theta}}\int_{\hat{\theta}_b}^{\bar{\theta}}\left[z-(1-\gamma)p^N\right]dz+\frac{1}{\bar{\theta}}\int_{\hat{\theta}_g}^{\hat{\theta}_b}\left[\alpha z-(1-\gamma)\tilde{p}^N\right]dz.$ All results are reported in Appendix 1.

We perform the effects of the home copayment rate on the equilibrium outcomes in the following lemma.

**Lemma 1.** *Under direct sales channel without ERP, we have:*

*(i) The profits of brand-name and generic firms, and expenditure in country H increase in the home copayment rate;*
*(ii) The consumer surplus and social welfare in country H are independent of the home copayment rate.*
*Proof:* See Appendix 1.

Lemma 1 is standard and in line with the findings by Birg (2015). A higher copayment rate gives rise to consumers' willingness-to-pay, which allows firms to charge higher prices that leads to higher profits. Next, it is found that $\frac{\partial p^N}{\partial\gamma}>0$ and $\frac{\partial\tilde{p}^N}{\partial\gamma}>0,$ indicating that the public expenditure increases with the home copayment rate. Without ERP, two countries H and F are segmented, and two drugs are vertically differentiated. Both firms in each country can adjust the prices to capture all reimbursed payments. Thus, any change in the copayment rate does not influence the effective prices, i.e., $\frac{\partial(1-\gamma)p^N}{\partial\gamma}=0$, $\frac{\partial(1-\gamma)\tilde{p}^N}{\partial\gamma}=0$. This implies that all public expenditure would be completely transferred into profits. Therefore, the consumer surplus and social welfare in country H are independent of the home copayment rate.

### 3.2. With ERP

With ERP, if the brand-name firm exports, the home price is regulated to be equal to its foreign price, i.e., $p=p^*$. Given that, in the final stage, solving the equation (1) and *s.t.* $p=p^*$ yields the equilibrium prices as:

$$p^E=p^{*E}=\frac{4(1-\alpha)\bar{\theta}}{(4-\alpha)\left[(1-\gamma)+(1-\gamma^*)\bar{\theta}\right]},\quad \tilde{p}^E=\tilde{p}^{*E}=\frac{2\alpha(1-\alpha)\bar{\theta}}{(4-\alpha)\left[(1-\gamma)+(1-\gamma^*)\bar{\theta}\right]}.$$

The superscript "*E*" denotes the equilibrium outcomes. By routine calculations, we have the profits as $\Pi^E$ and $\tilde{\pi}^E$. Similarly, we attain the home social welfare, i.e., $sw^E$. All results are reported in Appendix 2.

The following lemma represents the effects of the home copayment rate on the equilibrium outcomes in country H.

**Lemma 2.** *Under direct sales channel with ERP, the following hold:*

*(i) The home brand-name profit, total expenditure, and consumer surplus increase in the home copayment rate; while the home generic and foreign brand-name firms' profits decrease in the home copayment rate;*
*(ii) The home social welfare is a concave function of the home copayment rate.*
*Proof:* See Appendix 2.

It is straightforward to show that ERP generates some negative spillover effects on the foreign brand-name price. This is because when the home price is directly linked by its foreign price, the brand-name firm will set a higher foreign price to reduce its profit loss in country H. An increase in the home copayment rate leads to an increase in the home consumers' willingness-to-pay, leading to an increase in the home brand-name price. In other words, an increase in the home copayment rate makes the home (foreign) brand-name price move closer to (far away from) its free-trade price that increases (decreases) the home (foreign) brand-name profit.

For the home generic profit, we first notice that the copayment rate positively affects the home generic price. However, the copayment rate with ERP negatively affects the home generic demand. This is because the effect of copayment rate with ERP on the brand-name marginal consumer is significantly stronger than that on the generic marginal consumer, [2] suggesting that an increase in the copayment rate reduces the home generic demand. Since the demand effect is stronger than the price effect, the home generic profit is decreasing in the copayment rate.

The effects of the home copayment rate on the consumer surplus and expenditure in country H are intuitive. An increase in the home copayment rate lowers the effective prices, but raises the market prices, which directly increases the consumer surplus and expenditure.

For the home social welfare, we first note that Part (i) of Lemma 2 indicates that an increase in the home copayment rate generates the opposite effects on the components of home social welfare. In addition, when the home copayment rate is small (high), the beneficial effect of ERP on the home social welfare dominates (is dominated by) the negative effect of copayment rate. Therefore, the home social welfare is a concave function of the home copayment rate.

## 3.3. With vs. Without ERP

We first notice that under a case of no home reimbursement policy (i.e., $\gamma = 0$), irrespective of the foreign copayment rate, if the brand-name firm exports, ERP is always socially desirable, i.e., $sw^E\big|_{\gamma=0} > sw^N\big|_{\gamma=0}$. This is because there exists the effect of ERP only, which always benefits the home social welfare. This result is in line with the findings by Geng and Saggi (2017, 2020) and Iravani *et al.* (2020) whereby without reimbursement policy, ERP is always socially desirable for the home country.

We now discuss a case of with the reimbursement policy to see how it affects the home social welfare. Comparing $sw^N$ and $sw^E$, we arrive at the following proposition.

**Proposition 1.** *With direct sales channel, the home social welfare with ERP is lower than that without ERP if $\gamma > \bar{\gamma}$; otherwise, it is higher.*
*Proof*: See Appendix 3.

The finding indicates that incorporating the generic producer and the reimbursement policy may make the home social welfare worse-off with ERP. With ERP, the home generic price is relatively high, but the home generic demand significantly reduces, which results in a higher generic expenditure and a lower generic profit. Precisely, the contribution of generic producer to the home social

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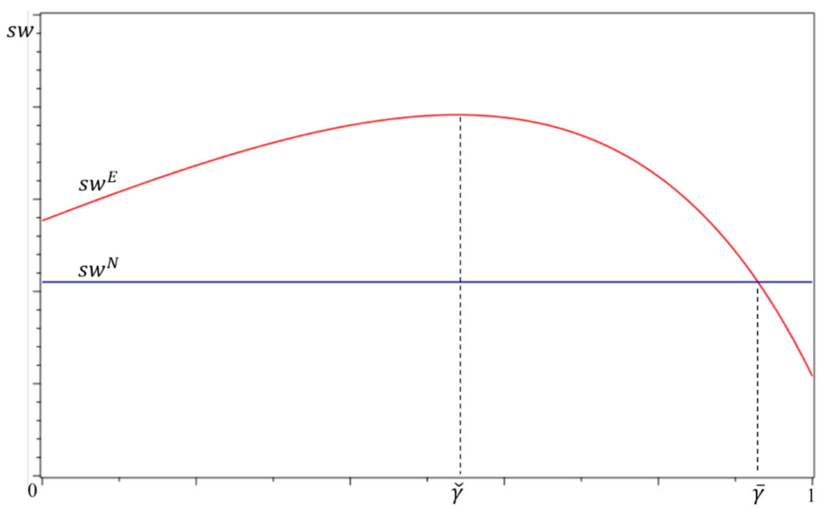
2 $\dfrac{\partial\theta_b^E}{\partial\gamma} = -\dfrac{2(2-\alpha)(1-\gamma^*)\bar{\theta}^2}{(4-\alpha)\left[(1-\gamma)+(1-\gamma^*)\bar{\theta}\right]^2} < 0$, $\dfrac{\partial\theta_g^E}{\partial\gamma} = -\dfrac{2(1-\alpha)(1-\gamma^*)\bar{\theta}^2}{(4-\alpha)\left[(1-\gamma)+(1-\gamma^*)\bar{\theta}\right]^2} < 0$, and $\left|\dfrac{\partial\theta_b^E}{\partial\gamma}\right| - \left|\dfrac{\partial\theta_g^E}{\partial\gamma}\right| = \dfrac{2(1-\gamma^*)\bar{\theta}^2}{(4-\alpha)\left[(1-\gamma)+(1-\gamma^*)\bar{\theta}\right]^2} > 0.$

welfare is considerably lower with ERP compared with one without ERP. In addition, Lemma 2 shows that the home copayment rate with ERP creates both negative and positive effects on the home social welfare. If the home copayment rate is high enough, the negative effects dominate the positive effects, suggesting that the home social welfare with ERP is decreasing in the home copayment rate. Note that the home copayment rate is independent of home social welfare without ERP from Lemma 1. Therefore, the home social welfare is worse-off with ERP when the home copayment rate is high enough, i.e., $\gamma > \bar{\gamma}$ (see Figure 1).

Marinoso *et al.* (2011) show that ERP is better-off for a country with a high copayment. Since the copayment in their setting is a fixed fee, an exporting firm located in a third country would set a relatively higher price with a higher copayment. Therefore, an importing country with a higher copayment is more likely to impose ERP to reduce prices. Our model, however, suggests that the ERP-enhancing social welfare with a relatively high copayment is not robust under an exporting country. The result by Geng and Saggi (2017, 2020) and Iravani *et al.* (2020), that ERP is socially desirable, is naturally sensitive with the presence of reimbursement policy. This is because they ignore the roles of expenditure and generic profit. Precisely, our findings provide a crucial recommendation for policy-makers on executing ERP in pharmaceutical-producing countries, especially in the United State, which has proposed to adopt ERP. Our findings are supporting for empirical literature by Fontrier *et al.* (2019), Gill *et al.* (2019), and Kanavos *et al.* (2020) that the social welfare can be worse-off with ERP. Thus, policy-makers are not necessary to pursue the implementation of ERP.

FIGURE 1

SOCIAL WELFARE COMPARISON UNDER DIRECT SALES CHANNEL



## 4. Indirect Sales Channel

In this section, we consider indirect sales channel where the brand-name firm sells the drug in country F by signing a linear contract with a foreign agent. The linear contracts are popular in pharmaceutical industry (Grennan, 2013; Gaudin, 2019). Under such a case, there are two possible types of ERP: Ex-factory price-based or list-price-based (EFP) ERP and pharmacy-purchasing-price-based (PPP) ERP (Iravani *et al.*, 2020; Ollendorf *et al.*, 2021). With EFP ERP, the home brand-name price is determined equally to its wholesale price. Many countries are applying EFP ERP such as Spain, Greece, and Belgium. EFP ERP is popular since the price is determined before country-specific markups are realized, therefore it moderates comparisons between countries (Ollendorf *et al.*, 2021). With PPP ERP, the home brand-name price is indexed equally to its foreign price. Some countries are using this approach such as Finland, the Netherlands, Austria, Cyprus, and Ireland.

Demands for the brand-name and generic drugs in each market are the same as those in section 2. The game is structured as follows. In the first stage, government H implements either no ERP or EFP (PPP) ERP. In the second stage, the brand-name producer determines a linear contract, i.e., $w$, to a foreign agent. In the last stage, the brand-name firm and local generic firms simultaneously determine the prices. The following assumption holds to ensure the imposition of ERP and the exporting decision of brand-name firm:

**Assumption 2:** $\dfrac{(3-\alpha)(1-\gamma)}{(2-\alpha)\left(1-\gamma^*\right)} \le \bar{\theta} \le \dfrac{(4-\alpha)^2(1-\gamma)}{(2-\alpha)^2\left(1-\gamma^*\right)}$.

To save space, we report all results for Section 4 in Appendix 4.

### 4.1. Without ERP

Without ERP, the brand-name firm freely competes with the local generic firm in each market. Given that, in the final stage, they maximize the following equation:

$$(3) \quad \begin{cases} \max\limits_{p} \Pi = \dfrac{1}{\bar{\theta}}\left[\bar{\theta} - \dfrac{(1-\gamma)(p-\tilde{p})}{1-\alpha}\right]p + wq^* \\ \max\limits_{p^*} \pi^* = \left[1 - \dfrac{\left(1-\gamma^*\right)\left(p^*-\tilde{p}^*\right)}{1-\alpha}\right]\left(p^*-w\right) \\ \max\limits_{\tilde{p}} \tilde{\pi} = \dfrac{1}{\bar{\theta}}\left[\dfrac{(1-\gamma)(p-\tilde{p})}{1-\alpha} - \dfrac{(1-\gamma)\tilde{p}}{\alpha}\right]\tilde{p} \\ \max\limits_{\tilde{p}^*} \tilde{\pi}^* = \left[\dfrac{\left(1-\gamma^*\right)\left(p^*-\tilde{p}^*\right)}{1-\alpha} - \dfrac{\left(1-\gamma^*\right)\tilde{p}^*}{\alpha}\right]\tilde{p}^* \end{cases}$$

By solving the maximizing problems in the equation (3), we derive the final-stage prices as:

$$p=\frac{2(1-\alpha)\bar{\theta}}{(4-\alpha)(1-\gamma)},\ \ \tilde{p}=\frac{\alpha(1-\alpha)\bar{\theta}}{(4-\alpha)(1-\gamma)},\ \ p^{*}(w)=\frac{2\left[(1-\alpha)+\left(1-\gamma^{*}\right)w\right]}{(4-\alpha)\left(1-\gamma^{*}\right)},$$

$$\tilde{p}^{*}(w)=\frac{\alpha\left[(1-\alpha)+\left(1-\gamma^{*}\right)w\right]}{(4-\alpha)\left(1-\gamma^{*}\right)}.$$

In the second stage, the brand-name firm maximizes:

$$\max_{w}\Pi=\frac{1}{\bar{\theta}}\left[\bar{\theta}-\frac{(1-\gamma)(p-\tilde{p}(w))}{1-\alpha}\right]p+wq^{*}(w). \tag{4}$$

Solving (4) yields the wholesale price, $w^{n}=\frac{1-\alpha}{(2-\alpha)\left(1-\gamma^{*}\right)}$. The variables with superscript “$n$” represent the equilibria. By using $w^n$, we can derive the equilibrium prices as:

$$p=\frac{2(1-\alpha)\bar{\theta}}{(4-\alpha)(1-\gamma)},\ \ \tilde{p}=\frac{\alpha(1-\alpha)\bar{\theta}}{(4-\alpha)(1-\gamma)},\ \ p^{*n}=\frac{2(1-\alpha)(3-\alpha)}{(2-\alpha)(4-\alpha)\left(1-\gamma^{*}\right)},$$

$$\tilde{p}^{*n}=\frac{\alpha(1-\alpha)(3-\alpha)}{(2-\alpha)(4-\alpha)\left(1-\gamma^{*}\right)}.$$

It is found $p^{n}\geq p^{*n}$ by Assumption 2, implying that government H has an incentive to impose ERP.[3] By substituting these prices into the profit functions, we obtain the equilibrium profits, $\Pi^{n}$ and $\tilde{\pi}^{n}$.

Then, the home social welfare is realized as $sw^n$. Similarly, it is found that without ERP, the consumer surplus and social welfare are independent of home copayment rate under indirect sales channel.

### 4.2. With EFP ERP

Under this context, the home brand-name price is equal to the wholesale price. Given that, in the last stage, we solve the equation (3) and *s.t.* $p = w$, then the final-stage prices are realized as:

[3] EFP ERP requires $p^{n}\geq w^{n}$. However, $p^{n}\geq p^{*n}$ and $p^{*n}\geq w^{n}$; thus, $p^{n}\geq w^{n}$ holds.

$$p = w,\quad \tilde{p}(w) = \frac{\alpha w}{2},\quad p^*(w) = \frac{2\left[(1-\alpha)+\left(1-\gamma^*\right)w\right]}{(4-\alpha)\left(1-\gamma^*\right)},$$
$$\tilde{p}^*(w) = \frac{\alpha\left[(1-\alpha)+\left(1-\gamma^*\right)w\right]}{(4-\alpha)\left(1-\gamma^*\right)}.$$

In the second stage, the brand-name firm maximizes:

(5) $$\max_w \Pi = \frac{1}{\bar{\theta}}\left[\bar{\theta} - \frac{(1-\gamma)(w-\tilde{p}(w))}{1-\alpha}\right]w + wq^*(w).$$

Solving (5) yields the wholesale price, i.e., $w^d = \frac{(1-\alpha)(6-\alpha)\bar{\theta}}{(2-\alpha)\left[(1-\gamma)(4-\alpha)+\left(1-\gamma^*\right)\bar{\theta}\right]}$. The variables with superscript "*d*" denote the equilibrium outcomes. Given that, we can achieve the optimal prices as:

$$p^d = \frac{(1-\alpha)(6-\alpha)\bar{\theta}}{(2-\alpha)\left[(1-\gamma)(4-\alpha)+\left(1-\gamma^*\right)\bar{\theta}\right]},\ \tilde{p}^d = \frac{\alpha(1-\alpha)(6-\alpha)\bar{\theta}}{2(2-\alpha)\left[(1-\gamma)(4-\alpha)+\left(1-\gamma^*\right)\bar{\theta}\right]},$$
$$p^{*d} = \frac{2\left(8-\alpha^3+7\alpha^2-14\alpha\right)(1-\gamma)+\left(3\alpha^2-13\alpha+10\right)\left(1-\gamma^*\right)\bar{\theta}}{(4-\alpha)\left(1-\gamma^*\right)(2-\alpha)\left[(1-\gamma)(4-\alpha)+\left(1-\gamma^*\right)\bar{\theta}\right]},$$
$$\tilde{p}^{*d} = \frac{\alpha\left(8-\alpha^3+7\alpha^2-14\alpha\right)(1-\gamma)+\left(3\alpha^2-13\alpha+10\right)\left(1-\gamma^*\right)\bar{\theta}}{(4-\alpha)\left(1-\gamma^*\right)(2-\alpha)\left[(1-\gamma)(4-\alpha)+\left(1-\gamma^*\right)\bar{\theta}\right]}.$$

By routine calculations, we can derive the profits, $\Pi^d$ and $\tilde{\pi}^d$. [4] Then, we obtain the home social welfare as $sw^d$.

### 4.3. With PPP ERP

Under this case, if the brand-name firm exports, its home price is regulated to be equal to its foreign price. Given that, in the final stage, by solving the equation (3) and *s.t.* $p = p^*$, we obtain the final-stage prices as:

$$p(w) = p^*(w) = \frac{2\left[(1-\alpha)+\left(1-\gamma^*\right)w\right]}{(4-\alpha)\left(1-\gamma^*\right)},\ \tilde{p}(w) = \tilde{p}^*(w) = \frac{\alpha\left[(1-\alpha)+\left(1-\gamma^*\right)w\right]}{(4-\alpha)\left(1-\gamma^*\right)}$$

4 $\Pi^d > \pi_H$ by Assumption 2.

In the second stage, the brand-name firm solves:

$$\text{(6)} \qquad \max_{w} \Pi = \frac{1}{\overline{\theta}}\left[\overline{\theta} - \frac{(1-\gamma)\left(p^{*}(w) - \tilde{p}(w)\right)}{1-\alpha}\right]w + wq^{*}(w).$$

By solving (6), we obtain the wholesale price, i.e., $w^{r} = \dfrac{2(1-\alpha)\left[(4-\alpha)\left(1-\gamma^{*}\right)\overline{\theta} - (2-\alpha)(1-\gamma)\right]}{\left(1-\gamma^{*}\right)\left[\left(\alpha^{2}-6\alpha+8\right)\left(1-\gamma^{*}\right)\overline{\theta} + 2(2-\alpha)(1-\gamma)\right]}$. The variables with superscript "*r*" represent the equilibria. Similarly, we can derive the equilibrium prices as:

$$p^{r} = p^{*r} = \frac{2(1-\alpha)(4-\alpha)\overline{\theta}}{(2-\alpha)\left[2(1-\gamma)+(4-\alpha)\left(1-\gamma^{*}\right)\overline{\theta}\right]},$$

$$\tilde{p}^{r} = \tilde{p}^{*r} = \frac{\alpha(1-\alpha)(4-\alpha)\overline{\theta}}{(2-\alpha)\left[2(1-\gamma)+(4-\alpha)\left(1-\gamma^{*}\right)\overline{\theta}\right]}.$$

By using these prices, we can obtain the profits, i.e., $\Pi^{r}$ and $\tilde{\pi}^{r}$. [5] Finally, we can achieve the home social welfare as $sw^{r}$.

*Firm's choice: Direct vs. Indirect sales channel*

Now, a question that arises is: Over which type of sales channel, either direct or indirect, results in a higher brand-name profit? By comparing $\Pi^{E}$ with $\Pi^{d}$ and $\Pi^{r}$, we build the following proposition.

**Proposition 2.** *The brand-name profit under direct sales channel is lower than that under indirect sales channel if the home copayment rate is high enough, i.e.,* $\Pi^{E} < \Pi^{d}\left(\Pi^{r}\right)$ *if* $\gamma > \gamma^{D}\left(\gamma^{R}\right)$.
*Proof*: See Appendix 5.

Some may think that indirect sales channel would result in a lower profit for the brand-name firm since some rent from country F comes to the foreign agent. However, indirect sales channel creates double-marginalization problem, which relatively raises the foreign brand-name price. Intuitively, the increasing magnitude of home brand-name price by an increase in the home copayment rate under indirect sales channel is stronger than that under direct sales channel.

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5 $\Pi^{r} > \pi_{H}$ by Assumption 2.

Keep in mind that country H is more lucrative than country F. Therefore, if the home copayment rate is high enough, the gain in country H dominates the loss in country F, which leads to a higher brand-name profit under indirect sales channel.

Our findings give theoretical evidence that the copayment rate is one of the crucial factors to determine the firm's behavior in choosing the distribution channel of drugs. To some extent the results practically explain why indirect distributions are common in pharmaceutical industry. Our results provide a framework for empirical works to test either direct sales channel or indirect sales channel with ERP is more profitable for exporting firms.

*Indirect sales channel: EFP ERP vs. PPP ERP*

As mentioned previously, it is popularly common in pharmaceutical industry that producers often distribute drugs internationally through indirect sales channels. Suppose the exporting brand-name firm signs a linear contract with a foreign agent. A question arises: If government H imposes ERP, which type of ERP, either EFP ERP or PPP ERP, results in a larger home social welfare? To explore this issue, we compare $sw^d$ and $sw^r$. We summarize the result in the following proposition.

**Proposition 3.** *Given indirect sales channel, the home social welfare is better-off with PPP ERP if the home copayment is high enough, i.e.,* $\gamma > \gamma^s$ .
*Proof*: See Appendix 6.

It is no doubt that the brand-name price with EFP ERP is lower than that with PPP ERP, i.e., $p^d < p^r$ .[6] For the home social welfare, this price effect is in favor of EFP ERP. However, it is found that the change in the brand-name price caused by an increase in the home copayment rate is much more intensified under EFP ERP versus under PPP ERP. This indicates that when the home copayment rate is higher, the negative effect of the home copayment rate on the home social welfare is stronger with EFP ERP than PPP ERP. Thus, when the home copayment rate is higher enough, the negative copayment rate effect is able to overweigh the positive price effect, which results in a higher home social welfare under PPP ERP. Again, our findings show that the presence of generic producer and copayment rate plays a significant role in the ERP-choosing decision of the home government. Our results are complementary to Iravani *et al.* (2020) that the home social welfare might be higher with PPP ERP. However, they conclude this result depends on the drug valuation of consumers, while the home copayment rate is crucial in our paper.

6 $p^d - p^r = -\dfrac{(1-\alpha)\left[2(5-\alpha)(1-\gamma)-(2-\alpha)\left(1-\gamma^*\right)\bar{\theta}\right]\bar{\theta}}{\left[2(1-\gamma)+(4-\alpha)\left(1-\gamma^*\right)\bar{\theta}\right]\left[2(1-\gamma)+(4-\alpha)\left(1-\gamma^*\right)\bar{\theta}\right]} < 0$ by Assumption 2.

### 4.4. With vs. Without ERP

Comparing $sw^n$ with $sw^d$ and $sw^r$ under indirect sales channel, we arrive at the following proposition.

**Proposition 4.** *Under indirect sales channel, there exists a critical value of the home copayment rate, i.e.,* $\gamma > \gamma^d (\gamma > \gamma^r)$, *the home social welfare is worse-off with EFP (PPP) ERP.*

*Proof*: See Appendix 7.

The findings confirm the key result obtained in Proposition 1, whereby ERP under the presence of home generic producer and reimbursement policy is worse-off if the home copayment rate is too high. Intuitions are similar to those in Proposition 1. However, the possibility of home social welfare being better-off without ERP is more likely to occur under indirect sales channel rather than direct sales channel, i.e., $\overline{\gamma} > \gamma^r$ $(\overline{\gamma} > \gamma^d)$.[7] This is because the existence of double-marginalization problem under indirect sales channel aggressively pushes up the foreign brand-name price, which directly (indirectly) gives rise on the home brand-name price due to inter-linking by ERP. This implies that both EFP ERP and PPP ERP create a higher home expenditure, a lower home generic profit and a lower foreign brand-name revenue compared with those under direct sales channel with ERP. Therefore, given a copayment rate, the home social welfare benefit of ERP is more likely to occur under direct sales channel rather than under indirect sales channel.

## 5. Conclusion

External reference pricing is a common policy in many countries. From 2018, ERP has received much attention as the U.S has proposed to adopt ERP, because many argue that ERP is socially desirable. However, some strongly criticize the efficiency of ERP. Therefore, our paper incorporates the copayment rate and generic producer to investigate whether ERP is efficient. Both direct and indirect sales channel are discussed in the paper.

We build a two-country model, whereby there are two local generic producers and a brand-name producer. The generic producers serve locally, while the brand-name producer potentially serves both markets. Our findings show that under direct sales channel the home social welfare is worse-off with ERP if the home copayment rate is too high. Our main insights are robust under indirect

7 It is complicated to perform a specific ranking of $\gamma$, we have simulated numerical examples to show $\overline{\gamma} > \gamma^r > \gamma^d$. The results are upon request. We thank a referee for this comment.

sales channel.[8] Our results indicate that the implementation of ERP is not necessary to be socially desirable. Thus, policymakers who are either implementing or planning to use ERP (the United State for example) should pay more attention to the roles of national healthcare policy in general, and the copayment rate in specific. Higher supports from the reimbursement actually generate disadvantages on the social welfare if ERP is incorporated.

Furthermore, if the exporting firm chooses indirect sales channel, the home social welfare with PPP ERP is larger than that with EFP ERP if the home copayment rate is high enough. In addition, the brand-name profit is higher under indirect sales channel than that under direct sales channel if the home copayment rate is too high. These findings provide theoretical frameworks for further empirical works to investigate whether the home governments (the exporting firms) is better-off with PPP ERP (indirect sales channel).

In practice, an imposition of ERP is more complicated than our settings. The current model ignores the international trade of generic drugs and restricts to the case of a brand-name firm locating in country H. Therefore, there may be some room to relax these assumptions to figure out firm's strategy and the ERP implementation. Some may also incorporate an endogenous copayment rate. We leave these potential topics for future research.

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[8] Our results hold when the reference pricing is given on the reimbursement. The results are upon request. We thank a referee for this comment.

# Appendix

## Appendix 1. Results for section 3.1 and Proof of Lemma 1

The results without ERP are as:

$$\pi^N = \frac{4(1-\alpha)\bar{\theta}}{(1-\gamma)(4-\alpha)^2},\ \pi^{*N} = \frac{4(1-\alpha)}{\left(1-\gamma^*\right)(4-\alpha)^2},\ \tilde{\pi}^N = \frac{\alpha(1-\alpha)\bar{\theta}}{(1-\gamma)(4-\alpha)^2},$$

$$cs^N = \frac{(5\alpha+4)\bar{\theta}}{2(4-\alpha)^2},\ E^N = \frac{\gamma(1-\alpha)(4+\alpha)\bar{\theta}}{(1-\gamma)(4-\alpha)^2},$$

$$sw^N = \frac{\left(1-\gamma^*\right)\left(12-2\alpha^2+\alpha\right)\bar{\theta}+8(1+\alpha)}{2\left(1-\gamma^*\right)(4-\alpha)^2}.$$

Direct calculations lead to the following results:

$$\frac{\partial \Pi^N}{\partial \gamma} = \frac{4\bar{\theta}(1-\alpha)}{(4-\alpha)^2(1-\gamma)^2} > 0,\ \frac{\partial \tilde{\pi}^N}{\partial \gamma} = \frac{\alpha\bar{\theta}(1-\alpha)}{(4-\alpha)^2(1-\gamma)^2} > 0,$$

$$\frac{\partial E^N}{\partial \gamma} = \frac{\bar{\theta}(1-\alpha)(4+\alpha)}{(4-\alpha)^2(1-\gamma)^2} > 0,\ \frac{\partial cs^N}{\partial \gamma} = 0,\ \frac{\partial sw^N}{\partial \gamma} = 0.$$

## Appendix 2. Results for section 3.2 and Proof of Lemma 2

The results with ERP are as:

$$\pi^E = \frac{4(1-\alpha)\left[\alpha(1-\gamma)+(4-\alpha)\left(1-\gamma^*\right)\bar{\theta}\right]\bar{\theta}}{(4-\alpha)^2\left[(1-\gamma)+\left(1-\gamma^*\right)\bar{\theta}\right]^2},\ \tilde{\pi}^E = \frac{4\alpha(1-\alpha)(1-\gamma)\bar{\theta}}{(4-\alpha)^2\left[(1-\gamma)+\left(1-\gamma^*\right)\bar{\theta}\right]^2},$$

$$\pi^{*E} = \frac{4(1-\alpha)\left[(4-\alpha)(1-\gamma)+\alpha\left(1-\gamma^*\right)\bar{\theta}\right]\bar{\theta}}{(4-\alpha)^2\left[(1-\gamma)+\left(1-\gamma^*\right)\bar{\theta}\right]^2},\ E^E = \frac{4\gamma(1-\alpha)\left[(4-\alpha)\left(1-\gamma^*\right)\bar{\theta}+2\alpha(1-\gamma)\right]\bar{\theta}}{(4-\alpha)^2\left[(1-\gamma)+\left(1-\gamma^*\right)\bar{\theta}\right]^2},$$

$$cs^E = \frac{\left\{\left[(4-\alpha)\left(1-\gamma^*\right)\bar{\theta}+\alpha(1-\gamma)\right]\left[(4-\alpha)\left(1-\gamma^*\right)\bar{\theta}+5\alpha(1-\gamma)\right]+4\alpha(1-\gamma)^2\right\}\bar{\theta}}{2(4-\alpha)^2\left[(1-\gamma)+\left(1-\gamma^*\right)\bar{\theta}\right]^2},$$

$$sw^E = \frac{(4-\alpha)^2\left(1-\gamma^*\right)^2\bar{\theta}^2+\left[4(4-\alpha)-2\alpha^2\gamma^*-(\alpha+8)\gamma\right]\bar{\theta}+\left[\left(14\gamma+11\gamma^2-3\right)\alpha^2-20\left(1-\gamma^2\right)\alpha+32(1-\gamma)\right]}{2(4-\alpha)^2\left[(1-\gamma)+\left(1-\gamma^*\right)\bar{\theta}\right]^2}.$$

Direct calculations lead to:

$$\frac{\partial \pi^E}{\partial \gamma} = \frac{4\bar{\theta}(1-\alpha)\left[(8-3\alpha)\left(1-\gamma^*\right)\bar{\theta} + \alpha(1-\gamma)\right]}{(4-\alpha)^2\left[(1-\gamma)+\left(1-\gamma^*\right)\bar{\theta}\right]^3} > 0,$$

$$\frac{\partial \pi^{*E}}{\partial \gamma} = -\frac{4\bar{\theta}(1-\alpha)\left[(4-3\alpha)\left(1-\gamma^*\right)\bar{\theta} - (4-\alpha)(1-\gamma)\right]}{(4-\alpha)^2\left[(1-\gamma)+\left(1-\gamma^*\right)\bar{\theta}\right]^3} < 0,$$

$$\frac{\partial \tilde{\pi}^E}{\partial \gamma} = -\frac{4\alpha\bar{\theta}(1-\alpha)\left[\left(1-\gamma^*\right)\bar{\theta} - (1-\gamma)\right]}{(4-\alpha)^2\left[(1-\gamma)+\left(1-\gamma^*\right)\bar{\theta}\right]^2} < 0,$$

$$\frac{\partial cs^E}{\partial \gamma} = \frac{4\bar{\theta}^2(1-\alpha)\left(1-\gamma^*\right)\left[\alpha(1-\gamma)+\left(1-\gamma^*\right)(2-\alpha)\bar{\theta}\right]}{(4-\alpha)^2\left[(1-\gamma)+\left(1-\gamma^*\right)\bar{\theta}\right]^3} > 0, \quad \frac{\partial E^E}{\partial \gamma} > 0,$$

$$\frac{\partial sw^E}{\partial \gamma} = \frac{4\bar{\theta}(1-\alpha)\left[\left(1-\gamma^*\right)(4-3\alpha)\bar{\theta} - (4-\alpha)(1-\gamma)\right]}{(4-\alpha)^2\left[(1-\gamma)+\left(1-\gamma^*\right)\bar{\theta}\right]^3} \gtreqless 0 \text{ if}$$

$$\gamma \lesseqgtr \check{\gamma} = \frac{4-\alpha}{(4-\alpha)+(4-3\alpha)\left(1-\gamma^*\right)\bar{\theta}}.$$

It is easy to show $0 < \check{\gamma} < 1$. In addition, $\left.\frac{\partial sw^E}{\partial \gamma}\right|_{\gamma=0} > 0$ and $\left.\frac{\partial sw^E}{\partial \gamma}\right|_{\gamma=1} < 0.$ Therefore, $sw^E$ is a concave function of $\gamma \in (0,1)$.

**Appendix 3. Proof of Proposition 1**

By using $sw^N$ and $sw^E$, we obtain $sw^N - sw^E > 0$ if $\gamma > \bar{\gamma} = \frac{M}{N}$, where $M = 9(4-3\alpha)\left(1-\gamma^*\right)^2\bar{\theta}^2 - (4-\alpha)\left(1-\gamma^*\right)\bar{\theta} + 8$ and $N = 3(4-3\alpha)\left(1-\gamma^*\right)\bar{\theta} + 8$. Precisely, we have $M > 0$, and $M - N = -\left(1-\gamma^*\right)\left[(4-3\alpha)\left(1-\gamma^*\right) + 8(1-\alpha)\right]\bar{\theta} < 0$, implying $\bar{\gamma} \in (0,1)$. Proposition 1 is realized.

## Appendix 4. Results for Section 4

*Results without ERP (Section 4.1):*

$$cs^n = \frac{(5\alpha+4)\bar{\theta}}{2(4-\alpha)^2},\ E^n = \frac{\gamma(1-\alpha)(\alpha+4)\bar{\theta}}{(1-\gamma)(4-\alpha)^2},$$

$$\Pi^n = \frac{(1-\alpha)\left[(1-\gamma)(4-\alpha)+4\left(1-\gamma^*\right)(2-\alpha)\bar{\theta}\right]}{\left(1-\gamma^*\right)(1-\gamma)(2-\alpha)(4-\alpha)^2},\ \tilde{\pi}^n = \frac{\alpha(1-\alpha)\bar{\theta}}{(1-\gamma)(4-\alpha)^2}.$$

*Results with EFP ERP (Section 4.2):*

$$cs^d = \frac{(2-\alpha)\left[(4-\alpha)(1-\gamma)+4\left(1-\gamma^*\right)\bar{\theta}\right]\left[\left(4+8\alpha-\alpha^2\right)(1-\gamma)+4(2-\alpha)\left(1-\gamma^*\right)\bar{\theta}\right]\bar{\theta}+\alpha(6-\alpha)^2(1-\gamma)^2\bar{\theta}}{8(2-\alpha)^2\left[(4-\alpha)(1-\gamma)+2\left(1-\gamma^*\right)\bar{\theta}\right]^2},$$

$$E^d = \frac{\gamma(6-\alpha)(1-\alpha)\bar{\theta}\left[\left(8-2\alpha-\alpha^2\right)(1-\gamma)+8(2-\alpha)\left(1-\gamma^*\right)\bar{\theta}\right]}{8(2-\alpha)^2\left[(4-\alpha)(1-\gamma)+2\left(1-\gamma^*\right)\bar{\theta}\right]^2},$$

$$\Pi^d = \frac{(1-\alpha)(6-\alpha)^2\bar{\theta}}{4(2-\alpha)(4-\alpha)\left[(4-\alpha)(1-\gamma)+2\left(1-\gamma^*\right)\bar{\theta}\right]},\ \tilde{\pi}^d = \frac{\alpha(1-\alpha)(6-\alpha)^2(1-\gamma)\bar{\theta}}{4(2-\alpha)^2\left[(4-\alpha)(1-\gamma)+2\left(1-\gamma^*\right)\bar{\theta}\right]^2}.$$

*Results with PPP ERP (Section 4.3):*

$$cs^r = \frac{(2-\alpha)\left[4\left(1-\gamma^*\right)\bar{\theta}-(2-\alpha)(1-\gamma)\right]\left[\left(12\alpha-3\alpha^2-4\right)(1-\gamma)+\left(8-6\alpha-\alpha^2\right)\left(1-\gamma^*\right)\bar{\theta}\right]\bar{\theta}+\alpha(4-\alpha)^2(1-\gamma)^2\bar{\theta}}{2(2-\alpha)^2\left[2(1-\gamma)+(4-\alpha)\left(1-\gamma^*\right)\bar{\theta}\right]^2},$$

$$E^r = \frac{\gamma(4-\alpha)(1-\alpha)\bar{\theta}\left[\left(8-12\alpha+3\alpha^2\right)(1-\gamma)+2\left(8-6\alpha+\alpha^2\right)\left(1-\gamma^*\right)\bar{\theta}\right]}{8(2-\alpha)^2\left[2(1-\gamma)+(4-\alpha)\left(1-\gamma^*\right)\bar{\theta}\right]^2},$$

$$\Pi^r = \frac{2(1-\alpha)\left[(2-\alpha)(1-\gamma)+(4-\alpha)\left(1-\gamma^*\right)\bar{\theta}\right]}{(2-\alpha)\left(1-\gamma^*\right)\left[2(1-\gamma)+(4-\alpha)\left(1-\gamma^*\right)\bar{\theta}\right]},\ \tilde{\pi}^r = \frac{\alpha(1-\alpha)(4-\alpha)^2(1-\gamma)\bar{\theta}}{(2-\alpha)^2\left[2(1-\gamma)+(4-\alpha)\left(1-\gamma^*\right)\bar{\theta}\right]^2}.$$

**Appendix 5. Proof of Proposition 2**

Let $\Delta\prod^{Ed}$ and $\Delta\prod^{Er}$ denote the profit differences between direct and indirect sales channel. We have:

$$\begin{cases} \Delta\prod^{Ed} = \prod^{E} - \prod^{d} \\ \Delta\prod^{Er} = \prod^{E} - \prod^{r} \end{cases}.$$

By using $\prod^{E}$ and $\prod^{d}$, we obtain:

$$\Delta\prod^{Ed} = \frac{(1-\alpha)I}{2(2-\alpha)(4-\alpha)^2\left[(1-\gamma)+\left(1-\gamma^*\right)\bar{\theta}\right]\left[(1-\gamma)(4-\alpha)+2\left(1-\gamma^*\right)\bar{\theta}\right]}.$$

$\Delta\prod^{Ed}$ depends on the sign of $I \equiv \left[\left(\alpha^3+16\alpha^2-108\alpha+112\right)(1-\gamma)-\left(16\alpha^2+16-\alpha^3-20\alpha\right)\left(1-\gamma^*\right)\bar{\theta}\right]$. Mathematically, $\Delta\prod^{Ed}<0$ if $\gamma>\gamma^D=1-\frac{A}{B}$, where $A=\left(16\alpha^2+16-\alpha^3-20\alpha\right)\left(1-\gamma^*\right)\bar{\theta}>0$ and $B=\alpha^3+16\alpha^2-108\alpha+112>0$ Clearly, $\frac{A}{B}<1$ since $A-B=-\left(20\alpha+16-\alpha^3-16\alpha^2\right)\left(1-\gamma^*\right)\bar{\theta}<0.$ Therefore, $0<\gamma^D<1.$

By using $\prod^{E}$ and $\prod^{r}$, we obtain:

$$\Delta\prod^{Er} = \frac{2(1-\alpha)H}{(2-\alpha)(4-\alpha)^2\left(1-\gamma^*\right)\left[(1-\gamma)+\left(1-\gamma^*\right)\bar{\theta}\right]\left[2(1-\gamma)+(4-\alpha)\left(1-\gamma^*\right)\bar{\theta}\right]}.$$

$\Delta\prod^{Er}$ depends on the sign of $H \equiv \left[\left(10\alpha^2+32-\alpha^3-32\alpha\right)(1-\gamma)^2\right]-\alpha^2\left(1-\gamma^*\right)^2\left[2(1-\gamma)+(4-\alpha)\left(1-\gamma^*\right)\bar{\theta}\right]\bar{\theta}.$ $H$ is a convex function of $\gamma$ since $\frac{\partial^2 H}{\partial\gamma^2}=2(2-\alpha)(4-\alpha)^2>0.$ Solving $H=0$ yields two roots, $\gamma^H$ and $\gamma^R$, where $\gamma^H>\gamma^R$, as follows:

$$\gamma^R = \frac{32(1-\alpha)+(10-\alpha)\alpha^2-\alpha\left(1-\gamma^*\right)\left(\alpha+\sqrt{\alpha^4-14\alpha^3+73\alpha^2-160\alpha+128}\right)}{(2-\alpha)(4-\alpha)^2},$$

$$\gamma^H = \frac{32(1-\alpha)+(10-\alpha)\alpha^2-\alpha\left(1-\gamma^*\right)\left(\alpha-\sqrt{\alpha^4-14\alpha^3+73\alpha^2-160\alpha+128}\right)}{(2-\alpha)(4-\alpha)^2}.$$

We have $H|_{\gamma=1} < H|_{\gamma=\gamma^H}$ since $H|_{\gamma=1} = -\alpha^2(4-\alpha)\left(1-\gamma^*\right)^2\bar{\theta}^2 < 0$. Moreover, $H|_{\gamma=0} > H|_{\gamma=\gamma^R}$ since $H|_{\gamma=0} > 0$. Thus, we have $0 < \gamma^R < 1 < \gamma^H$. Given that $H < 0$ if $\gamma > \gamma^R$, therefore $\Delta\prod^{Er} < 0$ if $\gamma > \gamma^R$. In short, $\Delta\prod^{Ed}\left(\Delta\prod^{Er}\right) < 0$ if $\gamma > \gamma^D\left(\gamma^R\right)$.

## Appendix 6. Proof of Proposition 3

Let $\Delta sw^{rd}$ denote the difference in social welfare between PPP ERP and EFP ERP. We then have:

$$\Delta sw^{rd} = sw^r - sw^d.$$

By some calculations, we find that $\Delta sw^{rd} = 0$ has a root, say $\gamma^s$. Since $\Delta sw^{rd}\big|_{\gamma=0} < 0$ and $\Delta sw^{rd}\big|_{\gamma=1} > 0$, thus $0 < \gamma^s < 1$. In addition, $\left.\frac{\partial \Delta sw^{rd}}{\partial \gamma}\right|_{\gamma=0} > 0$ and $\left.\frac{\partial \Delta sw^{rd}}{\partial \gamma}\right|_{\gamma=1} > 0$ indicate that $\Delta sw^{rd}$ is an increasing function of $\gamma \in [0,1)$. Therefore, $\Delta sw^{rd} > 0$ if $\gamma > \gamma^s$; otherwise, $\Delta sw^{rd} < 0$. Proposition 3 is proven.

## Appendix 7. Proof of Proposition 4

Let $\Delta sw^{nd}(\Delta sw^{nr})$ denote the differences in social welfare without and with EFP (PPP) ERP. We then have:

$$\begin{cases} \Delta sw^{nd} = sw^n - sw^d \\ \Delta sw^{nr} = sw^n - sw^r \end{cases}.$$

Solving $\Delta sw^{nd} = 0$ yields two roots, i.e., $\gamma = \gamma_1 = -\left[\frac{2(2-\alpha)\left(1-\gamma^*\right)\bar{\theta}}{4-\alpha} + 1\right] < 0$ and $\gamma = \gamma^d$. Solving $\frac{\partial \Delta sw^{nd}}{\partial \gamma} = 0$ yields $\gamma^o = \frac{K}{L}$, where $K \equiv \left(1-\gamma^*\right)\left(16-\alpha^3-8\alpha^2-4\alpha\right)\bar{\theta} + \left(64-48\alpha+12\alpha^2-\alpha^3\right) > 0$ and $L \equiv \left(1-\gamma^*\right)\left(48-68\alpha+28\alpha^2-3\alpha^3\right)\bar{\theta} + \left(64-48\alpha+12\alpha^2-\alpha^3\right) > 0$. We find that $K < L$, so $\gamma_1 < 0 < \gamma^o < \gamma^d$. In addition, $\left.\frac{\partial \Delta sw^{nd}}{\partial \gamma}\right|_{\gamma=\gamma_1} = -\frac{(1-\alpha)(4-3\alpha)}{(2-\alpha)(4-\alpha)(6-\alpha)\left(1-\gamma^*\right)} < 0$ implies that $\Delta sw^{nd}$

is a convex function. Since $\Delta sw^{nd}\big|_{\gamma=1} = \dfrac{\left(1-\gamma^{*}\right)\left(16-12\alpha+6\alpha^{2}\right)\overline{\theta}+\left(64-48\alpha+12\alpha^{2}-\alpha^{3}\right)}{4(2-\alpha)(4-\alpha)^{2}\left(1-\gamma^{*}\right)} > 0$,

$\Delta sw^{nd}\big|_{\gamma=1} > \Delta sw^{nd}\big|_{\gamma=\gamma^{d}}$ or $\gamma^{d} < 1$. Therefore, $\Delta sw^{nd} < 0$ for all $0 \le \gamma \le \gamma^{d}$, and $\Delta sw^{nd} > 0$ for all $\gamma > \gamma^{d}$.

Proceeding similar directions as ones shown in $\Delta sw^{nd}$, we find that $\Delta sw^{nr} > 0$ if $\gamma > \gamma^{r}$. Proposition 4 is thus realized.

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# Mothers' labor supply and conditional cash transfers: Evidence from Chile*

## *Oferta laboral materna y programas de transferencia condicionada de efectivo: Evidencia de Chile*

Gonzalo Dona**

**Abstract**

*Taking advantage of a reform that made Chile's most popular conditional cash transfer program substantially more generous, I study its impact on mothers' labor supply using a difference-in-difference strategy. Previous research has focused on these effects near the inauguration of CCTs, never before more than 20 years later. I find that older mothers respond to the reform by increasing their probability of working, but young mothers between 18 and 24 years old reduce their labor force participation. Meanwhile, intensive margin responses are always non-positive. This is policy-relevant information to many countries with CCTs today.*

Key words: *Mothers, labor supply, conditional cash transfer, welfare.*

JEL Classification: *J22, J10, I38.*

**Resumen**

*Aprovechando una reforma que aumentó sustancialmente la generosidad del programa de transferencia condicionada de efectivo más popular de Chile, estudio su impacto en la oferta laboral de madres usando una estrategia de diferencia en diferencia. Este es el primer trabajo que estudia esta respuesta a uno de estos programas más de 20 años después de su creación. Encuentro*

* I would like to thank my advisor and my wife, whose patience and counsel made this paper possible. I am also in debt with many colleagues that contributed to the end result, and with three anonymous referees whose comments on my manuscript were instrumental to a much better final draft. The errors and limitations still present are my sole responsibility.

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*que la probabilidad de trabajar aumenta para las madres de mayor edad, pero disminuye para las más jóvenes (18-24 años). Las respuestas a la reforma en el margen intensivo nunca son positivas. Esta es información relevante para países que usan CCTs.*

Palabras clave: *Madres, oferta laboral, CCT, subsidios.*

Clasificación JEL: *J22, J10, I38.*

## 1. Introduction

Conditional Cash Transfers (CCT) programs are immensely popular today in low- and middle-income countries as tools to improve investment in education and health of children. This is so because these programs have shown to be effective and efficient in achieving these goals. Although previous studies have generally concluded CCTs have no impact on maternal labor supply during their first years less is known about their effect on richer populations, likely less in need to be motivated to invest in their children's health and education. Research focused on this issue is important, as many of these programs are now moving into benefiting a second generation of children. Other effects of the program become more important in a scenario where these behaviors need not be motivated.

To answer this question, I take the case of Chile. World Bank (2018) data show that educational attainment progressed from six years to nearly ten years between 1981 and 2007. In part, this was the result of a successful CCT program called 'Unique Family Subsidy' (SUF, after its name in Spanish). In 2007 a reform to this program led to it reaching twice as many beneficiaries by 2010. At the same time, the government increased the real value of the transfer by 50%. However, it is not clear this program is raising schooling anymore, or if it is producing any important labor market distortion[1].

I find that the program has an effect on the labor supply of some mothers. Older mothers that live with another earner increase their labor supply. However, the youngest mothers become less likely to be working. Furthermore, there is a negative effect on working hours that concentrates on young and low educated mothers. The primary contribution of this paper is the analysis of a mature CCT program. At the time of its expansion, the SUF was 26 years old and the mothers benefiting from it had on average over eight years of schooling. In contrast, evaluations using randomized control trials have been done at the birth of the CCT program (within the first five years), when benefited mothers have on average

[1] Here and throughout the paper I speak in positive terms, a distortion may be desirable or undesirable, expected or unexpected.

very little schooling. Because these are rapidly changing countries, we would be wrong to think that a relatively rich country today, such as Chile, would have nothing of value to offer on this matter. The fact is that Chile's per capita GDP by PPP in 2007 ($18,373) implies it is a better comparison for Mexico in 2017 ($17,331) than even Mexico itself in 2000 ($15,683). This is true not only for Mexico, but for many other countries that use CCT programs (Federal Reserve Bank of St. Louis, 2019).

The rest of the paper is organized as follows. Section II discusses the current state of knowledge on the effects CCTs have on labor supply. Section III is devoted to explaining thoroughly the SUF subsidy and its recent evolution, including the event that will provide me with an identification strategy. Section IV describes the data used, Section V defines treatment and control groups, and Section VI presents the difference-in-difference model. Section VII provides a discussion of the results obtained for several labor supply outcomes. Finally, Section VIII concludes and suggests ways forward.

## 2. Background

### 2.1. Literature review: CCTs and labor supply distortions

Banerjee *et al.* (2017) review seven CCT evaluations using randomized controlled trials for four developing countries. Even though the authors conclude there are no statistically significant labor supply effects, their point-estimates are consistently negative and relatively large. One of these studies finds effects on employment for Honduras, Nicaragua, and Mexico that, even though not statistically significant, respectively represent reductions from the baselines of 5.2%, 11.3%, and 5.1%[2] (Alzúa *et al.*, 2013). Similarly, Skoufias and Di Maro (2008) find negative employment effects for young women in Mexico due to PROGRESA that represent a 10% reduction from its baseline, and positive effects for older women that are even larger (21% increase from the baseline for women older than 55), but can only statistically distinguish from zero the latter positive effect on the oldest group. These results are particularly interesting because their findings are consistent amongst themselves and with mine.

The studies considered in the review by Banerjee *et al.* (2017) include CCTs in Argentina, Brazil[3], Cambodia, Colombia, Honduras, Mexico, Nicaragua,

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2 These are all ITT effects, for PROGRESA (Mexico) they report the ATE effect, which would represent a reduction of only 1.5%.

3 A standard CCT program relies on indirect measures of income, such that people's actual labor supply will not impact their chances of getting the benefit. Argentina and Brazil however use administrative data to include current income considerations. The discussion in this paper applies to the standard CCT program, not to the type used by these two countries, which will create substantially different incentives. (Brazil: De Brauw *et al.*, 2015; Ribas and Soares, 2011; Argentina: Garganta and Gasparini, 2015)

Pakistan, and Philippines. Notably, children health and educational outcomes in all of these countries at the time research was conducted were far below the same outcomes for these countries today (World Bank Open Data, 2018). This accelerated progress may well be attributed to the CCT programs themselves. Indeed, CCTs have been proven remarkably successful welfare programs on reducing poverty (Fiszbein and Schady, 2009), improving children's educational outcomes (Schultz, 2004; Maluccio and Flores, 2005) and their access to health services (Gertler, 2004; Attanasio *et al.*, 2005). However, this raises the concern that the beneficiaries are likely changing importantly over time. They probably have significantly higher educational attainment today than when the program was introduced, and their decision to work or not is most likely affected by this.

According to Hernández Licona (2019), household head schooling in moderately poor households in Mexico receiving the conditional cash transfer has increased from 4.6 in 1994, three years before the program started, to 7.1 in 2016. Furthermore, for those in extreme poverty schooling increased from 3 to 5.8 years in the same period. If the tendency to higher schooling of household heads remains, soon the beneficiaries of PROGRESA will have as many years of schooling as the beneficiaries of the Chilean SUF in 2007.

This is important because we can expect education to impact labor supply of mothers in several ways. Research shows that women that receive more schooling have less children (Schultz, 1993; Lam and Duryea, 1999), if they get at least eight years of education they become significantly more likely to work (Lam and Duryea, 1999), and invest more in their children's health and education (Strauss and Thomas, 1995). Additionally, number of children and the willingness to invest in their education without the assistance of a welfare program, will modify the relationship between the CCT and its beneficiaries in ways that could further impact their labor supply responses to it. Alzúa *et al.* (2013) suggest CCTs distort labor supply via three main sources: the transfer (-, income effect), by reducing child labor (+, need to replace lost income), and limiting the time spent caring for children (+, more available time). These evaluations have been taking all these effects together but as time goes by, is the transfer that should be taking center stage.

### 2.2. The Chilean Context

Chile's SUF was started in 1981, when only 34% of its adult population had at least completed lower secondary education (World Bank Open Data, 2018). The same was true in 1990 for the countries studied by Banerjee *et al.* (2017), except for the Philippines (46%) and Colombia (41%). Analyses of the labor supply effects of CCT programs have been done in these conditions. However, educational attainment today in Mexico, Brazil, Colombia, and the Philippines are closer to 70% (respectively by 2018: 63%, 60%, 54%, and 70%); which might make them more similar to Chile (75% in 2007) in their responses than to their old selves.

The changes experienced by these countries over the last two decades cannot be ignored by researchers, as they challenge the relevance of our work. Studies of these countries twenty or even ten years ago may be of questionable relevance today for a country that is so strikingly different from the country originally under study. In these circumstances, Chile can provide other countries with policy relevant information. This study, looking at Chile in the early 2000s, can provide useful information to many of the sixty countries using CCT programs, today or in the near future.

This is an important consideration because we can expect the distortionary costs of a CCT program to vary over time, specifically as a function of school enrollment levels. This is so because the distortions that tend to increase labor supply depend critically on the preponderance of schooling among children. We may expect positive labor supply distortions to partially or completely offset negative distortions if schooling is low, and net distortions to be small or zero. However, if schooling is high it would tend to eliminate the positive labor supply distortions we recognize in theory, leading to larger negative net distortions. Therefore, distortions would tend to become more negative over time, countries that started a CCT program fifteen to twenty years ago would want to know whether their CCT program creates distortions in their current state, not in their initial situation.

## 3. The SUF program

The SUF program was established with the explicit goal of increasing parents' investment in their children, and in 2015 reached about 15% of the country's households. It provides a monthly transfer per child and mother conditional on either health or educational investments. Children up to six have to be taken to regular medical controls. Older children have to attend school full time and be at most twenty-four years old. If a family qualifies for the program, the per capita amount is the same for everyone.

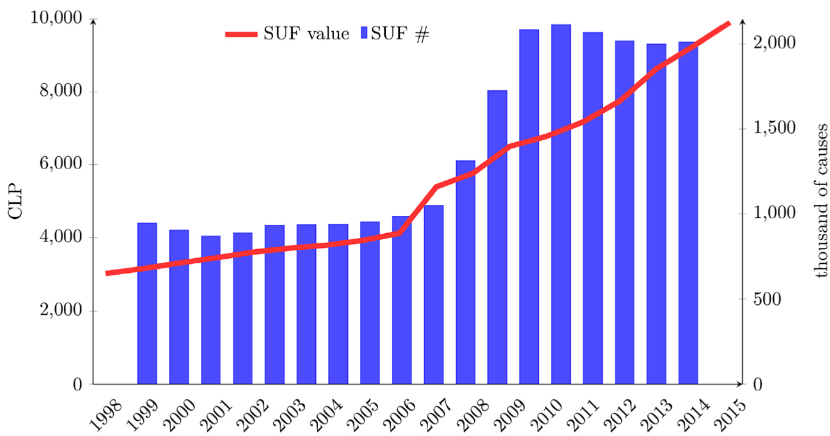
These conditions are easily controlled for by the authorities, making the system efficient and relatively simple to enforce. The SUF also requires families to be part of the poorest 40 percent. This was done by reference to past income declared by mothers, and by majors subjected to quotas (which meant no everyone who complied could receive it). However, a reform in 2007 changed this significantly. It eliminated the quotas and proxied income using a novel index called income generating capacity. This index is built using self-reported information, making it very manipulable (Herrera *et al.*, 2010; Irarrázabal *et al.*, 2010).

From 2007 to 2010, this subsidy was made more generous and expanded its reach. The former resulted from an increase in the transfer's value. The amount transferred in 2007 was 31% larger than the previous year, and its subsequent growth was increased as well. From 2006 to 2015 the nominal value of the SUF grew at an average annual rate of 10%, 2.5 times faster than during the period 1998-2006 (in real terms, annual growth exploded from 0.9% in the first period to 6.6% in the second, see Figure 1). Turned into an entitlement the program doubled its reach by 2010 (Figure 1). The reason it took some time for the CCT to grow is that the authorities needed to estimate the income generating capacity of the beneficiaries in order to add them to the program, which requires interviewing each family.

Overall, this overhaul to the SUF program could have important unintended effects as long as the program also meets two other requirements: being big with respect to some generally definable universe; and important enough to have noticeable effects on people's budget constraint. Chile's SUF is exceedingly popular, reaching large sections of the country's families. It currently benefits over two million people in about 850 thousand different families, according to official data for 2016 (Subsecretaría de Seguridad Social, 2018). In a country with 18 million people, and 5.5 million households, this represents more than 10% of the population, and 15% of families. Furthermore, by decile of income, the SUF reached over 25% of the first two deciles and 17% of the third, according to survey data from 2015 (even with 30% undercount of SUF recipients).

On the second requirement, the SUF makes only a modest contribution to the budget of an average family. The transfer awarded to any particular *cause*[4] would represent only 4.1% of the national minimum wage in 2015, and even less in previous years. However, the benefits received through the SUF can represent a very substantive proportion of some people's work income. In my sample the subsidy represents 7.5% of work income for those that receive it and have work income. However, for 25.6% of recipients the SUF represents

FIGURE 1
THE SUF BECOMES MORE GENEROUS




Source: Prepared by author using Subsecretaria de Seguridad Social (2018).

4 The benefit defines causes and beneficiaries. Causes are children or mothers entitled to the transfer, and beneficiaries are the adults perceiving the benefit.

at least twenty percent of their work income. The latter number goes to 45.8% for mothers that are between 18 and 24 years old.

Nevertheless, the SUF has a 'sister' program (the AF, 'Asignación Familiar') that may lead us to over-estimate the value of the SUF for some families. The AF requires beneficiaries to work and receive a low income, and is incompatible with the SUF. The transfer given by the two programs is the same for the lowest income workers but for workers earning over a threshold the SUF provides a higher transfer (the AF has three brackets, four if we count zero). Since the other brackets of the AF were not affected by the 2007 reform[5], eligible workers will be affected differentially by this event. In essence this means that the value of the SUF will be over-estimated for some groups. For some workers moving from the AF to the SUF will at best add stability. However, moving up the income distribution we meet a group that can grow their transfer 60% by choosing the SUF, and further up another group that can multiply it by five. Meantime, at all levels there will be people who are not working that will receive the full benefit of the SUF becoming an entitlement.

While this was done to the SUF, the 'Subsidies' budget of the central government grew from 4.8% of GDP in 2007 to 6.7% in 2010, and 7.6% for 2015 (DIPRES, 2017) raising the concern of potential spillovers from other welfare policies being expanded. If other important subsidies saw similar reforms as that of the SUF, then I would be identifying the response of the treated to this welfare system expansion, rather than specifically their response to the CCT program being expanded. Furthermore, many programs rely on the same income generating capacity index used to select eligible households for the SUF. However, a review of the most sizable subsidies that use this measure to determine eligibility can help mitigate this concern.

Most programs run by the government at this time are not a concern. This is because they either are addressed to a different population (pensions, scholarships) or because they are too small to be of significance nation-wide. However, a few programs are large and can target the same population that the conditional cash transfer program targets. The most salient example being that of housing subsidies. However, this subsidy can be received by both treatment and control and running the model controlling for it does not alter my results, suggesting it is not a critical issue. However, there are other large programs that at the same time are addressed exclusively to mothers. One of them provides free childcare and preschool, and is about half the size of the SUF. However, this program only grew 11% in beneficiaries between 2007 and 2011 and would only benefit a fraction of the people that can benefit from the SUF. The program that is most likely to create an identification problem for us is food subsidies for children at school, which had a budget 65% larger than the SUF's in 2010. This subsidy even

5 People receiving the maximum transfer from the AF would experience the same accelerated growth experienced by SUF recipients, but the growth for the other two brackets remained unaffected. Between 2006 and 2015 the highest transfer grew 140% while the next two grew 51% and 46%, in descending order.

reaches a similar number of children as the SUF and was significantly expanded after 2006. Insofar families are able to monetize this transfer, it may have some impact in my results. This would lead me to overestimate the importance of the CCT, but it should not lead to changes in sign as both policies would practically be ‘unconditional’ cash transfers. However, I do not find noticeably smaller effects when I compare mothers of younger children to mothers of older children, which should be more similar to each other in regard to free meals (the former only have marginally more children on average). This suggest my results are driven by the CCT program, as desired.

## 4. Data

The data used come from seven editions of a survey created to evaluate public policy in Chile, called Encuesta de Caracterización Socioeconómica Nacional (CASEN, ‘national socio-economical characterization survey’), covering the period from 1998 to 2015. This is a household survey first conducted in 1987, meant to be nationally representative of the population, that in 2015 reached almost 270 thousand people in 84 thousand households and 100 thousand different nuclear families, effectively interviewing 1.5% of the Chilean population.

The survey’s purpose is to measure poverty, describe the poor, and guide and evaluate public policy, which is why it contains detailed personal demographic information, sources of income and labor force participation, among other things. Because it is meant to be repeated indefinitely there is a substantive effort in making versions comparable and the survey trustworthy. By 1998 it has been repeated five times before, giving people no specific reasons to believe the survey would be used against them if they admitted to improper behavior.

The analysis is based upon four surveys before the 2007 policy change: 1998, 2000, 2003, and 2006; and three surveys after the SUF’s modification: 2011, 2013, and 2015. There is a 2009 survey that will be excluded from the principal analysis, because the expansion of the program is still incomplete at this point. However, including the survey and treating that year as a post-reform year does not affect the findings significantly.

Our relevant population are women between 18 and 60 years old, with at least one child younger than 24 (and full-time student). This results in a sample of 319,298 observations for which some general statistics can be seen in Table 1. This table shows how the change in the SUF led to a sharp increase in the probability of having the SUF subsidy after 2006.

Table 1 also shows the same basic statistics for the subgroup that declares to receive SUF. These women are younger, less schooled, have more children, they have their first child sooner, are more likely to be single, work less and earn less than the overall population. However, their trends are those of the general population, and the table does not suggest a change in the composition of SUF beneficiaries. The biggest difference is as expected, a rather significant jump in schooling and work income, likely a result of expanding the subsidy’s reach.

TABLE 1
SAMPLE GENERAL STATISTICS

| Year | Obs. | Age | Years Educ. | # children | First mom | % Single | % SUF | LF partic. | Work income | Work hours |
|---|---|---|---|---|---|---|---|---|---|---|
| All | | | | | | | | | | |
| 1998 | 35,095 | 36.9 | 10.0 | 2.07 | 24.1 | 21.4 | 11.2 | 44.7 | 375,665 | 17.0 |
| 2000 | 46,677 | 37.0 | 10.3 | 2.02 | 24.1 | 22.2 | 11.0 | 47.3 | 359,984 | 18.5 |
| 2003 | 47,703 | 37.6 | 10.6 | 1.98 | 24.3 | 23.6 | 11.4 | 50.5 | 363,797 | 17.7 |
| 2006 | 48,479 | 38.3 | 10.7 | 1.94 | 24.6 | 26.5 | 10.5 | 54.0 | 378,013 | 20.1 |
| 2009 | 43,506 | 38.9 | 11.0 | 1.9 | 24.8 | 29.4 | 13.3 | 54.5 | 425,094 | 19.2 |
| 2011 | 54,256 | 38.8 | 11.2 | 1.83 | 25.1 | 33.6 | 19.7 | 57.8 | 418,994 | 20.4 |
| 2013 | 39,985 | 38.9 | 11.5 | 1.79 | 25.3 | 35.6 | 20.5 | 60.0 | 389,168 | 21.4 |
| 2015 | 47,103 | 39.0 | 11.8 | 1.77 | 25.4 | 35.9 | 18.8 | 62.6 | 412,486 | 23.2 |
| SUF Recipients | | | | | | | | | | |
| 1998 | 5,851 | 33.9 | 7.2 | 2.46 | 22.5 | 24.7 | 100 | 30.4 | 123,739 | 9.5 |
| 2000 | 10,223 | 34.1 | 7.5 | 2.31 | 22.7 | 27.6 | 100 | 32.0 | 112,264 | 10.1 |
| 2003 | 10,844 | 34.4 | 7.8 | 2.23 | 22.8 | 28.9 | 100 | 34.7 | 128,147 | 8.9 |
| 2006 | 9,885 | 35.0 | 8.1 | 2.17 | 23.2 | 31.4 | 100 | 39.8 | 142,145 | 11.6 |
| 2009 | 9,110 | 35.0 | 9.1 | 2.02 | 23.2 | 35.7 | 100 | 41.7 | 202,609 | 11.6 |
| 2011 | 12,708 | 35.0 | 9.5 | 1.95 | 23.5 | 40.3 | 100 | 46.9 | 183,264 | 13.4 |
| 2013 | 9,686 | 35.6 | 9.6 | 1.92 | 23.8 | 41.4 | 100 | 47.2 | 181,434 | 14.2 |
| 2015 | 10,745 | 35.6 | 9.9 | 1.95 | 23.7 | 40.0 | 100 | 48.7 | 183,421 | 14.7 |

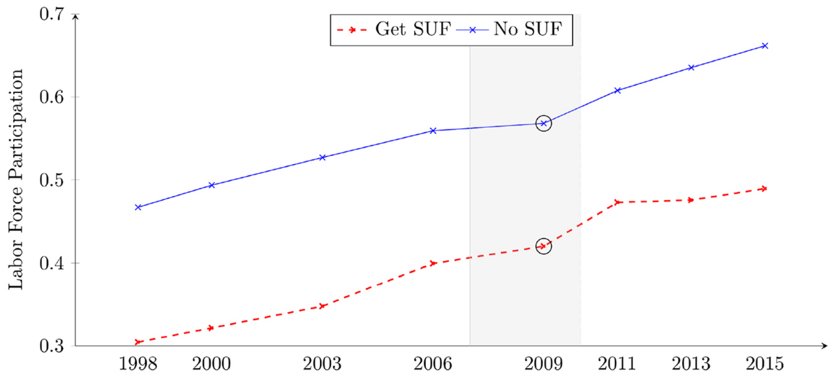
Samples averages. *Refers to real values in CLP for mothers working at least1 weekly hour.

This observation maps perfectly to the selection mechanism for the subsidy, that rests heavily on declared schooling. Therefore, controlling for education among other observables should help control for this issue. Additionally, the survey data show that income considerations need not necessarily be an issue in this respect. Even after the reform, there is still households belonging to the first decile of income that are not receiving the subsidy (50%).

There is also one trend that seems to differ between the tables in a way that is not warranted, and that is labor force participation. Figure 2 shows how the labor force participation of the two groups (with SUF and without SUF) trend together only before the policy change. This figure also makes evident the smooth trend observed for non SUF recipients and should help alleviate concerns about group composition changes. The grey area in this graph is meant to signify the SUF expansion period.

The data also include detailed information about other outcomes related to labor supply that we will use to study the program's effects: labor force participation, average hours worked, and average hours worked by the spouse (attributing zero to those without a job), average hours worked by those with positive hours, probability of working extra hours, and hourly wages. These six outcomes allow me to identify how individuals choose to respond to the change in the CCT program.

FIGURE 2
MOTHER'S LABOR FORCE PARTICIPATION




Source: Prepared by author using the CASEN surveys.

### 4.1. Definition of Treatment and Control

Ideally, we could choose a random sample of mothers, and compare the labor supply of those that benefit from the reform to the supply of those that do not. However, we do not have a group of beneficiaries that could not benefit from the program being expanded. Since the program was expanded both in reach and value, we must find another group that shares some similitudes to the group affected by the reform but that is not eligible for the subsidy.

In determining labor supply choices, we may think some personal characteristics are particularly important: having or not children, educational attainment, income, age, being in a couple, are some examples. To choose control group we need to discriminate along the lines of at least one of these dimensions. An analysis of the sample by years of schooling shows that the probability of participating in the welfare program is a function of educational attainment. However, it also shows that for all education levels there is an increase in the probability of receiving the subsidy.

Modifications to the SUF could potentially affect any woman that has children eligible for the program. Nominally, this would be limited to mothers with eligible children in the first forty percentiles for income, as the SUF should not be received by wealthier people. However, there is evidence that recipients misrepresent their situation in order to improve their chances. Indeed, according to Herrera *et al.* (2010) the data used to determine eligibility to the SUF differs importantly to survey data for the same population. The head of household is older and more likely to be woman, and the family is smaller and much more likely to have someone with disability. Similarly, Irarrázabal *et al.* (2010) show in their table 4.2.1 that according to the data used to determine SUF eligibility, with two thirds of the country surveyed, 35% belong to the first decile of income. That would mean that at least 22% of Chilean population belong to the first income decile, which is only possible because the data is self-reported with the intent to improve chances of being eligible to the program.

Schooling does not provide a clean cut either. The survey data used shows that for all schooling levels mothers experience an important change in probability of receiving the subsidy after 2007. The probability of benefiting from the SUF are significant for any mother with 12 years of schooling or less (high school diploma) but are still relevant for 15 or 16 years of schooling, probably a consequence of a selection mechanism that relies on self-reported and unchecked personal information.

Although we could define treatment and control groups by distinguishing mothers more or less exposed to the subsidy[6], there is a better option. There exists a group of women for whom the program is irrelevant, women with no eligible children. I will refer to them simply as 'not mothers', even though they could in principle have ineligible children (i.e., older tan eighteen and working, or older than twenty-four). It turns out that this control group complies with the necessary conditions to be used successfully.

Previous literature has suggested that CCT programs may have effects on fertility decisions (Olson *et al.*, 2019; Todd *et al.*, 2012; Gulemetova-Swan, 2009). If the choice to become a mother is affected by the cash transfer itself, then this will make my identification strategy biased. However, the results from these papers suggest these women are having children later and adding space between them; not having more children but fewer. This means that women are not becoming mothers in order to get the transfer.

I will also be limiting my attention to the age range 18 to 50. The lower limit corresponds to the minimum age for mothers to benefit from the SUF, making this restriction a necessary one. The upper limit is made convenient due to characteristics of the data. The CASEN is a household survey that only started asking for total number of children after 2011. Therefore, limiting attention to women younger than 50 helps keep demographics between treatment and control more balanced, since older women typically no longer live with all their children. Nevertheless, the results are not overly affected by eliminating the latter age restriction (replacing it with 60, the retirement age for women in Chile).

Table 2 shows some general demographics for mothers and women without children. We can see here important differences between the groups: women without eligible children are on average younger, more educated, work more and are more likely to be single. These are all expected differences, but it makes salient the concern that these women may not be a good control for mothers.[7]

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6 I did do this. In the appendix I define two alternative treatment/control definitions based one on the age of the youngest child and the other on number of children. The younger the children, the more children a mother has, the more she should value the transfer.

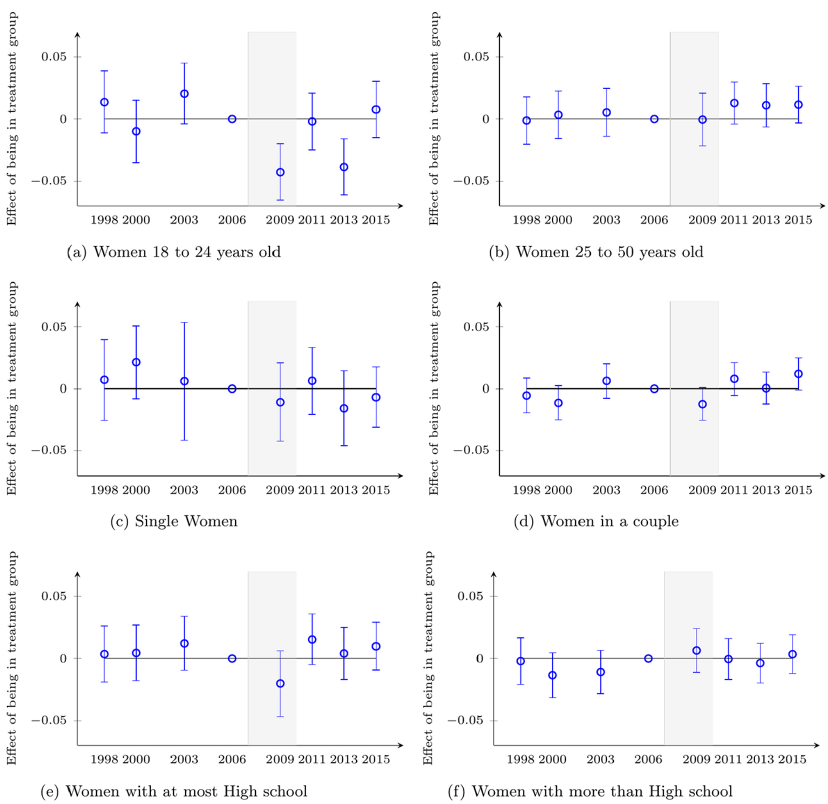
7 To address this concern, I have alternative specifications for treatment based on how exposed mothers were to the CCT program. The results proved robust to these tests and are included in the Appendix.

TABLE 2
DESCRIPTVIE STATISTICS FOR TREATMENT/CONTROL

| Year | Obs. | Age | Years Educ. | # children | First mom | % Single | % SUF | LF partic. | Work income* | Work hours |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | | | | | | | | | | |
| 1998 | 31,969 | 35.1 | 10.2 | 2.08 | 23.2 | 21.0 | 11.8 | 45.6 | 369,406 | 17.3 |
| 2006 | 43,159 | 36.3 | 10.9 | 1.96 | 23.7 | 26.5 | 11.2 | 54.7 | 366,155 | 20.2 |
| 2015 | 40,025 | 36.2 | 12.0 | 1.8 | 24.1 | 36.4 | 20.7 | 63.5 | 405,848 | 23.4 |
| Control | | | | | | | | | | |
| 1998 | 3,495 | 34.4 | 11.0 | - | - | 35.4 | 0.7 | 62.8 | 481,270 | 25.2 |
| 2006 | 5,050 | 34.7 | 11.8 | - | - | 35.7 | 1.0 | 69.6 | 517,106 | 27.6 |
| 2015 | 7,109 | 34.5 | 13.1 | - | - | 35.5 | 1.4 | 75.8 | 534,704 | 29.2 |

Samples averages. *Refers to real values in CLP for mothers working at least 1 weekly hour.

FIGURE 3
TESTS FOR PARALLEL TRENDS FOR SUBPOPULATIONS - LABOR FORCE PARTICIPATION




(a) Women 18 to 24 years old
(b) Women 25 to 50 years old
(c) Single Women
(d) Women in a couple
(e) Women with at most High school
(f) Women with more than High school

Source: Prepared by author using the CASEN surveys.

More importantly, Figure 3 tests for parallel trends on labor force participation for several subpopulations from 1998 to 2015. We can see here that even though there is a major difference in levels of labor force participation, trends prior to 2007 are comparable, which is the fundamental assumption that needs to hold for the difference-in-difference analysis I will describe later. Women without children are more likely to work, but do not seem to have reached a ceiling on labor force participation by 2015 either, which means there is no other reason for the series to separate after 2007. Furthermore, I assess the parallel trend assumption for several subpopulations in Figure 3 and do not find any violation of the assumption.

## 5. The Model

I use a difference-in-difference methodology to identify labor supply effects attributable to the SUF program being reformed. The preferred specification controls for several relevant covariates parsimoniously. Every regression includes controls for whether mothers have work experience, whether she has a spouse (de facto, regardless of legal standing), is part of the primary family in the household (i.e. not the family of a son or daughter), and whether she is married; I also include dummies for year of survey (6), age and its square, family size, number of children, an index capturing the growth of housing subsidies, and fixed effects for municipality (359 dummies). Because housing subsidies are the largest welfare program aimed at both treatment and control groups, I expect this covariate will allow me to control for the effects of the overall welfare expansion. If the regression is conditional on working, I replace the dummy for work experience with a variable that records years in her current job. I also use heteroskedastic robust errors on estimation, given that difference-in-difference models are prone to underestimate them (Bertrand *et al.*, 2004). Below is the model in its equation form.

$$y_{it} = \beta_0 + \beta_1 mom_i + \beta_2 \cdot post_t \cdot mom_i + \gamma_t + \Gamma X_{it} + \varepsilon_{it} \quad (1)$$

Where $y_{it}$ is one of several outcomes of interest: labor force participation, weekly working hours, weekly working hours of the spouse (declared couple regardless of legal standing), log of weekly working hours, work overtime, defined as working over 50 hours a week (in Chile the working week was reduced from 48 to 45 hours in 2005), and hourly wage. $post_t$ identifies the timing of treatment and is zero for data prior to 2007, and one for its complement. I also run this regression with three different interactions to evaluate possibly heterogeneous responses: whether the woman is single, whether she is younger (defined as in the age range 18 to 24), and whether she has a high school diploma (12 or more years of schooling).

As the results seem to be driven by all three characteristics, although with a clear distinction between the younger and the older groups, I run the regression combining two interactions. This allows me to closely identify the groups that are responding to the policy. It does not seem to be necessary to include more interactions to identify the groups reacting to the policy. Additionally, it may not even be wise as these additional subdivisions may not be supported by a valid pre-trend assumption.

I study the trends of the series in Figure 3. This figure analyzes trends for several subpopulations: young women (Figure 3a), older women (Figure 3b), single women (Figure 3c), women with a couple (Figure 3d), the less educated (Figure 3e), and those more educated (Figure 3f). The parallel trend assumption holds for all these populations. Furthermore, although the series for young women seems unstable, this is probably just a consequence of the small age range of the group.

## 6. Results

I analyze the effect of the CCT reform on six different labor supply outcomes. Three of these outcomes are not conditional on working, with the first two utilizing the entire sample: labor force participation and hours worked attributing to those not working zeros; while the third, hours worked by spouses attributing zeros to non-working spouses, only considers couples. The other three only apply to working women: log of working hours, probability of working overtime (defined as working more than 50 hours a week), and hourly wage. Each table presents these six outcomes in columns (1) through (6), in the same order as I just presented them. Coefficients in each row represent the entirety of the effect for that group. Under the coefficients I report standard deviations calculated using the delta method (using *deltamethod* function in R), and under these I report sample means by 2006.

Table 3 shows the effect of treatment on the population as a whole. This table suggest that the transfer created some distortions, as evidenced by a significant increase in spousal unconditional working hours and women's wages, but it is not clear exactly on whom. Taken together these two effects are not particularly sensible. A more natural response to higher wages for women with a couple is for their labor to replace men's labor in the affected households. The effect on wages should lead to an increase in working hours by women, even those without a couple, yet we do not see a significant effect on the related outcomes. Furthermore, the effect on conditional hours and probability of working overtime are negative, even though not statistically significant. Nevertheless, this table confirms that the SUF is important enough to create distortions in the labor market.

The fact that we cannot make sense of them from Table 3 alone suggests heterogeneous responses. Heterogeneity has been suggested by previous studies on CCT programs. The results may sensibly vary by educational attainment, age, and being a single mother. Having a relatively low educational attainment and

TABLE 3
LABOR SUPPLY RESPONSE OVERALL

| | Unconditional | | | Conditional | | |
|---|---|---|---|---|---|---|
| | Labor force partic. | Hours worked | Hours worked others | Hours worked (logs) | Prob. overtime | Hourly wage |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| treated | 0.004 | 0.043 | 0.832+ | -0.012 | -0.010 | 0.040+ |
| [s.e.] | [0.005] | [0.270] | [0.441] | [0.013] | [0.010] | [0.021] |
| mean | 54.7% | 20.2 | 33.5 | 40.8 | 13.1% | $2,517 |
| Observations | 308,245 | | 220,144 | 126,404 | | 122,056 |

Significant at: ***0.1%, **1%, *5%, +10%
All regressions include demographic controls. Unconditional outcomes control for whether the subject has work experience while conditional outcomes control for time in current job. The means used correspond to the year 2006.

being young can predict low wages, making the cash transfer more important relative to income. Meantime, single mothers may be less responsive to treatment given that their work is indispensable to sustain them. I prepared a binary comparison for each of these characteristics. First, compare women that did not finish high school to others that did. The former should be more responsive to the policy because we can expect them to have lower wages and consider the transfer more important. Second, I compare women under 25 years of age to those 25 to 50 years old. The former group has the possibility to study and of living in their parental house, which in general should make them more willing to work less. Third, single mothers' labor supply is predicted to be less sensitive to the subsidy. On the one hand, labor markets are understood to be relatively inflexible (one cannot really choose working hours from a continuum)[8]. On the other, the transfer afforded by the CCT is small, which means single mothers will need to keep working.

Heterogeneity is considered in Tables 4 and 5 (tables with only one interaction are consistent with these two tables and are available in Appendix B). These two tables confirm that young mothers reduce their labor force participation in response to the program's reform. However, when it comes to labor force participation single/couple status appears to be the meaningful characteristic. Young mothers reduce their labor force participation by 4.1% in response to the reform if single, and older mothers increase theirs by 1.2% if in a couple. This last response may be the most surprising of the two, especially considering this group is less likely to be affected directly by the program (i.e., free their time from childcare or lose income from child labor). However, Cogan (1980)

[8] However, if there is a large informal market, we may find larger intensive margin responses.

TABLE 4
LABOR SUPPLY RESPONSE BY AGE RANGE AND EDUCATIONAL ATTAINMENT

| | Unconditional | | | Conditional | | |
|---|---|---|---|---|---|---|
| | Labor force partic. | Hours worked | Hours worked others | Hours worked (logs) | Prob. overtime | Hourly wage |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| treated | | | | | | |
| 18 to 24 | | | | | | |
| ≤ High school | -0.021 | -0.01 | 2.738 | -0.194*** | 0.048 | 0.182+ |
| [s.e.] | [0.015] | [0.718] | [18.69] | [0.054] | [0.039] | [0.104] |
| mean | 40.5% | 13.2 | 25.0 | 40.8 | 12.7% | $1,333 |
| > High school | -0.020** | 0.351 | 3.306 | 0.019 | 0.010 | 0.102** |
| [s.e.] | [0.008] | [0.570] | [19.41] | [0.028] | [0.016] | [0.039] |
| mean | 46.0% | 13.6 | 14.6 | 36.8 | 6.4% | $1,629 |
| 25 to 50 | | | | | | |
| ≤ High school | 0.006 | -0.372 | 0.076 | -0.025 | -0.030 | 0.069 |
| [s.e.] | [0.009] | [0.493] | [0.747] | [0.029] | [0.021] | [0.043] |
| mean | 50.90% | 18.9 | 34.7 | 40.9 | 15.3% | $1,689 |
| > High school | 0.007+ | 0.168 | 0.064 | -0.019+ | -0.006 | 0.025+ |
| [s.e.] | [0.004] | [0.694] | [0.371] | [0.011] | [0.006] | [0.014] |
| mean | 74.1% | 28.2 | 34.5 | 40.6 | 8.6% | $4,592 |
| Observations | 308,245 | | 220,144 | 126,404 | | 122,056 |

significant at: ***0.1%, **1%, *5%, + 10%

All regressions include demographic controls. Unconditional outcomes control for whether the subject has work experience while conditional outcomes control for time in current job. The means used correspond to the year 2006.

showed that married women (a subset of those with couples) can increase their labor supply in response to a similar treatment in the presence of fixed costs. This could be a response to an increase in wages if these women have non-zero reservation hours (i.e., are not willing to work less than x > 0 hours a year). And, although we do not observe an increase in wages for the more educated women, we do observe a 4.4% increase on those with a couple. Further, the transfer itself could lead these women to lower their reservation hours, and in that way make them more likely to work. The second outcome, unconditional working hours, is almost always statistically indistinguishable from zero. However, the only result that is significant is that of older mothers in couples.

They lower their unconditional hours, although only by 1.6%. This may be reflective of the responses of these mothers on the intensive margin. They lower significantly both their conditional hours, by 2.6%, and their probability of working overtime, by 10%. In 2006 the probability a mother with a couple worked overtime was 14.7%, and these mothers worked on average 30 hours a week more than those not working overtime. A 1.5 percentage points decrease in this

TABLE 5
LABOR SUPPLY RESPONSE BY AGE RANGE AND SINGLE/COUPLE

| | Unconditional | | | Conditional | | |
|---|---|---|---|---|---|---|
| | Labor force partic. | Hours worked | Hours worked others | Hours worked (logs) | Prob. overtime | Hourly wage |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| treated | | | | | | |
| 18 to 24 | | | | | | |
| single | -0.021+ | -0.465 | - | -0.065+ | -0.002 | 0.254*** |
| [s.e.] | [0.011] | [0.367] | - | [0.037] | [0.022] | [0.066] |
| mean | 50.8% | 16.7 | - | 40.7 | 13.6% | $1,214 |
| in couple | -0.007 | 1.034 | 3.334 | 0.044 | 0.028 | 0.005 |
| [s.e.] | [0.008] | [1.247] | [16.73] | [0.034] | [0.019] | [0.043] |
| mean | 33.1% | 10.3 | 43.7 | 39.0 | 8.9% | $1,607 |
| 25 to 50 | | | | | | |
| single | -0.012 | -0.075 | - | -0.017 | -0.021 | 0.028 |
| [s.e.] | [0.009] | [0.593] | - | [0.021] | [0.019] | [0.034] |
| mean | 78.50% | 30.1 | - | 40.1 | 12.40% | $2,831 |
| in couple | 0.011** | -0.295+ | 0.161 | -0.026* | -0.015* | 0.044** |
| [s.e.] | [0.004] | [0.153] | [0.468] | [0.012] | [0.007] | [0.016] |
| mean | 49.2% | 18.2 | 45.7 | 42.2 | 14.7% | $2,152 |
| Observations | 308,245 | | 220,144 | 126,404 | | 122,056 |

Significant at: ***0.1%, **1%, *5%, + 10%.
All regressions include demographic controls. Unconditional outcomes control for whether the subject has work experience while conditional outcomes control for time in current job. The means used correspond to the year 2006.

probability translates to a loss of 0.45 hours per worker, which is a reduction of 1.0% in average conditional hours. This means that about 38% of the effect on conditional working hours is due to lower probability of working overtime, and the remaining 62% would be a reduction by individuals not working overtime, if we assume that other features did not change (which might not be the case, people working overtime may have reduced their hours more).

The third outcome on these tables, unconditional working hours of the spouse, shows no significant response. The effect is large for younger mothers, but very imprecise. However, the effect found for the overall group of mothers in Table 3 is significant and amounts to an increase of 2.5% in the spouse's hours. This effect could be a response from spouses of women that are now working, if they see their time as complementary.

Four groups significantly reduce their working hours conditional on working (column 4). Critically, this outcome is harder to explain than the previous three, because it applies only to workers. This means that changes in the composition of workers can lead to increases or decreases in this metric making it harder to interpret. For example, the effect of treatment on wages for these four groups is positive, and it could be the result of more productive workers that work on average less hours being attracted to the labor market, pushing the average down. Extra complexity stems from the fact that three of the four groups additionally shift their labor force participation in response to treatment. For these groups compositional changes may be more important. For example, while wage increases significantly more for less educated young mothers than for their more educated counterpart, the effect on conditional hours is only significant for the former group. This could stem from the negative labor force participation effect experienced by the younger mothers, if it pushes out of the labor market workers that on average work less hours. Nevertheless, likely some of the effect is not just compositional, as we observe negative responses for groups that increase labor force participation, sustain it, and decrease it. For all the effect to be compositional it would be necessary for each group to be affected very differently by the same treatment, and in fact we can observe some consistent patterns. Decreases in conditional working hours seem more pronounced between the less educated and younger workers.

In summary, we observe young mothers reducing their labor force participation and their conditional working hours, more so if they are less educated (hours) or single (both). We also see that older women increase their labor supply if they are in a couple, offsetting their extensive margin increase by reducing conditional working hours and probability of working overtime.

## 7. Mechanisms

It seems to me that the finding that younger mothers reduce their labor supply is particularly important. However, they could be replacing their working time with more leisure or with more education, and which they choose would be an important consideration in any analysis of this policy, and others like it. Alternatively, they could be moving their labor supply to the informal market. However, the reform did nothing to motivate more informal transactions. In fact, it further disconnected the subsidy from contemporaneous choices (and reality), which would make the informal market less interesting, if anything.

If the money gives these women the opportunity to increase their investment in their own education, we might see it as a positive externality of the SUF subsidy and would like to leave the program as is. However, if what is happening is that the extra money allows young and capable women to reduce their labor supply in order to increase their leisure time, we might think that the program must be modified.

To answer this question, I tried a few analyses. First, I ran the model with a new outcome, whether a woman is a student at the time of the survey. I find no evidence that mothers are increasing their educational investment after the reform from this analysis. The model suggests instead that young mothers become less likely to become students because of the policy reform, although the point estimates of some subpopulations are too large to be sensible. Nevertheless, this raises the concern that maybe some behaviors could be worsen by the reform, so I decided to look at fertility rates among teenagers. Although I cannot analyze this metric correctly using my model, a review of the probability of a teenage woman to be a mother shows no significant change around the year the policy was modified or after; another check using only the 2015 survey and computing the years at which the women interviewed for the survey became teenage mothers (for those that did) shows similarly no increase after the 2007-2010 reform of the SUF.

These analyses show no evidence that the response to the policy by young mothers creates some positive externalities. Although a few other positive externalities that I cannot test for could still exist (i.e., time dedicated to raising their children could be affected positively), these results should help inform this debate.

## 8. Conclusions

This paper provides the first piece of evidence that CCT programs are likely to create labor supply distortions for second or third generations of beneficiaries. I show here that we can expect both positive and negative externalities, depending on beneficiaries' personal characteristics as well as the relative size for the transfer.

The analysis shows that younger mothers between 18- and 24-years old experience a relatively large reduction in labor supply that becomes more pronounced if they are less educated or single, on both the intensive and the extensive margin. This makes the distortion strongest for the people in more need, which is at the same time a logical conclusion and a concerning outcome.

We also find a positive response by older mothers on the extensive margin, if they studied beyond high school and/or are part of a couple. However, these groups also show negative intensive margin responses that are more in line with the prior expectations. These responses appear to be driven by the transfer and its effect on wages at least partially and may warrant a look at the family unit as a whole to fully understand the dynamics at play.

These findings provide valuable information to countries that today have been using CCT programs for almost twenty years and may be wondering about their implications today and in the future. Additionally, they stress the need for research beyond that done through randomized control trials to answer this type of questions, which cannot be considered properly at the beginning of the process but need to be asked much later and may require larger samples. Nevertheless, my strategy has limitations, evident in Figure 3a for younger mothers (which shows a zig-zag form survey to survey) and makes more research necessary. Ideally, a look at a CCT program from a country that currently is poorer, and were the CCT is relatively larger, could be very helpful to continue to understand their labor supply implications. Progress needs to be made on studying other distortions as well. The incipient research on CCTs distortions has concentrated in labor supply, as this study itself. However, my results suggest that young mothers may be particularly affected by this type of welfare program. It would be interesting to see whether this demographic is also responding to the CCT by changing their education choices, fertility timing, and even family composition. I do not find any evidence that young women are moved towards what might be considered undesirable behaviors (other than leisure), but my design was not meant to capture these responses primarily.

If these results are confirmed and expanded upon, CCTs could be redesigned to avoid the most egregious distortions created. For example, my results suggest that increasing the age of eligibility for the program to 25 years old would possibly eliminate arguably the most concerning (labor supply) responses, in this particular case.

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## Appendix A

Having children can be so transformative that we may doubt a comparison between women with and without children. Correspondingly, I evaluated alternative definitions of treatment and control groups that bridge this gap. However, these definitions have limitations by design, which lead me to create two alternative definitions, so that they can confirm and complete each other. Non mothers are completely ignored in what follows, with control being conformed instead by mothers that we can logically expect to be less responsive to the system's reform, as they can expect lesser gains.

One of these alternative definitions relies on number of children to distinguish treatment from control, and the other uses the age of the youngest child for the same purpose.

### Number of Children

The subsidy under study is given in per capita basis, one per child (and one for the mother). This means that each extra child increases the transfer significantly. The second child increases the monthly transfer by one third, third child increases its overall value by only twenty five percent, and each subsequent child provides a smaller increase (in percentages). The chosen categorization in column three of Table A.1 means that the average number of children of the control group is 1.47, and for treatment is 3.34. This implies that the value of the monthly transfer for the treatment group is 76% higher, assuming all these children are complying with the conditions for the transfer. We would expect therefore that when the program is reformed in 2007, and turned into an entitlement, women with more children will be more likely to apply to the program, since it benefits them more. This allows for some significant differences between the original treatment and control group to be abridged. First, and most important, all are mothers. But also, other differences are reduced: years of schooling, albeit marginally; percentage receiving the subsidy; and labor supply related variables. In fact, only the percentage of mothers that have no spouse is considerably different between treatment and control still. Nevertheless, Figure A.1 puts some doubt on whether the parallel trends assumption holds for this model.

There is another penalty to pay for this choice. Almost no women under twenty-five years old has three or more children, making the analysis of that important demographic impossible using this definition for treatment and control.

### Youngest Child

To address the important limitations of the previous approach I explored an additional dimension along which the benefits of the policy differ: age of the youngest child, The argument is essentially unchanged. Mothers with younger children can expect to receive the subsidy for a longer time, so they benefit more from applying to it after the reform makes it more accessible.

Indeed, when mothers whose youngest child is at most eleven years old, the average age of the youngest child for mothers in the treatment group is 4.7, compared to 16.1 for control. That means that, even at a ten percent discount rate, the program is almost three times more beneficial for the mother of the younger child, if considered till the age of eighteen, and still fifty percent more valuable when estimated till twenty-four years of age. Furthermore, all things equal, a mother with a younger child is more likely to have more children in the program as well, adding to the difference.

As Table A.3 shows, these groups are more comparable in terms of numbers of children, single status, and income; and are also not too unbalanced in labor force participation, education, and hours worked. As we would expect, mothers with younger children are significantly more likely to participate in the program. Additionally, the parallel trends assumption is better supported by this approach, as is shown in Figure A.2.

The limitation of this third definition is that again all younger mothers are _t squarely in one category, although in this case is treatment. This means that we will be using as control for them older mothers exclusively.

**Results**

Tables A.4 through A.9 show the same analysis done in the paper for the chosen treatment/control definition for both approaches. To note particularly, these results confirm the negative response by young mothers to treatment and the positive response by more educated mothers. Furthermore, although the result is not shown here the approach by youngest child also confirms that older mothers with spouse marginally increase their labor force participation, even though the approach by number of children suggests zero response.

## TABLE A.1
MOTHERS BY NUMBER OF CHILDREN

| Children | Frequency | Status |
|---|---|---|
| 1 | 138,983 | control |
| 2 | 124,275 | control |
| 3 | 54,543 | treatment |
| 4 | 14,887 | treatment |
| 5 | 3,691 | treatment |
| 6 | 1,038 | treatment |
| 7 | 330 | treatment |
| 8 | 143 | treatment |
| 9 | 32 | treatment |
| 10 | 20 | treatment |

## TABLE A.2
DESCRIPTIVE STATISTICS FOR TREATMENT/CONTROL – NUMBER OF CHILDREN

| Year | Obs. | Age | Years Educ. | # children | First Mom | % Single | % SUF | LF partic. | Work Income* | Work hours |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | | | | | | | | | | |
| 1998 | 31,969 | 37.3 | 9.6 | 3.42 | 21.9 | 12.7 | 17.7 | 40.2 | 422,151 | 14.8 |
| 2006 | 43,159 | 38.6 | 10.6 | 3.38 | 22.3 | 16 | 15 | 49.9 | 397,500 | 18.2 |
| 2015 | 40,025 | 37.8 | 11.4 | 3.26 | 22 | 26.3 | 28.2 | 57.8 | 411,245 | 20.5 |
| Control | | | | | | | | | | |
| 1998 | 3,495 | 33.6 | 10.6 | 1.5 | 23.9 | 24.4 | 9.9 | 48.0 | 346,391 | 18.3 |
| 2006 | 5,050 | 35.0 | 11.1 | 1.48 | 24.3 | 29.8 | 10.3 | 56.3 | 357,779 | 20.9 |
| 2015 | 7,109 | 35.3 | 12.1 | 1.44 | 24.7 | 38.9 | 19.5 | 64.8 | 405,913 | 24.0 |

*Refers to real values in CLP for mothers working at least 1 weekly hour.

## TABLE A.3
DESCRIPTIVE STATISTICS FOR TREATMENT/CONTROL – YOUNGEST CHILD

| Year | Obs. | Age | Years Educ. | # children | First Mom | % Single | % SUF | LF partic. | Work Income* | Work hours |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | | | | | | | | | | |
| 1998 | 31,969 | 32.7 | 10.4 | 2.13 | 23.1 | 20.6 | 13.8 | 43.6 | 343,981 | 16.0 |
| 2006 | 43,159 | 33.4 | 11.2 | 2.02 | 23.3 | 26.1 | 13.1 | 52.3 | 362,499 | 18.9 |
| 2015 | 40,025 | 33.1 | 12.2 | 1.86 | 23.7 | 35.7 | 23.8 | 60.9 | 407,706 | 21.7 |
| Control | | | | | | | | | | |
| 1998 | 3,495 | 43.2 | 9.5 | 1.92 | 23.9 | 22.3 | 5.3 | 52.5 | 439,798 | 21.7 |
| 2006 | 5,050 | 43.4 | 10.3 | 1.81 | 24.4 | 27.3 | 6.5 | 60.4 | 373,503 | 23.4 |
| 2015 | 7,109 | 43.8 | 11.3 | 1.63 | 24.9 | 38.0 | 13.0 | 69.9 | 401,836 | 27.5 |

*Refers to real values in CLP for mothers working at least 1 weekly hour.

## TABLE A.4
LABOR SUPPLY RESPONSE OVERALL – NUMBER OF CHILDREN

| | Unconditional | | | Conditional | | |
|---|---|---|---|---|---|---|
| | Labor force partic. | Hours worked | Hours worked others | Hours worked (logs) | Prob. overtime | Hourly wage |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| treated | 0.005 | 0.113 | 1.007** | -0.008 | 0.008 | -0.025 |
| [s.e.] | [0.004] | [0.238] | [0.374] | [0.016] | [0.009] | [0.023] |
| Mean | 49.9% | 18.2 | 38.8 | 40.0 | 13.3% | $2,704 |
| Observations | 262,353 | | 187,718 | 103,917 | | 100,236 |

Significant at: ***0.1%, **1%, *5%, +10%.
All regressions include demographic controls. Unconditional outcomes control for whether the subject has work experience while conditional outcomes control for time in current job. The means used correspond to the year 2006.

## TABLE A.5
LABOR SUPPLY RESPONSE OVERALL – YOUNGEST CHILD

| | Unconditional | | | Conditional | | |
|---|---|---|---|---|---|---|
| | Labor force partic. | Hours worked | Hours worked others | Hours worked (logs) | Prob. overtime | Hourly wage |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| treated | 0.003 | -0.344 | -1.056** | -0.032** | 0.012 | 0.038 |
| [s.e.] | [0.004] | [0.216] | [0.333] | [0.012] | [0.009] | [0.027] |
| mean | 52.3% | 18.9 | 34.0 | 40.2 | 12.1% | $2,566 |
| Observations | 271,939 | | 195,186 | 107,693 | | 103,885 |

Significant at: ***0.1%, **1%, *5%, +10%.
All regressions include demographic controls. Unconditional outcomes control for whether the subject has work experience while conditional outcomes control for time in current job. The means used correspond to the year 2006.

TABLE A.6
LABOR SUPPLY RESPONSE BY AGE AND EDUCATIONAL ATTAINMENT–
NUMBER OF CHILDREN

| | Unconditional | | | Conditional | | |
|---|---|---|---|---|---|---|
| | Labor force partic. | Hours worked | Hours worked others | Hours worked (logs) | Prob. overtime | Hourly wage |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| treated | | | | | | |
| 18 to 24 | | | | | | |
| ≤ High school | -0.027 | -1.366** | -2.767*** | -0.134 | -0.066 | 0.103 |
| [s.e.] | [0.023] | [0.148] | [0.510] | [0.110] | [0.065] | [0.182] |
| mean | 40.5% | 13.2 | 25.0 | 40.8 | 12.7% | $1,333 |
| > High school | -0.086** | 1.604 | -2.444*** | 0.005 | -0.294*** | 0.226 |
| [s.e.] | [0.062] | [8.607] | [0.242] | [0.146] | [0.060] | [0.228] |
| mean | 46.0% | 13.6 | 14.6 | 36.8 | 6.4% | $1,629 |
| 25 to 50 | | | | | | |
| ≤ High school | 0.006 | 0.324 | 0.400 | -0.005 | -0.002 | -0.029 |
| [s.e.] | [0.007] | [0.393] | [0.619] | [0.031] | [0.017] | [0.045] |
| mean | 50.9% | 18.9 | 34.7 | 40.9 | 15.3% | $1,689 |
| > High school | 0.001 | 0.08 | 1.011 | -0.014 | 0.016** | -0.037** |
| [s.e.] | [0.004] | [0.200] | [0.778] | [0.011] | [0.006] | [0.014] |
| mean | 74.1% | 28.2 | 34.5 | 40.6 | 8.6% | $4,592 |
| Observations | 262,353 | | 187,718 | 103,917 | | 100,236 |

Significant at: ***0.1%, **1%, *5%, +10%.
All regressions include demographic controls. Unconditional outcomes control for whether the subject has work experience while conditional outcomes control for time in current job. The means used correspond to the year 2006.

TABLE A.7
LABOR SUPPLY RESPONSE BY AGE AND EDUCATIONAL ATTAINMENT–
YOUNGEST CHILD

| | Unconditional | | | Conditional | | |
|---|---|---|---|---|---|---|
| | Labor force partic. | Hours worked | Hours worked others | Hours worked (logs) | Prob. overtime | Hourly wage |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| treated | | | | | | |
| 18 to 24 | | | | | | |
| ≤ High school | -0.175+ | -11.74*** | 12.0 | -0.101 | -0.07 | -0.580* |
| [s.e.] | [0.103] | [0.00001] | [148,197] | [0.334] | [0.191] | [0.263] |
| mean | 40.5% | 13.2 | 25.0 | 40.8 | 12.7% | $1,333 |
| > High school | 0.008 | -1.187 | -3.14*** | -0.154 | -0.075 | -0.461 |
| [s.e.] | [0.083] | [1.316] | [0.321] | [0.314] | [0.188] | [0.293] |
| mean | 46.0% | 13.6 | 14.6 | 36.8 | 6.4% | $1,629 |
| 25 to 50 | | | | | | |
| ≤ High school | 0.014* | -0.257 | -0.723* | -0.034 | 0.015 | -0.01 |
| [s.e.] | [0.006] | [0.338] | [0.519] | [0.024] | [0.017] | [0.054] |
| mean | 50.9% | 18.9 | 34.7 | 40.9 | 15.3% | $1,689 |
| > High school | -0.001 | -0.408*** | -1.014*** | -0.033*** | 0.007 | 0.061*** |
| [s.e.] | [0.003] | [0.111] | [0.098] | [0.009] | [0.005] | [0.013] |
| mean | 74.1% | 28.2 | 34.5 | 40.6 | 8.6% | $4,592 |
| Observations | 271,939 | | 195,186 | 107,693 | | 103,885 |

Significant at: ***0.1%, **1%, *5%, +10%.
All regressions include demographic controls. Unconditional outcomes control for whether the subject has work experience while conditional outcomes control for time in current job. The means used correspond to the year 2006.

TABLE A.8
LABOR SUPPLY RESPONSE BY AGE AND SINGLE STATUS –
NUMBER OF CHILDREN

| | Unconditional | | | Conditional | | |
|---|---|---|---|---|---|---|
| | Labor force partic. | Hours worked | Hours worked others | Hours worked (logs) | Prob. overtime | Hourly wage |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| treated | | | | | | |
| 18 to 24 | | | | | | |
| single | -0.048 | -4.079*** | - | -0.396** | -0.05 | 0.316 |
| [s.e.] | [0.035] | [0.032] | - | [0.120] | [0.383] | [0.346] |
| mean | 50.8% | 16.7 | - | 40.7 | 13.6% | $1,214 |
| in couple | -0.038+ | 1.673 | -1.366** | 0.234 | -0.23 | -0.018 |
| [s.e.] | [0.022] | [6.340] | [0.231] | [0.151] | [0.184] | [0.149] |
| mean | 33.1% | 10.3 | 43.7 | 39.0 | 8.9% | $1,607 |
| 25 to 50 | | | | | | |
| single | -0.004 | -0.246 | - | -0.016 | 0.015 | 0.010 |
| [s.e.] | [0.010] | [0.633] | - | [0.027] | [0.017] | [0.032] |
| mean | 78.5% | 30.1 | - | 40.1 | 12.4% | $2,831 |
| in couple | -0.001 | 0.083 | 1.032** | -0.025** | 0.007 | -0.028* |
| [s.e.] | [0.003] | [0.172] | [0.381] | [0.011] | [0.005] | [0.014] |
| mean | 49.2% | 18.2 | 45.7 | 42.2 | 14.7% | $2,152 |
| Observations | 262,353 | | 187,718 | 103,917 | | 100,236 |

Significant at: ***0.1%, **1%, *5%, +10%.
All regressions include demographic controls. Unconditional outcomes control for whether the subject has work experience while conditional outcomes control for time in current job. The means used correspond to the year 2006.

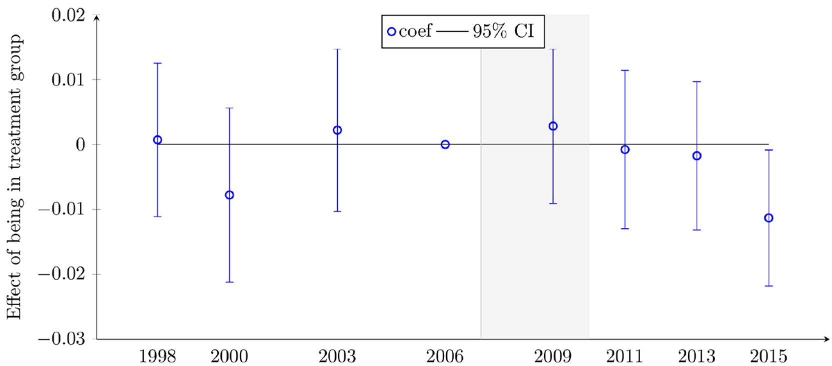
TABLE A.9
LABOR SUPPLY RESPONSE BY AGE AND SINGLE STATUS – YOUNGEST CHILD

| | Unconditional | | | Conditional | | |
|---|---|---|---|---|---|---|
| | Labor force partic. | Hours worked | Hours worked others | Hours worked (logs) | Prob. overtime | Hourly wage |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| treated | | | | | | |
| 18 to 24 | | | | | | |
| single | -0.271** | -18.06*** | - | -0.294 | -0.041 | -1.516*** |
| [s.e.] | [0.102] | [0.000001] | - | [0.542] | [0.383] | [0.207] |
| mean | 50.8% | 16.7 | - | 40.7 | 13.6% | $1,214 |
| in couple | 0.006 | 0.351 | 5.092 | -0.225 | -0.23 | -0.253 |
| [s.e.] | [0.008] | [5.895] | [911.4] | [0.334] | [0.184] | [0.408] |
| mean | 33.1% | 10.3 | 43.7 | 39.0 | 8.9% | $1,607 |
| 25 to 50 | | | | | | |
| single | -0.006 | -0.699 | - | -0.040* | -0.02 | 0.046+ |
| [s.e.] | [0.007] | [0.460] | - | [0.019] | [0.015] | [0.025] |
| mean | 78.5% | 30.1 | - | 40.1 | 12.4% | $2,831 |
| in couple | 0.008** | -0.059 | -1.039** | -0.016 | -0.013* | 0.027* |
| [s.e.] | [0.003] | [0.139] | [0.339] | [0.010] | [0.005] | [0.013] |
| mean | 49.2% | 18.2 | 45.7 | 42.2 | 14.7% | $2,152 |
| Observations | 271,939 | | 195,186 | 107,693 | | 103,885 |

Significant at: ***0.1%, **1%, *5%, +10%.
All regressions include demographic controls. Unconditional outcomes control for whether the subject has work experience while conditional outcomes control for time in current job. The means used correspond to the year 2006.

FIGURE A.1
TEST FOR PARALLEL TRENDS - BY NUMBER OF CHILDREN


FIGURE A.2
TEST FOR PARALLEL TRENDS - BY NUMBER OF CHILDREN



## Appendix B

### TABLE B.1
LABOR SUPPLY RESPONSE BY AGE GROUP

| | Unconditional | | | Conditional | | |
|---|---|---|---|---|---|---|
| | Labor force partic. | Hours worked | Hours worked others | Hours worked (logs) | Prob. overtime | Hourly wage |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| treated | | | | | | |
| 18 to 24 | -0.017** | 0.265 | 3.334 | -0.016 | 0.011 | 0.114** |
| [s.e.] | [0.007] | [0.456] | [16.73] | [0.024] | [0.014] | [0.036] |
| mean | 41.3% | 13.2 | 23.4 | 40.1 | 11.6% | $1,385 |
| 25 to 50 | 0.006 | -0.047 | 0.161 | -0.018 | -0.016 | 0.036 |
| [s.e.] | [0.005] | [0.307] | [0.468] | [0.014] | [0.011] | [0.023] |
| mean | 56.3% | 21.1 | 34.7 | 40.8 | 13.2% | $2,602 |
| Observations | 308,993 | | 220,756 | 126,404 | | |

Significant at: ***0.1%, **1%, *5%, +10%.
All regressions include demographic controls. Unconditional outcomes control for whether the subject has work experience while conditional outcomes control for time in current job. The means used correspond to the year 2006.

### TABLE B.2
LABOR SUPPLY RESPONSE BY SINGLE/COUPLE

| | Unconditional | | | Conditional | | |
|---|---|---|---|---|---|---|
| | Labor force partic. | Hours worked | Hours worked others | Hours worked (logs) | Prob. overtime | Hourly wage |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| treated | | | | | | |
| single | -0.014 | -0.174 | - | -0.021 | -0.018 | 0.049 |
| [s.e.] | [0.009] | [0.508] | - | [0.020] | [0.018] | [0.032] |
| mean | 73.0% | 27.6 | - | 40.1 | 12.3% | $2,048 |
| in couple | 0.009* | -0.010 | 0.832+ | -0.010 | -0.007 | 0.036* |
| [s.e.] | [0.004] | [0.183] | [0.441] | [0.011] | [0.006] | [0.015] |
| mean | 48.0% | 17.6 | 33.5 | 42.0 | 14.6% | $2,774 |
| Observations | 308,993 | | 220,756 | 126,404 | | |

Significant at: ***0.1%, **1%, *5%, +10%.
All regressions include demographic controls. Unconditional outcomes control for whether the subject has work experience while conditional outcomes control for time in current job. The means used correspond to the year 2006.

TABLE B.3
LABOR SUPPLY RESPONSE BY EDUCATION ATTAINMENT

| | Unconditional | | | Conditional | | |
|---|---|---|---|---|---|---|
| | Labor force partic. | Hours worked | Hours worked others | Hours worked (logs) | Prob. overtime | Hourly wage |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| treated | | | | | | |
| ≤ High school | -0.005 | -0.287 | 0.552 | -0.036 | -0.022 | 0.077+ |
| [s.e.] | [0.008] | [0.447] | [0.698] | [0.028] | [0.020] | [0.041] |
| mean | 49.7% | 18.2 | 33.6 | 40.9 | 15.0% | $1,660 |
| > High school | 0.003 | 0.236 | 0.733 | -0.007 | -0.001 | 0.026* |
| [s.e.] | [0.003] | [0.230] | [0.642] | [0.010] | [0.006] | [0.013] |
| mean | 72.1% | 27.1 | 33.0 | 40.5 | 8.5% | $4,474 |
| Observations | 308,993 | | 220,756 | 126,404 | | |

Significant at: ***0.1%, **1%, *5%, +10%.
All regressions include demographic controls. Unconditional outcomes control for whether the subject has work experience while conditional outcomes control for time in current job. The means used correspond to the year 2006.

# Corrupción y desigualdad de ingresos, evidencia empírica para México (2010-2020)*

## *Corruption and Income Inequality, Empirical Evidence for Mexico (2010-2020)*

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Omar Neme Castillo***
Humberto Ríos Bolívar****

**Resumen**

*México, entre los países de la OCDE, es el país que presenta la mayor diferencia de ingresos entre ricos y pobres. Esta situación ha venido acompañada de altos niveles en la percepción de corrupción. El objetivo es demostrar que la corrupción y la desigualdad de ingresos están correlacionadas. Las estimaciones se ven afectadas por el problema de endogeneidad originada por la causalidad bidireccional de la corrupción y la desigualdad de ingresos y por los errores de medición de la variable utilizada para la corrupción. Por ello, se emplea el método de ecuaciones simultáneas y se estima mediante Mínimos Cuadrados en Dos Etapas con Componentes en el Error (MC2ECE), alternativamente se emplea el Método Generalizado de Momentos (GMM, por sus siglas en inglés) y sys-GMM, para analizar la sensibilidad de los resultados. Se encuentra evidencia robusta de una relación positiva entre corrupción y desigualdad de ingresos en México en el periodo de 2010-2020.*

Palabras clave: *Desigualdad de ingresos, corrupción, ecuaciones simultáneas, MC2ECE, GMM, sys-GMM*

Clasificación JEL: *C01, C26, D31, D63.*

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**Abstract**

*Mexico, among the OECD countries, is the country with the greatest difference in income between rich and poor. This situation has been accompanied by high levels of perception of corruption. The goal is to show that corruption and income inequality are correlated. The estimates are affected by the endogeneity problem caused by the two-way causality of corruption and income inequality, and by measurement errors of the variable used for corruption. Therefore, the method of simultaneous equations is used and it is estimated by error-component two stage least squares (EC2SLS), alternatively the Generalized Method of Moments (GMM) and sys-GMM are used, to analyze the sensitivity of the results. Robust evidence is found of a positive relationship between corruption and income inequality in Mexico in the period 2010-2020.*

Key words: *Income inequality, corruption, simultaneous equations, EC2SLS, GMM, sys-GMM.*

JEL Classification: *C01, C26, D31, D63.*

## 1. Introducción

Una preocupación fundamental para los gobiernos y para la sociedad en general, es la redistribución equitativa del ingreso. De acuerdo con el Fondo Monetario Internacional (2007) la alta desigualdad de ingresos sería perjudicial para la estabilidad y el crecimiento económico. Además, también afecta la calidad de vida de la población, en especial de grupos vulnerables, lo que podría conducir a disturbios sociales e inestabilidad política (Jauch y Watzka, 2016).

En este contexto, México se encuentra en un estado considerado no aceptable con una brecha de desigualdad de ingresos importante (Risso *et al.*, 2013). Según datos de la Organización para la Cooperación y el Desarrollo Económicos (OCDE), el 10% de la población que ostenta mayor ingreso, en promedio percibe 30 veces más recursos que la población del grupo de menor ingreso. Del grupo de países de la OCDE, es el que presenta la mayor diferencia de ingresos en su población.

A nivel mundial, en el 2020 México obtuvo solo 31 puntos de 100 posibles en el Índice de Percepción de la Corrupción (IPC) de Transparencia Internacional, que lo posicionó en el lugar número 124 de 180 países, a la par de Bolivia, Kenia, Kirguistán y Pakistán, y por debajo de países como Argentina, Chile y Brasil. En términos económicos, la corrupción le cuesta al país entre 2 y 10% del PIB (Casar, 2015).

Adicionalmente, los resultados del informe 2018 de la Oxford Committee for Famine Relief (Oxfam), revelan que 7 de cada 10 mexicanos encuestados considera que un individuo genera su riqueza gracias a "esquemas injustos", entre los que se encuentran las prácticas corruptas, como tener acceso al poder y a contactos privilegiados. La Oxfam puntualiza que la corrupción es un mecanismo que agrava las desigualdades.

Al respecto, la desigualdad de ingresos impulsaría los actos de corrupción. En particular, al generar distorsiones en el acceso a los servicios y contratos públicos y favorecer a los que pertenecen a un grupo o red de actores ligados al poder económico-político, acentuando la brecha de ingreso entre deciles de ingreso. Por ejemplo, Esquivel (2015) argumenta que la riqueza de los cuatro mexicanos más acaudalados es de alrededor del 9,5% del Producto Interno Bruto (PIB) del país, en contraste al 2002, cuando solo representó 2% del PIB.

En breve, considerando los altos niveles de corrupción y de desigualdad en el ingreso en México, se plantea como objetivo demostrar que la corrupción afecta positivamente la desigualdad de ingreso en México, es decir, propicia el aumento de la brecha entre ricos y pobres. En particular, se utilizan datos de las 32 entidades federativas. Wängnerud (2010) sugiere diferencias a nivel regional. En concreto, indica que la corrupción es diez veces más probable que ocurra –al solicitar o recibir servicios públicos– en la entidad más afectada por la corrupción en comparación con la entidad menos afectada. Se emplea como variable dependiente el coeficiente de Gini. De igual manera, se utilizan variables de control que inciden en la desigualdad de ingreso en el periodo de 2010-2020, porque la mayoría de las variables utilizadas no cuentan con observaciones posteriores al año 2020.

En este contexto, la literatura concerniente a la relación entre corrupción y desigualdad en el ingreso no ha sido ampliamente tratada, quedando pendiente la discusión acerca de la relación causal. Al respecto, los estudios de este tema tienen dos enfoques. El primero se centra en los determinantes de la corrupción y considera a la desigualdad de ingresos como un factor que propicia su incidencia, esto es, analiza los efectos de la desigualdad de ingresos a causa de la corrupción. Por ejemplo, al revisar estudios de Alam (1997), Jong y Khagram (2005), Chong y Gradstein (2007) y Apergis *et al.* (2010), encuentran una relación positiva. No obstante, Husted (1999) no encuentra ninguna correlación significativa.

El segundo enfoque se orienta hacia los determinantes de la desigualdad de ingresos y se considera a la corrupción como uno de ellos. Estos estudios también encuentran resultados disímiles. Johanson (1998), Gyimah (2002) y Gupta *et al.* (2002) concluyen que la corrupción aumenta la desigualdad de ingreso. En contraste, Dobson y Dobson (2010) muestran un resultado opuesto para países de América Latina.

De acuerdo con la literatura, no parece existir consenso acerca del sentido de la relación entre corrupción y distribución del ingreso. La visión convencional del efecto dañino de la corrupción en la distribución del ingreso es desafiada por la idea contraintuitiva que la corrupción reduciría las desigualdades de ingresos y aumentaría el bienestar social (Keneck *et al.*, 2021).

Una de las posibles explicaciones de esta discrepancia se origina por el problema de endogeneidad que enfrentan las estimaciones econométricas respecto de la corrupción, la que puede tener origen en dos distintos problemas.

El primero, es causado por los errores de medición de las variables utilizadas para la corrupción. Estos errores son inherentes al fenómeno, porque por su naturaleza es difícil contabilizar con exactitud los actos corruptos que ocurren en una sociedad al darse en la clandestinidad. De esta manera, las mediciones se basan en la opinión sobre la percepción de corrupción de diferentes sectores de la sociedad, la que puede diferir de la corrupción efectiva. Adicionalmente, la endogeneidad también puede tener origen en la causalidad inversa de la corrupción. Los países con una distribución del ingreso más equitativa suelen ser menos corruptos, pero a su vez, la corrupción puede afectar la distribución del ingreso (Apergis *et al.*, 2010).

Además, en la literatura se reconoce que los estudios de la corrupción se deberían realizar en regiones geográficas que comparten características culturales, institucionales y económicas, en lugar de estudios globales, debido a la heterogeneidad para la conceptualización y medición del fenómeno. Kutan *et al.* (2007) puntualizan la importancia de tomar en cuenta que los efectos de la corrupción son variables entre las regiones, por ejemplo, en América Latina y el Caribe no se logra probar una relación estadísticamente significativa con el PIB per cápita, sin embargo, para la región de Oriente Medio y África del Norte encuentran una relación positiva estadísticamente significativa.

Para abordar el problema de endogeneidad originado por la causalidad inversa, se utiliza la metodología de ecuaciones simultáneas y se estima mediante Mínimos Cuadrados de Dos Etapas con Componentes en el Error (MC2ECE), utilizando el Índice de rendición de cuentas (*Rcue*) y el índice de gobierno electrónico (*Egob*), como variables instrumentales para la corrupción. Asimismo, el error de medición se aborda estimando mediante el método generalizado de momentos (GMM) propuesto por Arellano y Bover (1995), el que toma las primeras diferencias para eliminar los efectos invariables por entidad federativa. Adicionalmente, se estima el modelo dinámico ampliado conocido como sistema-GMM (sys-GMM, por sus siglas en inglés), que combina las primeras diferencias rezagadas de la variable dependiente con sus niveles rezagados.

La relevancia de esta investigación se centraliza en tres aportes principales, a diferencia del trabajo realizado por Gupta *et al.* (2002), referente en esta materia, que integra una cantidad significativa de países del mundo, este es un estudio regional para México, por lo que los resultados adquieren mayor relevancia para este país que los obtenidos de un estudio global, pero con interés tanto para la academia como los hacedores de política a nivel global. El segundo, es la estimación de modelos empíricos de la corrupción tomando en cuenta los problemas de endogeneidad que tienen origen en la simultaneidad y en posibles errores de medición, utilizando tres técnicas de estimación (MC2ECE, GMM y sys-GMM). De esta manera, los resultados obtenidos son más consistentes que los presentados en los estudios que no consideran este problema (Gupta *et al.*, 2002; Li *et al.*, 2000). Por último, se prueba la sensibilidad de los resultados al utilizar dos mediciones para la corrupción, el Índice de percepción de corrupción (*Ipc*) publicado por la Fundación Konrad Adenauer, y la tasa de incidencia de la corrupción (*T_corr*) publicada por el Instituto Nacional de Estadística y Geografía (INEGI) de México.

Los resultados de las estimaciones de MC2ECE, GMM y sys-GMM son los esperados, esto es, el *Ipc* presenta una relación negativa con el coeficiente de Gini y la *T_corr* una relación positiva. En consecuencia, altos niveles de corrupción son acompañados de una distribución menos equitativa del ingreso en las entidades federativas. Asimismo, los signos de los coeficientes tienden a permanecer y sus valores se mantienen en el mismo rango. Esto contribuye a la robustez de los resultados y, por tanto, a aceptar las inferencias respecto de la relación positiva de la corrupción sobre la desigualdad de ingresos.

El trabajo se divide en cinco secciones. En la siguiente se incluye una revisión de la literatura entre corrupción y desigualdad de ingresos. En la tercera se describen los datos, la metodología y los modelos econométricos. En la cuarta se muestran los resultados y su discusión. Por último, se presentan las principales conclusiones.

## 2. Corrupción y desigualdad de ingreso: revisión de literatura

La corrupción es definida como “el abuso del poder público para la obtención de beneficios privados” (Nye, 1967). Existe un número importante de estudios enfocados en el análisis sobre los efectos de la corrupción en distintas actividades de la economía. Autores tales como Mauro (1995), Mo (2001), Pellegrini y Gerlagh (2004), Policardo y Carrera (2018), Epstein y Gang (2019), Hamdi y Hakimi (2020), entre otros, presentan evidencia empírica persuasiva sobre los efectos perjudiciales de la corrupción en diversas variables económicas. Sin embargo, la corrupción no solo afecta el nivel de ingreso, también afecta su distribución (Gupta *et al.*, 2002).

Dos visiones surgen de la literatura empírica sobre corrupción como determinante de la desigualdad de ingreso. La primera considera la corrupción como factor que acentúa la desigualdad de ingresos (Gupta *et al.*, 2002; Glaeser *et al.*, 2003; Apergis *et al.*, 2010). Bajo esta orientación, la corrupción crea distorsiones permanentes en la redistribución del ingreso en los sistemas fiscales, facilitando la evasión de impuestos y reduciendo los recursos para programas sociales que permiten fomentar mejores oportunidades para la población (Gupta *et al.*, 2002). Estos programas resultan críticos para el desarrollo de la sociedad; en consecuencia, al reducir los recursos destinados a ellos, se propicia que se mantenga o crezca la desigualdad de ingresos en la población.

Del mismo modo, Chetwyn *et al.* (2003) detallan que la corrupción posibilita la desviación del gasto público a programas de defensa o infraestructura, debido a que estos últimos ostentan mayor oportunidad para obtener ganancias privadas por actos de corrupción. De esta forma, las decisiones de inversión no están basadas en lograr el mayor beneficio social, sino en elevar la posibilidad de extracción de rentas.

Asimismo, la corrupción puede cambiar la composición del gasto social de manera que aumenta los ingresos de una clase específica (usualmente las élites) a expensas de los grupos sociales más vulnerables como los indígenas (Glaeser *et al.*, 2003). A la par, también puede generar un sistema fiscal que favorece desproporcionadamente a las personas de altos ingresos y causa desigualdad en la propiedad de los activos, debido a que solo las personas mejor conectadas obtienen los proyectos gubernamentales más rentables (Gupta *et al.*, 2002). El caso mexicano apoya este punto de vista, ya que la excesiva burocracia explicaría los efectos de la corrupción en la desigualdad (Pedauga *et al.*, 2016).

Del mismo modo, Alesina y Rodrik (1994) establecen que la corrupción afecta el crecimiento económico debido a que genera mayor incertidumbre, desalentando la inversión y, como consecuencia, acentúa la desigualdad de ingresos. Bajo el mismo argumento, Apergis *et al.* (2010) afirman que, a largo plazo, los niveles más altos de corrupción resultan en tasas de desempleo más altas, lo que crea desigualdad de ingreso y empobrece aún más a los económicamente vulnerables. Además, la mayor desigualdad conduce a una mayor deuda de los hogares, lo que a su vez exacerba la desigualdad de ingreso (Berisha *et al.*, 2018), lo que sugiere un "ciclo vicioso" de desigualdad de ingreso para quienes viven en países altamente corruptos.

Contrariamente, la segunda visión de la literatura apunta a que la corrupción mitiga la desigualdad de ingreso y aumenta el bienestar social, especialmente en países que ostentan una burocracia ineficaz, actuando como aceite lubricante de la economía (Leff, 1964; Lui, 1985). Del mismo modo, la corrupción contribuye a superar las rigideces burocráticas y a mantener una asignación eficiente de los recursos cuando los agentes compiten por el mismo servicio (Bardhan, 1997). Por tanto, la corrupción es un mecanismo de negociación que tiene al "soborno" como unidad de pago compensatorio, contribuyendo a reducir la desigualdad de ingresos (Boycko *et al.*, 1995).

En un intento de conciliar estas dos corrientes de la misma literatura, algunos autores postularon la existencia de una relación en forma de U-invertida entre corrupción y desigualdad (Murphy *et al.*, 1993). De acuerdo con esta hipótesis, existe un nivel óptimo de corrupción por debajo del cual la corrupción aumenta la desigualdad de ingresos mientras que esta última disminuye por encima del umbral. Empíricamente, Li *et al.* (2000) encontraron un umbral óptimo de corrupción para una muestra de 47 países desarrollados y en desarrollo durante 1980-1992, entre estos, 26 tienen un nivel de corrupción por encima del umbral.

Chong y Calderón (2000) utilizaron una muestra de 105 países desarrollados y en desarrollo para demostrar que las políticas públicas anticorrupción son solo eficaces por debajo de un umbral de tolerancia. Sin embargo, los países en desarrollo con alta desigualdad y corrupción pueden quedar atrapados en un círculo vicioso, independientemente de su desarrollo institucional.

Si bien el debate sobre la asociación entre corrupción y desigualdad de ingresos no es concluyente (Andrés y Ramlogan, 2011), generalmente se acepta que la relación entre estas dimensiones es en ambos sentidos (Policardo y Carrera, 2018). De esta forma, la desigualdad de ingreso puede propiciar un entorno favorable para la corrupción (Dutta y Mishra, 2013), que a su vez debilita las instituciones y afecta los mecanismos de distribución del ingreso (Sonin, 2003; Chong y Gradstein, 2007).

## 2.1. Corrupción y desigualdad de ingresos en México

En México, la corrupción ha estado históricamente arraigada en el seno de la sociedad. Sin embargo, en las últimas tres décadas su práctica se ha ampliado a diferentes aspectos y actividades (Accinelli y Sánchez, 2012). México es conocido como uno de los países con mayor corrupción a nivel mundial, con un valor sistemáticamente muy por debajo de la media en el índice de percepción de la corrupción. En particular, el INEGI mediante la Encuesta Nacional de Calidad e Impacto Gubernamental (ENCIG), revela que, en el 2020, 8 de cada 10 mexicanos considera que la corrupción es frecuente en su entidad federativa. La entidad con mayor percepción de corrupción es Jalisco, donde 90,7% de los encuestados consideran que las prácticas de corrupción son frecuentes, seis puntos porcentuales por encima de la media nacional (84,6%). En contraste, Querétaro es la entidad que presenta menor nivel de percepción con 64,4%, esto es, cerca de 20 puntos porcentuales por debajo del promedio nacional. Existen ciertas diferencias en la percepción del fenómeno en las entidades federativas, sin embargo, no hay ninguna que muestre un desempeño por debajo del 60%. Del mismo modo, la ENCIG reporta para el mismo año la tasa de incidencia de corrupción a nivel nacional en 14.701 por cada 100.000 habitantes. Significando un costo de hasta 9,5 mil millones de pesos consecuencia de la corrupción.

Los altos niveles de corrupción pueden provocar una desigual distribución de la riqueza debido a dos principales motivos. Por un lado, la interacción de la sociedad con el poder público, y por otro, las imperfecciones del mercado, estas dos condiciones influyen sobre las políticas y el diseño de las instituciones. Los vínculos entre el poder, las instituciones que estructuran las oportunidades, y la elección de las políticas económicas, generan que los mercados no asignen los recursos en función de la eficacia sino de otros criterios, como, por ejemplo, mantener el poder de los que ya lo detentan en lugar de alcanzar el crecimiento económico sostenido con armonía social (Levy y Walton, 2009).

Estas ideas aplicadas al caso mexicano plantean que la desigual distribución del poder, expresada en la riqueza extrema y el control operativo del sector empresarial y de los sindicatos (heredados de la época del corporativismo) se han constituido en condicionantes de la desigualdad de ingresos, lo que impide el diseño de políticas sociales y deteriora el funcionamiento de las instituciones, y las pone al servicio de los grupos que ostentan el poder (Levy y Walton, 2009).

Bigio y Ramírez-Rondan (2006) mencionan que los efectos que la corrupción tiene sobre la desigualdad de ingresos en México son varios, y estos pueden ser tanto directos como indirectos, pero todos se basan en las distorsiones que la corrupción crea en la gestión pública. Algunos de los efectos incluyen un sistema fiscal que favorece a las élites empresariales, las preferencias en programas públicos que se otorgan a los grupos de interés más poderosos y que por tanto desvían recursos de transferencias hacia los más pobres, particularmente el gasto en especial en salud y educación. Dicho gasto tiende a mostrar un efecto mayor en la reducción de la desigualdad de ingresos (Scott, 2014).

## 3. Metodología y datos

### 3.1. Descripción de los datos

La base de datos comprende el período de 2010 a 2020 con 4.576 observaciones y combina estadísticas de varias fuentes: a saber, el Instituto Nacional de Estadística y Geografía (INEGI), el Consejo de Evaluación de la Política de Desarrollo Social (CONEVAL), la Fundación Konrad Adenauer México y la Secretaría del Trabajo y Previsión Social (STPS) del gobierno de México. Las variables son utilizadas en logaritmo natural, para normalizar su valor y expresar los resultados en elasticidad (ver Cuadro 1). Su definición se muestra más adelante.

#### *3.1.1. Desigualdad de ingresos*

La desigualdad de ingresos es la diferencia en cómo se distribuyen los ingresos entre la población (Galindo y Ríos, 2015). Se utiliza el coeficiente de Gini, la medida más común en la literatura. Según Sen *et al.* (1997), para cualquier distribución de ingresos dada sobre una población con individuos $i = 1, 2, 3,...,$ $n$, si $y_i$ es el ingreso para el individuo $i$, $y_j$ es el ingreso para el individuo $j$, y el ingreso promedio para esta población es $\mu$, entonces el coeficiente Gini viene dado por (Dincer y Gunlap, 2008):

(1) $$Gini = \left( \frac{1}{2\ n^2 \mu} \right) \sum_{i=1}^{n} \sum_{j=1}^{n} \left| y_i - y_j \right|$$

El coeficiente Gini varía desde el valor más bajo, 0 (igualdad perfecta), al valor más alto, 1(desigualdad perfecta).

#### *3.1.2. Corrupción*

La corrupción no puede medirse directamente, porque la mayoría de los actos ocurren en la ilegalidad y no son observados. Por esta razón, para su medición se ha dado especial importancia a la percepción que la sociedad tiene del fenómeno. Existe una amplia literatura sobre las virtudes y defectos de las diferentes medidas de corrupción. Seldadyo y De Haan (2006) destacan que las tres formas más habituales de medirla son: *i*) índices de corrupción percibida por un grupo puntual de personas; *ii*) incidencia de las actividades corruptas en

CUADRO 1
SUMARIO ESTADÍSTICO DE VARIABLES UTILIZADAS

| Variable | Observaciones | Media | Desviación Estándar | Min | Max | Fuente |
|---|---|---|---|---|---|---|
| *Gini* | 352 | -0.779 | 0.085 | -0.992 | -0.526 | Desigualdad en el ingreso a nivel entidad federativa. CONEVAL |
| *Ipc* | 352 | 4.443 | 0.076 | 4.165 | 4.567 | Subcomponente del Índice de desarrollo democrático (IDD). Fundación Konrad Adenauer México. |
| *T_corr* | 352 | 1.221 | 1.634 | -6.908 | 2.303 | Encuesta nacional de calidad e impacto gubernamental (ENCIG). INEGI |
| *Rcue* | 352 | 1.480 | 1.382 | -6.908 | 2.303 | Subcomponente del Índice de desarrollo democrático (IDD). Fundación Konrad Adenauer México. |
| *Egob* | 352 | 3.573 | 0.257 | 3.102 | 4.515 | Encuesta nacional de calidad e impacto gubernamental (ENCIG). INEGI |
| *Pibper* | 352 | 11.639 | 0.855 | 9.871 | 15.245 | Banco de información económica. INEGI |
| *Des* | 352 | 1.394 | 1.255 | -4.605 | 2.303 | Encuesta nacional de ocupación y empleo (ENOE). IINEGI |
| *Sin* | 352 | 2.603 | 0.304 | 1.615 | 3.466 | Indicadores estratégicos del sector. STPS |
| *Redu* | 352 | 2.865 | 0.282 | 2.133 | 3.490 | Evaluación de carencias sociales por entidad federativa. CONEVAL |
| *Emsos* | 352 | 14.190 | 1.163 | 12.103 | 18.110 | Censo de Población y vivienda. INEGI. |
| *Opri* | 352 | -1.723 | 0.961 | -5.285 | -0.323 | Encuesta nacional de ocupación y empleo (ENOE). INEGI |
| *Osec* | 352 | -1.920 | 0.260 | -2.747 | -1.441 | Encuesta nacional de ocupación y empleo (ENOE). INEGI |
| *Oter* | 352 | -0.570 | 0.345 | -1.563 | -0.077 | Encuesta nacional de ocupación y empleo (ENOE). INEGI |
| Total | 4576 | | | | | |

Fuente: Elaboración propia con datos de las diferentes fuentes señaladas
Nota: Todas las variables se presentan en logaritmos naturales. Las variables Redu, Emsos y T_corr cuentan con observaciones en periodos bienales por lo que se estimaron los valores anuales utilizando la tasa de crecimiento promedio.

la economía; y, *iii*) índices compuestos, construidos a partir de la combinación de varios índices, generalmente de percepción.

Las fuentes que existen para México a nivel entidad federativa son: el Índice de Percepción de corrupción (*Ipc*), que forma parte del Índice de Desarrollo Democrático (IDD) publicado por la Fundación Konrad Adenauer; la tasa de incidencia de corrupción (*T_corr*), publicada en la ENCIG-INEGI; y el Índice Nacional de Corrupción y Buen Gobierno (INCBG) realizado por la organización Transparencia Mexicana, aunque este último no se actualiza desde el 2010.

Para el estudio se utilizan dos índices: el *Ipc* y la *T_corr*. El *Ipc* captura la percepción sobre la corrupción de diferentes sectores de la sociedad, la escala es del 0 al 10, donde 0 refleja una mayor percepción (más corrupción) y 10 menor percepción (menos corrupción). *T_corr* captura la incidencia de la corrupción en trámites gubernamentales por cada 100 mil habitantes. Es una aproximación de la corrupción efectiva, por lo que mayores valores de *T_corr* representan niveles más altos de corrupción.

### *3.1.3. Variables de control*

Se utilizan variables de control para tener en cuenta otros factores importantes que pueden afectar la desigualdad de ingresos. Se incluyen el Producto Interno Bruto per cápita (*Pibper*), la población que cuenta con educación media superior o superior (*Emsos*), la tasa de sindicalización (*Sin*)[1], la ocupación en el sector primario (*Opri*)[2], la ocupación en el sector secundario (*Osec*)[3], la ocupación en el sector terciario (*Oter*)[4], la tasa de desempleo (*Des*)[5], y el rezago educativo (*Redu*)[6].

El *Pibper* se utiliza como variable que aproxima el crecimiento económico. En condiciones de expansión se espera un incremento en la inversión y empleo y, por tanto, en el nivel de ingresos de la población. Dollar *et al.* (2013) encuentran que los ingresos promedio de los quintiles más pobres crecen a la misma tasa que los ingresos promedio. De esta forma, se espera que el crecimiento económico reduzca la desigualdad de ingresos (Vo *et al.*, 2019). Por otro lado, Kuznets (1955) plantea que la relación de largo plazo entre crecimiento y desigualdad presenta la forma de una U invertida, la que, no proviene de una progresión en

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1 Tasa de sindicalización es la proporción de trabajadores afiliados a algún sindicato respecto del total de trabajadores.

2 Proporción de trabajadores que laboran en el sector primario respecto del total de trabajadores (agricultura, ganadería, explotación forestal, pesca y acuicultura).

3 Proporción de trabajadores que laboran en el sector secundario respecto del total de trabajadores (industria de extracción y eléctrica, construcción y manufactura).

4 Proporción de trabajadores que laboran en el sector terciario respecto del total de trabajadores (comercio, servicios y transportes).

5 Definida como el porcentaje de la población económicamente activa que se encuentra desempleada pero que busca trabajo activamente en zonas urbanas.

6 Es la proporción de población que están en edad escolar y no asiste a la escuela o si de acuerdo con su edad no ha concluido la primaria o secundaria.

el desarrollo de los países, sino más bien de diferencias históricas entre países pobres y ricos. La industrialización, el crecimiento demográfico, las migraciones del campo a la ciudad y la existencia de diferenciales de productividad son las principales razones que explican el comportamiento anteriormente mencionado.

Respecto de la educación técnica o superior, se considera que genera mayores oportunidades para la obtención de ingresos más elevados, debido a que incrementan la probabilidad de insertarse al mercado laboral y conseguir un salario competitivo (Nielsen y Alderson, 1995).

De igual forma, se relaciona a los sindicatos como un mecanismo que genera una mayor igualdad de ingresos para los trabajadores, mediante la negociación colectiva de los contratos y salarios (Caniglia y Flaherty, 1989; Card y Freeman, 1994; Levernier *et al.*, 1995; Glaeser, 2005).

Asimismo, la calidad del empleo y los ingresos promedio percibidos entre sectores son diferentes, en consecuencia, su impacto en la desigualdad de ingresos es variado. Mehic (2018) y Siami y Hudson (2019) encuentran que el empleo industrial genera oportunidades de obtener mayores ingresos para los trabajadores, sin necesidad de contar con un nivel alto de instrucción. Del mismo modo, Siami y Hudson (2019) descubren que el empleo agrícola y en los servicios en general los salarios son más bajos. Además, en estos sectores se concentra mayor porcentaje de ocupación informal.

La *Des* recoge las condiciones de oferta en el mercado laboral. Anand *et al.* (2016) detectan que economías con mayores tasas de desempleo a largo plazo provocan un incremento en la desigualdad de ingresos a nivel global. Finalmente, la *Redu* aproxima las condiciones de rezago social. Tapia y Valenti (2016) argumentan que el sistema educativo mexicano estratifica el acceso a los aprendizajes llevando a reproducir desigualdades. En otras palabras, las condiciones de enseñanza-aprendizaje, que incluye infraestructura, son comparativamente peores para las personas de menores ingresos. Aiyar y Ebeke (2019) encuentran que la carencia de oportunidades disminuye la movilidad social e incrementa la desigualdad en el ingreso.

### *3.1.4. Variables instrumentales para la corrupción*

La endogeneidad se produce cuando una variable independiente se correlaciona con el término de error en una regresión. En particular, el problema de endogeneidad puede explicarse por la omisión de algunas variables que influyen en la relación desigualdad-corrupción o por causalidad inversa en esta. Se realiza la prueba de endogeneidad de Hausman (1978)[7], que confirma la existencia de endogeneidad entre la desigualdad (*Gini*) y la corrupción (*Ipc*). Para resolver este

[7] Después se realiza la regresión de la ecuación original incluyendo los residuales del modelo auxiliar. El coeficiente de los residuos del modelo auxiliar = -0,0817, estadísticamente significativo al 95%, se le realiza la prueba F de significancia con valor de 6,53 y Valor-P=0,010. Por lo que se confirma endogeneidad entre corrupción y desigualdad de ingresos.

problema se utilizan variables instrumentales, correlacionadas con la corrupción, pero no con el término de error, a saber: el índice de rendición de cuentas (*Rcue*)[8] y el índice de gobierno electrónico (*Egob*)[9]. Estas variables son relacionadas en la literatura con la corrupción (véase Andersen, 2009; Kolstad, y Wiig, 2016; Jetter *et al.,* 2015; Yunusa, 2016; Brusca y Aversano, 2018; Bu *et al.*, 2021).

### 3.2. Metodología

Para abordar el sesgo e inconsistencia derivado de la endogeneidad con origen en la causalidad inversa de las variables explicativas *Ipc* y *T_corr*, se utiliza un modelo de ecuaciones simultáneas, que plantea un conjunto de ecuaciones con influencia simultánea tanto entre variables como ecuaciones, y se estima mediante Mínimos Cuadrados en Dos Etapas con Componentes en el Error (MC2ECE). En concreto, los problemas derivados de la presencia de una variable explicativa endógena se corrigen utilizando nuevas variables exógenas no incluidas en el modelo, llamadas instrumentos, para lo que se sigue el método de variables instrumentales (Gujarati y Porter, 2009).

Dicho método radica en encontrar una variable aleatoria instrumental válida $z_{it}$, que reúna ciertas condiciones, asegurando que los estimadores obtenidos sean consistentes, es decir, converjan hacia sus verdaderos valores a medida que el tamaño de la muestra crece.

El método de mínimos cuadrados en dos etapas (MC2E), desarrollado independientemente por Theil (1953) y Basmann (1957), es un método que permite estimar modelos de ecuaciones simultáneas con información limitada. Consiste en aplicar MCO en dos etapas. En la primera, se estima mediante MCO cada una de las ecuaciones de forma reducida para obtener los estimadores $\widehat{\Pi_{ij}}$, de cada variable endógena $Y_i$. En la segunda, se remplazan las variables endógenas que aparecen del lado derecho de las ecuaciones estructurales por sus estimadores $\hat{Y}_i$ obtenidos de sustituir $\widehat{\Pi_{ij}}$.

Baltagi (1981) extendió el método de mínimos cuadrados en dos etapas (MC2E) al modelo con componentes en el error (ECMC2E). La expresión del estimador puede interpretarse como la combinación ponderada de los estimadores por MC2E que recogen la variación entre los grupos, períodos de tiempo y residual. Es posible utilizar un modelo de ecuaciones simultáneas a partir de un contexto de datos en panel. Esta combinación consiste en eliminar los efectos no observados de las ecuaciones por medio de las estimaciones de datos de panel

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8 El Índice de rendición de cuentas publicado por la Fundación Konrad Adenauer, componente del Índice de Desarrollo Democrático (IDD), combina diferentes indicadores que permiten evaluar el grado de rendición de cuentas en cada entidad, incorporando datos de la elección de los jueces del Supremo Tribunal de Justicia, funcionamiento de la institución Defensor del Pueblo, mecanismos de democracia directa vigentes en el estado para la expresión ciudadana, existencia y desempeño de órganos de control externo.

9 Porcentaje de la población que ha tenido al menos una interacción con el gobierno por medios electrónicos.

y la aplicación de variables instrumentales para la construcción del modelo de ecuaciones simultáneas (Wooldridge, 2009).

*3.2.1. Modelo econométrico*

Para la estimación del modelo econométrico se sigue lo planteado por Baltagi (1981). Debido al problema de endogeneidad confirmado mediante la prueba de endogeneidad de Hausman (1978), se emplea un modelo de ecuaciones simultáneas y se estima mediante mínimos cuadrados de dos etapas con componentes en el error (MC2ECE), utilizando el *Rcue* y el *Egob* como variables instrumentales para la corrupción. Las ecuaciones del modelo MC2ECE se definen como:

$$\begin{aligned} Gini_{it} = {} & \beta_0 + \beta_1 Corrupción_{it} + \beta_2 Pibper_{it} + \beta_3 Emsos_{it} + \beta_4 Sin_{it} + \beta_5 Des_{it} \\ & + \beta_6 Redu_{it} + \beta_7 Opri_{it} + \beta_8 Osec_{it} + \beta_9 Oter_{it} + \mu_{it} \end{aligned} \tag{2}$$

$$Corrupción_{it} = \gamma_0 + \gamma_1 Rcue_{it} + \gamma_2 Egob_{it} + \nu_{it} \tag{3}$$

En la primera etapa se estima la corrupción (corrupción: *Ipc, T_corr*) en función de las variables instrumentales y las variables exógenas definidas en las ecuaciones (2) y (3). En la segunda etapa se estima la ecuación estructural (2), remplazando la variable endógena (*Corrupción*) por su estimador, $\widehat{Corrupción_{it}}$ obtenido de la primera etapa. Cuando existe el problema de endogeneidad las estimaciones con variables instrumentales por el método de MC2ECE son superiores a las estimaciones de MCO porque estas últimas tienden a estar sesgadas, tener errores de medición y no abordan el problema de causalidad inversa; mientras que las estimaciones MC2ECE resuelve estos problemas (Jong y Khagram, 2005). El método MC2ECE se considera más eficiente que MC2E para explicar un sistema de ecuaciones simultáneas (Baltagi, 1981).

Para atacar el problema de la endogeneidad con origen en los errores de medición de las variables utilizadas para la corrupción, se emplea el método generalizado de momentos (GMM) propuesto por Arellano y Bover (1995), que detalla un modelo dinámico con efectos específicos por entidad federativa invariables en el tiempo. Esto parece plausible para el caso de la variable *Gini* si se considera que otras variables fuera del análisis, como el marco institucional, muestran solo pequeñas variaciones en el tiempo. El modelo toma las primeras diferencias para eliminar los efectos invariables por entidad federativa. Así, la ecuación (2) se especifica como:

$$\begin{aligned} Gini_{it} - Gini_{it\text{-}1} = {} & \alpha + \beta_1 \left( Gini_{it\text{-}1} - Gini_{it\text{-}2} \right) + \beta_2 \left( Corrupción_{it\text{-}1} - Corrupción_{it\text{-}2} \right) \\ & + \sum_{k=1}^{n} \beta_k (X_{kit} - X_{kit-1}) + (\mu_{it} - \mu_{it\text{-}1}) \end{aligned} \tag{4}$$

Para considerar la endogeneidad entre la variable explicativa (Corrupción: *Ipc*, *T_corr*) y la variable dependiente, *Gini*, la ecuación (4) se estima usando los valores rezagados de las variables endógenas como instrumentos, los que son válidos si el término de error, $\mu_{it}$, no está correlacionado serialmente, es decir, son independientes. No obstante, existen algunas limitaciones estadísticas para una estimación directa de variables instrumentales con la metodología GMM. En concreto, los niveles rezagados hacen que los instrumentos sean débiles cuando se especifican en diferencias, principalmente en muestras pequeñas. Alonso y Arellano (1996) establecen que el estimador GMM en primeras diferencias enfrenta sesgo de muestra finita y baja precisión. Como solución, Blundell y Bond (1998) proponen un modelo dinámico ampliado conocido como sistema-GMM (sys-GMM, por sus siglas en inglés), que combina las primeras diferencias rezagadas de la variable dependiente con sus niveles rezagados.

Los instrumentos de la regresión en niveles son las diferencias rezagadas y los instrumentos para las regresiones en primeras diferencias son los niveles rezagados. Un problema es que los instrumentos adicionales pueden no ser válidos (sobreidentifican a las variables instrumentadas). Empero, Blundell *et al.*, (2001) establecen que el sys-GMM tiene mejores propiedades de muestra finita en términos de sesgo. Para ello es necesario realizar, tanto para el GMM como para sys-GMM, la prueba de sobreidentificación de restricciones de Hansen, que se distribuye asintóticamente como una chi-cuadrada, y que es consistente en presencia de heterocedasticidad y autocorrelación. Además, tal como el GMM, el modelo supone que el término de error no está correlacionado serialmente.

La autocorrelación puede presentarse porque la variable dependiente rezagada también se asocia con los efectos específicos a nivel entidad federativa. Es razonable aceptar cierto grado de persistencia en las condiciones que determinan el *Gini* de una determinada entidad federativa. Para la consistencia del estimador se requiere que no exista correlación serial de segundo orden en los residuos diferenciados; por esta razón, se aplica la prueba de Arellano y Bond (1991) de autocorrelación.

## 4. Resultados

Se calcula la matriz de correlación de las variables de control para descartar multicolinealidad. Las variables que presentan colinealidad significativa son *Redu* y *Opri* con un coeficiente de correlación de 0,723 (ver Cuadro 2).

Adicionalmente, se realiza la prueba del factor de inflación de la varianza (FIV). Así, el FIV es la razón entre la varianza observada y la potencial en caso de que la variable estuviera correlacionada con el resto de regresores del modelo. En otras palabras, muestra la inflación de la varianza del estimador como consecuencia de la no ortogonalidad de los regresores. Belsley *et al.* (1980) consideran que existe un problema grave de multicolinealidad cuando el FIV de algún coeficiente es mayor de 10. En el Cuadro 3 se observa que ningún coeficiente se acerca al valor de referencia. Las variables con mayor

CUADRO 2
MATRIZ DE CORRELACIONES

| | *Gini* | *Pibper* | *Des* | *Sin* | *Redu* | *Emsos* | *Opri* | *Osec* | *Oter* |
|---|---|---|---|---|---|---|---|---|---|
| *Gini* | 1,000 | | | | | | | | |
| *Pibper* | -0,039 | 1,000 | | | | | | | |
| *Des* | -0,044 | -0,043 | 1,000 | | | | | | |
| *Sin* | 0,252 | 0,194 | -0,113 | 1,000 | | | | | |
| *Redu* | 0,282 | -0,107 | 0,288 | -0,072 | 1,000 | | | | |
| *Emsos* | 0,256 | -0,257 | -0,134 | -0,124 | 0,006 | 1,000 | | | |
| *Opri* | 0,152 | -0,060 | 0,150 | 0,173 | 0,723 | -0,083 | 1,000 | | |
| *Osec* | -0,179 | 0,041 | 0,033 | 0,319 | -0,114 | -0,166 | 0,073 | 1,000 | |
| *Oter* | 0,057 | -0,268 | 0,056 | -0,097 | 0,061 | 0,513 | -0,076 | 0,031 | 1,000 |

Fuente: Elaboración propia con datos calculados con *software* STATA 14.

CUADRO 3
FACTOR DE INFLACIÓN DE LA VARIANZA PARA LAS VARIABLES DE CONTROL

| Variable | FIV | 1/FIV |
|---|---|---|
| *Redu* | 2,58 | 0,388 |
| *Opri* | 2,49 | 0,402 |
| *Emsos* | 1,51 | 0,664 |
| *Oter* | 1,49 | 0,673 |
| *Sin* | 1,27 | 0,790 |
| *Osec* | 1,21 | 0,825 |
| *Des* | 1,16 | 0,863 |
| *Pibper* | 1,15 | 0,870 |
| Media FIV | 1,61 | |

Fuente: Elaboración propia con datos calculados con *software* STATA 14.

FIV son *Redu* y *Opri*, sin embargo, su valor no representa un problema grave de multicolinealidad.

Asimismo, para resolver la endogeneidad derivada de la relación bidireccional entre la corrupción y la desigualdad de ingresos, se procede a realizar las estimaciones con variables instrumentales bajo el método de MC2ECE con errores aleatorios. Este método resuelve los problemas de sesgo e inconsistencia provocados por la correlación de la variable endógena con los errores de la estimación (Hausman, 1978; Angrist y Imbens, 1995; Jong y Khagram, 2005). Los resultados del procedimiento de estimación MC2ECE se presentan en el Cuadro 4. En la columna [I] se muestran los resultados utilizando la variable dependiente *Ipc* y en [II] los resultados con la variable dependiente *T_corr*. Adicionalmente, en [III] y [IV] se presentan los resultados de los modelos de GMM, y en [V] y [VI] los resultados de los modelos sys-GMM.

# CUADRO 4
## RESULTADOS DE LOS MODELO MC2ECE, GMM Y SYS-GMM

| Variable endógena: *Gini* | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variables explicativas | MC2ECE | | | | | | GMM | | | | | | sys-GMM | | | | | |
| | [I] | | | [II] | | | [III] | | | [IV] | | | [V] | | | [VI] | | |
| | Coef. | | ES | Coef. | | ES | Coef. | | ES | Coef. | | ES | Coef. | | ES | Coef. | | ES |
| *Gini_t-1* | | | | | | | 0,491 | * | 0,015 | 0,497 | * | 0,013 | 0,543 | * | 0,030 | 0,554 | * | 0,018 |
| *T_corr* | | | | 0,044 | ** | 0,018 | | | | 0,004 | * | 0,001 | | | | 0,005 | * | 0,001 |
| *T_corr_t-1* | | | | | | | | | | 0,003 | ** | 0,002 | | | | 0,003 | * | 0,001 |
| *Ipc* | -0,559 | ** | 0,263 | | | | -0,055 | * | 0,017 | | | | -0,096 | * | 0,018 | | | |
| *Ipc_t-1* | | | | | | | -0,124 | * | 0,040 | | | | -0,107 | ** | 0,044 | | | |
| *Pibper* | 0,004 | | 0,008 | -0,005 | | 0,013 | 0,060 | ** | 0,025 | 0,025 | | 0,020 | 0,018 | | 0,031 | -0,030 | | 0,028 |
| *Des* | -0,003 | | 0,004 | 0,000 | | 0,003 | 0,004 | * | 0,001 | 0,005 | * | 0,001 | 0,005 | * | 0,002 | 0,004 | ** | 0,002 |
| *Sin* | 0,105 | * | 0,026 | 0,132 | * | 0,029 | 0,074 | * | 0,016 | 0,100 | * | 0,015 | 0,124 | * | 0,014 | 0,146 | * | 0,018 |
| *Redu* | 0,118 | ** | 0,058 | 0,104 | *** | 0,063 | 0,086 | | 0,098 | 0,037 | | 0,060 | -0,149 | | 0,127 | 0,029 | | 0,096 |
| *Emsos* | -0,025 | * | 0,005 | -0,027 | * | 0,007 | -0,009 | * | 0,001 | -0,009 | * | 0,001 | -0,011 | * | 0,001 | -0,011 | * | 0,001 |
| *Opri* | -0,028 | * | 0,011 | -0,021 | *** | 0,012 | 0,056 | * | 0,009 | 0,046 | * | 0,009 | 0,035 | * | 0,006 | 0,029 | * | 0,007 |
| *Osec* | -0,067 | * | 0,024 | -0,079 | * | 0,027 | -0,029 | ** | 0,015 | -0,039 | * | 0,018 | -0,039 | *** | 0,022 | -0,054 | * | 0,021 |
| *Oter* | -0,057 | | 0,037 | -0,029 | | 0,036 | 0,017 | | 0,021 | 0,039 | | 0,027 | 0,025 | | 0,023 | 0,045 | | 0,029 |
| Constante | 0,488 | | 1,260 | -2,011 | * | 0,279 | -0,330 | | 0,304 | -1,158 | * | 0,126 | 0,283 | | 0,256 | -0,653 | * | 0,151 |
| R2 | 0,352 | | | 0,160 | | | | | | | | | | | | | | |
| F estadístico /Wald Chi2 | 199,26 | * | | 118,3 | * | | 4940,4 | * | | 6619 | * | | 6077,210 | * | | 3194,1 | * | |
| Test Arellano-Bond para AR(1) | | | | | | | -4,15 | * | | -4,04 | * | | -4,050 | * | | -4,15 | * | |
| Test Arellano-Bond para AR(2) | | | | | | | -1,31 | | | -1,34 | | | -1,500 | | | -1,59 | | |
| Test de Sargan/Hansen | | | | | | | 30,10 | | | 30,11 | | | 30,500 | | | 29,46 | | |

Fuente: Elaboración propia con datos calculados con *software* STATA 14.
Nota: Error estándar (ES), Coeficiente (Coef.). *P<.01, **p<.05, ***p<.10; Gini_t-1, *Ipc*_t-1 y *T_corr*_t-1: son las variables Gini *Ipc* y *T_corr* rezagadas un periodo.

La estimación se realiza mediante el método de ecuaciones simultáneas con MC2ECE. Para corroborar que los instrumentos utilizados sean válidos se realizan las pruebas de sobreidentificación de las variables instrumentales. Se rechaza la $H_0$ (la significancia conjunta de las variables es cero), dado el valor del estadístico F = 199.26 (p=0,0000) para el caso del *Ipc* y F = 118,30 (p=0,0000) para la *T_corr*. Además, el estadístico F muestra un valor superior a 10 en ambos modelos, lo que sugiere que los instrumentos son adecuados (Stock y Yogo, 2005). Asimismo, se realizan estimaciones auxiliares por MCO para las variables endógenas y sus instrumentos, las que permiten confirmar que los instrumentos están correlacionados con las variables endógenas[10].

Para el caso de la restricción de exclusión de los instrumentos no es posible contrastar si se verifica dicha condición debido a que $Cov(Z_i, u_i)$ no es observable. No obstante, en la literatura se establece una estrecha conexión de la *Rcue* con la corrupción (Jetter *et al.* 2015; Brusca, y Aversano 2018; Bu *et al.* 2021). Los mecanismos de rendición de cuentas inhiben la ocurrencia de los actos corruptos, al fortalecer la observancia y fiscalización. En el mismo sentido, la instauración de un gobierno electrónico, simplifica las tareas administrativas y fomenta los mecanismos de transparencia. También, la realización de trámites por intermedio de internet limita la interacción de la sociedad con los funcionarios públicos, disminuyendo el riesgo de corrupción (Andersen, 2009). La simplificación de trámites y la transparencia en el manejo de recursos públicos generan mayor certidumbre, fomentando la economía mediante el incremento de la inversión y el empleo, lo que puede generar una reducción en la desigualdad de ingresos. De esta forma, la *Rcue* y el *Egob* se relacionan con la desigualdad de ingresos de manera indirecta mediante el canal de la corrupción. El riesgo que las variables utilizadas como instrumentos estén correlacionadas con el término de error es bajo debido a que no tienen una conexión directa con la variable dependiente (*Gini*).

En el Cuadro IV se muestran los resultados de las estimaciones de MC2ECE, GMM y sys-GMM. En general, se observa que los coeficientes de las variables que aproximan a la corrupción (*Ipc* y *T_corr*) tienden a ser sistemáticamente significativos por medio de las especificaciones. Asimismo, los signos de los coeficientes tienden a permanecer y sus valores se mantienen en el mismo rango. Esto contribuye a la robustez de los resultados y, por tanto, a aceptar las inferencias respecto del efecto de la corrupción sobre la desigualdad de ingresos.

No se encuentra sensibilidad significativa de los resultados utilizando diferentes variables que miden la corrupción, si bien se estiman diferencias en sus efectos. En el caso del *Ipc* presenta una relación negativa con el *Gini* y el *T_corr* una relación positiva. Este resultado es el esperado, ya que valores altos del *Ipc* significan mejor desempeño y por tanto menor nivel de corrupción. En contraste, valores mayores de la *T_corr* representan mayor ocurrencia de actos

[10] Los coeficientes de las regresiones auxiliares son: para *Rcue*= 1,60 (p=0,0000) $R^2$ = 0,533; *Egob*=1,23 (p=0,000) $R^2$ = 0,988 para el *Ipc* y *Rcue*=-0,416 (p=0,0000) $R^2$ = 0,171; *Egob*=-0,333 (p=0,000) $R^2$ = 0,342 para la *T_corr*

corruptos. Resultados similares son estimados en Gupta *et al.* (2002), Jong y Khagram (2005), aunque contrarios a Rosas (2018).

Este hallazgo sugiere que la corrupción tiende aumentar la desigualdad de ingresos entre entidades federativas. Esta idea está en línea con los hallazgos de CEI (2005) y Morris (2009). En particular, los primeros señalan que la brecha entre el gasto público en infraestructura y la infraestructura existente, explicada por una deficiente gestión pública o corrupción en el manejo de fondos públicos, difiere entre entidades. El segundo establece que el tamaño de la población incide en el nivel de corrupción, lo que sugiere que entidades más grandes ejercen mayor demanda de servicios públicos abriendo más oportunidades para actos de corrupción.

Aparte, como el mecanismo central de redistribución está ligado a la corrupción (Rosas, 2018), aquellos agentes que operan dentro de estructuras corruptas tienen más oportunidades de obtener ingresos extraordinarios. Al respecto, González y Sánchez (2019) indican que en México los ricos son más propensos a soportar un sistema corrupto, por las ventajas que pueden obtener; mientras que los pobres se ven muy afectados por un sistema de esta naturaleza. De este modo, se coincide con la idea que la corrupción es un determinante central de la inequitativa distribución del ingreso.

Los posibles canales de transmisión de la corrupción hacia la desigualdad de ingresos se asocian con la gestión pública, esto es, la toma de decisiones, el desvío de recursos, inversiones en infraestructura, distorsión en el sistema fiscal, acceso a contratos públicos para un grupo de poder, inestabilidad de las finanzas públicas (Cooray *et al.*, 2017), reducción en el presupuesto destinado a programas sociales dirigidos a combatir la desigualdad (Chetwyn *et al.*, 2003) y las relaciones clientelistas de las clases más pobres (Zúñiga, 2017). Asimismo, es posible que la corrupción impacte en la desigualdad de ingresos indirectamente mediante otras variables como la calidad y cantidad de los servicios públicos (especialmente en los sectores de educación y salud), que finalmente se traduce en una menor efectividad del gasto público, tal como señalan Policardo *et al.* (2019).

Además, este resultado se explica también por la desigualdad de oportunidades entre grupos sociales, que dificultan el acceso a servicios de salud o de educación. Esta carencia relativa de oportunidades se refleja en perspectivas futuras de ingresos limitados y, por tanto, esto llevaría a actuar dentro de un sistema corrupto o fuera de la ley. Así, siguiendo el enfoque de Eicher *et al.* (2009), los grupos sociales en las entidades federativas con niveles intermedios de educación y salud permanecen en una trampa de desigualdad, ya que el nivel de capacidades crea limitados ingresos laborales, pero suficientes rentas de corrupción en aquellos ciudadanos dentro del sistema de corrupción.

Otro mecanismo por el cual la corrupción afecta a la desigualdad de ingresos es el relacionado con el crecimiento económico. De esta forma, niveles altos de corrupción incrementan la incertidumbre del mercado, debido a que erosiona el estado de derecho y la protección de los derechos de propiedad (Iwasaki y Suzuki, 2012), un clima de elevada incertidumbre desalienta la inversión, afectando el crecimiento, el empleo y por tanto el ingreso personal de los trabajadores.

Esto genera un círculo perverso donde niveles altos de corrupción conducen a mayor desigualdad de ingreso y la mayor desigualdad incrementa el riesgo de corrupción. Una idea similar se establece en Jong y Khagram (2005).

Respecto de las variables de control utilizadas en el modelo, la *Des* muestra una relación positiva y estadísticamente significativa con el *Gini* en los modelos III, IV, V y VI. La tasa de desempleo es un producto de la incapacidad de la economía para absorber la mano de obra debido al crecimiento insuficiente. Esta condición afecta mayoritariamente a la población más vulnerable, reduciendo la oportunidad de conseguir ingresos (Berisha *et al.*, 2018). Así pues, la población en situación de desempleo encuentra una fuente de ingresos en el sector informal, a costa de menores ingresos y remuneraciones totales. En este sentido la corrupción distorsiona indirectamente la *Des*, debido a que crea condiciones de incertidumbre en la economía afectando el nivel de empleo y facilitando el crecimiento del sector informal (Pérez, 2005).

Asimismo, el *Redu* muestra una relación con signo positivo con *Gini* y es estadísticamente significativo en los modelos I y II. La relación entre el número de años de estudio y el ingreso personal es ampliamente documentada; la población que presenta rezago educativo tiene menos oportunidades de acceder a un empleo bien remunerado (Székely, 1995), el rezago educativo limita la movilidad social del sector más vulnerable.

En cuanto al PIB per cápita (*Pibper*), los resultados muestran un efecto positivo y estadísticamente significativo sobre el *Gini* en el modelo III. Es un resultado contraintuitivo ligado a que el crecimiento económico no representa una mejora para el grueso de la población, lo que posiblemente suceda en economías con niveles elevados de desigualdad. Rubin y Segal (2015) argumentan una idea similar al señalar que el ingreso de los más ricos es sensible al crecimiento, lo que genera brechas entre deciles de la población. Por consiguiente, para que el crecimiento del *pibper* se traduzca en una reducción de la brecha de desigualdad de ingresos, es necesario mejorar los mecanismos para la redistribución. En este contexto, como señalan Shleifer y Vishny (1993), la corrupción deteriora dichos mecanismos por medio de la distorsión en la estructura del gasto, redireccionando el presupuesto a tareas de seguridad, obras faraónicas y pago de deuda, en vez de destinar recursos para programas sociales de salud y educación. También, los resultados se alinean a los presentados por Kuznets (1955), que menciona que a corto plazo el crecimiento económico empeora la desigualdad; pero en el largo plazo, a partir de un cierto nivel de ingresos, el crecimiento económico provoca menores niveles de desigualdad. Según la Organización de las Naciones Unidas (ONU)[11], para el 2019, más del 57% de los ingresos nacionales se concentraron en el 10% de la población más rica y el 28% en el 1%. En contraste, el 48,8% de la población percibió ingresos inferiores a la línea de pobreza por ingresos.

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[11] Véase https://www.onu.org.mx/mexico-de-los-paises-con-mayor-concentracion-de-riqueza-en-manos-de-unos-cuantos-undp/

La *Sin* muestra un efecto positivo y estadísticamente significativo con el *Gini* en todos los modelos, resultado contrario al esperado. Los sindicatos en el contexto mexicano están relacionados con dirigentes corruptos, que suelen establecer prácticas del *favoritismo* para la obtención de beneficios superiores para sus agremiados. Esto tiende a obstaculizar la entrada de nuevos trabajadores, al establecer mecanismos que no se basan en el mérito, generando una brecha salarial entre los trabajadores que pertenecen a un sindicato y los excluidos. Además, las prácticas corruptas dentro de los sindicatos generan distorsión en la distribución de beneficios de los agremiados, los afiliados que son cercanos al grupo de poder obtienen mayores beneficios que los demás. El resultado se alinea con Fairris (2003), quien señala que los sindicatos en México perdieron capacidad para reducir la desigualdad salarial. Asimismo, Campos *et al.* (2018) indican que el aumento de la tasa de sindicalización de los trabajadores se dio simultáneamente al aumento de la desigualdad de ingresos en el sector formal.

La *Emsos* presenta un signo negativo y estadísticamente significativo con el *Gini* en todos los modelos. La formación educativa para el trabajo es un elemento esencial para la reducción de la desigualdad de ingresos en México, ya que permite acceder a oportunidades de empleo con mayores ingresos, además dota a los trabajadores de una mayor propensión para acceder a un empleo formal (Salas y Murillo, 2013). Se ha observado que los ingresos de los graduados aumentan con el nivel educativo, sucediendo esto en mayor proporción en México, en comparación con la mayoría de los países de la OCDE (OCDE, 2016). Los estudios superiores otorgan mayor bienestar a los trabajadores debido a que tienen mayor propensión a contar con más prestaciones a corto y largo plazo; a la vez que propician mayor estabilidad laboral. Esto tiene implicaciones en la calidad de vida, ya que el acceso a los empleos de mayor calidad está más acotado al pequeño grupo que cuenta con educación superior (Salas, 2018).

La *Osec* registra el signo esperado en todos los modelos. El empleo en el sector secundario colabora a la disminución de la desigualdad de ingresos, posiblemente porque la industria como la manufactura, genera oportunidades a la mano de obra poco calificada para ganar mayores ingresos relativos, en especial en industrias destinadas a la exportación (Mehic, 2018).

En cambio, la *Opri* tiene un resultado no concluyente, ya que presenta un signo negativo en los modelos I y II y un signo positivo en los modelos III, IV, V y VI. Existen dos vertientes respecto de la asociación del empleo agrícola y la desigualdad en el ingreso. La primera puntualiza que el sector ofrece salarios bajos comparado con otras actividades como la industria. No obstante, diversos estudios mencionan que aun con salarios bajos, el sector ofrece la oportunidad de obtener ingresos en las zonas rurales, por lo que contribuye a disminuir la desigualdad de ingresos (Siami y Hudson, 2019). Por último, la *Oter* no es estadísticamente significativa en ninguno de los modelos, lo que significa que no se encuentra evidencia de su conexión con el *Gini*.

## 5. Conclusiones

Los resultados exponen evidencia robusta del rol de la corrupción como determinante de la desigualdad de ingresos en México en el periodo 2010-2020. Además, no se encuentra sensibilidad significativa de los resultados ante diferentes mediciones para la corrupción. Estos hallazgos sugieren que la corrupción podría aumentar la desigualdad de ingresos al interior de las entidades federativas. Los resultados obtenidos concuerdan con los trabajos realizados por Gupta *et al.* (2002) y Berisha *et al.* (2018), sin embargo, a diferencia de estos, las estimaciones se realizan tomando en cuenta la endogeneidad inherente a los modelos empíricos de corrupción. En este sentido, el documento proporciona nueva evidencia robusta del efecto de la corrupción en la desigualdad de ingresos.

Los resultados muestran cierta sensibilidad de algunas variables de control ante los diferentes métodos de estimación. Por ejemplo, el *Pibper* es significativo solo con el GMM, en el caso de la *Des* y la *Redu,* no son significativos mediante MC2ECE, pero sí tienen significancia en los modelos GMM y sys-GMM. Estas diferencias serían provocadas por las distintas formas en que se aborda el problema de endogeneidad. El método de MC2ECE trata la endogeneidad causada por la relación bidireccional entre la corrupción y la desigualdad de ingresos por medio de variables instrumentales. Asimismo, los modelos de GMM y el sys-GMM atacan ambos orígenes de la endogeneidad (causalidad inversa y errores de medición), al combinar las primeras diferencias rezagadas de la variable dependiente con sus niveles rezagados como instrumentos.

Es posible que la corrupción distorsione el efecto de ciertas variables de control, generando un resultado negativo para la distribución del ingreso. Un entorno con altos niveles de corrupción, provocaría un mayor desempleo, sindicatos que propician la desigualdad salarial entre trabajadores y afectar el crecimiento económico.

De igual modo, siguiendo la argumentación de Nieto (2021), en muchos países en desarrollo, y particularmente en México, tanto la desigualdad como la corrupción son fenómenos crónicos y sistémicos arraigados en la sociedad y en el sistema político-económico, que se manifiestan en relaciones como el clientelismo, amiguismo, nepotismo, padrinos, caciquismo y caudillismo. Estas dos dimensiones imponen un sólido obstáculo para alcanzar estándares de vida más elevados para toda la población que van más allá de la desigualdad de ingresos.

Al respecto, una alternativa para mejorar el bienestar de la población y reducir la desigualdad de ingresos es el fortalecimiento de las instituciones democráticas y económicas. Esto facilita las políticas redistributivas y la promoción del crecimiento económico inclusivo, al tiempo que reduce significativamente la corrupción. Al respecto, instrumentar políticas públicas que fomenten el crecimiento del sector secundario, específicamente la industria, podría generar efectos positivos para la reducción de la desigualdad de ingresos, debido a que dicho sector representa una oportunidad para obtener ingresos mayores, sin necesidad de un nivel de instrucción elevado.

Adicionalmente, combatir el rezago educativo es fundamental para reducir la desigualdad de ingresos, ya que fomenta la movilidad social. Sin embargo, la corrupción genera una distorsión en la estructura del presupuesto público, desviando recursos de los programas sociales que buscan combatir el rezago educativo hacia proyectos que permitan generar ganancias ligadas a la comisión de actos corruptos.

En particular, las políticas públicas orientadas a la reducción de la desigualdad de ingresos serían ineficaces si no se acompañan de un fortalecimiento de las instituciones de fiscalización y observancia, que permitan robustecer las estructuras de gobernanza, el estado de derecho y la protección de los derechos de propiedad. Estas condiciones propician un entorno para que se genere mayor inversión y por tanto un incremento en el ingreso de la población. Al mismo tiempo, el fortalecimiento de las instituciones favorece el manejo más eficiente de los recursos públicos, generando una distribución del ingreso más equitativa.

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