

Calijuri, Monica et al.

Working Paper

Detecting envelope wages with e-billing information

IDB Working Paper Series, No. IDB-WP-1397

Provided in Cooperation with:

Inter-American Development Bank (IDB), Washington, DC

Suggested Citation: Calijuri, Monica et al. (2023) : Detecting envelope wages with e-billing information, IDB Working Paper Series, No. IDB-WP-1397, Inter-American Development Bank (IDB), Washington, DC,
<https://doi.org/10.18235/0004927>

This Version is available at:

<https://hdl.handle.net/10419/289932>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by-nc-nd/3.0/igo/legalcode>

Detecting Envelope Wages with E-billing Information

Monica Calijuri
Carola Pessino
Andrea Lopez-Luzuriaga
Simeon Schächtele
Ubaldo Gonzalez
Carla Chamorro

Inter-American Development Bank
Institutions for Development Sector
Fiscal Management Division

May 2023

Detecting Envelope Wages with E-billing Information

Monica Calijuri
Carola Pessino
Andrea Lopez-Luzuriaga
Simeon Schächtele
Ubaldo Gonzalez
Carla Chamorro

Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library

Detecting envelope wages with e-billing information / Monica Calijuri, Carola Pessino, Andrea Lopez-Luzuriaga, Simeon Schächtele, Ubaldo Gonzalez, Carla Chamorro.

p. cm. — (IDB Working Paper Series ; 1397)

Includes bibliographical references.

1. Electronic invoices-Ecuador. 2. Income Tax-Ecuador. 3. Wages-Taxation-Ecuador. I. Calijuri, Monica.

II. Pessino, Carola. III. Lopez-Luzuriaga, Andrea. IV. Schächtele, Simeon. V. González, Ubaldo.

VI. Chamorro, Carla. VII. Inter-American Development Bank. Fiscal Management Division. VIII. Series.

IDB-WP-1397

<http://www.iadb.org>

Copyright © 2023 Inter-American Development Bank. This work is licensed under a Creative Commons IGO 3.0 Attribution-NonCommercial-NoDerivatives (CC-IGO BY-NC-ND 3.0 IGO) license (<http://creativecommons.org/licenses/by-nc-nd/3.0/igo/legalcode>) and may be reproduced with attribution to the IDB and for any non-commercial purpose, as provided below. No derivative work is allowed.

Any dispute related to the use of the works of the IDB that cannot be settled amicably shall be submitted to arbitration pursuant to the UNCITRAL rules. The use of the IDB's name for any purpose other than for attribution and the use of IDB's logo shall be subject to a separate written license agreement between the IDB and the user and is not authorized as part of this CC-IGO license.

Following a peer review process, and with previous written consent by the Inter-American Development Bank (IDB), a revised version of this work may also be reproduced in any academic journal, including those indexed by the American Economic Association's EconLit, provided that the IDB is credited and that the author(s) receive no income from the publication. Therefore, the restriction to receive income from such publication shall only extend to the publication's author(s). With regard to such restriction, in case of any inconsistency between the Creative Commons IGO 3.0 Attribution-NonCommercial-NoDerivatives license and these statements, the latter shall prevail.

Note that the link provided above includes additional terms and conditions of the license.

The opinions expressed in this publication are those of the authors and do not necessarily reflect the views of the Inter-American Development Bank, its Board of Directors, or the countries they represent.



Contents

- ABSTRACT III

- 1. INTRODUCTION..... 1

- 2. LITERATURE REVIEW 5

- 3. CONCEPTUAL FRAMEWORK..... 7

- 4. INSTITUTIONAL BACKGROUND..... 9

- 5. DATA AND EMPIRICAL STRATEGY 11

- 6. RESULTS 15
 - 6.1 Main Results 15
 - 6.2 Heterogeneous Effects by Firm Size..... 19
 - 6.3 Robustness Checks 21
 - Breadwinner versus primary spender 21
 - Job tenure 26

- 7. DISCUSSION AND CONCLUSIONS 29

- REFERENCES..... 31

- ANNEX 33

Abstract*

This paper studies tax evasion in the form of under-reported wages in Ecuador using micro-data from a combination of electronic billing and personal income tax returns filed in 2017. Bringing together this novel combination of data, the study applies the standard method Pissarides and Weber (1989) used to estimate the under-reporting of income by comparing public- and private-sector employees. The results demonstrate empirically that under-reporting of income in private-sector employees is between 7 and 9 percent of their income, which translates to an estimated 3 percent of unregistered GDP. The under-reporting has important

implications for social security, reducing these contributions by about 10 percent. Beyond the overall picture of under-reporting, the study detects substantial heterogeneities concerning firm size, concluding that the gap size is negatively correlated with the number of employees at the firm, which is consistent with different risks and administrative costs of envelope wages in small versus large firms.

JEL Codes: H24, H26, D83

Keywords: income tax, evasion, electronic billing

* The authors are grateful to the staff of the Research Center for Fiscal Studies of the Ecuadorian Tax Authority for their outstanding collaboration, as well as the valuable comments of the participants of the 2022 Annual Congress of the International Institute of Public Finance.



Introduction

Informality is a key feature of emerging markets and developing economies (Ohnsorge and Yu, 2021). It constitutes an extraordinary challenge for their development as the shadow economy eschews taxation and social security contributions while hindering the state's ability to deliver benefits and enforce regulations. One form of informality that is only beginning to draw attention is quasi-informality in the form of envelope wages. Envelope wages is a term which refers to the practice of firms paying formal workers part of their remuneration off the books. Taxpayers thus avoid payroll and income tax but also lose out on entitlements. Alongside the more than 25 percent of the world population that live in emerging markets and developing economies, this type of informality and collusive evasion also occurs in OECD countries (Franic and Cichocki, 2022; Williams and Padmore, 2013) and affects their collection of business taxes (Besim and Jenkins, 2005).

Technology holds much promise as a means for curbing evasion and increasing formality. First, under the right circumstances, the withholding of payroll tax by the employer is believed to make the under-reporting of wages

close to impossible (Kleven et al., 2011; Jensen, 2022; Slemrod, 2019), leaving self-employment as the main source of unreported labor income. Second, by increasing traceability and reducing transaction costs, digital payments and electronic bills could make tax evasion and informality a thing of the past. However, withholding payroll tax may not work equally well in all countries and therefore the theory that, for employees, tax authority income records can be regarded as the gold standard (Cabral, Gemmell, and Alinaghi, 2021) is not necessarily watertight.

Moreover, in all countries the extent of envelope wage payments is unknown and the phenomenon is complicated to measure, due to its hidden nature. Furthermore, while digitization presents opportunities to leapfrog development (World Bank Group, 2017), the type of data matching required for measuring tax evasion, for instance, has been a challenge across the globe. To estimate the size of the shadow economy, researchers have resorted to survey data as a substitute for electronic payment data, but survey data has been shown to yield biased results (Cabral, Gemmell, and Alinaghi, 2021; Paulus, 2015).

Against these knowledge gaps, this paper seeks to answer the question: To what extent do employees under-report income? The study uses a novel approach that matches electronic billing data on consumption with income tax records and sheds light on how well withholding payroll tax works in a middle-income country. In addition, it provides empirical results on the theoretical prediction that collusive tax evasion is easier and more likely in small firms.

We use the Pissarides and Weber (1989) expenditure-based methodology to estimate the gap in reported income between public and private sector employees in Ecuador, briefly estimating the consumption and income relationship, while controlling for individuals' demographic characteristics for public and private sector employees. The assumption is that the relationship between consumption and real income is independent of the employment sector and any differences observed are due to a difference between real and reported income. Ecuador has a comprehensive electronic billing system. This detailed data on consumption is matched to employees' income tax records.

At the core of the estimation is the assumption that individuals with similar demographic characteristics and real income will have similar consumption patterns, particularly of food, independently of the source of their income. If differences are found in the relationship between consumption and reported income, those differences are consistent with income misreporting. Crucially, public employers have no incentive or opportunity to misreport their employees' wages, so employees in the public sector can be used as the benchmark: the difference in reported income between otherwise similar employees in the public and private sectors is a lower bound estimate for under-reporting and undervaluation of employee income in the private sector.

Overall, we find that the withholding system works for private sector employees. For a given consumption level, the reported income from these employees is smaller than that reported by public sector employees. Specifically, estimates center around 10 percent of under-reporting, but do not reach conventional significance levels in the standard specification that uses food consumption as a consumption proxy, although it is statistically significant if we use total consumption reported on the electronic billing system. However, once firm size is considered, the under-reported income is between 25 and 12 percent for small- and medium-sized firms, respectively, and the gap is statistically significant in all cases. For this reason, we calculate the size of the under-reported amount using an estimate for the whole sample, to be conservative. This reveals that the wages not reported amount to 3 percent of Ecuador's GDP. The income tax loss is relatively small due to the tax's progressive nature, making up around 1 percent of total tax revenue. However, the unpaid social security contributions are sizable and equivalent to 9 percent of all contributions.

This overall result masks considerable heterogeneity by firm size: the reporting gap is largest—up to 40 percent of income—for small firms with 3 employees or less. It increases with firm size until it vanishes for larger firms with more than 50 employees. This finding confirms theoretical predictions that collusive tax evasion is less likely in large firms, which are under more scrutiny from tax authorities, and where many employees may be exposed to the practice.

This study makes several contributions to the literature. First, while much of the literature estimates only parts of the shadow economy, the present paper is the first to use consumption data from electronic billing (matched to income tax records), avoiding biases inherent in survey data. It has the advantage of being third-party reported. Among the studies using the microeconomic Pissarides Weber “traces-

of-income” approach, most rely on survey data, which has been shown to be unreliable for this purpose (Cabral, Gemmell, and Alinaghi, 2021; Paulus, 2015). Notable exceptions use income tax deductions such as donations (Feldman and Slemrod, 2007; Torregrosa-Hetland, 2020), but these cannot be applied equally, in particular among developing countries.

Second, this study makes a specific contribution in terms of measuring under-reporting of employee income and envelope wages. According to evidence from the European Union, 5 percent of employees in this region receive envelope wages, with considerable heterogeneity by country (e.g., 15 percent in Romania) (Williams and Padmore, 2013). With one exception, the few studies that attempt to measure under-reporting by employees beyond self-reports also rely on survey data. In this way, Ekici and Besim (2016), following the Pissarides-Weber approach, find that private sector employees in North Cyprus report 86 percent of their income. Bergolo and Cru-

ces (2014) show that Uruguayan employees of small firms increased reported income once a social security reform introduced the tying of benefits to reported wages. Similarly, Kummer, Verhoogen, and Frias (2020) found that in Mexico, reported wages increased following a social security reform that increased incentives for truthful reporting. Using administrative data, Bjørneby, Alstadsæter, and Telle (2017) find that Norwegian firms due to be audited, particularly small ones, due to be audited, increased their subsequent wage reporting.

Third, evidence herein points to withholding as an effective strategy within the institutional framework of Ecuador, although less so for smaller firms. Lastly, the empirical results are consistent with the theoretical prediction that collusive evasion is more likely in smaller firms (Kleven, Kreiner, and Saez, 2016; Barth and Ognedal, 2018a). From a practical viewpoint, the methodology herein may allow tax authorities to target their taxpayer education and enforcement measures.



2

Literature Review

Measuring evasion is a complex problem due to the nature of evasion itself, similar to measuring any other illegal activity. There are two main ways of evading taxes, either by staying in the informal sector and not registering with the tax authority (extensive margin) or under-reporting transactions to the tax authority (intensive margin). The present study focuses on the latter problem, analyzing the intensive margin of under-reporting wages (i.e., envelope wages). The majority of literature that explores the under-reporting of income uses the methodology proposed by Pissarides and Weber, which assumes that the source of income does not systematically have differing effects on the consumption of food by the self-employed and employees. Therefore, any systematic difference between those two groups is due to differences in the opportunity for under-reporting. From this seminal work, the volume of literature has grown, using different groups, types of consumption, and contexts.

Artavanis, Morse, and Tsoutsoura (2016) detect systematic differences in reported income between employees and self-employed individuals by comparing their access to credit

in Greece. In this context, self-employed individuals report around 55 percent of their actual income. Cabral, Myles, and Kotsogiannis (2015) present a similar exercise for Great Britain using food consumption and find that self-employed individuals report around 81 percent of their income. Engstrom and Holmlund (2009) find that the self-employed in Sweden report around 70 percent of their income. Geoffrey and Chunling (2015), using the Survey of Financial Security and the Survey of Household Spending, estimate that in Canada, between 35 and 50 percent of households under-report their income by an amount equivalent to between 14 and 19 percent of GDP.

Other authors have used consumption reported on the same tax form. Feldman and Slemrod (2007) estimate the under-reporting of income in the United States using donations and find that self-employed people report 65 percent of their income. Torregrosa-Hetland (2020) measures the same gap for Spain, using donations, and finds that the self-employed report between 50 and 70 percent of their true income (the lower estimation corresponds to the top 10 percent of earners). Dominguez-Barrero, López-Laborda, and Rodrigo-

Sauco (2017) show, also for Spain, compliance changes with the economic cycle.

The comparison group of the studies mentioned above is of employees who have, in theory, less opportunity to hide income due to third-party reporting. There is some evidence that a possibility of under-reporting wages exists when part of the income received by the employee is kept off the books and not reported, either to social security or the tax authority—that is, envelope wages. The presence of these wages varies widely with context. For instance, in Denmark, the evasion of third-party reported income is close to zero (Kleven et al., 2011). However, there is evidence that low evasion on reported wages is not the norm in all European Union (EU) countries. Barth and Ognedal (2018b) present survey evidence for EU countries and find that around 5 percent of employees received part of their wages off the books and did not report it to the tax authority. Still, there is significant heterogeneity across EU countries. For example, in Romania, the share is 15 percent, Bulgaria 10 percent, and Spain between 5 and 7 percent (Di Nola, Kocharkov, and Vasilev, 2019). Williams and Horodnic (2017), using information from the Eurobarometer, find that 3 percent of workers of the 28 EU countries covered by the survey received under-reported salaries, and the percentage is more significant for unskilled workers, although there is a considerable variation between Eastern and Western European countries.

A few studies estimate the extent of under-reporting of income by employees, mainly

taking advantage of variation in incentives created by a social security reform. Bergolo and Cruces (2014) show that when a social insurance reform tying benefits to reported wages was introduced in Uruguay, employees of small firms increased their reported income by about 25 percent. Kumler, Verhoogen, and Frias (2020) measure the instance of under-reporting of wages to evade payroll taxes in Mexico, comparing two sources of information: individual wages reported by their employers to social security and a household-labor survey. They are not able to measure under-reporting at the individual level but rather in cells defined by the metropolitan area, sector, firm size, and employees' age group. They take advantage of the change in the incentive structure, owing to a 1997 social security reform, which encourages the truthful reporting of one's wages.

After the reform, there was an increase in reported wages, especially among smaller firms and younger workers. Using the Pissarides and Weber method, Ekici and Besim (2016) estimate that private employees in North Cyprus report 86 percent of their true income. Gorodnichenko, Martinez-Vazquez, and Sabirianova Peter (2009) find that the workers of smaller firms in Russia are more likely to under-report income than the workers of larger firms. They provide the different levels of monitoring according to firm size as possible mechanisms. The present study contributes to this literature by calculating the under-reporting of income by firm size, testing this mechanism directly, and using electronic billing information to calculate proxies of consumption.



3

Conceptual Framework

This study considers a standard tax evasion model similar to the Allingham and Sandmo version presented by Kleven et al. (2011), which includes a third party in the structure of the probability of detection. We use the model to guide the intuition of our estimation. Assume that the taxpayer is risk neutral and she has a real income of y and a reported income of y ; the under-reported income is the difference between them ($e \equiv \underline{y} - y$). The probability of detection increases based on evasion (e) and on firm size (k); $p = p(e, k)$, where

$$\frac{\partial p(e,k)}{\partial e} > 0, \quad \frac{\partial p(e,k)}{\partial k} > 0 \quad \text{and} \quad \frac{\partial^2 p(e,k)}{\partial e \partial k} > 0.$$

The larger a firm, the more likely it is to report its withholdings to the tax authority correctly, and the less likely the rise of informal contracts where the employee is paid envelope wages. Several rationales can support this assumption. Assume an individual is willing to under-report income; there is no reason for him to choose to be an employee over being self-employed unless the former can provide a higher pay-off. When larger firms are more productive and provide a productivity boost to their employees, there might be a trade-off between productivity and the opportu-

nity for evasion. Some individuals may choose to work for a larger and more productive firm even when there are no opportunities to evade; others might choose to be in less productive, smaller operations but compensate for part of their loss of productivity by under-reporting their income (Barth and Ognedal, 2018b).

Alternatively, if part of the contract is an envelope wage, there is always the chance that an employee will be a whistle-blower. This probability will increase with the amount of under-reported work (Kleven, Kreiner, and Saez, 2016; Barth and Ognedal, 2018b). The present study assumes a linear tax (t) levied on the reported income. The penalty for evading is proportional to the evaded tax and is given by $\theta > 1$. The risk neutral taxpayer chooses the level of evasion e to maximize:

$$E(U) = [1 - p(e,k)] [(\underline{y}) (1-t) + et] + p(e,k) [(\underline{y}) (1-t) - e\theta t] \quad (1)$$

Expected return if not being audited + Expected return on being audited

The corresponding first-order condition after some manipulation is:

$$\left[p(e,k) + \frac{\partial p(e,k)}{\partial e} e \right] [1 + \theta] = 1 \quad (2)$$

The left-hand side of Equation 2 represents the marginal cost for hiding an extra dollar, and the right-hand side is the marginal benefit.

Since, and , it is easy to see that the marginal cost increases with firm size, but the marginal benefit is constant; hence, employees of larger firms (more than 50 employees) will evade to a lesser degree.



4

Institutional Background

Ecuador is a middle-income country with a sizable part of the economy in the informal sector. The National Institute of Statistics and Censuses (INEC) defines the people involved in informal activities as economic units that belong to households not legally incorporated in a company (ILO, 2013). Following this definition, employees in the formal sector work in registered firms, public or private, and due to a constitutional mandate, there are no part-time workers (Ecuador, 2008). In 2017, people employed in the urban area were approximately 50.4 percent in the formal sector and 44.1 percent in the informal sector (Reporte de Economía Laboral; INEC, 2017). The informal sector consists of all the economic activity engaged in by agents who do not report to the government, pay taxes, or contribute to social security.

In this context, Ecuador has a progressive income tax with nine tax brackets and marginal tax rates from 0 to 35 percent. The taxable income for employees is their pay, minus the payroll tax (a flat rate of around 9 percent paid by the employee and around 12 percent paid by the employer¹) and deductions. All taxpayers are entitled to a deduction for personal

expenses in education, clothing, health care, housing, and food. Seniors and disabled people are entitled to an extra deduction. Employers must withhold taxes monthly, and the tax year coincides with the calendar year. Employers have to fill out an income tax return on behalf of their employees in February of the following year; if adjustments need to be made, they have until the end of March to report them. All formal employees have a 40-hour work week.

Ecuador started implementing an electronic billing system in 2012. By 2017, the system included all incorporated and non-incorporated firms required to keep accounting books, and taxpayers who can print sales receipts through computerized systems (instead of using pre-printed bills). The total amount of transactions reported on the electronic billing in 2017 is equivalent to about 75 percent of sales reported in the value-added tax form that all taxpayers report.

¹ The percentage is slightly different depending on the type of contract.



Data and Empirical Strategy

5

The present study uses two primary sources of information: income tax returns and information provided for the electronic billing system. We obtain details of reported wages from the tax return and generate a consumption proxy for each individual. The analysis of information from 2017 herein takes advantage of the fact that, as of this year, the electronic billing system covers a large portion of businesses in Ecuador; in practical terms, only the small, unincorporated businesses using pre-printed paper bills are not included. Due to deductions for personal expenses and design of the electronic billing system, the default in Ecuador is to get a tax receipt that includes the consumer's tax ID. The electronic billing system stores each transaction, including the information of consumers and vendors (e.g., the tax ID, location of the store where the transaction is registered, total purchase amount, and date).

Using the vendor's economic activity code, we identify a proxy for food consumption for each individual. For instance, if Person A buys from a registered grocery store, Store B, consumption is registered as food consumption. In addition, the tax and national registries are used to recover demographic characteris-

tics, tenure in the job in months, and employer's characteristics (e.g., public or private and firm size). The taxpayer's address and whether he or she is an employee (and does not own a business) or self-employed, is not part of the tax registry or its income tax form. As a result, there is no information about the canton where each individual lives that may affect employment opportunities. However, since the location of each vendor that the taxpayer purchases from is known, it is possible to assume that each person lives in the canton where she purchased the most by dollar amount during the year.

This study uses the income tax returns for all the employees of the country that were self-reported or reported by their employees, excluding from the sample all individuals with self-employed income. The income tax returns give access to reported wages, paid taxes, and employer-employee relationships. This data is used to identify public and private sector employees, which totaled 2,762,860 in 2017. It is possible to construct the variable of total consumption for 2,707,161 of them and the variable of food consumption for 1,798,517 of them. We use Pissarides and Weber methodology to

estimate the reporting income gap between public and private sector employees.

In a nutshell, the estimation consists of estimating a food expenditure equation based on the reported income and the individuals' demographic characteristics. At the core of the estimation is the assumption that individuals with similar demographic characteristics and levels of real income have similar consumption patterns, particularly of food, independently of income source (in this case, the wages reported by the public and private sectors). Differences in the relationship between consumption and income would be due to a misreporting of income. The regular relationship between food consumption and income level has been widely used in economics and is commonly known as Engel's Law. The expenditure of food share falls as income level increases. Still, it is relatively stable for a given level of income.²

Public employers have no incentive to misreport their employees' wages. We have chosen to use the electronic billing information to calculate the consumption proxies because there is no reason to think that public and private sector employees had incentives to select the store they consume from based on the availability of the electronic billing system. Also, 2017 was the first year all incorporated firms and a large portion of the non-incorporated firms were included in the electronic system.³ In fact, close to 75 percent of sales reported in the value-added tax form pass through the electronic billing system and this covers all formal transactions in the country. It is unclear whether consumers would be perfectly informed as to which stores would report the transaction to the tax authority using the electronic billing system. Although individuals could be maximizing their personal expenses deduction, the deduction is the same for all taxpayers. If anything, this behavior might introduce measurement error and corresponding attenuation bias to our estimation.

The measurement error on consumption does not bias the estimation if uncorrelated to the categories of employees being compared (i.e., public and private sector employees). To address the concern that the proxy of consumption in use could be correlated with the type of employment, the calculations herein are based on the probability of being reported in the electronic billing system when buying food based on the employment sector, demographic characteristics, and personal expenses deduction status. First, we notice that people who reached the maximum deduction for food in the previous month are more likely to have been reported in the electronic billing system in the current month. In other words, people who consume more significant amounts are more likely to appear in the electronic system. Being a private employee does not significantly affect the probability of being reported in the electronic billing system. This is evidence that individuals do not systematically try to hide their consumption from the tax authority, and they might not even be aware that the system creates the third-party reported channel for consumption (Table 1).

As a result, it does not appear using purchases reported in the electronic billing system to calculate the proxy of consumption, generates a systematic bias in the estimation. Following the estimation proposed by Feldman and Slemrod (2007) instead of using charitable contributions, we constructed two variables of consumption (food and total) with information from the electronic billing system.

² See Chai and Moneta (2010) for a historical review of the applications of Engle's Law and some examples of its application, and Roed Larsen (2014) and Li (2021) for more recent applications.

³ Incorporated firms are companies that have legal structure for corporate governance (e.g., board of directors, CEO, etc.). Non-incorporated are all other firms that have employees but do not include the self-employed.

TABLE 1

CORRELATION BETWEEN BEING REPORTED ON THE E-BILLING SYSTEM AND REACHING THE MAXIMUM FOOD DEDUCTION FOR PRIVATE AND PUBLIC EMPLOYEES – LPM

	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Max. food ded.	0.32***	0.33***	0.31***	0.33***	0.33***	0.31***	0.31***	0.29***	0.30***	0.30***	0.23***
	(0.03)	(0.04)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)
Private employee	0.01	0.01	0.01**	0.00	0.01**	0.00	0.00	0.01	0.00	0.00	-0.01**
	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Max. ded. x private emp.	-0.01	-0.01	-0.02	-0.03**	-0.00	-0.01	-0.00	0.01**	0.01***	0.00	0.02***
	(0.06)	(0.03)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
Canton of residency F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster unit	Canton	Canton	Canton	Canton	Canton	Canton	Canton	Canton	Canton	Canton	Canton
Observations	2,102,371	2,102,371	2,102,371	2,102,371	2,102,371	2,102,371	2,102,371	2,102,371	2,102,371	2,102,371	2,102,371

Notes: The dependent variable is a binary variable equal to one if the taxpayer had food purchases reported on the e-billing system. The maximum food consumption is a binary variable equal to one if the taxpayer reached the maximum food deduction from income tax, equivalent to US\$3,670 for 2017, by the previous month. Taxpayers have been divided into two disjoint groups: public employees and private employees. Taxpayers who can fit in more than one category have been excluded because they have more evasion opportunities since they have different reporting margins. Demographic controls such as education, age, marital status and gender are included. Each column represents a model for a different month; the month is indicated on the column label. Canton of residency is described as the canton where the taxpayer had the largest portion of her total reported consumption. Standard errors are in parentheses and clustered at the canton level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.0$

The estimation consists of a log-log estimation using a non-linear procedure that allows individuals to be included in the sample, during the same year, work for private and public sector employers. We estimate the relationship between the log of consumption and the individual's real income, both visible and non-visible. The visible income is the one that cannot be under-reported. We assume the wage of public sector employees is assumed always to be visible income, and while allowing for the wage of private sector employees to be non-visible. If income is not under-reported, the real income will coincide with the reported income for both groups. In particular, the following is estimated:

$$\ln(C_i) = \beta_0 + \beta_1 \ln(V_i + kW_i + \pi S_i) + \gamma X_i + \mu_i \quad (3)$$

where C_i is total consumption or food consumption depending on the specification; V_i is the visible income, in this case, the wage of the public sector employees; W_i is the private sector wage; S_i is a dichotomous variable equal to one if the individual has a private sector wage; X_i is a vector of demographic characteristics such as age, level of education, marital status, gender, and canton of residency; and μ_i is the error term.

The null hypothesis is that k is equal to one. If k were similar to one, there would be no evidence of consumption differences between public and private sector employees, and there would not be under-reporting of income (the wages of both public and private sector employees would be visible). If k were larger than one, the private sector employees would be under-reporting their income, compared

with the public sector employees. Alternatively, the under-reported income could come from a different source that was not reported (e.g., moonlighting). However, the probability of having this extra source of income should not be different for public and private sector employees or be affected by firm size. If there were differences in the reporting of income between both sectors, then for each dollar that a public sector employee reported, the private sector

would have reported $\frac{1}{k}$ dollars. A positive coefficient for S_i indicates that being a private sector employee has a positive income of π .

We make all estimations twice, with food consumption and total consumption being the former our preferred estimation. We make some subgroup analyses to determine any difference depending on the firm size; this study's conceptual framework guides this later specification.



6

Results

This section presents and discusses results for the whole sample. Guided by this study's conceptual framework, this paper presents the analysis by firm size, comparing all public with private sector employees who work in firms of different sizes. Finally, it offers some robustness checks that verify whether marital status changes the estimation or if job stability plays a role in the different consumption patterns.

6.1 Main Results

The sample for the present study consists of all public and private sector employees with an income tax form for 2017 who were reported on the electronic billing system as buyers. Public sector employees are around 25 percent of the sample, and their annual wage is on average US\$13,195. Private sector employees have a lower annual average wage of US\$8,185 but with a higher variance, as can be observed in the histogram of wages for each group of employees (Figure 1).

We estimate Equation 3 using food consumption and total consumption (Tables 2 and 3 show the results respectively). In general, our estimation shows that there is little to no

evasion on reported wages on average when considering all the sample of employees independently of the firm's size. Using food consumption, we cannot reject the null hypothesis that k is equal to 1 (Figure 2). Using total consumption, we find a small gap: on average, for each dollar a public employee reports, a private employee reports 91 cents (Figure 3).

To understand this gap, following Ekici and Besim (2016), this study calculates the size of the shadow economy due to this intensive margin under-reporting, estimating how much larger the country's gross domestic product (GDP) would be if all the wages were reported truthfully. In general, the shadow economy has three components: the economic activity of individuals who do not report any information to the government and are fully in the informal sector, the economic activity of self-employed individuals who are registered but hide some income from the government, and the wages that are paid to formal employees that are not fully reported to the government (envelope wages). The last two components constitute quasi-formality. We calculate that the portion of the shadow economy generated by envelope wages is between 2 and 4 percent of GDP. To make

FIGURE 1

HISTOGRAM OF PUBLIC AND PRIVATE SECTOR EMPLOYEES' WAGES

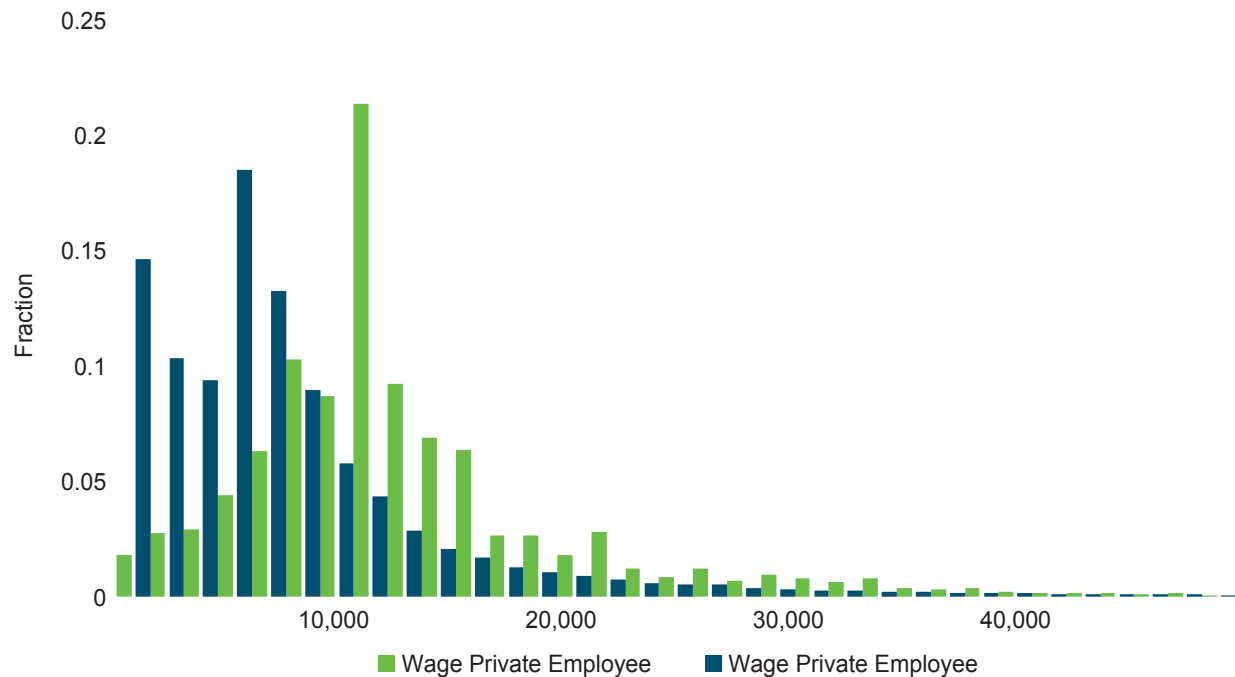


TABLE 2

REPORTED INCOME COMPLIANCE OF PRIVATE SECTOR EMPLOYEES BASED ON EXPENDITURES ON FOOD

Dependent Variable: \ln (Food Consumption)

	(1)	(2)	(3)	(4)
k_i : Wage in the private sector	1.02*** (0.05)	1.04*** (0.06)	1.08*** (0.05)	1.10*** (0.05)
ρ_i : Private sector employee	1,875.29*** (142.14)	1,967.86*** (158.40)	2,169.14*** (166.14)	2,276.30*** (183.56)
Age			0.01*** (0.00)	0.01*** (0.00)
Woman			0.19*** (0.02)	0.20*** (0.02)
Married			0.17*** (0.01)	0.17*** (0.01)
Finished high school			0.34*** (0.05)	0.34*** (0.05)
Finished college			0.62*** (0.08)	0.61*** (0.08)

(continued on next page)

TABLE 2 (continued)

REPORTED INCOME COMPLIANCE OF PRIVATE SECTOR EMPLOYEES BASED ON EXPENDITURES ON FOOD

Dependent Variable: ln (Food Consumption)

	(1)	(2)	(3)	(4)
Ratio of private sector compliance			0.93	0.91
Sample	Everybody	Single sector	Everybody	Single sector
Canton of residency F.E.	No	No	Yes	Yes
Controls	No	No	Yes	Yes
Observations	1,798,517	1,742,676	1,798,204	1,742,537

Source: Authors' elaboration.

Notes: The dependent variable is the natural logarithm of the expenditure on food reported to the e-billing system. The consumption variable is calculated using the third-party reported purchases made by the taxpayer to a company that reports to the e-billing system. The sample includes only individuals who purchased from a company with an e-billing system and worked in the formal sector as an employee. Public sector and private sector wages are third-party reported by the employer (government, or private entity). Columns (1) and (3) include all individuals. Columns (2) and (4) include only individuals who worked solely in the private or public sector (i.e., excluding individuals who worked in both). All monetary values are in dollars. Canton of residency is defined as the canton where the taxpayer had the largest portion of their total reported consumption. Standard errors are in parentheses and are clustered at the canton level. The number of employees that worked in the formal sector and did not report self-employment income was 2,762,860. We had information of food consumption for 1,798,517 of those individuals. *p < 0.10 , ** p < 0.05 , *** p < 0.01.

TABLE 3

REPORTED INCOME COMPLIANCE OF PRIVATE SECTOR EMPLOYEES BASED ON EXPENDITURES IN ALL CATEGORIE

Dependent Variable: ln (Total Consumption)

	(1)	(2)	(3)	(4)
k_i : Wage in the private sector	0.85*** (0.01)	0.86*** (0.01)	1.10*** (0.02)	1.11*** (0.02)
ρ_i : Private sector employee	1,138.76*** (101.67)	1,216.72*** (112.88)	1,192.51*** (154.43)	1,270.84*** (167.63)
Age			0.01*** (0.00)	0.01*** (0.00)
Woman			0.11** (0.04)	0.11*** (0.04)
Married			0.19*** (0.02)	0.19*** (0.02)
Finished high school			0.71*** (0.04)	0.71*** (0.04)
Finished college			1.20*** (0.05)	1.18*** (0.05)
Ratio of private sector compliance			0.91	0.90

(continued on next page)

TABLE 3 (continued)

**REPORTED INCOME COMPLIANCE OF PRIVATE SECTOR EMPLOYEES
BASED ON EXPENDITURES IN ALL CATEGORIES**
Dependent Variable: ln (Total Consumption)

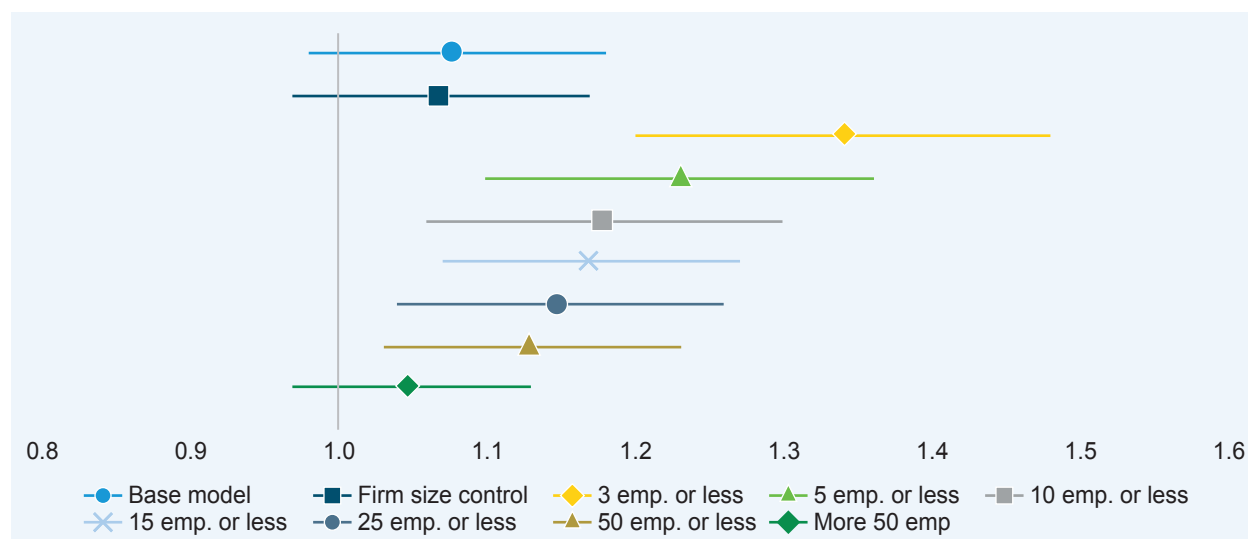
	(1)	(2)	(3)	(4)
Sample	Everybody	Single sector	Everybody	Single sector
Canton of residency F.E.	No	No	Yes	Yes
Controls	No	No	Yes	Yes
Observations	2,707,161	2,640,457	2,706,427	2,639,933

Source: Authors' elaboration.

Notes: The dependent variable is the natural logarithm of the expenditure reported to the e-billing system. The consumption variable is calculated using the third-party reported purchases made by the taxpayer to a company that reports to the e-billing system. The sample includes only individuals who purchased from a company with an e-billing system and worked in the formal sector as an employee. Public sector and private sector wages are third-party reported by the employer (government, or private entity). Columns (1) and (3) include all individuals. Columns (2) and (4) include only individuals who worked solely in the private or public sector (i.e., excluding individuals who worked in both). All monetary values are in dollars. Canton of residency is defined as the canton where the taxpayer had the largest portion of their total reported consumption. Standard errors are in parentheses and are clustered at the canton level. The number of employees that worked in the formal sector and did not report self-employment income was 2,762,860. We had information of total consumption for 2,707,161 of those individuals. *p < 0.10, ** p < 0.05, ***p < 0.0.

FIGURE 2

K COEFFICIENT FOR THE ESTIMATION OF THE EVASION GAP BETWEEN PUBLIC AND PRIVATE SECTOR EMPLOYEES USING CONSUMPTION OF FOOD



Source: Authors' elaboration.

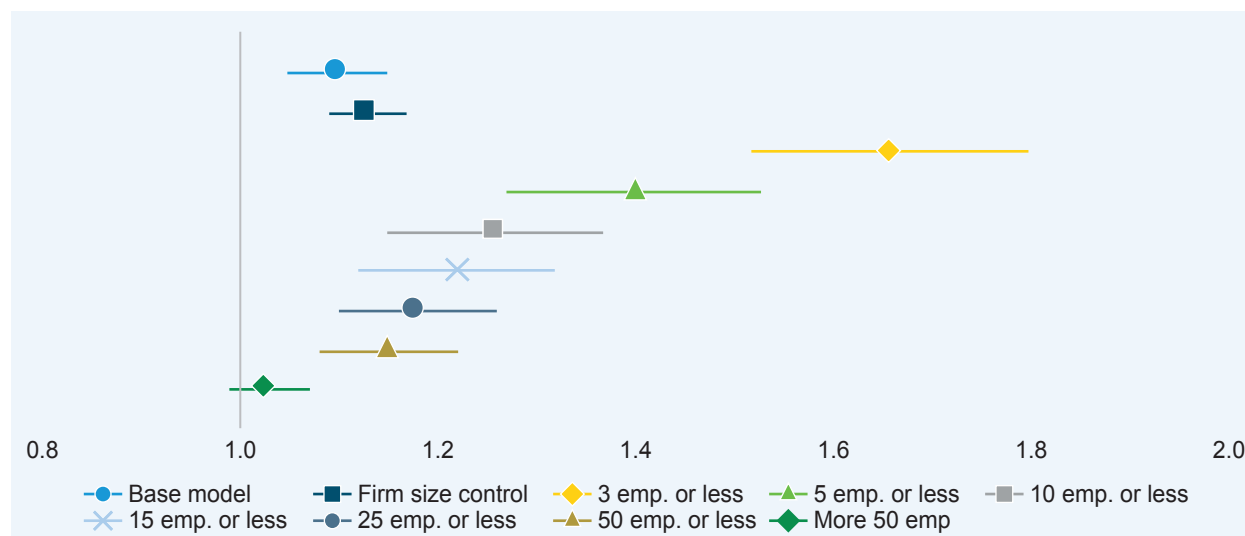
Notes: The coefficient from Equation 3 can be understood as the constant that the private wage will be multiplied by. The reported wage should be consistent with the food consumption and public sector employee's pattern of consumption. The null hypothesis is that k is equal to one. If were equal to one, there would be no evidence of differences of consumption between public and private sector employees. When is larger than one, the private sector employees of the corresponding firm size is under-reporting their income, as compared with the public sector employees. For each dollar that a public sector employee reports, the private sector reports dollars.

Source: Authors' elaboration.

Notes: The coefficient from Equation 3 can be understood as the constant that the private wage will be multiplied by. The reported wage should be consistent with the food consumption and public sector employee's pattern of consumption. The null hypothesis is that k is equal to one. If were equal to one, there would be no evidence of differences of consumption between public and private sector employees. When is larger than one, the private sector employees of the corresponding firm size is under-reporting their income, as compared with the public sector employees. For each dollar that a public sector employee reports, the private sector reports $\frac{1}{k}$ dollars.

FIGURE 3

COEFFICIENT FOR THE ESTIMATION OF THE EVASION GAP BETWEEN PUBLIC AND PRIVATE SECTOR EMPLOYEES USING TOTAL CONSUMPTION



Source: Authors' elaboration.

Notes: The coefficient from Equation 3 can be understood as the constant that the private wage will be multiplied by. The reported wage should be consistent with the food consumption and public sector employee's pattern of consumption. The null hypothesis is that k is equal to one. If were equal to one, there would be no evidence of differences of consumption between public and private sector employees. When is larger than one, the private sector employees of the corresponding firm size is under-reporting their income, as compared with the public sector employees. For each dollar that a public sector employee reports, the private sector reports dollars.

this calculation, we assume that every private employee would increase their income based on their under-reported income gap (between a 7 and 9 percent increase). Using the national accounts, we estimate that the private sector employees' gross disposable income is 49 percent of GDP; keeping that proportion constant, we estimate how much larger the reported GDP would be if all the wages were reported.

Income tax in Ecuador is progressive, so instead of multiplying the under-reported income by the average marginal tax rate, as did Ekici and Besim (2016), we calculate the tax loss for each individual. In particular, we calculate the income tax with the reported income and calculated income considering the evasion gap. The tax loss is the difference between those calculations aggregated across all individuals. The income tax loss is between 0.7 and 1 percent of the total tax revenue. The social

security contribution is a payroll tax with a flat tax rate. We calculate the unpaid contributions by multiplying the under-reported income by the payroll tax rate. The unpaid contributions are fairly sizable and equivalent to over 7 to 9 percent of total contributions (Table 4). In general terms, considering all employees, the withholding system creates incentives to report income truthfully. However, interesting patterns arise in subgroup analysis by firm size.

6.2 Heterogeneous Effects by Firm Size

There are several rationales for predicting different levels of compliance for different firm sizes. Smaller firms might be less likely to have a dedicated accountant and navigate the tax system correctly. Also, contracts that include envelope wages might be more difficult to

TABLE 4

IMPLICATIONS FOR NATIONAL ACCOUNTS, TAX AND SOCIAL SECURITY CONTRIBUTION GAP

	Auxiliary: Source/Calc	Private sector employees		
		Food consumption	Total consumption	
1	Reported income (\$)	Section 6.1	8.185,53	8.185,53
2	Degree of under-reporting (percent)	1-1/k	0,07	0,09
3	True income (\$)	R1/(1-R2 percent)	8.840,37	9.004,08
4	Unreported income (\$)	R3-R1	654,84	818,55
5	Registered contributors		2.235.000	2.235.000
6	Unreported income (\$)	R4*R5	1.463.572.764	1.829.465.955
7	Shadow Economy - Intensive Margin Employees (\$)	R6*(1/alpha)	2.975.005.723	3.718.757.153
8	Shadow Economy - Intensive Margin Employees percent of GDP	R7/GDP	2,85 percent	3,57 percent
9	Tax losses		92.313.343	122.744.788
10	Tax losses percent of total tax revenue		0,71 percent	0,95 percent
11	Unpaid social security contributions		301.495.989	376.869.987
12	Unpaid social security contributions percent		7,37 percent	9,22 percent

Source: The calculation follows Ekici and Besim (2016).

Notes: Comments to specific rows follow:

R1: Average annual salary reported to the tax authority for each group.

R2: Estimates of k on Table 2 and 3, row 1 column 3.

R5: There were 2,762,860 employees on the formal sector in 2017. We use 2.235.000 as a proxy of the registered contributors for this calculation because survey data suggests that this is approximately the number employed at any given time.

R7: According to the national accounts by sector published by the Ecuadorian Central Bank^a household gross disposable income is 69 percent of GDP. It is not possible to tell which part of that income corresponds to households with self-employed income, private employees' wages, or public employees' wages. However, if we assume the proportion of households corresponds to the proportion of registered taxpayers, private sector employees' gross disposable income is 49 percent of GDP. This is because employees are roughly 92 percent of the registered taxpayers of income tax, the other 8 percent have only self-employed income. Private employees are around 71 percent of registered payers of income tax.

R8: The GDP of Ecuador in 2017 was 104,295,862 dollars.

R9: We calculated the tax for each individual in our sample with their reported and calculated income. The tax losses are the aggregate of those differences.

R10: Total tax collection^b in 2017 was 12,925,955 dollars^c.

R11: Social security contribution (similar to a payroll tax in the United States) is a flat rate of 20.6 percent over and above the salary. Employees pay 9.45 percent and employers 11.15 percent^d.

R12: The total social security contribution in 2017 was 4,088,719 dollars^e.

^a <https://www.bce.fin.ec/index.php/informacioneconomica/sector-real>.

^b Excluding import and export duties.

^c <https://www.sri.gob.ec/estadisticas-generales-de-recaudacion-sri>.

^d <https://www.iess.gob.ec/documents/10162/33703/C.D.+501>.

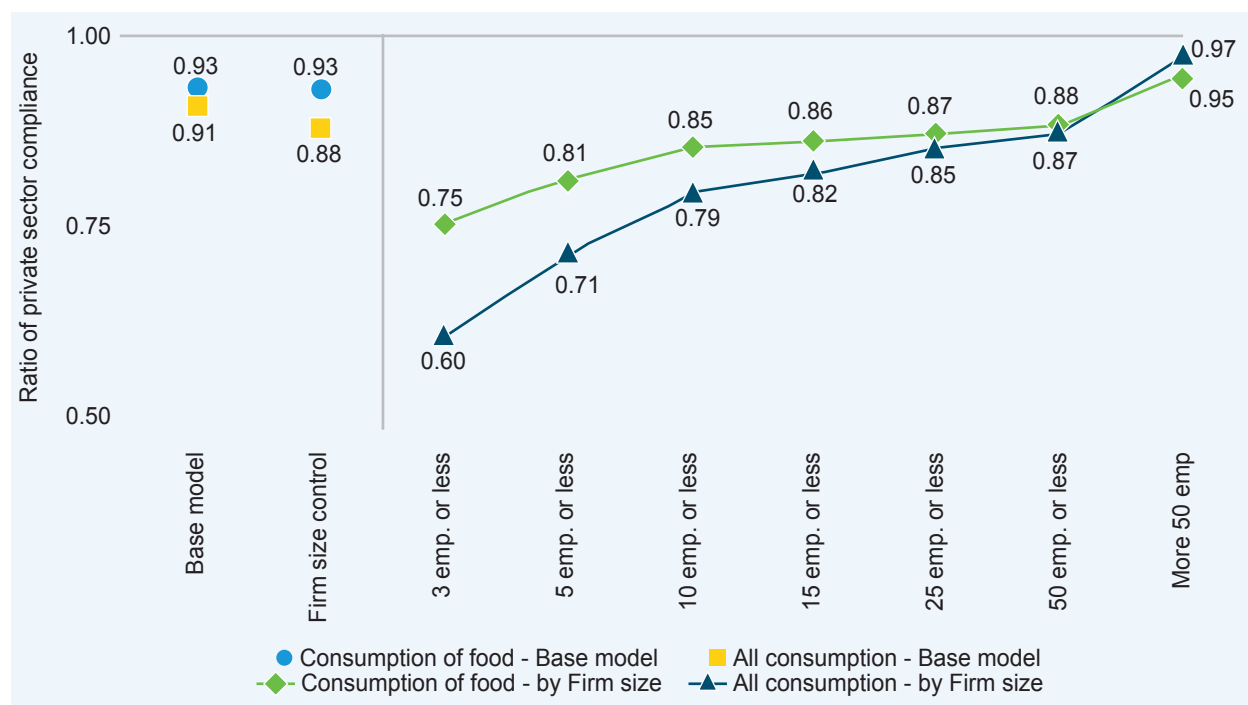
^e <https://www.iess.gob.ec/documents/10162/33703/C.D.+545>.

keep confidential as the number of employees, and thus the number of people who need to be coordinated, increases. These rationales apply in the private sector but not in the public sector. Hence, we construct groups that include all public sector employees and only employ-

ees of small private firms (Figure 4). We create 7 groups, including private sector employees in firms with 3 or fewer, 5, 10, 15, 25, 50, and more than 50 employees (large firms). For each group, we estimate Equation 3 using food consumption and total consumption (Tables 5 and

FIGURE 4

RATIO OF PRIVATE SECTOR COMPLIANCE



Source: Authors' elaboration.

Notes: The ratio of private sector compliance is from equation 3. A ratio of one means that there is no gap between the income reported by public and private sector employees. A ratio of 0.85 means that for every dollar a public sector employee reports, a private sector employee reports 85 cents.

6, respectively, show the results). Using food consumption, we find a reporting gap ranging from 0.75 to 0.88 and confirm that the smaller the firm, the larger the gap is. For instance, for each dollar that public sector employees report, employees of firms with 3 or fewer employees report 75 cents. If we increase the sample size to 25 employees or less, the difference is 87 cents on the dollar. We do not find significant differences if we compare only employees of large firms. We find similar patterns with the total consumption estimation.

6.3 Robustness Checks

This subsection explores the shortcomings of our estimation. There is no joint filing in Ecuador, so the household's primary breadwinner might be different from the person who makes

the household purchases. This could bias our estimation if there are systematic differences in the household composition of public and private sector employees. Also, there might be systematic differences in consumption for the same income level between the sectors if their savings patterns vary, depending on the relative stability in their sector.

Breadwinner versus primary spender

The Ecuadorian tax code does not allow joint filing, so each household income earner files their taxes independently. For example, imagine a household with two members, Chris and Pat. Chris earns more, but Pat makes all household purchases. If that is the case, it would appear that Pat is overspending and Chris is saving. In principle, our estimation is unbiased

TABLE 5

ROBUSTNESS CHECK: REPORTED INCOME COMPLIANCE OF PRIVATE SECTOR EMPLOYEES, CONTROLLING FOR FIRM SIZE, BASED ON EXPENDITURES ON FOOD
Dependent Variable: ln (Food Consumption)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
k_1 : Wage in the private sector	1.08*** (0.05)	1.07*** (0.05)	1.34*** (0.07)	1.23*** (0.06)	1.18*** (0.06)	1.17*** (0.06)	1.15*** (0.06)	1.13*** (0.05)	1.05*** (0.04)
p_1 : Private sector employee	2,169.14*** (166.14)	2,176.91*** (164.08)	3,747.75*** (302.60)	3,381.39*** (277.30)	2,940.56*** (269.74)	2,755.44*** (251.31)	2,585.25*** (252.73)	2,465.11*** (226.05)	1,667.91*** (122.91)
Age	0.01*** (0.00)	0.01*** (0.00)	0.00 (0.00)	0.00* (0.00)	0.00*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.00 (0.00)
Woman	0.19*** (0.02)	0.19*** (0.02)	0.10*** (0.01)	0.10*** (0.01)	0.11*** (0.01)	0.12*** (0.01)	0.12*** (0.01)	0.14*** (0.02)	0.20*** (0.02)
Married	0.17*** (0.01)	0.17*** (0.01)	0.14*** (0.01)	0.15*** (0.01)	0.16*** (0.01)	0.16*** (0.01)	0.17*** (0.01)	0.17*** (0.01)	0.15*** (0.02)
Finished high school	0.34*** (0.05)	0.34*** (0.05)	0.23*** (0.04)	0.26*** (0.04)	0.30*** (0.04)	0.31*** (0.04)	0.32*** (0.04)	0.33*** (0.05)	0.32*** (0.05)
Finished college	0.62*** (0.08)	0.62*** (0.08)	0.54*** (0.05)	0.58*** (0.05)	0.61*** (0.06)	0.61*** (0.06)	0.62*** (0.06)	0.62*** (0.07)	0.58*** (0.08)
Firm size (# employees)	-0.00 (0.00)								
Ratio of private sector compliance	0.93	0.93	0.75	0.81	0.85	0.86	0.87	0.88	0.95
Public employees	All	All	All	All	All	All	All	All	All
All Private employees'	All	All	Emp. less 3	Emp. 3-5	Emp 5-10	Emp 10-15	Emp 15-25	Emp. 25-50	Emp. > 50
Canton of residency F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,798,204	1,797,725	570,530	619,230	719,555	780,691	862,221	969,466	1,342,846

Source: Authors' elaboration.

Notes: The dependent variable is the natural logarithm of the expenditure on food reported to the e-billing system. The consumption variable is calculated using the third-party reported purchases made by the taxpayer to a company that reports to the e-billing system. The sample includes only individuals who purchased from a company with an e-billing system and worked in the formal sector as an employee. Public sector and private sector wages are third-party reported by the employer (government, or private entity). The firm size is the number of employees reported in the year. Ecuador does not allow part-time workers, and all employees are counted irrespective of how much of the year they worked. All columns include all public employees. Columns (3) to (8) include employees in private firms with fewer than 3, 5, 10, 15, 25, and 50 employees, respectively. Column (9) includes private employees who work for firms with at least 51 employees. All monetary values are in dollars. Canton of residency is defined as the canton where the taxpayer had the largest portion of their total reported consumption. Standard errors are in parentheses and are clustered at the canton level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 6

ROBUSTNESS CHECK: REPORTED INCOME COMPLIANCE OF PRIVATE SECTOR EMPLOYEES, CONTROLLING FOR FIRM SIZE, BASED ON EXPENDITURES IN ALL CATEGORIES Dependent Variable: ln (Total Consumption)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
k_i : Wage in the private sector	1.10*** (0.02)	1.13*** (0.02)	1.66*** (0.07)	1.40*** (0.06)	1.26*** (0.06)	1.22*** (0.05)	1.18*** (0.04)	1.15*** (0.04)	1.03*** (0.02)
ρ_i : Private sector employee	1,192.51*** (154.43)	1,213.93*** (159.18)	2,111.42*** (246.17)	1,786.01*** (209.93)	1,372.57*** (177.10)	1,267.72*** (169.73)	1,210.53*** (165.31)	1,186.87*** (166.78)	895.79*** (108.14)
Age	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.00*** (0.00)
Woman	0.11** (0.04)	0.11*** (0.04)	-0.10*** (0.03)	-0.09*** (0.03)	-0.06** (0.03)	-0.04 (0.03)	-0.02 (0.03)	0.01 (0.03)	0.10** (0.04)
Married	0.19*** (0.02)	0.19*** (0.02)	0.11*** (0.01)	0.13*** (0.01)	0.16*** (0.01)	0.17*** (0.02)	0.18*** (0.02)	0.18*** (0.02)	0.15*** (0.02)
Finished high school	0.71*** (0.04)	0.71*** (0.04)	0.63*** (0.02)	0.69*** (0.02)	0.74*** (0.02)	0.75*** (0.02)	0.75*** (0.02)	0.75*** (0.02)	0.67*** (0.05)
Finished college	1.20*** (0.05)	1.21*** (0.05)	1.02*** (0.03)	1.10*** (0.03)	1.19*** (0.03)	1.22*** (0.03)	1.23*** (0.03)	1.24*** (0.04)	1.09*** (0.06)
Firm size (# employees)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)
Ratio of private sector compliance	0.91	0.88	0.60	0.71	0.79	0.82	0.85	0.87	0.97
Public employees	All	All	All	All	All	All	All	All	All
Private employees	All	All	Emp. less 3	Emp. 3-5	Emp 5-10	Emp 10-15	Emp. 15-25	Emp. 25-50	Emp. >50
Canton of residency F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,706,427	2,705,818	760,143	841,086	1,010,489	1,112,700	1,247,831	1,423,025	1,956,502

Source: Authors' elaboration.

Notes: The dependent variable is the natural logarithm of the expenditure reported to the e-billing system. The consumption variable is calculated using the third-party reported purchases made by the taxpayer to a company that reports to the e-billing system. The sample includes only individuals who purchased from a company with an e-billing system and worked in the formal sector as an employee. Public and private sector wages are third-party reported by the employer (government, or private entity). The firm size is the number of employees reported in the year. Ecuador does not allow part-time workers, and all employees are counted irrespective of how much of the year they worked. All columns include all public employees. Columns (3) to (8) include employees in private firms with fewer than 3, 5, 10, 15, 25, and 50 employees, respectively. Column (9) includes private employees who work for firms with at least 51 employees. All monetary values are in U.S. dollars. Canton of residency is defined as the canton where the taxpayer had the largest portion of their total reported consumption. Standard errors are in parentheses and are clustered at the canton level. *p < 0.10, ** p < 0.05, *** p < 0.00.

TABLE 7

ROBUSTNESS CHECK: REPORTED INCOME COMPLIANCE OF PRIVATE SECTOR EMPLOYEES - ONLY SINGLE INDIVIDUALS BASED ON EXPENDITURES ON FOOD Dependent Variable: \ln (Food Consumption)

	(1)	(2)	(3)	(4)
k_i : Wage in the private sector	0.98*** (0.04)	1.00*** (0.04)	1.07*** (0.05)	1.10*** (0.05)
ρ_i : Private sector employee	1,645.20*** (127.14)	1,725.91*** (139.45)	1,909.20*** (145.36)	2,008.69*** (159.04)
Age			0.01*** (0.00)	0.01*** (0.00)
Woman			0.30*** (0.02)	0.30*** (0.02)
Finished high school			0.32*** (0.06)	0.32*** (0.06)
Finished college			0.57*** (0.09)	0.56*** (0.10)
Ratio of private sector compliance			0.93	0.91
Sample	Everybody	Single sector	Everybody	Single sector
Canton of residency F.E.	No	No	Yes	Yes
Controls	No	No	Yes	Yes
Observations	1,028,917	997,194	1,028,917	997,194

Source: Authors' elaboration.

Notes: The dependent variable is the natural logarithm of the expenditure on food reported to the e-billing system. The consumption variable is calculated using the third-party reported purchases made by the taxpayer to a company that reports to the e-billing system. The sample includes only individuals who purchased from a company with an e-billing system and worked in the formal sector as an employee. Public sector and private sector wages are third-party reported by the employer (government, or private entity). Columns (1) and (3) include all individuals. Columns (2) and (4) include only individuals who worked solely in the private or public sector (i.e., excluding individuals who worked in both). All monetary values are in dollars. Canton of residency is defined as the canton where the taxpayer had the largest portion of their total reported consumption. Standard errors are in parentheses and are clustered at the canton level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 8

ROBUSTNESS CHECK: REPORTED INCOME COMPLIANCE OF PRIVATE SECTOR EMPLOYEES - NLY SINGLE INDIVIDUALS BASED ON EXPENDITURES IN ALL CATEGORIES Dependent Variable: ln (Total Consumption)

	(1)	(2)	(3)	(4)
k_1 : Wage in the private sector	0.78*** (0.01)	0.80*** (0.01)	1.06*** (0.02)	1.07*** (0.02)
ρ_1 : Private sector employee	932.03*** (80.62)	1,000.76*** (91.62)	983.96*** (109.78)	1,053.59*** (120.52)
Age			0.01*** (0.00)	0.01*** (0.00)
Woman			0.23*** (0.03)	0.24*** (0.03)
Finished high school			0.68*** (0.05)	0.68*** (0.05)
Finished college			1.17*** (0.06)	1.16*** (0.06)
Ratio of private sector compliance			0.95	0.93
Sample	Everybody	Single sector	Everybody	Single sector
Canton of residency F.E.	No	No	Yes	Yes
Controls	No	No	Yes	Yes
Observations	1,614,325	1,575,931	1,614,325	1,575,931

Source: Authors' elaboration.

Notes: The dependent variable is the natural logarithm of the expenditure reported to the e-billing system. The consumption variable is calculated using the third-party reported purchases made by the taxpayer to a company that reports to the e-billing system. The sample includes only individuals who purchased from a company with an e-billing system and worked in the formal sector as an employee. Public sector and private sector wages are third-party reported by the employer (government, or private entity). Columns (1) and (3) include all individuals. Columns (2) and (4) include only individuals who worked solely in the private or public sector (i.e., excluding individuals who worked in both). All monetary values are in dollars. Canton of residency is defined as the canton where the taxpayer had the largest portion of their total reported consumption. Standard errors are in parentheses and are clustered at the canton level. *p < 0.10, **p < 0.05, ***p < 0.01.

as long as there is no correlation between this household consumption structure and being a public or private sector employee. Unfortunately, we do not have information on the household composition, nor can we identify the members of each household to construct income and consumption at a household level. However, we can observe marital status, and thus to address this concern, we repeat the main estimation using only single individuals and do not observe differences from our main estimation (Tables 7 and 8). This result indicates that the household composition affects private and public sector employees similarly, demonstrating that our estimation is not biased.

Job tenure

There is a possibility of systematic differences in consumption between public and private sector employees. The concern is that public sector jobs might be more stable; therefore, bureaucrats might have smaller precautionary savings than private sector employees because they are less worried about losing their jobs. In general, there is an expectation that public sector jobs may pay less but are more stable; if that were the case, our estimation would be biased downward because the consumption of public sector employees would be higher for

all levels of income. We do not have an effective way to construct a permanent income for each individual because we have access to consumption and tax return information for only one year; however, we can test to what extent each individual's job is stable and compare private and public employees with the same tenure with the same employer.⁴

We are also able to calculate the number of months each individual has been working for their current employer.⁵ The oldest reliable records we have access to go back to January 2005; our maximum sample number of months is 156. As the tenure increases, we observe that k becomes lower than one, indicating that public employees systematically consume a larger share than private employees, which is consistent with the idea that career bureaucrats will have very stable jobs (see Tables 9 and 10). This means that the share of food consumption and total consumption for private sector employees should be larger than the proportion for public sector employees. Therefore, our estimation is conservative and we estimate a lower bound of the under-reporting of wages in the private sector.

⁴ We cannot tell if someone has held the same position, only if they have worked for the same employer.

⁵ If someone has more than one job, we take the tenure of the job with the largest wage

TABLE 9

ROBUSTNESS CHECK: REPORTED INCOME COMPLIANCE OF PRIVATE SECTOR EMPLOYEES, CONTROLLING FOR TENURE ON THE JOB, BASED ON EXPENDITURES ON FOOD
Dependent Variable: ln (Food Consumption)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
k_1 : Wage in the private sector	1.08*** (0.05)	1.03*** (0.05)	1.08*** (0.06)	0.84*** (0.05)	0.85*** (0.05)	0.85*** (0.05)	0.86*** (0.05)
ρ_1 : Private sector employee	2,169.14*** (166.14)	2,377.94*** (148.28)	2,065.03*** (174.23)	3,841.63*** (190.38)	3,874.74*** (224.10)	3,828.45*** (253.52)	3,766.56*** (280.38)
Age	0.01*** (0.00)	0.00*** (0.00)	0.01*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00** (0.00)
Woman	0.19*** (0.02)	0.19*** (0.02)	0.18*** (0.02)	0.21*** (0.02)	0.21*** (0.03)	0.21*** (0.03)	0.21*** (0.03)
Married	0.17*** (0.01)	0.16*** (0.01)	0.18*** (0.01)	0.15*** (0.02)	0.15*** (0.02)	0.14*** (0.02)	0.14*** (0.02)
Finished high school	0.34*** (0.05)	0.35*** (0.05)	0.33*** (0.05)	0.37*** (0.06)	0.39*** (0.05)	0.39*** (0.05)	0.39*** (0.05)
Finished college	0.62*** (0.08)	0.62*** (0.09)	0.60*** (0.09)	0.65*** (0.10)	0.67*** (0.10)	0.68*** (0.09)	0.67*** (0.09)
Job tenure (months)		0.00* (0.00)					
Ratio of private sector compliance	0.93	0.97	0.93	1.19	1.18	1.17	1.16
Restriction by job tenure	None	None	m 0-48	m 48-72	m 48-96	m 48-120	m 48-144
Canton of residency F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,798,204	1,712,210	1,001,430	234,656	395,804	510,445	573,229

Source: Authors' elaboration.

Notes: The dependent variable is the natural logarithm of the expenditure on food reported to the e-billing system. The consumption variable is calculated using the third-party reported purchases made by the taxpayer to a company that reports to the e-billing system. The sample includes only individuals who purchased from a company with an e-billing system and worked in the formal sector as an employee. Public sector and private sector wages are third-party reported by the employer (government or private entity). Job tenure is the number of months that the employee worked in the job reported in 2017, going back to 2005 (maximum number of months: 156). If the person has more than one job, the longest tenure is considered. All monetary values are in dollars. Canton of residency is defined as the canton where the taxpayer had the largest portion of their total reported consumption. Standard errors are in parentheses and are clustered at the canton level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE 10

ROBUSTNESS CHECK: REPORTED INCOME COMPLIANCE OF PRIVATE SECTOR EMPLOYEES, CONTROLLING FOR TENURE ON THE JOB, BASED ON EXPENDITURES IN ALL CATEGORIES

Dependent Variable: \ln (Total Consumption)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
k_1 : Wage in the private sector	1.10*** (0.02)	1.09*** (0.02)	1.17*** (0.03)	0.93*** (0.04)	0.93*** (0.04)	0.92*** (0.03)	0.92*** (0.03)
ρ_1 : Private sector employee	1,192.51*** (154.43)	1,449.75*** (190.72)	1,119.70*** (165.30)	2,484.86*** (289.59)	2,427.90*** (302.28)	2,424.26*** (298.02)	2,442.36*** (308.63)
Age	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)
Woman	0.11** (0.04)	0.11*** (0.04)	0.11*** (0.04)	0.12*** (0.04)	0.13*** (0.04)	0.14*** (0.05)	0.14*** (0.05)
Married	0.19*** (0.02)	0.17*** (0.02)	0.17*** (0.02)	0.17*** (0.02)	0.18*** (0.02)	0.18*** (0.02)	0.18*** (0.02)
Finished high school	0.71*** (0.04)	0.71*** (0.04)	0.66*** (0.04)	0.77*** (0.04)	0.79*** (0.03)	0.80*** (0.04)	0.80*** (0.04)
Finished college	1.20*** (0.05)	1.22*** (0.05)	1.21*** (0.06)	1.25*** (0.05)	1.28*** (0.05)	1.29*** (0.05)	1.28*** (0.05)
Job tenure (months)	0.00***	(0.00)					
Ratio of private sector compliance	0.91	0.91	0.86	1.07	1.08	1.09	1.09
Restriction by job tenure	None	None	m 0-48	m 48-72	m 48-96	m 48-120	m 48-144
Canton of residency F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,706,427	2,579,673	1,580,194	330,938	561,578	728,791	814,913

Source: Authors' elaboration.

Notes: The dependent variable is the natural logarithm of the expenditure reported to the e-billing system. The consumption variable is calculated using the third-party reported purchases made by the taxpayer to a company that reports to the e-billing system. The sample includes only individuals who purchased from a company with an e-billing system and worked in the formal sector as an employee. Public sector and private sector wages are third-party reported by the employer (government or private entity). Job tenure is the number of months that the employee worked in the job reported in 2017, going back to 2005 (maximum number of months: 156). If the person has more than one job, the longest tenure is considered. All monetary values are in dollars. Canton of residency is defined as the canton where the taxpayer had the largest portion of their total reported consumption. Standard errors are in parentheses and are clustered at the canton level. *p < 0.10, **p < 0.05, ***p < 0.01.



7

Discussion and Conclusions

This study analyzes the under-reporting of income by private sector employees. Using a novel data source, electronic billing data on consumption matched to income tax records, we apply an otherwise standard method to estimate under-reporting of income (Pissarides and Weber, 1989). The estimated under-reporting of income is between 9 and 12 cents for each dollar of reported income from private sector employees, suggesting that the self-employed are not the only ones who under-report their income and offers nuance to the prevalent practice to regard tax authority income records of employees as the gold standard. The estimated under-reporting of income in the private sector translates to an estimate of 3 percent of unregistered GDP from this source. For social security, under-reporting has significant implications, reducing contributions by about 10 percent. Beyond the overall picture of under-reporting, we detect substantial heterogeneities, notably a clear gradient of under-reporting with respect to firm size. For example, in small firms of 3 employees or less, under-reporting reaches 40 cents per dollar reported. A firm size gradient is in line with different risks and administrative costs of enve-

lope wages in small versus large firms. There are two ways in which our result is relevant. First, this study takes place in the context of a middle-income country, which generally has weaker institutions than those found in the fully developed world. Second, our study makes innovative use of e-billing technology, which has only recently been adopted by Ecuador.

The key assumption of the Pissarides and Weber (1989) method applied herein is that observationally similar public and private sector employees have comparable consumption patterns, particularly of food, independently of their income source. Our robustness analyses suggest that potential confounders, such as different household consumption structures or differential propensity to appear in the electronic billing system between public and private sector employees, are not biasing the results. If public sector employees have more stable jobs, and consequently less precautionary savings than private sector employees, our under-reporting estimates are biased downward. The fact that the estimated reporting gap decreases with tenure is consistent with this notion.

The main limitation of the present study is that we could not measure long-term income,

because we used only one year of electronic billing information and tax return for data availability. However, the findings and methodology raise interesting policy questions and trade-offs. First, the data matching and methodology might enable tax and social security authorities to increase compliance and revenues. Second, given the underreporting gradient, it may seem as if tax authorities want to audit more small businesses. However, the fixed costs of audits and small expected additional revenues from small firms have put a limit on that implication. In fact, because small firms tend to be more economically vulnerable, non-enforcement of liabilities may be a cost-efficient way of flexibly supporting them. Third, there are additional reasons for curbing envelope wages: (i) full formalization has positive externalities and might bring benefits to an individual small firm; (ii) enforcement might shift economic activity to more productive sectors and level the playing field among noncompliant and compliant firms; and (iii) envelope wages may affect both income and business tax as well as social security and employee benefits.

Neither the status quo of leaving envelope wages and quasi-informality unaddressed, nor massive enforcement based on informative data, likely constitute an optimal policy. An information campaign for small firms and their employees might be a more cost-effective strategy as

they are less likely to understand all of the tax regulations and how they can be compliant and cost efficient at the same time. In addition, disrupting incentives for paying envelope wages is key. The difference between the estimated income tax loss and social security contributions loss and experiences across Latin America suggests that changes in social security might be a better tool to decrease envelope wages. For example, in Mexico and Uruguay, under-reporting of wages responded to changes in social security contributions and benefits (Bergolo and Cruces, 2014; Kumler, Verhoogen, and Frias, 2020). In Ecuador, however, because retirement benefits are roughly calculated based on the five years with the highest contribution, employees do not have incentives to report their full wages, especially at the beginning of their careers. A social security reform that links pensions more continuously to contributions could strengthen these incentives and could be enhanced with a complementary information campaign.

Future research may investigate the effects of incentive reforms and information campaigns on envelope wages and related underreporting and evasion practices. Moreover, in light of advances in data availability and technology, the benefits and limitations of the methodology for measuring the shadow economy and tax and social security administration policy are interesting research areas.

References

- Allingham, Michael G. and Agnar Sandmo. 1972. Income Tax Evasion: A Theoretical Analysis. *Journal of Public Economics* 1.3-4: 323-38.
- Artavanis, Nikolaos, Adair Morse, and Margarita Tsoutsoura. 2016. Measuring Income Tax Evasion Using Bank Credit: Evidence from Greece. *Quarterly Journal of Economics* 131.2: 739-98.
- Barth, Erling and T. Ognedal. 2018. Tax Evasion in Firms. *LABOUR* 32.1: 23-44. E-print: <https://onlinelibrary.wiley.com/doi/pdf/10.1111/labr.12111>.
- Bergolo, Marcelo and Guillermo Cruces. 2014. Tax Evasion Incentive Effects of Social Insurance Programs: Evidence from an Employment-based Benefit Extension. In: *Journal of Public Economics* 117: 211-28.
- Besim, Mustafa and Glenn P. Jenkins. 2005. Tax Compliance: When Do Employees Behave Like the Self-employed? In: *Applied Economics* 37.10: 1201-18. E-print: <https://doi.org/10.1080/00036840500109407>.
- Bjørneby, Marie, Annette Alstadsæter, Kjetil Telle. 2017. Collusive Tax Evasion by Employers and Employees: Evidence from a Randomized Field Experiment in Norway. Tech. rep.
- Cabral, Ana Cinta G., Norman Gemmell, and Nazila Alinaghi. 2021. Are survey-based self-employment income under-reporting estimates biased? New Evidence from Matched Register and Survey Data. *International Tax and Public Finance* 28: 284-22.
- Cabral, Ana Cinta G., Gareth Myles, and Christos Kotsogiannis. 2015. Self-Employment Under-reporting in Great Britain: Who and How Much? In: *14th Journées Louis-André Gérard-Varet*.
- Chai, Andreas and Alessio Moneta. 2010. Retrospectives: Engel Curves. *Journal of Economic Perspectives* 24.1: 225-40.
- Di Nola, Alessandro, Georgi Kocharkov, and Aleksandar Vasilev. 2019. Envelope Wages, Hidden Production and Labor Productivity. *B.E. Journal of Macroeconomics* 19.2: 1-30.
- Domínguez-Barrero, F., J. López-Laborda, and F. Rodrigo-Sauco. 2017. Tax Evasion in Spanish Personal Income Tax by Income Sources, 2005-2008: From the Synthetic to the Dual Tax. *European Journal of Law and Economics* 44.1: 47-65.
- Ekici, Tufan and Mustafa Besim. 2016. A Measure of the Shadow Economy in a Small

- Economy: Evidence from Household-Level Expenditure Patterns. In: *Review of Income and Wealth* 62.1: 145–160.
- Engström, Per and Bertil Holmlund. 2009. Tax Evasion and Self-employment in a High-tax Country: Evidence from Sweden. *Applied Economics* 41.19: 2419–30.
- Feldman, Naomi E. and Joel Slemrod. 2007. Estimating Tax Noncompliance with Evidence from Unaudited Tax Returns. *The Economic Journal* 117.518: 327–52.
- Franic, Josip and Stanislaw Cichocki. 2022. Envelope Wages as a New Normal? An Insight into a Pool of Prospective Quasi-formal Workers in the European Union (EU). *Employee Relations* 44.1: 37–53.
- Geoffrey R. Dunbar and Chunling Fu. 2015. Sheltered Income: Estimating Income Under-Reporting in Canada, 1998 and 2004. *Staff Working Papers*.
- Gorodnichenko, Yuriy, Jorge Martinez-Vazquez, and Klara Sabirianova Peter. 2009. Myth and Reality of Flat Tax Reform: Micro Estimates of Tax Evasion Response and Welfare Effects in Russia. *Journal of Political Economy* 117.3: 504–54.
- International Labour Office. 2013. *The Measurement of Informality: Statistical Manual on the Informal Sector*.
- Jensen, Anders. 2022. Employment Structure and the Rise of the Modern Tax System. *American Economic Review* 112.1: 213–34.
- Kleven, Henrik Jacobsen, et al. 2011. Unwilling or Unable to Cheat? Evidence from a Tax Audit Experiment in Denmark. *Econometrica* 79.3: 651–92.
- Kleven, Henrik Jacobsen, Claus Thustrup Kreiner, and Emmanuel Saez. 2016. Why Can Modern Governments Tax So Much? An Agency Model of Firms as Fiscal Intermediaries. In: *Economica* 83.330: 219–46.
- Kumler, Todd, Eric Verhoogen, and Judith Frias. 2020. Enlisting Employees in Improving Payroll Tax Compliance: Evidence from Mexico. *Review of Economics and Statistics* 102.5: 881–96.
- Li, Nicholas. 2021. An Engel Curve for Variety. *Review of Economics and Statistics* 103.1: 72–87
- Ohnsorge, Franziska and Shun Yu. 2021. *The Long Shadow of Informality: Challenges and Policies*. Tech. rep.
- Paulus, Alari. 2015. *Income Underreporting Based on Income-Expenditure Gaps: Survey vs Tax Records*. ISER Working Paper Series (2015–15). Institute for Social and Economic Research.
- Pissarides, Christopher A and Guglielmo Weber. 1989. An Expenditure-based Estimate of Britain's Black Economy. *Journal of Public Economics* 39.1: 17–32.
- Roed Larsen, Erling. 2014. Is the Engel Curve Approach Viable in the Estimation of Alternative PPPs? *Empirical Economics* 47.3: 881–904.
- Slemrod, Joel. 2019. Tax Compliance and Enforcement. *Journal of Economic Literature* 57.4: 904–54.
- Torregrosa-Hetland, Sara. 2020. Inequality in Tax Evasion: The Case of the Spanish Income Tax. *Applied Economic Analysis* 28.83: 89–109.
- Williams, Colin and Jo Padmore. 2013. Envelope Wages in the European Union. *International Labour Review*.
- Williams, Colin C. and Horodnic, Ioana A. 2017. Evaluating the Illegal Employer Practice of Under-Reporting Employees' Salaries. *British Journal of Industrial Relations* 55.1: 83–11
- World Bank Group. 2017. *China Development. Leapfrogging: The Key to Africa's Development*.

Annex

TABLE A1

NUMBER OF EMPLOYEES

	Mean	P25	P50	P75	P90	Obs.
Public firms	271.92	8	22	183	568	2,699
Private firms	9.90	1	2	5	12	326,457
All firms	12.04	1	2	5	12	329,156

Source: Authors' elaboration.

Notes: The number of employees is the total number of employees reported in 2007. If a person had more than one job, she is counted by all of their employers. The first column shows the mean; the second to the fifth, the 0.25, 0.50, 0.75, and 0.9 percentiles respectively; and the last column the number of firms in that category.

TABLE A2

JOB TENURE IN 2017, GOING BACK TO 2005

	Mean	P25	P50	P75	P90	Obs.
Public employees	52.45	23	41	64	131	579,731
Private employees	50.48	13	38	77	120	2,198,629
All employees	50.89	15	40	75	121	2,778,360

Source: Authors' elaboration.

Notes: Job tenure is the number of months worked in the job, reported by the employee in 2017 and going back to 2005. If a person had more than one job, the one with largest salary is considered. The first column shows the mean; the second to the fifth the 0.25, 0.50, 0.75 and 0.9 percentiles, respectively; and the last column the number of observations on that category.

