

# Enlisting Workers in Monitoring Firms: Payroll Tax Compliance in Mexico\*

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## Abstract

Non-compliance of firms with tax regulations is a major constraint on state capacity in developing countries. We focus on an arguably under-appreciated dimension of non-compliance: under-reporting of wages by formal firms to evade payroll taxes. Comparing wage distributions for demographically similar workers in the administrative records of the Mexican social security agency and a household labor-force survey, we document extensive under-reporting of wages. We further argue that the 1997 Mexican pension reform had a differential effect by age on the incentives of workers to ensure that their wages were reported accurately. Using a difference-in-differences strategy, we show that the increase in the incentive for workers to ensure accurate reports led to a significant decline in under-reporting. The results suggest that enlisting workers in monitoring their employers is an effective way to increase payroll tax compliance.

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# 1 Introduction

A growing body of research suggests that lack of state capacity—in particular, difficulty in raising taxes to fund the provision of public goods—is a major constraint on the growth of developing countries (Burgess and Stern, 1993; Besley and Persson, 2009, 2011). Developing countries tend to have low ratios of tax revenues to GDP and large informal sectors. Mexico is no exception: it has the lowest tax revenue share of GDP in the OECD, between 15 and 20 percent during the period we study, and the informal sector is estimated to make up 40 percent or more of total output (OECD, 2011b; IMF, 2010; Schneider and Enste, 2000).<sup>1</sup> Given weak enforcement institutions and widespread evasion, it is not obvious how to improve the fiscal capacity of developing-country governments, and there is great interest from both academics and policy-makers in potential solutions.

A key element of the general weakness of fiscal capacity in developing countries is non-compliance of firms with tax regulations. A large literature has focused on one dimension of non-compliance: the failure of firms to register with tax authorities. Researchers have argued that this form of non-compliance generates a variety of market distortions, including limits on informal firms' employment growth and access to formal credit markets (Gordon and Li, 2009; La Porta and Shleifer, 2008; Levy, 2008).<sup>2</sup> Governments in a number of countries have implemented programs to reduce registration costs and induce firms to formalize (Fajnzylber, Maloney, and Montes-Rojas, 2011; Bruhn, 2011; Kaplan, Piedra, and Seira, forthcoming).

In this paper, we focus on a different dimension of non-compliance by firms, less appreciated but arguably no less important: the under-reporting of wages by registered firms to evade payroll taxes. This dimension of non-compliance has received surprisingly little empirical attention. One reason may be that it has been shown not to be a significant issue in developed countries. For instance, using detailed audits of individual tax returns in Denmark, Kleven et al (2011) find little evasion when incomes are reported by employers or other third parties.<sup>3</sup> Another reason may be

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<sup>1</sup>Another indicator of the size of the informal sector is that the Mexican social security agency, the *Instituto Mexicano del Seguro Social* (IMSS), which is supposed to cover all private-sector employees, in fact covers about 55 percent of the private-sector workforce.

<sup>2</sup>Notable theoretical work on firms' decisions about whether to formalize includes Rauch (1991), De Paula and Scheinkman (2011), and Galiani and Weinschelbaum (forthcoming). McKenzie and Sakho (2010) find empirically that registering leads firms to be more profitable on average, but also find significant heterogeneity in the effects.

<sup>3</sup>In another example, Saez (2010) finds significant bunching around the first kink point of the Earned Income Tax Credit, suggesting misreporting, only among the self-employed. The Internal Revenue Service has documented that compliance is higher for income groups with greater third-party reporting in the U.S. (Internal Revenue Service, 1996, 2006). The view that third-party reporting is effective in ensuring compliance is widespread among practitioners and government agencies (OECD, 2006).

that under-reporting is difficult to study. It has been rare for researchers to have information on firms' wage reports, and rarer still to have access to an alternative source of information on wages at a level of disaggregation sufficient to make inferences about the extent of non-compliance (Slemrod and Yitzhaki, 2002, Sec. 4.1.1). As a consequence, it has not been clear to what extent the accuracy of third-party reporting carries over to developing-country settings.

In this paper, we draw on two independent sources of wage information from Mexico: firms' wage reports to the Mexican social security agency and workers' responses to a household labor-force survey. We use these to draw inferences about the extent of wage under-reporting and how it responds to incentives inherent in the social security system. We make two main points. First, comparing wage distributions from each source for demographically similar workers, we show that under-reporting of wages is substantial. Second, using a major pension reform in 1997 as a source of exogenous variation, we show that under-reporting responds to economic incentives, and in particular to the ability and incentives of employees to ensure the accuracy of their employers' reports. On July 1, 1997, the Mexican government switched from a pay-as-you-go pension system to a system of personalized savings accounts. Prior to the reform, the pensions of most workers were largely insensitive to the wages reported by firms, for reasons we discuss below. The reform tied individual pensions more closely to firms' wage reports and made it easier for employees to observe those reports. The change affected different age groups differently. In particular, all workers already in the pay-as-you-go system prior to July 1, 1997 retained the right to choose, at the time of retirement, the pension that they would have received under the pre-reform regime. Because older workers had little time to accumulate sufficient balances in their personal accounts, they had a clear incentive to opt for the old regime. Younger workers, by contrast, could expect to be better off under the new regime and hence had stronger incentives to ensure accurate reporting. Using a difference-in-differences strategy, we show that the extent of under-reporting declined relatively more for younger workers.

Our results are broadly consistent with the theoretical model of firms as fiscal intermediaries presented in a recent paper by Kleven, Kreiner, and Saez (2009). In that model, firms are cooperatives of workers who may collude in under-reporting wages to the government.<sup>4</sup> The authors spell out two reasons why collusion may be more difficult to sustain in larger firms, in cases where workers are unable to commit not to "blow the whistle" on evasion. First, workers may be subject to random shocks (e.g. may become disgruntled); since it only requires one worker

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<sup>4</sup>The possibility that employees and employers may collude in under-reporting wages had earlier been formalized by Yaniv (1992).

to signal to the authorities that a firm should be audited, collusion is more difficult to sustain in larger firms. Second, the government may offer a reward to workers for whistle-blowing; if the reward is increasing in the amount of taxes evaded, as the authors assume, then workers in larger firms have a greater incentive to expose evasion. In our setting, the reward for whistle-blowing is not proportional to total evasion (indeed, there is no explicit reward), and hence the reward mechanism alone is not sufficient to generate greater compliance in larger firms. But it would be straightforward to combine the two mechanisms, such that there are both disgruntlement shocks and a low-powered incentive for workers to ensure accurate reporting, in the form of dependence of an individual's pension on wage reports. In such a hybrid model, one would again expect greater compliance among larger firms, and one could interpret the 1997 pension reform as an increase in the reward for monitoring, which would be expected to increase compliance.<sup>5</sup>

This paper appears to be the first empirical study of the extent to which under-reporting of wages responds to changes in the incentives of employees to monitor their employers. Our findings support the idea that the design of social-security taxes and other forms of payroll taxes should take into account the incentives of employees to ensure accurate reporting. This argument should not be interpreted as advocating a system of personal accounts *per se*; one could imagine a change in pension benefits under the pay-as-you-go system that would have had similar effects. The key point is that giving employees greater incentives to monitor their employers appears to be an effective way to improve tax compliance.

This argument of this paper is in the spirit of recent work on the attractive enforcement properties of value-added taxes (VATs) relative to retail sales taxes (Kopczuk and Slemrod, 2006; Keen and Lockwood, 2010; Pomeranz, 2011). VATs are thought to reduce administrative costs of enforcement both because the tax authorities receive reports on arm's-length transactions from two parties, and because each party has an incentive to ensure that the other reports accurately. In our setting, the social security agency receives reports only from firms, but the increased incentive of workers to monitor those reports appears to have been sufficient to improve compliance.

This paper is related to a small literature on misreporting of social security contributions. Nyland, Smyth, and Zhu (2006) relate the outcomes of social-security tax audits in Shanghai to firm characteristics, but do not investigate how the extent of under-reporting responds to workers' incentives. Tonin (2011) investigates the effect of an imposition of a minimum wage on reporting patterns in Hungary, using the relationship between household income and expenditures (rather

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<sup>5</sup>Bailey and Turner (2001) suggest that tying pension benefits to contributions in this way would have the effect of reducing evasion.

than an alternative source of wage reports) to draw inferences about the extent of evasion.

This paper is related more broadly to an active recent literature on the role of firms in tax systems, discussed in more detail in Kopczuk and Slemrod (2006), Slemrod (2008), and Gordon and Li (2009), and more broadly still to a voluminous literature on tax avoidance and tax compliance, reviewed by Andreoni, Erard, and Feinstein (1998) and Slemrod and Yitzhaki (2002).

There is an active policy debate, in Mexico and in many other developing countries, about how to encourage formalization and whether the provision of social insurance to workers employed in informal firms discourages it; see, for instance, Levy (2008), Campos-Vazquez and Knox (2008), Arias, Azuara, Bernal, Heckman, and Villarreal (2010), and Amarante, Manacorda, Vigorito, and Zerpa (2011). The current paper can be viewed as somewhat orthogonal to this literature, since it focuses on an intensive margin of compliance (the extent of compliance by formal firms reporting wages of formal workers) rather than the extensive margin (the decision of firms and/or workers to participate in the formal economy), but in a broad sense it shares a policy interest in improving tax compliance.

The next section describes the Mexican social security system and the 1997 pension reform. Section 3 describes the datasets. Section 4 presents cross-sectional comparisons of the wage distributions in the different datasets. Section 5 presents the difference-in-differences analysis of the effect of the pension reform. Section 6 concludes.

## 2 The Mexican Social Security System

Because our empirical strategy relies crucially on incentives in the Mexican social insurance system, this section describes the system and the 1997 reform in some detail. Hereafter we focus primarily on male workers. The incentives and empirical patterns for women are complicated by changes in women's labor force participation and the fact that many women receive IMSS benefits through their spouses, which may induce them to remain in the informal sector.<sup>6</sup>

### 2.1 Overview

The *Instituto Mexicano de Seguridad Social* (IMSS), the Mexican social security agency, is the primary source of social insurance for private-sector workers in Mexico. It administers pension

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<sup>6</sup>We do not currently have access to information on whether individuals are married or receive coverage through their spouses. Investigating whether having a covered spouse induces women to remain in the informal sector is an interesting subject for future work.

benefits, disability insurance, work injury compensation, childcare centers, and a large number of clinics and hospitals, which are the primary source of health care for the formal, private-sector Mexican workforce. Public-sector workers and workers for PEMEX, the state-owned oil company, are covered by separate systems. In 2003, the government created an alternative system called *Seguro Popular*, which provides basic health coverage for all individuals and is not tied to formal employment. In this paper, we focus on the IMSS system and sectors with minimal government employment.

Beginning with its creation in 1944, IMSS operated as a pay-as-you-go (PAYGO) scheme financed by payroll taxes. By the late 1980s, however, rising health care costs and an increase in the number of pensioners relative to the working-age population led to projected shortfalls in the IMSS financial accounts. Because of concerns about the financial viability of the system, the Mexican congress enacted a first attempt at pension reform in 1992. That reform created personal retirement accounts to exist alongside and complement the PAYGO system. The personal retirement accounts were plagued by administrative problems and did not resolve the underlying financial imbalance in the PAYGO program, however. In December 1995, the congress enacted a new, more comprehensive pension reform, to take effect on July 1, 1997. As mentioned above, this reform replaced the entire PAYGO pension system with a system of personal retirement accounts (PRA). Because of data constraints, discussed in more detail in Section 3 below, we focus on the years 1988-2003. More extensive discussions of the motivation for and consequences of the pension reform are provided in Grandolini and Cerda (1998), Sales-Sarrapy, Solis-Soberon, and Villagomez-Amezcu (1996), and Aguila (forthcoming).

## 2.2 Contribution Rates

IMSS requires contributions from both employers and employees based on reported wages; these are supplemented by government contributions. Figure 1 presents the contribution schedule for employers as a function of the reported real daily wages of each employee, for selected years. The schedule reflects a complicated set of formulas determining contributions to the various components of the IMSS system, principally health care, pension, and child care. The figure illustrates that the most significant changes in the schedule are for the highest-wage workers, earning above 500 pesos per day, due to changes in the maximum taxable income over the period, from 10 times to 25 times the minimum wage in Mexico City.<sup>7</sup> The topcodes apply to no more

<sup>7</sup>There are three minimum wage zones in Mexico, corresponding to higher-, medium- and lower-wage municipalities, respectively. The minimum wage in Mexico City is typically used for indexing purposes, and where we refer

than 5 percent of wage-earners in any year, and will play little role in our analysis. The total employer contribution varied between 18 percent and 22 percent of the wage over the period over the range in which almost all workers fall. There was an increase in the employer contribution from 1990 to 1993, and then the reform in 1997 introduced a kink in the schedule, which raised contributions disproportionately on the lowest-wage workers. This change was relatively subtle, however, and the overall message is that the changes in employer contributions over the period were not drastic. Figure 2 displays worker contributions. Contributions vary between 2 percent and 5 percent over the relevant range. We see that the required worker contribution dropped with the 1997 reform; this is likely to have made formal employment more attractive relative to informal employment, other things equal.

## **2.3 Non-pension Benefits**

Any worker on whose behalf contributions are made to the system is entitled to free health care at IMSS hospitals and clinics, for himself or herself, as well as for members of his or her immediate family. In addition, working mothers covered by IMSS in their jobs and widowed or divorced working fathers covered by IMSS in their jobs are entitled to free child care during workdays for children ages seven weeks to four years old.<sup>8</sup> It is difficult to estimate workers' valuations of the IMSS non-pension benefits. Conveniently for our empirical strategy, however, the health care and child care benefits did not change with the 1997 pension reform. Under the assumption that employees' valuations of the constant set of benefits did not change differentially by sex and age group over the study period, the valuations will be differenced out by our difference-in-differences procedure.

## **2.4 Pension Benefits**

The pension system is the component of the social security system that experienced the largest change over our study period. Here we describe the pre-reform and post-reform regimes separately.

### **2.4.1 Pre-reform (pay-as-you-go) system**

Under the pre-reform regime, workers became vested in the system after 10 years of contributions, and were then entitled to receive at least the minimum pension. Panel A of Figure 3 illustrates to the minimum wage (without specifying zone) we are referring to the minimum wage in Mexico City.

<sup>8</sup>IMSS also provides an individual savings account for housing expenditures, which in some cases can be used to contribute to an individual pensions. The housing sub-accounts are described in more detail in Appendix A.2.

the expected daily pension, a function of the average nominal wage in the five years preceding retirement, for workers with 10, 20 and 30 years of contributions in selected years. The schedules combine a minimum pension guarantee with a benefit proportional to an individual's wage.

At first glance, the pensions do not appear to be insensitive to the reported nominal average wage, at least for workers with 20 or 30 years of contributions. But the responsiveness of pensions to wage reports over the period was dampened by two factors: the erosion of the real value of wages and pensions by inflation and the relatively low tenure of workers in the system. Inflation exceeded 50 percent in every year in the volatile 1982-1989 period, and exceeded 100 percent in 1987 and 1988. (See Appendix Table A2.) Given that pensions were based on the average *nominal* wage in the five years prior to retirement, the high inflation sharply reduced the real value of pensions. In response to public pressure, the Mexican congress in 1989 increased the minimum pension to 70 percent of the minimum wage and indexed it to the minimum wage going forward, without raising the value of pensions greater than the minimum. In 1991, benefits were indexed to the minimum wage, which slowed the erosion of the values of pensions above the minimum.<sup>9</sup> Over time, the congress also raised the value of the minimum pension relative to the minimum wage, until it reached 100 percent of the minimum wage in Mexico City in 1995.

We do not observe total years of contributions in our data, but we do observe the number of years a worker has appeared in the data since 1985. Using data from the IMSS administrative records, described in more detail in Section 3 below, Table 1 presents statistics on male workers' observed tenure in the IMSS system since 1985. The key point is that even among the older age groups a relatively small share of workers are continuously attached to the formal, private-sector labor force. In the 56-65 age group, for instance, fewer than 45 percent appear in the IMSS records for 10 or more years over the 1985-1997 period. While the absence from the IMSS system could reflect employment in the public or petroleum sectors, it seems more likely that workers were simply out of the formal labor force altogether.

As a consequence of the erosion of the real value of pensions above the minimum, the low tenure of many workers in the IMSS system, and the legislative interventions to raise the minimum, the fraction of workers who expected to receive the minimum pension remained high throughout the pre-reform period. Panel B of Figure 3 plots the real value of the pension for male workers with 10, 20 or 30 years of contributions against the nominal average wage percentile of workers in the

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<sup>9</sup>That is, if a worker's nominal average wage was twice the minimum wage in 1991, the pension payment in 1992 was calculated on the basis of twice the minimum wage. The real minimum wage declined steadily over the period (see Appendix Table A2) so the slowing of the erosion of pensions as a result of this change was modest.



60-65 age group, for selected years in the IMSS data.<sup>10</sup> In 1990, approximately 80 percent of male retirees with 10 years of contributions received the minimum pension over the period.<sup>11</sup> The corresponding numbers for male workers with 20 or 30 years of contributions were 70 percent and 60 percent respectively. In 1997, just prior to the implementation of the pension reform, nearly all workers with 10 years of contributions, roughly 50 percent of those 20 years, and 40 percent of those with 30 years could expect to receive the minimum pension. (The numbers for female workers in both years were even higher.) In addition, there was a penalty for retirement before age 65 of 5 percent per year (i.e. a workers who retired at age 60 would have her pension reduced by 25 percent), but this penalty was not allowed to reduce the pension below the minimum. This may have given workers who would have been near the minimum pension had they worked until 65 an incentive to retire early and accept the minimum pension (Aguila, forthcoming). Analysts with access to direct information on pensions received upon retirement have confirmed that prior to the reform approximately 80 percent of retirees were receiving the minimum pension (Grandolini and Cerda, 1998).

#### **2.4.2 Post-reform (personal retirement accounts) system**

Under the personal retirement accounts (PRA) system, employees, employers and the government are required to make contributions to workers' personal retirement accounts in each period. Over the 1997-2003 period, employers were required to contribute 5.15 percent of each employee's wage, and employees 1.125 percent; the government contributed 0.225 percent, as well as a "social quota" equal to 5.5 percent of the current minimum wage in Mexico City. The agency that collects the contributions is the *Comisión Nacional del Sistema de Ahorro para el Retiro* (CON SAR). Each worker is required to choose an investment institution, known as an *Administrador de Fondos de Ahorro para el Retiro* (AFORE), to manage his or her account.<sup>12</sup> The reform also specified a minimum pension equal to the minimum wage on July 1, 1997, with further increases in the minimum pension indexed to the Consumer Price Index. Eligibility for the minimum pension was raised from 10 years of contributions to 25 years of contributions. The standard retirement age remained 65.

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<sup>10</sup>To calculate the national average wage percentile, we calculate the nominal wage at each quantile of the IMSS wage distribution for 60-65 year old men in each of preceding five years, then average over the five years to calculate the pension benefit.

<sup>11</sup>Although Figure 3 suggests that in 1989 range of wages that corresponded to the minimum pension was small, in fact because of the high inflation approximately 80 percent of male workers were at the minimum.

<sup>12</sup>The AFORE management fees are in many cases substantial, and it is not clear that workers choose AFORES optimally. Duarte and Hastings (2010) investigate the role of behavioral issues in employees' choices of AFORES.

Under the PRA system, individuals have three options upon retirement. One is to receive programmed withdrawals from the individual's AFORE, where the withdrawal amount is calculated based on the account balance as well as the age and life expectancy of the individual and dependents.<sup>13</sup> A second option is to purchase an annuity from a private insurance company that guarantees a fixed monthly pension. A third option, available to workers with a PRA balance exceeding 130 percent of the cost of an annuity providing a monthly payment equal to the minimum pension, is to take a lump sum payment upon retirement.

The establishment of the new pension regime created two categories of workers: "transition" workers who first registered with IMSS prior to July 1, 1997, and new workers who first registered after July 1, 1997. At retirement, transition workers are given a choice between receiving pension benefits under the PAYGO scheme or the PRA scheme. The PAYGO pension is calculated as if workers' post-reform contributions were under the old regime. If a transition worker opts for the PAYGO pension, IMSS appropriates the balance of his or her personal retirement account. The only option for new workers is the PRA.

To illustrate the impact of the reform on pension wealth, we conduct a simulation of pension wealth under the two regimes, based on a similar simulation by Aguila (forthcoming). Table 2 displays the real present value of pension wealth under the two schemes for workers who entered the IMSS system on June 30, 1997, and hence retained the right to opt for the old-regime pension. In carrying out the simulation, we choose a relatively optimistic annual return on the personal accounts: 8.59 percent, the average return from 1998-2002, as in one of the scenarios considered by Aguila (forthcoming). Assumptions of lower interest rates, for instance the 4 percent rate considered in the other scenario by Aguila (forthcoming), are less favorable to the PRAs. Details of the simulation are in Appendix A.3. The key message of the simulation is that, even under the optimistic assumption about interest rates, effectively all workers with real daily wages below 200 pesos (who make up 80 percent of our sample) and 20 or fewer years of contributions to the PRA are better off under the old regime. In the bottom-left cells of Table 2, workers with low wages and fewer than 25 years of contributions are markedly worse off under the new regime, since they do not qualify for the minimum. The relative attractiveness of the PRA increases for workers with more years of contributions and higher wages, as one moves up and to the right in the table. To save space, we do not report simulation results for transition workers, but the pattern is similar: the PRA is preferable to the PAYGO pension only for workers with many years of contributions,

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<sup>13</sup>A worker who receives the minimum pension must choose this option.

typically 20 or more, and wages above the median.

We do not attempt to infer from the simulation an exact crossing point at which the PRA becomes preferable to the PAYGO pension; any such calculation is sensitive to assumptions about the path of interest and inflation rates, and it is not clear in any case that workers are sophisticated in calculating the precise values of pensions under the different systems. The basic message of the simulation, which we believe was understood by participants at the time of the reform, is that the personal accounts could be expected to be relatively more attractive only for workers with a significant number of years of contributions to the PRAs.

Another aspect of the pension reform, which appears to be important in practice, is that the law required AFOREs to send an account statement to each holder of a personal retirement account every four months. A redacted example of such an account statement appears as Figure 4. The account statement reports previous balances (*saldo anterior*), new contributions (*aportaciones*), withdrawals (*retiros*), interest earned (*rendimientos*), AFORE commissions charged (*comisiones*), and final balances (*saldo final*) for the pension account as well as for two additional accounts (a voluntary savings account and a housing savings account). The bottom section reports 3-year returns and commissions for each AFORE, as well as the average 5-year net return (at left). It appears that these account statements made it significantly easier for workers to discover how much employers were contributing on their behalf. This mechanism would not be expected to reduce evasion if employers and employees were colluding in under-reporting wages, but it may have reduced evasion in cases in which workers were unaware that their employers were under-reporting their wages.

The social security law provides for fines if establishments are caught evading taxes. The fines ranged from 70-100 percent of the amount of evasion over the 1995-2001 period, and have ranged from 40-100 percent, with most exactly at 40 percent, since 2001. In practical terms, however, IMSS has not had the resources to do extensive auditing of employers. It is also worth noting that neither before nor after the reform was there a reward to employees for revealing evasion by their employers.

As will be seen below, one aspect of IMSS reporting requirements does appear to be strictly enforced. By law, firms in Mexico are required to pay the relevant minimum wage and a holiday bonus called an *aguinaldo*, worth two weeks of salary or approximately 4.5 percent of annual earnings. In order to avoid fines, establishments are required to report wages of at least the corresponding minimum wage plus 4.5 percent throughout the year. Prior to 1991, there are a

scattered few reports of wages below this level; beginning in 1991, IMSS stepped up enforcement of this rule and such wages are no longer observed.

## **2.5 Other Dimensions of Tax System in Mexico**

One reason that firms in developed countries engage in relatively little under-reporting of wages may be that it does little to reduce their overall tax burden. If corporate or personal income taxes are as high as payroll taxes and difficult to evade, then lower payroll taxes due to under-reporting will be offset by higher taxes on corporate or personal income. In Mexico, corporate and personal income taxes are generally higher than payroll taxes on paper. The corporate income tax rate went from 37 to 34 percent and the highest marginal personal income tax rate from 40 to 28 percent over the 1989-2003 period.<sup>14</sup> But tax evasion and avoidance is rampant in Mexico. For instance, the OECD in 1992 found that, in part due to various loopholes, 70 percent of corporate tax declarations reported no taxable income (OECD, 1992). By all accounts, tax evasion remains high (OECD, 2011a). It appears, in other words, that payroll taxes evaded by under-reporting wages can be pocketed by firms, and are not offset by increases in other taxes.<sup>15</sup>

## **3 Data**

The source for firms' wage reports are the IMSS administrative records. All private Mexican employers are legally obligated to report wages for their employees, and pay social-security taxes on the basis of the reports.<sup>16</sup> The IMSS data contain the full set of wage reports for formal, private-sector, non-petroleum employees over the period 1985-2005.<sup>17</sup> While the IMSS data contain rich information on wage reports, they contain a limited set of variables: age, sex, daily wage (including benefits), state and year of the individual's first registration with IMSS, an employer-specific identifier, and industry and location of the employer.

Wages are reported in spells (with a begin and end date for each wage level) and in theory we could construct a day-by-day wage history for each individual. To keep the dataset manageable, we extract wages for a single day, June 30, in each year. Prior to 1997, the capture of temporary

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<sup>14</sup>Source: OECD Tax Database, [www.oecd.org/ctp/taxdatabase](http://www.oecd.org/ctp/taxdatabase).

<sup>15</sup>Madzharova (2011) provides a formalization of the idea that lower corporate taxes give firms greater incentives

workers in the administrative records was somewhat haphazard. To ensure comparability before and after 1997, we focus on workers identified in the IMSS data as permanent, defined as having a written contract of indefinite duration. As mentioned above, we focus on men. We select ages 16-65. To maintain consistency across years, we impose the lowest real value of the IMSS topcode (which occurred in 1991) in all years. In the interests of comparability with the ENEU data, we include only the metropolitan areas included in the ENEU samples (described below). We also focus on sectors for which we are confident that IMSS is the only available formal-sector social insurance program: manufacturing, construction, and retail/hotel/restaurants. In other sectors, e.g. professional services, we could not be sure that the gap between the number of workers in IMSS and the total number of workers in the sector (from the ENEU or the population census) could be interpreted as informal employment in the sector. We refer to the sample selected following these criteria as our IMSS baseline sample. Further details are in Appendix B.1.

The household data we use are from the *Encuesta Nacional de Empleo Urbano* (ENEU) [National Urban Employment Survey], a household survey modeled on the Current Population Survey (CPS) in the United States, collected by the *Instituto Nacional de Estadísticas y Geografía* (INEGI), the Mexican statistical agency. The original ENEU sample, beginning in 1987, focused on the 16 largest Mexican metropolitan areas; although the coverage expanded over time, to maximize the number of pre-reform years we focus on the original 16 areas. As in the IMSS data, we include male workers ages 16-65, focus the second quarter of each year, exclude self-employed workers, impose the 1991 IMSS topcode in all years, and include only manufacturing, construction, and retail/hotels/restaurants. All calculations below use the sampling weights provided by INEGI.

A very useful feature of the ENEU for our purposes is that it asks respondents whether they receive IMSS coverage as an employment benefit. Beginning in the third quarter of 1994 (but unfortunately not earlier), the ENEU also asked respondents whether they had a written contract of indefinite duration, the legal definition of a permanent employee used by IMSS. Hourly wages are calculated as monthly wages divided by 4.3 times hours worked in the previous week, and daily wages as 8 times hourly wages. We drop workers with reported daily wages below 30 pesos (in 2002 constant pesos, approximately US\$3, which is approximately 50 percent of the minimum wage.) To maintain comparability with the IMSS data, we imposed the 1991 real value of the IMSS topcode on the ENEU data. In principle, both the IMSS and the ENEU data are available over the 1987-2005 period, but in the interest of consistency over time in the ENEU we focus on

the years 1988-2003.<sup>18</sup>

Our goal in the preparation of the datasets is to construct samples in the IMSS and ENEU data containing workers as similar as possible. Table 3 presents summary statistics for the IMSS baseline sample and various ENEU samples for 1990 and 2000, for a set of variables that are common between the sources: daily wage, age, and share in large establishments (with >100 employees). Column 1 presents statistics for the the IMSS baseline sample, and Columns 2-6 present statistics for various ENEU samples. Comparing columns 2-4, for the "full" ENEU sample, we see, perhaps not surprisingly, that ENEU workers with IMSS coverage tend to be higher-wage and more likely to work in large establishments than workers without IMSS coverage.

Column 5 contains the sample that in principle should be the best match for the IMSS baseline sample: ENEU workers who report receiving IMSS coverage and having a written contract of indefinite duration. The average wage for this ENEU sample is greater than for the IMSS baseline sample, consistent with our argument below that there is under-reporting of wages in the IMSS data. Because the contract-type variable is available only beginning in 1994, however, we have prohibitively few years of pre-reform data for this sample. Instead, we will focus hereafter on the Column 6 sample, ENEU workers who report receiving IMSS coverage and working full-time (i.e. at least 35 hours in the previous week), which can be defined consistently over the entire period. We refer to the Column 6 sample as our ENEU baseline sample.

The ENEU baseline sample is not an ideal comparison group, for several reasons. Some temporary workers may work full-time, and some permanent workers may work part-time. Comparing Columns 5 and 6 for the year 2000, we see that average wage are significantly lower in the Column 6 sample; this is attributable to the facts that temporary full-time workers earn relatively low wages and that permanent part-time workers earn relatively high wages. It may be that firms interpret "permanent" to mean something different from the legal definition (i.e written contract of indefinite duration) when reporting wages. In addition, patterns of non-response may differ between the IMSS and ENEU samples. It is well known, for instance, that richer households tend to be less likely to respond to income questions in household surveys (Groves and Couper, 1998; Korinek, Mistiaen, and Ravallion, 2006). The weighted employment totals from the ENEU data in Columns 5 and 6 are below the IMSS totals in Column 1; this may in part reflect such non-response. These potential discrepancies recommend caution in interpreting cross-sectional

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<sup>18</sup>There appear to be a number of data inconsistencies in the ENEU in 1987, the first year of the survey. The ENEU sampling scheme was redesigned in the third quarter of 2003; to avoid introducing inconsistencies (with little benefit, since the IMSS data are available only until 2005) we focus on the period before the redesign.

differences between the IMSS and ENEU baseline samples. It is worth emphasizing, however, that our difference-in-difference strategy will focus on changes over time in the discrepancies between the samples, and any time-invariant sources of discrepancy will be differenced out.

As a further comparison, Figure 5 plots employment totals over the 1988-2003 period for the same samples as in Table 3. Perhaps surprisingly, we see that over most of the period the number of workers in the IMSS sample is slightly *greater* than the numbers in any of the ENEU samples. There are several potential explanations. The difference may reflect non-response by households in the ENEU (perhaps varying systematically with income, as mentioned above). It may be that many individual respondents are unaware that they receive IMSS coverage from their employer. It may also be that individuals live outside of the boundaries of the metropolitan area in which they work, and hence are included in our IMSS sample but not our ENEU sample. For our purposes, however, the most important lesson of the figure is that there does not appear to have been a large change over time in the extent of the employment discrepancy between the IMSS and ENEU samples in response to the pension reform.

## 4 Cross-Sectional Comparisons of Wage Distributions

In this section, we consider cross-sectional differences in wage distributions between the IMSS and ENEU baseline samples prior to the 1997 pension reform. As discussed in Section 2 above, in the pre-reform period the key issue for workers was simply whether or not they were in the IMSS system; for almost all workers, the IMSS benefits that they enjoyed were insensitive to the wages that employers reported on their behalf.

Figure 6 plots simple histograms of daily wages in the IMSS baseline sample (gray bars) and the ENEU baseline sample (bars with black borders and no fill color) in 1990, using bins that are 5 pesos wide. The three vertical lines between 50 and 70 pesos (approximately US\$5-US\$7/day) represent the three minimum wages in Mexico, with the rightmost corresponding to the minimum wage in Mexico City. Figure 7 plots similar histograms using the same samples but using only observations below 200 pesos (approximately US\$20), with bins 2 pesos wide. The pattern is striking: there is clear evidence of stacking in the IMSS sample slightly above the three minimum wages. These stacks correspond to 104.5 percent of the minimum wages in each zone | the minimum reports to IMSS that did not incur penalties. It is also evident that the IMSS distribution lies largely to the left of the ENEU distribution.<sup>19</sup> The stacking and shift to the left

<sup>19</sup>The exception to this generalization is at the far right tail. In Figure 6, we see that there is relatively more

of the distribution is precisely what one would have expected, given the incentives inherent in the social security system.

A key prediction of the theoretical framework of Kleven et al. (2009) is that collusion in under-reporting wages is more difficult to sustain in larger firms. It may also be the case simply that the intensity of IMSS monitoring and auditing is greater in larger firms. In either case, we would expect the difference between the IMSS and ENEU wage distributions to be smaller in larger firms. Figure 8 presents figures similar to Figure 7 (focused on daily wages below 200 pesos), separately for five firm sizes. Caution is warranted in interpreting these figures, since observed establishment size in the IMSS data is itself affected by firms' compliance decisions. Subject to this caveat, it appears that there is less stacking on the minimum allowable wage reports at larger firm sizes, suggesting greater compliance. Even in establishments with 250 workers or more, however, there is evidence of stacking at the minimum allowable wage report, suggesting some under-reporting even in quite large firms.

Another insight from the taxation literature is that the larger the number of reports the tax authorities receive from firms, the more difficult it is for firms to evade taxes. To investigate this prediction, we consider the wage distributions for two subsets of plants that appear in plant-level datasets collected by INEGI, the Mexican statistical agency.<sup>20</sup> The plant-level datasets do not contain individual-level wage information on the full distribution of wages, but it is nevertheless instructive to consider firms' wage reports in plants that appear in the plant-level datasets. Figure 9 plots the IMSS wage distribution for workers in manufacturing establishments that also appear in the main Mexican longitudinal plant panel, the *Encuesta Industrial Anual* (EIA) [Annual Industrial Survey], which excludes assembly-for-export *maquiladora* plants.<sup>21</sup> There is little evidence of stacking at the minimum allowable wage values, suggesting relatively little under-reporting of wages. The EIA sample consists mainly of plants with more than 100 employees, and, as shown by Figure 8, large plants are less likely to under-report. But the EIA plants display less stacking even than plants in the 100-250 and >250 employees categories in Figure 8. By contrast, Figure 10 plots the IMSS wage distribution for workers in assembly-for-export *maquiladora* plants, on which monthly statistics are reported in the *Estadísticas Mensuales de la Industria Maquiladora*

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weight at the topcode in the IMSS sample; there is also slightly more weight at high wage values just below the topcode. This appears to reflect non-response by high-income households in the ENEU – a common pattern in household surveys, as mentioned above.

<sup>20</sup>INEGI does not share plant-level information collected in INEGI surveys with the Mexican tax authorities. It is not clear that plants are aware of this, however.

<sup>21</sup>The links between establishments in the IMSS data and the EIA were constructed and first exploited in Frías, Kaplan, and Verhoogen (2009); see that paper for details of the linking.



*de Exportación* (EMIME) [Monthly Statistics on Export Maquiladora Industry]. Maquiladoras captured in the EMIME generally tend to have lower wages than the non-*maquiladoras* captured in the EIA, and we see in the figure that there is significant stacking at the minimum allowable wage values. While the requirement of supplying data to the Mexican statistical agency may have helped to induce compliance among non-*maquiladora* plants, the pattern for *maquiladoras* suggests that the mere presence of additional reporting requirements is not sufficient to guarantee compliance.

## 5 Effect of 1997 Pension Reform

We now consider how the differences in wage distributions between the IMSS and ENEU samples varied over time, and in particular whether the 1997 pension reform had the expected differential effect by age. We begin with a set of figures illustrating the key patterns. Figure 11 plots non-parametric estimates of the wage distribution for men by age group, for three years, 1990, 1997 (the quarter before the reform), and 2003. The non-parametric densities, solid red for the IMSS baseline sample and dashed blue for the ENEU baseline sample, are analogous to the histograms for low wage levels in Figure 7; non-parametric densities are chosen because they are visually clearer on the page. Each column of graphs corresponds to an age group (indicated in the x-axis titles) and each row to a year. There is a visible reduction in the extent of stacking for the youngest workers, but little apparent change in stacking for the highest age group.

To illustrate the differential reduction in the discrepancy between wage distributions in another way, Figure 12 plots the difference in log median wages the IMSS and ENEU samples by age group over the 1988-2003 period. We refer to the difference in log median wages between the IMSS and ENEU samples as the "wage gap." One noticeable fact is that the gap is initially larger for the youngest age group, 16-25. But the key point is that the gap for the oldest age group, 56-65, clearly increases relative to the log differences in medians for the other groups. The other group that appears to see a relative increase, albeit smaller, is the second-oldest age group, 46-55.

A possible concern with Figure 12 is that the differential changes may reflect shocks to local labor markets which differ in their age composition. To address this possibility, we deviate the wage gaps from metropolitan area-year means: we collapse the data to the age group-year-metro area level, regress the corresponding wage gaps on a full set of metro area-year effects, recover the residuals and then average them at the age group-year level. Figure 13 plots these averages.

Again we see a clear relative increase in the wage gap in the oldest group. It is worth noting that although there is some volatility in the estimates prior to 1997, the relative increase in wage gaps for the oldest group only becomes evident in 1998, the first observation after the 1997 pension reform.

The difference in log medians does not capture the shape of the tails of the wage distributions, and in particular does not directly reflect the extent of stacking at the minimum wage. An alternative measure of the divergence between two distributions is the Kullback-Liebler divergence (Kullback and Leibler, 1951), which has been used by DiNardo, Fortin, and Lemieux (1996) among others. The Kullback-Liebler divergence between two densities,  $f_1$  and  $f_2$ , is given by:

$$D_{12} = \int_0^{\infty} [f_1(w) - f_2(w)] \frac{f_1(w)}{f_2(w)} dw \quad (1)$$

While in principle this measure could be computed using the histograms displayed in Figures 6-8 (and a discrete version of the definition of  $D_{12}$ ), the measure is only defined if  $f_2(w)$  is positive, and in the histograms this cannot be guaranteed. For this reason, we first estimate non-parametric densities at the age group-year level (using entire wage distributions, not just wages below 200 pesos as in Figure 11) and then apply (1). Figure 14 plots the Kullback-Liebler divergence measure over the 1988-2003 period, separately by age group. Once again a relative increase in divergence for the oldest wage group is evident.

To put standard errors on the estimates, we turn to simple regressions. The "treatment" in this case is the interaction of the 1997 pension reform with age group, which varies at the age group-year level, so if we want to allow for arbitrary correlation of the error terms within age group-years (as the literature following Moulton (1986) has suggested may be important), then we do not have enough degrees of freedom to be completely flexible about how the pension reform interacts with age. Instead, motivated by the pension simulation in Table 2 and by the patterns in Figures 12 and 13 above, we model the differential effect by age as captured by an interaction of an 56-65 age-group indicator and a full set of year indicators. We then cluster errors at the age group-year level. Table 4 reports the regressions. The columns differ in the sets of dummy variables included (year effects only, year and metro area effects, metro area-year effects in Columns 1-3, respectively) but the coefficient estimates hardly change. The take-home message from this table is that the patterns observed in Figures 12-13 are statistically significant, despite the small number of clusters (80). There is some volatility in the estimates prior to 1997, but beginning in 1998 the

coefficient on the interaction of the oldest age group indicator and the corresponding year effect rises in magnitude well above previous years and remains statistically greater than zero at the 1 percent level.

Table 5 presents analogous regressions for employment gaps (log differences between employment in the IMSS and ENEU samples). Consistent with our earlier impressions from Figure 5, there does not appear to be a systematic response of employment reports to the pension reform. This may be because the reform had opposing effects on firms' incentives to report employment. On one hand, the increase in the number of years to vest in the system, from 10 to 25, would be expected to increase the incentive of workers to be reported, and workers might be willing to accept lower wages in order to be reported; on the other hand, if firms' scope for under-reporting wages is reduced, then a given worker may effectively be more expensive, all else equal. It may be that these two effects roughly offset.

## 6 Conclusion

Reducing non-compliance of firms with tax regulations is a first-order policy issue in many developing countries. Much of the debate has focused on how to induce firms to register with tax authorities in the first place — what we might call the *extensive* margin of non-compliance. In this paper, we have shown that under-reporting of wages among firms that are already registered — non-compliance on an *intensive* margin — is also substantial and that it responds to the incentives of workers to monitor their employers. A clear policy implication is that social insurance systems should be designed to give employees such incentives.

The findings of this paper raise a number of questions for the literature on estimating the incidence of payroll taxes and social-insurance benefits. There is an active literature on incidence, including Summers (1989), Gruber and Krueger (1991), Gruber (1994), Gruber (1997), Marrufo (2001), Kugler and Kugler (2009), Cruces, Galiani, and Kidyba (2010), but relatively little attention has been paid to the effects of non-compliance — and changes in non-compliance — on measures of incidence. This seems a potentially fruitful topic for future work.

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## A Additional Institutional Background

In this appendix, we provide additional details about IMSS, including information on the 1992 pension reform, the housing sub-account, and the pension simulation.

### A.1 1992 Pension Reform

In an effort to restore financial stability to the IMSS system, the Mexican congress enacted a first attempt at pension reform in May 1992. This reform created a system of personal retirement accounts called the *Sistema de Ahorro para el Retiro* (SAR) to operate alongside the established PAYGO pension system. The SAR accounts were funded by employers, who contributed two percent of each worker's wage to the worker's SAR account. Employers deposited the contributions into a commercial bank of their own choosing; the commercial bank then transmitted the funds to the Mexican central bank. The central bank guaranteed a minimum two percent real return, and workers were supposed to receive a lump-sum payment at retirement equal to the accumulated balances. Several problems plagued the implementation of the SAR system, however. The scheme suffered from poor regulatory oversight and management. Commercial banks received low fees for administering the collection of employer contributions, weakening incentives for these banks to provide efficient record-keeping or enforce the mandatory contributions. In addition, workers were often unaware of the balances in their accounts or even of which bank held their accounts. This led to the creation of multiple accounts, especially for workers who changed employers; by 1997, over half of the 20 million accounts were duplicates (Grandolini and Cerda, 1998). As a result of these difficulties, the reform was widely considered a failure, with workers and employers viewing the reform as simply another payroll tax (Grandolini and Cerda, 1998; Aguila, forthcoming).

### A.2 Housing Sub-Account

As an additional social-security benefit for workers, employers contribute five percent of a worker's wage, up to 10 times the minimum wage, to the *Instituto del Fondo Nacional de la Vivienda de los Trabajadores* (INFONAVIT). Employees can apply for housing loans through INFONAVIT. If approved, a worker can use the accumulated funds as a down payment on a house purchase; loan payments are subsequently deducted from employees' paychecks.

Prior to 1992, accumulated contributions in INFONAVIT not used toward housing were provided to the worker at the time of retirement. However, INFONAVIT only provided nominal

accumulated contributions. Given the high inflation rates, the real value of nominal contributions was typically quite small. The 1992 IMSS reform sought to correct this problem by requiring that INFONAVIT provide workers with any unused contributions plus interest based on the operational surplus of the agency. In practice, however, INFONAVIT continued to suffer from several problems, including high rates of delinquency of loans, which limited the agency's ability to pay interest and resulted in a negative real rate of return (Grandolini and Cerda, 1998).

Following the 1997 reform, new workers and transition workers who choose the PRA system at retirement receive the unused accumulated balances in their INFONAVIT account upon retirement. Transition workers that choose the PAYGO pension at retirement only receive the account balances that were accumulated between 1992 and 1997, thus forfeiting balances accumulated after 1997.

### **A.3 Pension Simulation**

As described in the main text, we conduct a pension simulation based on the pension simulation in Aguila (forthcoming) in order to compare pension wealth at retirement under the PAYGO and the PRA systems. We simulate the pension wealth that a worker would expect under the two systems as of June 30, 1997.

For the PAYGO system, the monthly pension is calculated based on the benefit schedule in Table A1, which was in effect from Jan. 1, 1991 to June 30, 1997. To calculate the final average wage (the average nominal wage in the five years before retirement), we assume a constant real wage and an annual inflation rate of 13.65 percent (the average annual inflation rate from 1988-2003, excluding the high-inflation years of 1988, 1989, 1995, and 1996). The average wage in the five years prior to retirement turns out to be approximately 79 percent of the wage at retirement. Since pensions exceeding the minimum pension were indexed to the minimum wage, we adjust the monthly pension benefits to reflect an expected decline in the real minimum wage over time;<sup>22</sup> following Aguila (forthcoming), we assume a 6.4 percent annual decrease in the real value of the minimum wage.<sup>23</sup> Again following Aguila (forthcoming), we discount the value of the monthly pension benefits to the present assuming a discount rate of one percent.

Under the PRA regime, we calculate the total value of contributions over a worker's career,

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<sup>22</sup>Starting in 2001, the minimum pension was indexed to inflation rather than the minimum wage, but participants would not have known this in 1997.

<sup>23</sup>The real value of the minimum wage declined steadily beginning in the early 1980s and throughout our study period; see Table A2.



assuming a constant real wage.<sup>24</sup> We then determine the total value of accumulated wealth at retirement assuming a 8.59 percent annual return (the average return from 1998-2002).<sup>25</sup> We next calculate the schedule of monthly annuity payments equivalent in expected value to total pension wealth at retirement, assuming life expectancies of 93 years for men and 87 years for women.<sup>26</sup> As with the PAYGO pension, we discount the monthly pension assuming a one percent discount rate.

It is important to note that we have imposed a relatively optimistic assumption about future interest rates and a relatively pessimistic assumption (from the point of view of pension wealth) for the real value of the minimum wage. Both assumptions have the effect of making the PRA pension relatively more attractive. We emphasize that the simulation is mainly to illustrate that younger workers are more likely to expect to opt for the PRA pension; we are not arguing that the pension reform made workers better off overall. Indeed, it seems clear from the simulation that workers with low wages and weak attachment to the formal sector labor force who enter the system after the reform are strictly worse off than they would have been under the old regime.

## B Data Appendix

### B.1 IMSS individual-level data

As mentioned above, all private Mexican employers are legally required to report wages for their employees to the Mexican social security agency, *Instituto Mexicano del Seguro Social (IMSS)*. Not all employers comply; those that do not are commonly defined as being in the informal sector. The raw IMSS data can thus be considered a census of private, formal-sector, non-petroleum-sector establishments and their workforces for 1985-2005.<sup>27</sup> (Public-sector workers and employees of the state-run oil company are covered by other insurance programs.) The IMSS data contain information on the daily wage of individuals. The wages are a measure of total compensation, called the *salario base de cotización*, which includes earnings and benefits, including payments made in cash, bonuses, commissions, room and board, overtime payments, and in-kind benefits.

<sup>24</sup>For the PRA regime, we include housing account contributions, which assumes that workers do not use housing accounts for loans. Note that we do not include the housing account under the PAYGO system, as workers opting to take the PAYGO pension at retirement only receive housing account contributions accumulated between 1992 and 1997.

<sup>25</sup>These real interest rates are net of management fees charged by AFORES.

<sup>26</sup>Aguila (forthcoming) notes that these are the life expectancy assumptions employed by IMSS. Life expectancy is higher for men to account for expected survivor benefits paid out to widows or dependent children.

<sup>27</sup>We do not have access to information on which establishments belong to which firms, and treat each establishment as a single-establishment firm.

The data are reported as a sequence of spells for each worker, with beginning and end dates. In principle it is possible to recover a wage for every individual for every day of every year. We extracted data for June 30 for each year. At the level of individuals, the data also contain information on age, sex, and state and year of the individual's first registration with IMSS. At the establishment level, the data contain information only on location and industry (using the IMSS's own 4-digit industrial categories, of which there are 276.)

We impose the following criteria in cleaning the data. (1) In its internal records, IMSS classifies wage records according to different types, referred to as *modalidades*. We use only *modalidades* corresponding to permanent workers for which consistent, reliable wage figures are available.<sup>28</sup> (2) We require that an individual have a positive wage. (3) We treat workers in single-worker establishments as self-employed and exclude them. (4) If two observations appear for the same individual, we select the standard *modalidad* (*modalidad* in the internal IMSS system) and the highest-wage observation within it. (5) We require that individuals be 16 years or older and 65 years or younger. (6) We drop observations with missing sex, industry, or location. (7) We drop workers outside of non-petroleum manufacturing, construction, retail, restaurants, and hotels, as explained in the main text. (8) We include workers employed by firms located in the original 16 metropolitan areas sampled in the ENEU (described below).

Over time, IMSS raised the maximum reported income in conjunction with the maximum taxable income. Initially, the maximum reported income was set at 10 times the minimum wage; this was increased to 18 times the minimum wage in 1993 and to 25 times the minimum wage in 1994. The lowest real value for the maximum reported income occurred in 1991; we impose a topcode equal this value to ensure comparability across years. Prior to 1991, IMSS allowed firms to report wages below the relevant minimum wage, and in other years a very small number of observations have wages below the minimum wage (which appear to be due to typographical errors.) We drop all observations with real daily wages below 30 pesos; observations with wages greater than 30 pesos but lower than the minimum wage are kept unchanged.

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<sup>28</sup>In the internal classification system, we use *modalidades* 10, 13, and 17. This excludes rural casual laborers, self-employed individuals who are insured through IMSS, employees of rural agricultural cooperatives and credit unions, freelance workers, taxi drivers, miscellaneous public-sector workers insured through IMSS, and a number of smaller categories.

## B.2 ENEU Household Data

The *Encuesta Nacional de Empleo Urbano (ENEU)* [National Urban Employment Survey] is a household survey modeled on the Current Population Survey (CPS) in the United States. Households are interviewed quarterly for five quarters, and then rotate out of the sample. The original ENEU sample focused on the 16 largest Mexican metropolitan areas.<sup>29</sup> Over time, the coverage of metropolitan areas expanded but we focus on the original 16 metropolitan areas in order to maintain a consistent sample for as many years as possible.<sup>30</sup>

The hourly wage figures were constructed as follows. (1) We recovered monthly wages for the job worked last week (as converted from weekly or bi-weekly basis by INEGI enumerators). For a small number of workers, wages were reported in wage categories relative to the minimum wage; we calculated monthly wages for these workers using the midpoint of the wage categories.<sup>31</sup> Individuals who reported not working in the previous week or who were missing wage information were dropped. (2) Monthly hours were calculated as 4.3 times hours worked in the previous week. Responses of "irregular hours, less than 35", "irregular hours, between 35 and 48" and "irregular hours, more than 48" were assigned values of 20, 42 and 60 hours per week, respectively. Workers with missing weekly hours were dropped. (3) Hourly wage was calculated as monthly wage/monthly hours. (4) Daily wage was calculated by multiplying the hourly wage by eight. (5) The wage was deflated to constant 2002 pesos using the main consumer price index (INPC) from *Banco de Mexico*, the Mexican central bank. (6) We imposed a topcode equal to the real value of the IMSS topcode in 1991 and dropped workers with a real daily wage below 30 pesos (approximately US\$3).

The ENEU asks individuals about their main job as well as any secondary employment. We focus solely on the main job reported in the ENEU. We follow sample selection criteria similar to those we impose on the IMSS. Our baseline ENEU sample includes men ages 16-65 working in

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<sup>29</sup>The 16 metropolitan areas are: Mexico City, Guadalajara, Monterrey, Puebla, Leon, Torreon, San Luis Potosi, Merida, Chihuahua, Tampico, Orizaba, Veracruz, Ciudad Juarez, Tijuana, Matamoros and Nuevo Laredo. Mexico also had a nationally representative survey that covered rural areas, the *Encuesta Nacional de Empleo (ENE)*, but until it was combined with the ENEU in 2000 it was carried out at less regular intervals: 1991, 1993, 1995, 1996, 1997, 1998, and 1999. Beginning in 2000, the combined ENEU/ENE survey was referred to as the *Encuesta Nacional de Empleo Trimestral (ENET)* and following a redesign in 2004 as the *Encuesta Nacional de Ocupación y Empleo (ENOE)*.

<sup>30</sup>The 16 metropolitan areas gradually expanded to include additional municipalities over our sample period. We include the new municipalities (and include establishments in the IMSS data in the new municipalities.)

<sup>31</sup>Prior to 1994, the categories were (for some wage  $w$  and the relevant minimum wage  $MW$ ):  $w < .25 MW$ ;  $.25 MW < w < .5 MW$ ;  $.5 MW < w < 1 MW$ ;  $1 MW < w < 2 MW$ ;  $2 MW < w < 3 MW$ ;  $3 MW < w < 5 MW$ ;  $5 MW < w < 10 MW$ ; and  $10 MW < w$ . In 1994, the survey combined the first three categories into a single "less than the minimum wage" category and added a category of greater than 20 times the minimum wage.

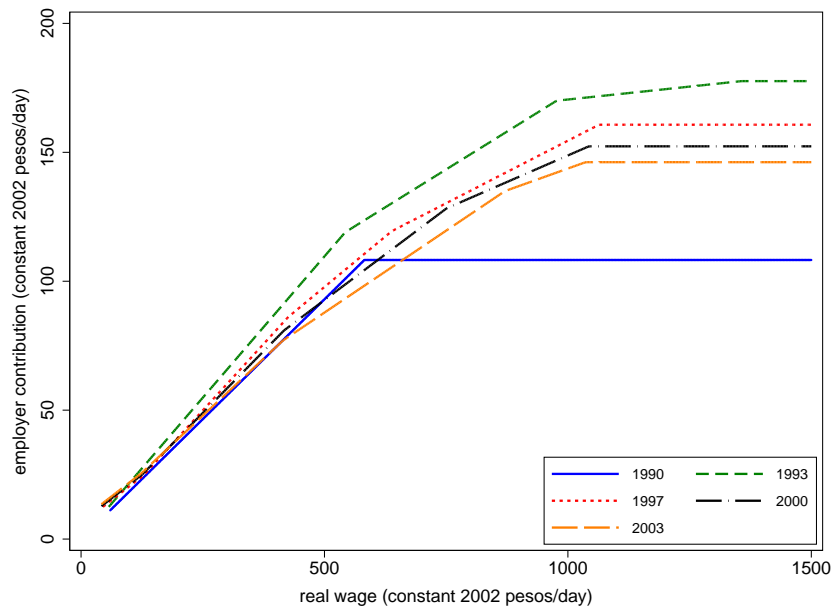
non-petroleum manufacturing, construction, retail, restaurants, and hotels. We also require these workers to receive a fixed wage, work for a commission, or work in a cooperative. This drops self-employed workers, owners, and unpaid workers from our ENEU sample. The sample thus constructed is referred to as the "full ENEU sample" in Table 3. As explained in Section 3, in our ENEU baseline sample we focus on workers who report receiving IMSS through their main employment and who work full-time, defined as at least 35 hours in the last week.

All calculations in the paper use the sampling weights reported by INEGI.

### B.3 Plant-level datasets

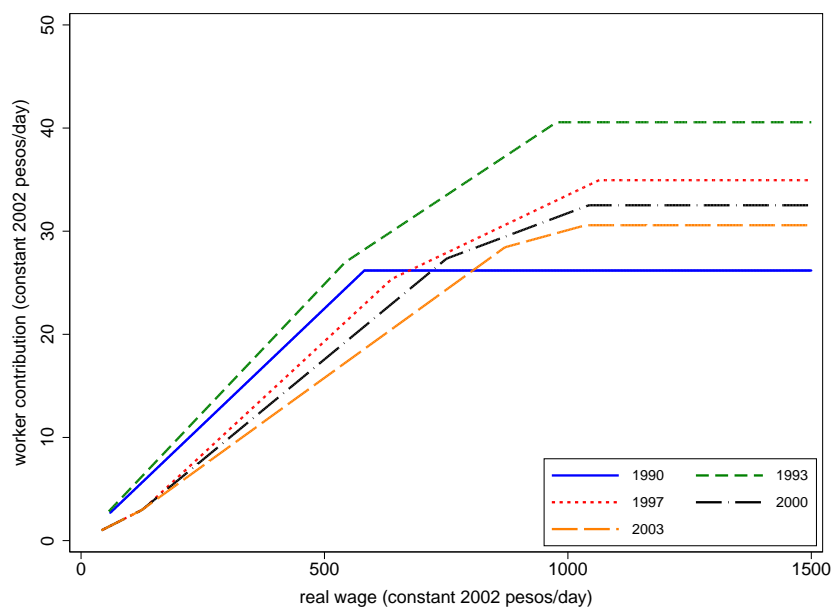
Figures 9 and 10 focus on establishments in the IMSS data that also appear in panel datasets of manufacturing firms from the *Encuesta Industrial Anual (EIA)* [Annual Industrial Survey] and the *Estadísticas Mensuales de la Industria Maquiladora de Exportación (EMIME)* [Monthly Statistics on Maquiladora Export Industry], respectively. The former excludes assembly-for-export *maquiladora* plants and the latter includes only *maquiladora* plants. In this paper the only information used from these datasets is which IMSS establishments appear in them. For details on the cleaning of these datasets, readers are referred to Verhoogen (2008) and Frías, Kaplan, and Verhoogen (2009).

**Figure 1. Employer contributions**



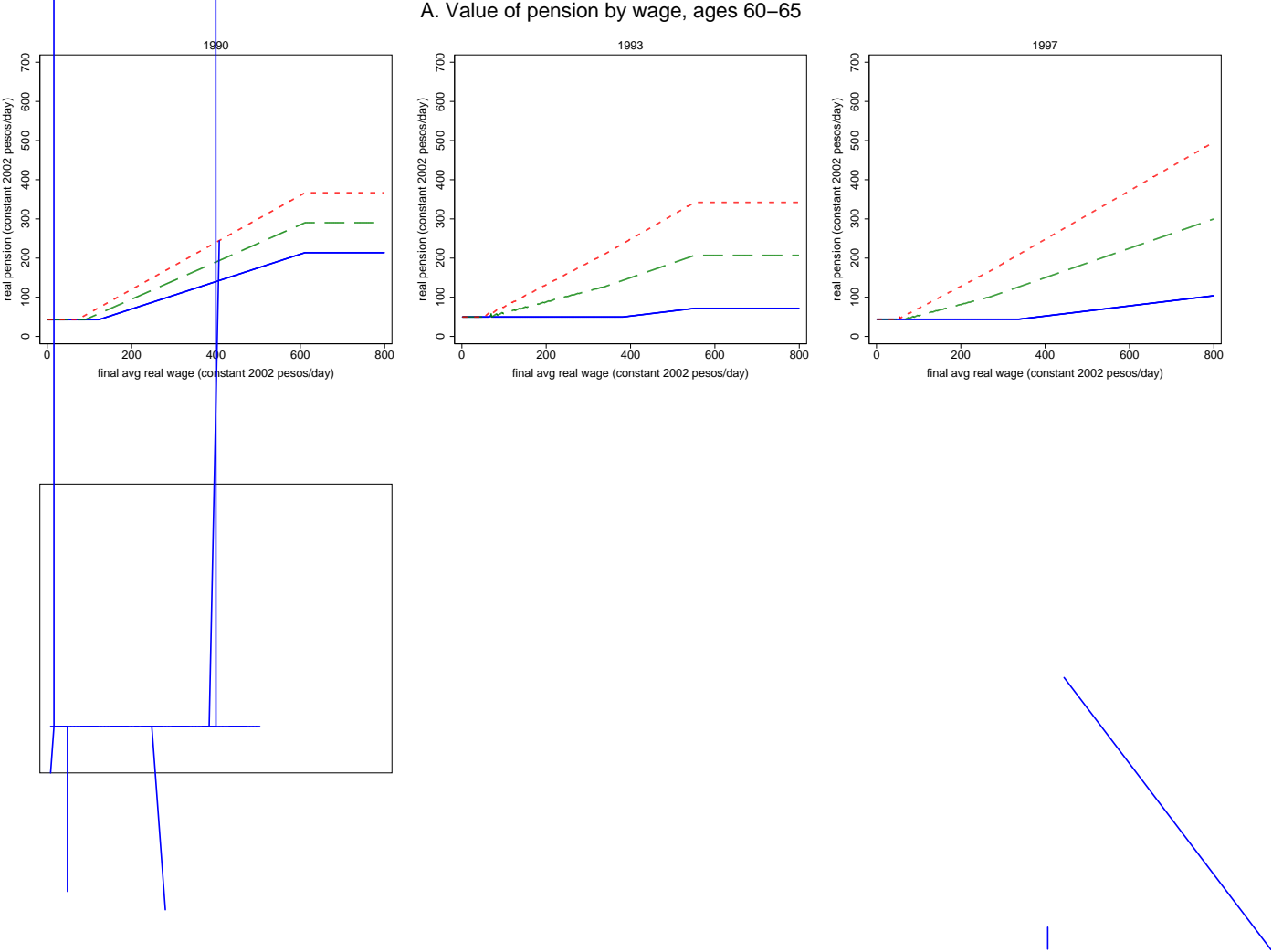
Notes: Variation in IMSS employer contribution rates at levels above 500 pesos/day are primarily due to changes in topcodes, which varied from 10 to 25 times the minimum wage in Mexico City over the period. Average 2002 exchange rate: 9.66 pesos/dollar.

**Figure 2. Worker contributions**



Notes: Variation in IMSS worker contribution rates at levels above 500 pesos/day are primarily due to changes in topcodes, which varied from 10 to 25 times the minimum wage in Mexico City over the period. Average 2002 exchange rate: 9.66 pesos/dollar.

Figure 3. Pension values, selected years

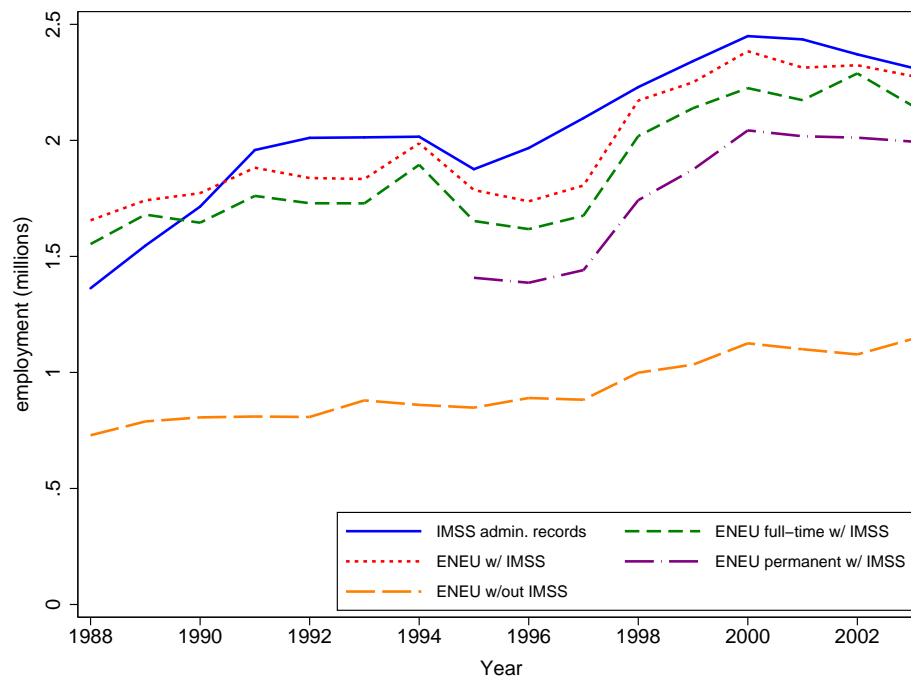


**Figure 4. Estado de Cuenta**

[illegible]

Notes: This document is an individual account statement required by law, beginning in 1997, to be sent to all individual workers registered in IMSS every four months. The box at top right ("Cuanto tengo en mi cuenta individual") reports total balance in the three sub-accounts administered by CONSAR: retirement pension, voluntary savings account, and housing savings account. The first row of boxes in the middle section ("Mi ahorro para el retiro") pertains to the retirement pension and reports previous balance ("Saldo anterior"), new contributions ("Aportaciones"), withdrawals ("Retiros"), interest earned ("Rendimientos"), AFORE commission charged ("Comisiones"), and final balance ("Saldo final"). The bottom section reports 3-year returns and commissions for each AFORE, as well as the average 5-year net return (at left).

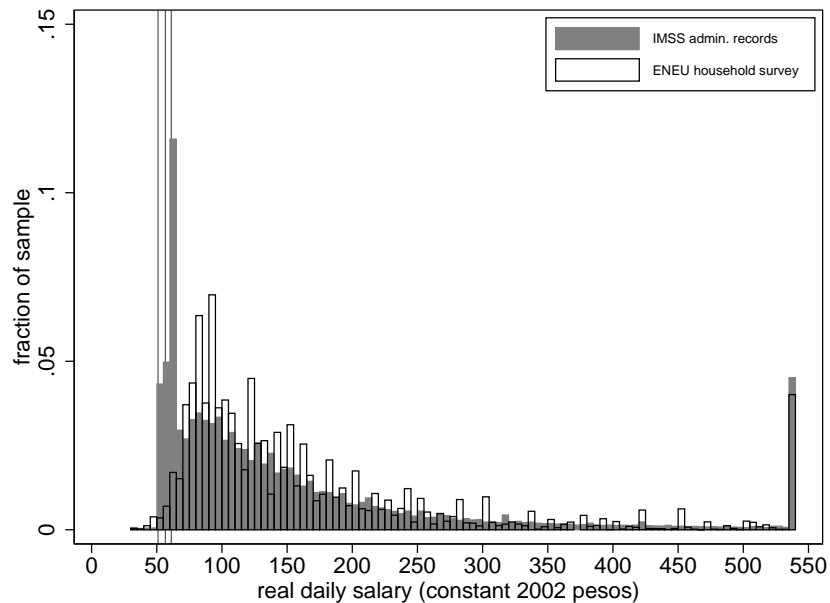
**Figure 5. Employment, IMSS admin. records vs. ENEU household data, men**



Notes: Samples are the same as those in Table 3; refer to that table for details. ENEU totals are calculated using sampling weights. See Section 3 and Appendix B for details of sample selection.

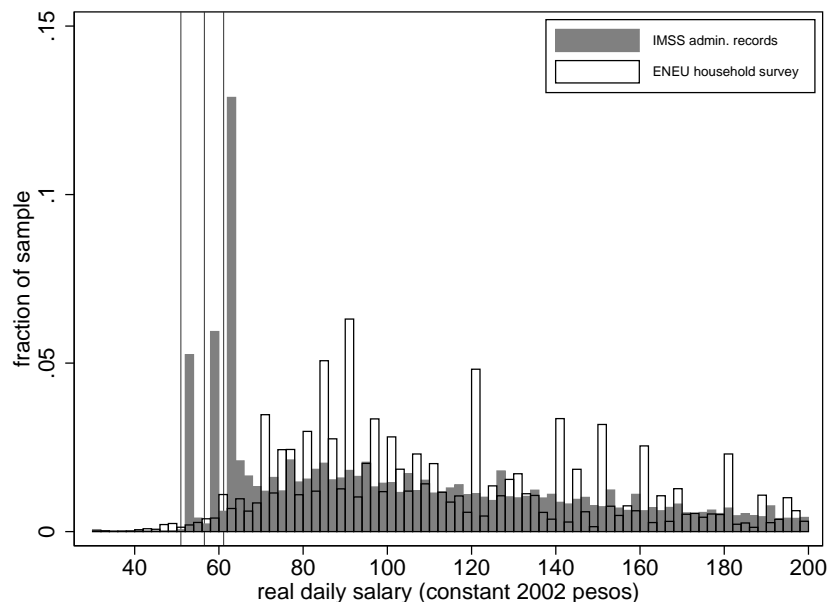


**Figure 6. Wage histograms, men, 1990**

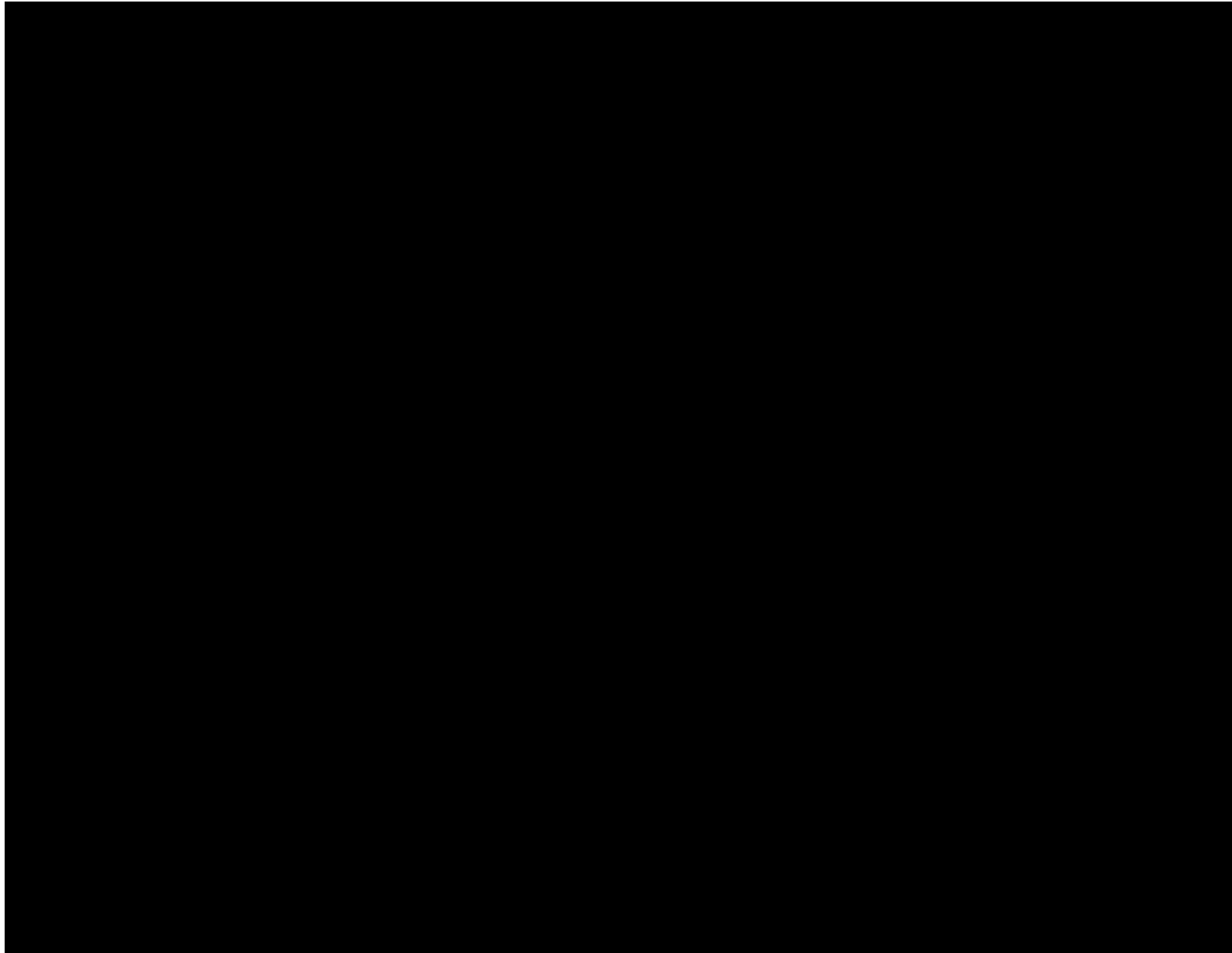


Notes: Samples are "baseline" samples of men: IMSS sample is permanent male workers ages 16-65 in 16 cities in original ENEU sample; ENEU sample includes full-time male workers ages 16-65 in 16 cities in original ENEU sample who report receiving IMSS coverage as an employment benefit. Data are from second quarter. Vertical lines indicate minimum wages in the three minimum-wage zones in Mexico (A, B, C). Bins are 5 pesos wide. The rightmost bin captures all individuals with reported wages at or above the minimum IMSS topcode over the study period (from 1991). Average 2002 exchange rate: 9.66 pesos/dollar.

**Figure 7. Wage histograms, men, 1990, low wage levels**

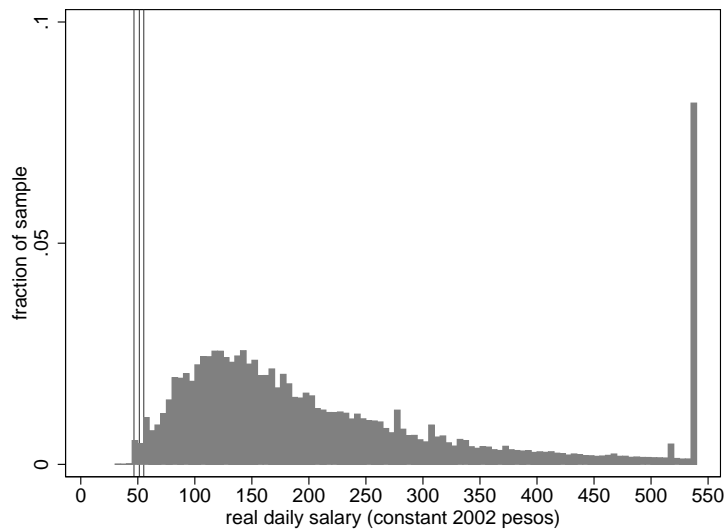


Notes: Histogram is similar to Figure 6 but only includes workers with wages less than 200 pesos/day (approx. \$20/day) in constant 2002 pesos. Bins are 2 pesos wide.



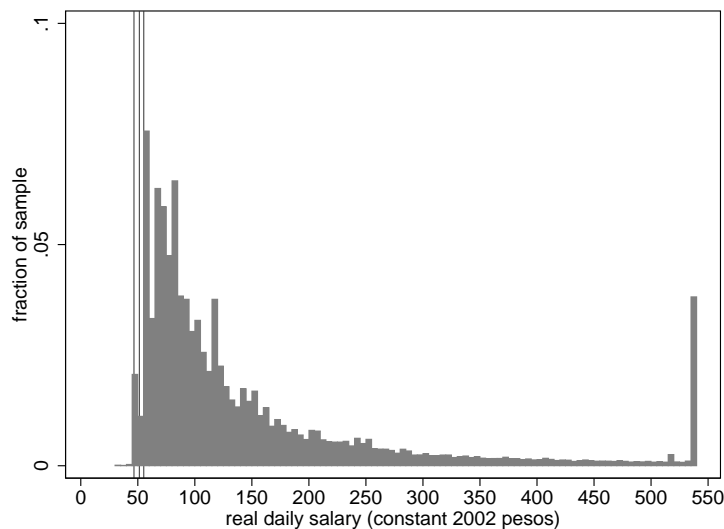
Notes: Samples are "baseline" samples of men, similar to those used in Figure 6 but only including workers with wages less than 200 pesos/day in constant 2002 pesos. ENEU sample only includes observations for which firm size variable is observed. Data are from second quarter. Vertical lines indicate minimum wages in the three minimum-wage zones in Mexico (A, B, C). Bins are 2 pesos wide. Average 2002 exchange rate: 9.66 pesos/dollar. See Section 3 and Appendix B for details of sample selection.

**Figure 9. Wage histograms, men, 1993, establishments linked to EIA**



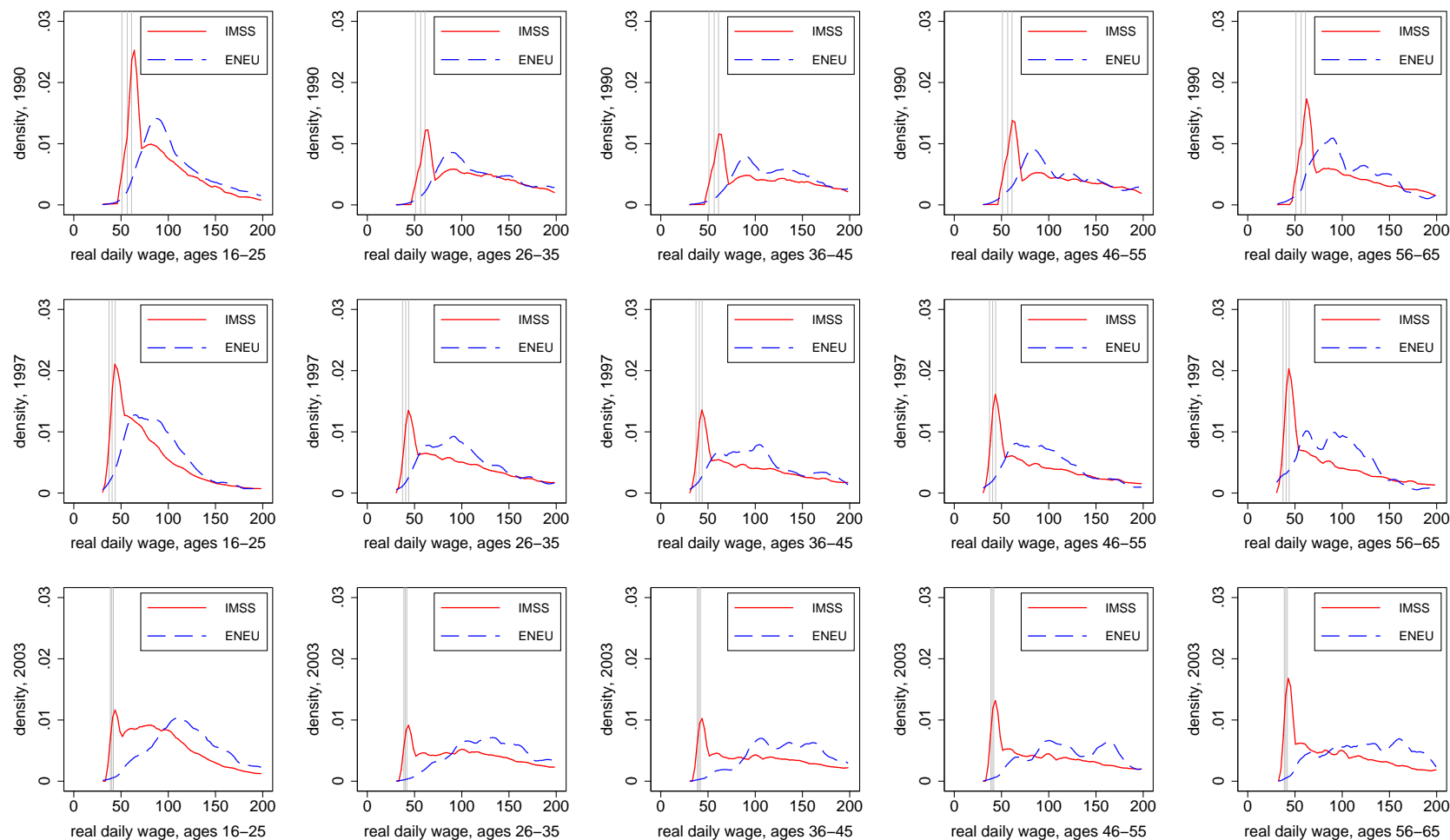
Notes: Sample is permanent male workers ages 16-65 in IMSS data in 2405 establishments that can be linked to a balanced 1993-2003 panel from the *Encuesta Industrial Anual (EIA)* [Annual Industrial Survey], which excludes assembly-for-export *maquiladora* plants. Data are from second quarter. Vertical lines indicate minimum wages in the three minimum-wage zones in Mexico (A, B, C). Bins are 5 pesos wide. See Section 3 and Appendix B for details of sample selection.

**Figure 10. Wage histograms, men, 1993, establishments linked to EMIME**



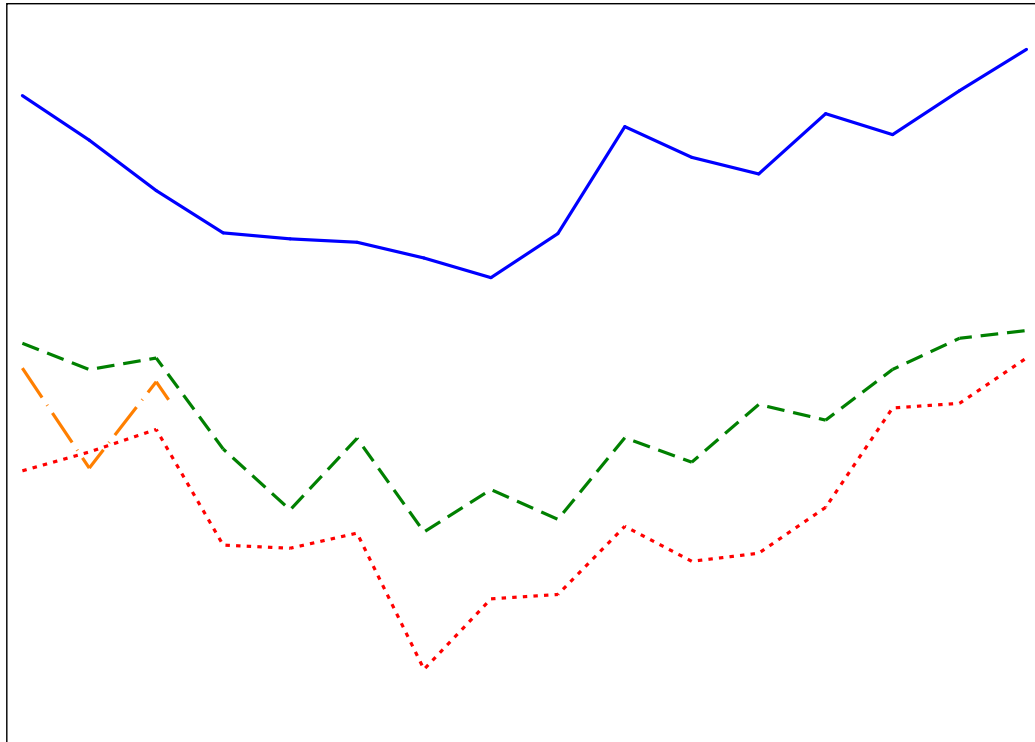
Notes: Sample is permanent male workers ages 16-65 in IMSS data in 506 establishments that can be linked to a balanced 1993-2003 panel from the *Estadísticas Mensuales de la Industria Maquiladora de Exportación (EMIME)* [Monthly Statistics on Maquiladora Export Industry], a dataset made up exclusively of assembly-for-export *maquiladora* plants. Data are from second quarter. Vertical lines indicate minimum wages in the three minimum-wage zones in Mexico (A, B, C). Bins are 5 pesos wide. See Section 3 and Appendix B for details of sample selection.

Figure 11. Wage densities by age group, 1990, 1997, 2003, men



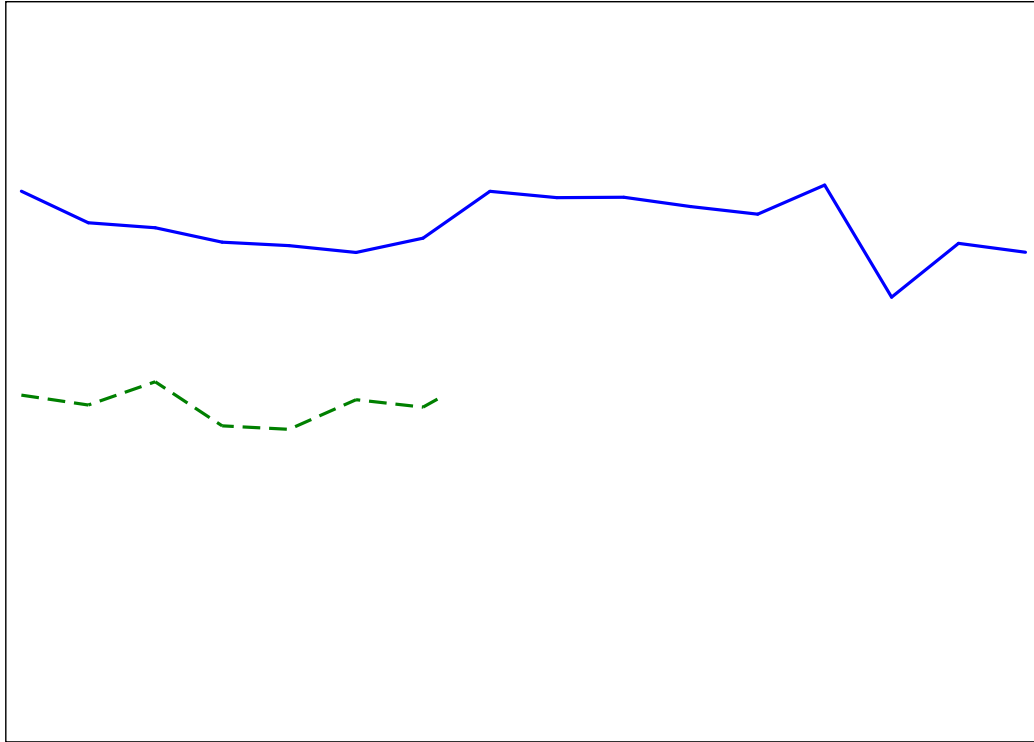
Notes: Densities are estimated an Epanechnikov kernel and bandwidth 3 pesos for IMSS data and 6 pesos for ENEU data (using Stata `kdensity` command). Rows correspond to years 1990, 1997, 2003; columns to age groups 16-25, 26-35, 36-45, 46-55, 56-65. Wages (on x-axes) are real daily wages in 2002 pesos. Average 2002 exchange rate: 9.66 pesos/dollar. Samples are baseline samples of men, only including workers with wages less than 200 pesos/day. See Section 3 and Appendix B for details of sample selection.

**Figure 12. Wage gaps by age group**



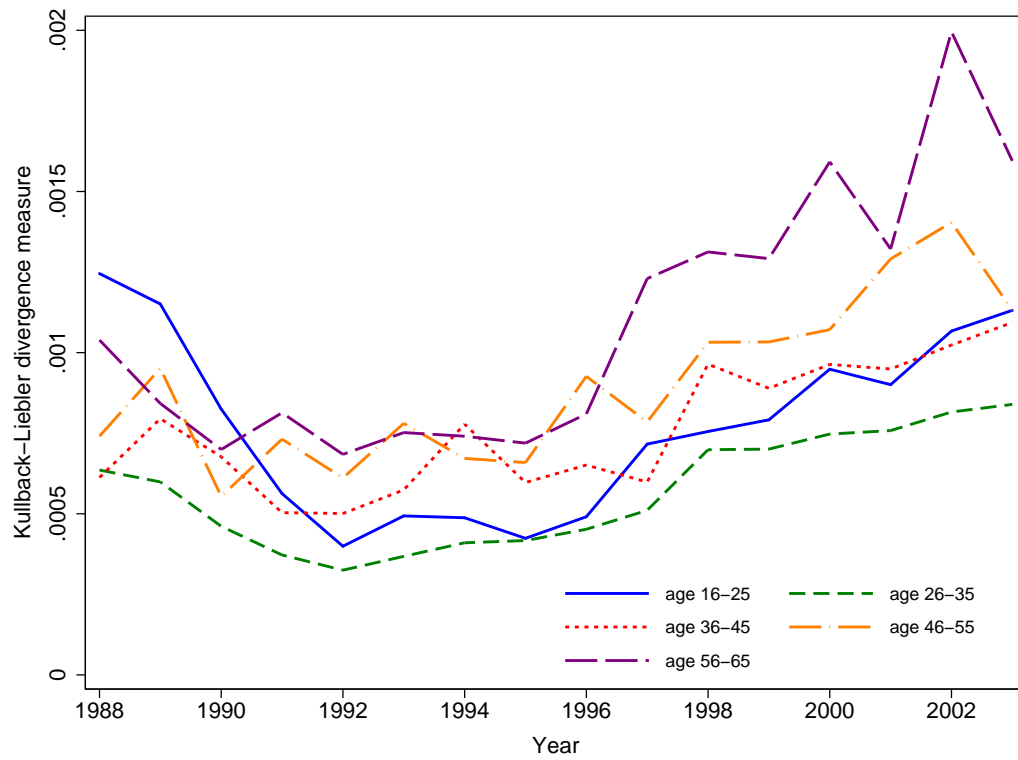
Notes: Wage gap is difference in log median real daily wages between ENEU and IMSS baseline samples, here calculated separately by age group. See Section 3 and Appendix B for details of sample selection.

**Figure 13. Wage gaps by age group, men, deviated from metro-year means**



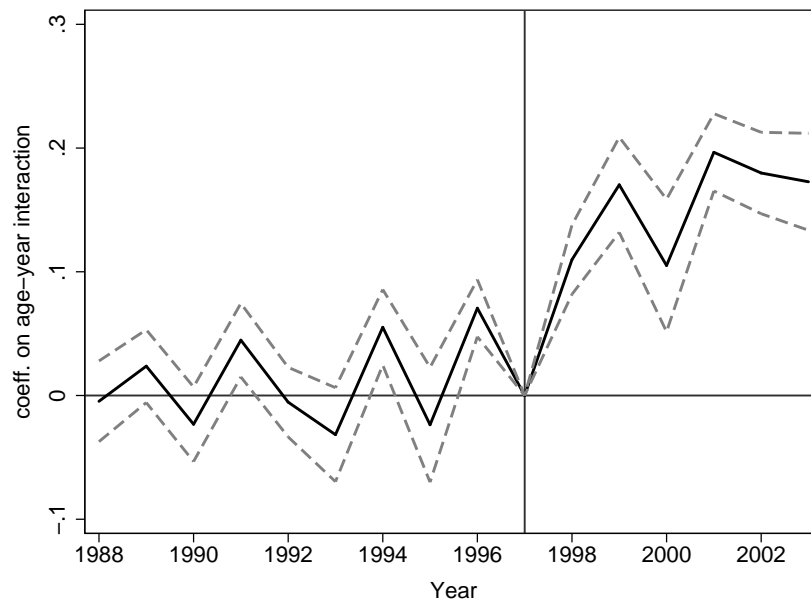
Notes: Wage gap is difference in log median real daily wages between ENEU and IMSS baseline samples. To calculate deviated wage gaps, we calculate wage gaps separately by age group-metro area, regress them on a full set of metro area-year dummies, recover the residuals and average them at the age-group level. See Section 3 and Appendix B for details of sample selection.

**Figure 14. Kullback-Liebler divergence by age group, men**



Notes: Samples are IMSS and ENEU baseline samples. For details on calculation of Kullback-Liebler divergence measure, see Section 5 of text. See Section 3 and Appendix B for details of sample selection.

**Figure 15. Differential effect of reform on wage gap, ages 55-65, men**



Notes: Figure plots coefficients for  $1(\text{age} > 55) * \text{year}$  interaction term from Column 3 of Table 4. The dotted lines indicate the 99 percent confidence interval.



**Table 1. Tenure in IMSS system, 1997**

Years in IMSS	16-25 (%)	26-35 (%)	36-45 (%)	46-55 (%)	56-65 (%)
0	27.9	6.7	4.4	4.4	6.1
1	23.0	8.0	4.6	4.4	5.8
2	14.1	7.4	4.1	3.7	4.4
3	11.7	8.0	4.4	3.7	4.1
4	8.9	8.3	4.6	3.9	4.3
5	6.7	9.1	5.2	4.3	4.5
6	4.5	10.5	7.3	6.3	6.1
7	2.3	9.4	6.4	5.5	5.2
8	0.8	8.6	6.5	5.4	4.9
9	0.1	7.3	9.0	9.7	10.1
10	0.0	5.6	7.4	6.3	4.8
11	0.0	5.2	9.8	8.7	6.8
12	0.0	5.9	26.5	33.5	32.9
N (000s)	646.3	767.3	412.3	198.2	71.8

Notes: Sample is permanent male workers, defined as workers with a written contract of indefinite duration, employed in quarter 2, 1997. Tenure in IMSS system is defined as years in IMSS data since quarter 1, 1985, hence tenure is censored from above at 12 years. Years in IMSS refers to the number of completed years of contributions.

**Table 2. IMSS Pension simulation, new workers**

Years of Contributions	Plan	Real Daily Wage					
		43	100	200	300	500	1079
35	PRA	399.0	815.0	1626.2	2437.3	4059.7	8759.2
	PAYGO	399.0	399.0	603.8	890.2	1483.6	3202.7
30	PRA	399.0	523.4	1044.3	1565.3	2607.1	5625.1
	PAYGO	399.0	399.0	510.7	743.3	1238.9	2674.3
25	PRA	399.0	399.0	659.1	987.8	1645.3	3549.9
	PAYGO	399.0	399.0	406.9	579.5	965.8	2085.0
20	PRA	88.0	202.4	403.9	605.4	1008.4	2175.7
	PAYGO	399.0	399.0	399.0	449.6	749.3	1617.5
15	PRA	51.2	117.8	235.0	352.2	586.6	1265.7
	PAYGO	399.0	399.0	399.0	399.0	504.5	1089.1
10	PRA	26.8	61.7	123.1	184.5	307.4	663.2
	PAYGO	399.0	399.0	399.0	399.0	399.0	560.7

Notes: Values represent real present discounted value of the future stream of pension benefits in thousands of 2002 pesos under the pre-reform pay-as-you-go (PAYGO) and personal retirement (PRA) systems, for a male worker who enters the system on July 1, 1997. 43 pesos is real daily minimum wage (in Mexico City) in 1997, 1079 pesos is the topcode we impose (corresponding to the lowest real value of IMSS topcode over study period.) See Section 2.4 and Appendix A.3.

**Table 3. Comparison of IMSS baseline sample and various ENEU samples**

	IMSS baseline sample (1)	full ENEU sample (2)	ENEU w/ IMSS (3)	ENEU w/o IMSS (4)	ENEU permanent w/ IMSS (5)	ENEU full-time w/ IMSS (6)
<b>A. 1990</b>						
real avg daily wage	156.41 (0.09)	164.01 (1.58)	173.12 (1.94)	144.00 (2.62)		166.87 (1.85)
age	31.81 (0.01)	31.46 (0.15)	32.13 (0.17)	29.98 (0.29)		32.22 (0.17)
fraction employed in ests >100 employees	0.52 (0.00)	0.43 (0.01)	0.55 (0.01)	0.18 (0.01)		0.55 (0.01)
N (raw observations)	1714518	16169	11592	4577		10978
N (population, using weights)	1714518	2578847	1772523	806324		1645229
<b>B. 2000</b>						
real avg daily wage	160.28 (0.09)	148.32 (1.31)	161.28 (1.60)	120.88 (2.16)	166.56 (1.80)	155.93 (1.59)
age	32.77 (0.01)	32.22 (0.14)	32.82 (0.16)	30.94 (0.28)	33.22 (0.17)	32.88 (0.16)
fraction employed in ests >100 employees	0.58 (0.00)	0.44 (0.01)	0.59 (0.01)	0.10 (0.01)	0.63 (0.01)	0.59 (0.01)
N (raw observations)	2449442	19171	14063	5108	11918	13246
N (population, using weights)	2449442	3509828	2384267	1125561	2042988	2225318

Notes: All columns focus on wage-earning male workers ages 16-65 in manufacturing, construction, and retail/hotel/restaurant sectors in 16 metropolitan areas from the original ENEU sample. Column 1 includes IMSS baseline sample; Column 2 includes full ENEU (household survey) sample (satisfying aforementioned criteria); Column 3 includes employees in ENEU who report receiving IMSS benefit in current employment; Column 4 includes employees in ENEU who report not receiving IMSS benefit; Column 5 includes employees in ENEU who report receiving IMSS benefit and having a written contract of indefinite duration; and Column 6 includes employees in ENEU who report receiving IMSS benefit and working at least 35 hours in previous week. Standard errors of means in parentheses. In IMSS data, fraction in establishments with >100 employees variable refers to permanent employees. In the ENEU survey, the establishment-size question asks the total number of employees (without specifying permanent vs. temporary.) For further details, see Section 3 and Appendix B.

**Table 4. Differential effects on wage gap**

	dep. var.: log(median wage, ENEU) - log(median wage, IMSS)		
	(1)	(2)	(3)
1(age > 55)*1988	-0.005 (0.011)	-0.005 (0.011)	-0.005 (0.013)
1(age > 55)*1989	0.024** (0.010)	0.024** (0.010)	0.024** (0.011)
1(age > 55)*1990	-0.024** (0.010)	-0.024** (0.010)	-0.024** (0.012)
1(age > 55)*1991	0.045*** (0.010)	0.045*** (0.010)	0.045*** (0.012)
1(age > 55)*1992	-0.005 (0.010)	-0.005 (0.010)	-0.005 (0.011)
1(age > 55)*1993	-0.032** (0.013)	-0.032** (0.013)	-0.032** (0.015)
1(age > 55)*1994	0.055*** (0.011)	0.055*** (0.011)	0.055*** (0.012)
1(age > 55)*1995	-0.024 (0.016)	-0.024 (0.016)	-0.024 (0.018)
1(age > 55)*1996	0.071*** (0.008)	0.071*** (0.008)	0.071*** (0.009)
1(age > 55)*1998	0.110*** (0.010)	0.110*** (0.010)	0.110*** (0.011)
1(age > 55)*1999	0.170*** (0.013)	0.170*** (0.013)	0.170*** (0.015)
1(age > 55)*2000	0.105*** (0.019)	0.105*** (0.019)	0.105*** (0.021)
1(age > 55)*2001	0.197*** (0.011)	0.197*** (0.011)	0.197*** (0.012)
1(age > 55)*2002	0.180*** (0.011)	0.180*** (0.012)	0.180*** (0.013)
1(age > 55)*2003	0.173*** (0.014)	0.173*** (0.014)	0.173*** (0.015)
metro area effects	N	Y	
year effects	Y	Y	
metro-year effects	N	N	Y
age category effects	Y	Y	Y
R-squared	0.14	0.67	0.77
N	1280	1280	1280

Notes: Samples are IMSS and ENEU baseline samples, collapsed to metro area-age group-year level. Wage gap is difference in log median real daily wages between ENEU and IMSS baseline samples, calculated separately by metro area-age group. Standard errors are clustered at the age group-year level. \*\*\* 1%, \*\* 5%, \* 10% level. See Section 3 and Appendix B for further details of data processing

**Table 5. Differential effects on employment gap**

	dep. var.: log(employment, IMSS) - log(employment, ENEU)		
	(1)	(2)	(3)
1(age > 55)*1988	0.042 (0.028)	0.042 (0.028)	0.042 (0.031)
1(age > 55)*1989	-0.046*** (0.018)	-0.046*** (0.018)	-0.046** (0.020)
1(age > 55)*1990	-0.073*** (0.024)	-0.073*** (0.024)	-0.073*** (0.027)
1(age > 55)*1991	-0.140*** (0.037)	-0.140*** (0.037)	-0.140*** (0.041)
1(age > 55)*1992	-0.060 (0.038)	-0.060 (0.038)	-0.060 (0.042)
1(age > 55)*1993	-0.096*** (0.022)	-0.096*** (0.022)	-0.096*** (0.025)
1(age > 55)*1994	0.252*** (0.019)	0.252*** (0.019)	0.252*** (0.022)
1(age > 55)*1995	-0.051** (0.026)	-0.051** (0.026)	-0.051* (0.029)
1(age > 55)*1996	-0.004 (0.023)	-0.004 (0.023)	-0.004 (0.026)
1(age > 55)*1998	-0.021 (0.018)	-0.021 (0.018)	-0.021 (0.020)
1(age > 55)*1999	-0.023 (0.018)	-0.023 (0.018)	-0.023 (0.020)
1(age > 55)*2000	0.007 (0.015)	0.007 (0.015)	0.007 (0.017)
1(age > 55)*2001	-0.007 (0.033)	-0.007 (0.033)	-0.007 (0.037)
1(age > 55)*2002	-0.096*** (0.021)	-0.096*** (0.021)	-0.096*** (0.023)
1(age > 55)*2003	-0.043* (0.023)	-0.043* (0.024)	-0.043* (0.026)
metro area effects	N	Y	
year effects	Y	Y	
metro-year effects	N	N	Y
age category effects	Y	Y	Y
R-squared	0.28	0.40	0.57
N	1280	1280	1280

Notes: Samples are IMSS and ENEU baseline samples, collapsed to metro area-age group-year level. Standard errors are clustered at the age group-year level. \*\*\* 1%, \*\* 5%, \* 10% level. See Section 3 and Appendix B for further details of data processing

**Table A1. IMSS Pension Benefit Schedule, 1/1/1991 to 6/30/1997**

Wage as multiple of min wage	Base replacement rate (%)	Extra benefit for each additional year (%)
1 or less	80.00	0.563
1.01 to 1.25	77.11	0.814
1.26 to 1.5	58.18	1.178
1.51 to 1.75	49.23	1.430
1.76 to 2	42.67	1.615
2.01 to 2.25	37.65	1.736
2.26 to 2.5	33.68	1.868
2.51 to 2.75	30.48	1.958
2.76 to 3	27.83	2.033
3.01 to 3.25	25.60	2.096
3.26 to 3.5	23.70	2.149
3.51 to 3.75	22.07	2.195
3.76 to 4	20.65	2.235
4.01 to 4.25	19.39	2.271
4.26 to 4.5	18.29	2.302
4.51 to 4.75	17.30	2.330
4.76 to 5	16.41	2.355
5.01 to 5.25	15.61	2.377
5.26 to 5.5	14.88	2.398
5.51 to 5.75	14.22	2.416
5.76 to 6	13.62	2.433
6.01 or higher	13.00	2.450

Notes: Base replacement rate is based on average nominal wage in the five years preceding retirement. Extra benefit is for each year of contribution exceeding the minimum contribution length of ten years.

**Table A2. Inflation rate and minimum wage over time**

Year	Inflation rate	Real value of minimum wage
1983	112.50	118.11
1984	67.14	110.25
1985	53.43	110.08
1986	83.17	99.28
1987	126.73	77.61
1988	135.81	71.94
1989	17.58	66.07
1990	26.11	61.13
1991	23.10	58.62
1992	15.85	56.68
1993	9.87	55.23
1994	6.85	55.31
1995	37.72	48.13
1996	31.82	45.09
1997	20.35	43.85
1998	15.31	43.42
1999	17.39	42.19
2000	9.41	42.42
2001	6.57	42.38
2002	4.94	42.18
2003	4.27	41.90
2004	4.37	41.60
2005	4.33	41.25

Notes: Data from second quarter of each year. Real minimum wages are for daily wages in Mexico City (zone A), reported in constant 2002 pesos. Average 2002 exchange rate: 9.66 pesos/dollar.