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Pooling my personal account: Income responses to the payroll tax in China

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ABSTRACT

Developing countries collect not only a far lower share of GDP in taxes, but also less payroll taxes than rich countries. This paper explores income responses to the payroll tax by evaluating the 2006 pension reform that subtracted 3 percentage points of employees' Defined Contribution account in China. First, our estimate of total income elasticity with respect to the pension rate is larger than 2, implying a lower optimal payroll tax rate than in rich countries. Second, we separate total income into labor and non-labor income, and show significant income shifting from labor to non-labor income. Third, we provide suggestive evidence that income responses to the pension reform are from evasion rather than real responses. We emphasize the necessity of administrative capacity for developing countries to extend the pension system. Remarkably, sharing the employer payroll tax with employees may be a self-enforcement mechanism, similar to the value-added tax, of the payroll tax.

1. Introduction

Elasticity of taxable income (ETI hereafter), which captures taxable income responses to tax, is an important parameter in modern public economics. In developed countries with reinforced information and administrative capacity, ETIs range from 0.12 to 0.40 (Chetty, 2012; Saez, Slemrod, & Giertz, 2012). In developing countries, however, ETIs are high for the sake of the informal sector, income shifting, tax avoidance, and evasion (Bachas & Soto, 2018; Best, Brockmeyer, Kleven, Spinnewijn, & Waseem, 2015; Carrillo, Pomeranz, & Singhal, 2017). That is why developing countries favor indirect taxes in raising revenue (Besley & Persson, 2014; Emran & Stiglitz, 2005; Gordon & Li, 2009; Jensen, 2022). Another stylized fact in developing countries is that people are insufficiently covered by state or market-organized social security systems (Ahmad, Drèze, Hills, & Sen, 1991; Van Ginneken, 1999). Recent literature reveals that labor income responds less to payroll taxes than income taxes (Lehmann, Marical, & Rioux, 2013; Sicsic, 2022; Tazhitdinova, 2015), indicating a higher optimal payroll tax rate. It is puzzling why developing countries do not extend the social security system through higher payroll tax?

In this paper, we exploit a pension reform in 2006 and 2003–2009 data in urban China to provide evidence on income responses to the payroll tax. The urban Chinese pension system—which is composed of an individual Defined Contribution (DC) account and a government Defined Benefit (DB) plan—is similar in structure to that in the United States and other developed countries. The payroll tax rate is flat in China, with an employer pension tax rate of about 20% and an employee pension tax rate of 8%. Before 2006, 3

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percentage points of the employer payroll tax are accrued to the DC account and the remaining are accrued to the government DB account. In December 2005, China enacted a reform in its pension system that applied to all employees covered by the pension system. That is, the employer payroll tax will no longer be allocated to the DC account. For those covered by the pension system, their DC account decreases by 3 percentage points, or equivalently, their payroll tax rate increases by 3 percentage points. The reform provides a scarce opportunity to study the responsiveness to payroll-tax reform in a developing country where indirect taxes dominate. Since urban China has a similar pension system as other developed countries, we believe there are general lessons to be drawn from China for other middle-income countries' pension reform and low-income countries' pension establishment. In addition, the 2006 pension reform is not cohort-based. Problems such as mean reversion and external validity can be alleviated to some extent. Meanwhile, the reform may be such minuscule in quantity that will be ignored by employees (Chetty, 2009b; Chetty, Friedman, Olsen, & Pistaferri, 2011).

Due to information and administrative capacities, both employer and employee payroll taxes are nominally collected through employers. After deducting the employee payroll tax from posted wages, employees get taxable income, which is similar to that in Greece (Saez, Matsaganis, & Tsakloglou, 2012). One significant characteristic of the labor market in developing countries is the high proportion of the informal sector that is not covered by the mandatory social security system. Therefore, employees in the informal sector are not affected by the 2006 pension reform, which can be regarded as the control group of the formal sector. We exploit a Difference-in-Difference (DD) approach to estimate the effects of the 2006 pension reform.

Our main findings are as follows. First, the income elasticity with respect to the pension rate is large. A 3 percentage points increase in payroll rate results in a 6% reduction in total income (including labor and non-labor income before tax, and the employee payroll tax; but excluding the employer payroll tax), which implies a large elasticity of total income with respect to the payroll tax. Second, employees shift labor income to non-labor income when the pension rate increases. After decomposing the effects on total income into effects on labor and non-labor income, we find that labor income decreases by about 13.4%, but non-labor income increases by about 60.9%. Labor income responses to the 2006 pension reform are even more fierce. Labor income is shifted to non-labor income that is unrelated to the payroll tax. Third, pension evasion is associated with the increase of the pension rate. Payroll taxes are collected by two agencies in China, that is, the Tax bureau or the Social security bureau in different provinces. It has been proven that the enforcement of the Tax bureau is higher than that of the Social security bureau. Compared to provinces where payroll taxes are collected by the Tax bureau, employees in provinces where payroll taxes are collected by the Social security bureau respond more to the 2006 pension reform. Finally, the employee pension rate decreases by 0.49–0.77 percentage point due to the 2006 pension reform. We attribute these results to payroll tax evasion when the payroll tax rate increases.

Our results suffer from several caveats. First, employees in the informal sector may not be an appropriate control group for employees in the formal sector. Reassuringly, we confirm that the two groups satisfied the parallel trend well in the years prior to the reform and then start to diverge precisely in 2006—the first post-reform year. The pension-reform effects build up gradually and materialize within two years. Second, our results may suffer from spurious problem if other confounding factors affect sector composition and income simultaneously. Since the retirement age is 55 for females and 60 for males in China, those above the retirement age are not affected by the pension reform. We conduct a placebo test among employees of retirement age and observe insignificant effects as expected.

This paper contributes to the literature in three aspects. First, we build on the literature estimating the elasticity of taxable income. According to the comprehensive literature reviewed by Saez, Slemrod, and Giertz (2012), cohort-based reform suffers from the mean reversion problem (Gruber & Saez, 2002; Kopczuk, 2005; Weber, 2014). High-income (low-income) groups are more prone to have lower (higher) income. The mechanical effect may confound the tax effects. In our setting, 3 percentage points of the employer payroll tax are subtracted from employees' DC account, which is equivalent to increasing the employee payroll tax rate by 3 percentage points with some assumptions. Our paper complements the extant literature by evaluating a reform based on sectors rather than income-cohorts or income share, which may avoid the external validity limitation when applying the conclusion to the full population. Prior studies find that the income responses to changes in marginal tax rates are concentrated at the top of the income distribution, with less responses for the middle-income class (Saez, Slemrod, & Giertz, 2012). We build on the literature by revealing that most employees, except the top-income class since there is a ceiling on the payroll tax as almost all countries do (Lehmann et al., 2013), respond to the payroll tax rate change.

Second, we build on the literature documenting responses to taxes in developing countries (Bachas & Soto, 2018; Basri, Felix, Hanna, & Olken, 2021; Best et al., 2015; Carrillo et al., 2017; Waseem, 2018). While ETIs are relatively small (ranging from 0.12 to 0.40) in developed countries (Kleven & Schultz, 2014; Saez, Slemrod, & Giertz, 2012), they suffer from selective reporting bias (Neisser, 2021). Most papers find that income elasticities with respect to tax rates in developing countries are high, which are mainly resulted from evasion (Bachas & Soto, 2018; Best et al., 2015) such as over-reporting deductions (Carrillo et al., 2017) and income shifting (Harju & Matikka, 2016; Waseem, 2018) rather than "real" responses. Although "real" responses are relatively small, all behavioral responses to income tax rate changes are symptoms of inefficiency (Feldstein, 1995, 1999). Given the administrative capacity and labor market composition, developing countries tax so little and favor indirect taxes (Emran & Stiglitz, 2005; Gordon & Li, 2009; Pomeranz, 2015). Remarkably, this paper adds to the literature by highlighting that large income elasticity with respect to the pension rate is also a big challenge for the establishment of the social security system in developing countries.

Third, we contribute to the responses to the payroll tax. Employees may change their working hours in response to social security contributions (Adam, Phillips, & Roantree, 2019). We demonstrate that employees shift labor income to non-labor income when the payroll tax increases, which is consistent with Gruber and Saez (2002) who find that the behavioral responses are higher for taxable income than that of broader range of income. In addition, we provide suggestive evidence that employees evade more payroll tax in regions with weak payroll tax enforcement.

The remainder of the paper proceeds as follows. Section 2 describes the institutional background. Section 3 presents data and methods. Section 4 shows results and mechanisms. Section 5 analyzes the welfare of the policy. Section 6 concludes.

2. Chinese pension system and the 2006 pension reform

The transition process of the social security system in China was deeply rooted in its' economy. During the planned-economy period in China (1949–1978), the state-owned enterprises (SOEs) were almost the sole player in the economy. While employees in the SOEs and the public sector were covered by the Public Employee Pension (PEP) operated by the central government, old residents in rural areas mainly relied on their offspring (like a pay-as-you-go pension system) or private savings. When the planned economy transited into a market-oriented one from the mid-1980s to the early 1990s, the social security system transformed from a government-based pension system to a hybrid one in which both employees and employers were responsible for financing the pension system. The reformation of the social security system was also essential for the subsequent reform of the SOEs, because privatization of the SOEs will be difficult if they undertake their employees' social security responsibilities such as pension, medicine, or even children's schooling. The anatomy of the pension system in urban China did not stabilize until 1997, which was similar in structure to the United States and many other developed countries (Chetty, Friedman, Leth-Petersen, Nielsen, & Olsen, 2014). More detailed information about the Chinese pension system can be found in Fang and Feng (2018).

The pension system scheme in China was dual-track between urban employees and other rural/urban residents, the latter of which was not established until 2009. Since then, the resident pension participants rose sharply, however, the expenses were quite small compared to that of the employee pension (see Fig. 1) because the per capita benefits were small. The pension plans for employees in the formal sector in urban China (named Basic Old Age Insurance, BOAI) were composed of a Defined Benefit plan and a Defined Contribution account. Before 2006, employers were required to contribute another 20% payroll tax of posted wages paid to their workforce, 3 percentage points of which were accrued to employees' DC account; and the remainder were allocated to the PAYG system. Employees had to mandatorily save 8% of wages to the DC account, which were directly deducted from posted wages through employers. Hence, the DC account amounted to 11% of wages. China also adopted voluntary retirement saving plans—Enterprise Annuity and Commercial Annuity Insurance—to build the second and third pillars of the pension system, which were analogous to the 401(k) and the Individual Retirement Arrangements (IRAs) in the United States, respectively. The DB plan and the DC account built the primary pillar of the pension system, and the latter two pillars could be ignored in scale.

It is well acknowledged that the biggest challenge to the DB pension system is the aging of the population. To keep the pension system balanced, the DC account was misappropriated to pay for the DB plan, causing the DC account an "empty account". To replenish the revenue of the DB pension system and reduce the burden of filling the "empty" DC account,[1] the policy makers made a reformation in 2005. In December 2005, the State Council of China enacted a reform stipulating that employers' payroll tax will no longer be attributable to the DC account since January 1st, 2006. As flexible employees were not associated with any employer payroll tax, they were not affected by the 2006 pension reform. For those possessing the employer payroll tax before, their DC account will reduce by 3 percentage points since 2006, which is equivalent to a 3 percentage points increase of income tax after the pension reform given the characteristics of the pension system.

3. Data and empirical strategy

3.1. Data

Our data source for this paper is the Urban Household Survey (UHS) over the 2003–2009 period. Collected by the National Bureau of Statistics, the data are used in publishing statistics on earnings, income distribution, and poverty in urban China. The survey is designed as a rotating panel with each household exists for three years. Gustafsson, Shi, and Sato (2014) made an intensive description of the data. Households in the survey are randomly drawn from a large sampling frame of households with an urban *hukou*. The data used in this paper are a random subsample of the UHS data, including 16 provinces ranging from east to west China.[2] Our sample period ranges in 2003–2009 because data after 2009 are not available and variables in surveys before 2003 are differently designed. The data include about 232,424 and 350,926 observations on households and individuals, respectively. The 2006 pension reform was exactly in the middle of our sample period. The data contain basic characteristics of household members, income, and consumption on detailed items. Individual and household income are collected separately. We analyze income and pension at the individual rather than household level because Chinese pension and tax system was individual-based during the sample period.

We exploit a DD approach to study income responses to the 2006 pension reform, which recovers the elasticity of taxable income based on 2SLS regressions using instrumental variables (IV). The DD approach is more transparent in the pre-trend analysis and the dynamic effects of the reform than that in the IV approach. Our core task lies in defining the treatment and control groups. Recall Section 2, only employees possessing the employer payroll tax suffer from a 3 percentage points loss of the DC account. Since the survey did not collect information on whether their employers pay the employer payroll tax for them, we construct the treatment and

[1] Liaoning province was selected as a pilot province before 2006 to complement the DC account, which may affect the employee's perception on the DC account. We drop the sample of Liaoning province and the results remain robust.

[2] Beijing, Shanghai, Jiangsu, Zhejiang, Shandong, Guangdong in eastern provinces (municipalities), Henan, Hubei, Henan, Jiangxi, Shanxi, Sichuan, Chonqing, and Yunnan in Midwest provinces, and Liaoning and Heilongjiang in Northeastern provinces.

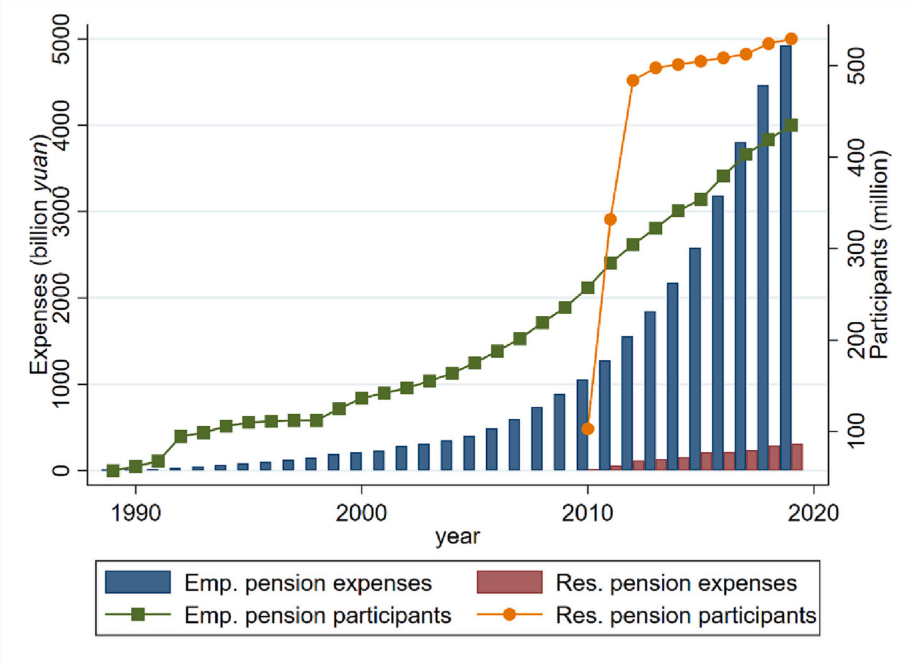

Fig. 1. Participants and expenses of the employee and resident pensions.
(Source: China's Statistical Yearbook, various years.)

control groups by sector and the employee payroll tax. The survey contains information on working status, employment sector, and employee pension expenses.[3] We first drop unemployed individuals. The employed individuals are classified into seven sectors: (1) the SOEs and the public sector, (2) the collective-owned sector, (3) Other formal sectors including the joint-equity enterprises, foreign-owned firms, (4) individual employers and self-employed, (5) employees by individual employers or self-employed, (6) other employees such as flexible and individual employees, and (7) re-employed after retirement. We drop type (7) since they receive both pension benefits and wages from the re-employed job, which will be systematically different from other individuals. We define sectors (1)(2)(3) and sectors (4)(5)(6) as the formal and informal sectors, respectively. It is worth mentioning that the definition of formal/informal is mainly based on whether employees are likely to be entitled to the employer payroll tax. Employers in the formal sector are obligated to pay the payroll tax for their employees. In the meanwhile, employees will have to pay the employee payroll tax. The ordinance is not strictly complied with among some informal employers due to the administrative capacity, which is of the similar rationale as Pomeranz (2015). If employers pay the employer payroll tax for their employees, the employee payroll tax is automatically deducted from posted wages. In Table 1, we summarize total income and an indicator for whether individuals pay the employee payroll tax. While 63.5% of employees in the formal sector pay the employee payroll tax, only 30.5% of employees in the informal sector pay the employee payroll tax. Among those who have non-zero employee payroll tax, the *de facto* employee payroll tax rate (the denominator is total income) is approximately the same as the *de jure* employee pension rate (8%) in the formal sector. For those in the informal sector, however, the *de facto* employee payroll tax rate is about 12.9% on average. Since some employees in the informal sector attend the BOIA voluntarily, their employee tax rates are higher than 8% of total income (see above for the rules for individuals who attend the BOIA voluntarily). These summary statistics indicate that employees in the formal (informal) are more (less) likely to possess the employer payroll tax, which coincides with whether the two groups are affected by the 2006 pension reform. Compared to employees in the informal sector, employees in the formal sector also have higher total income. Whether the two groups are comparable in income remains to be examined.

The key dependent variable in this paper is income, which is a little different from traditional research on ETI since the 2006 pension reform reduced the DC account. We define total income by summing wages,[4] operating income, property income, and transferring income. Total income is divided into labor and non-labor income. Based on items correlated with the payroll tax, we define labor income as wages before the employee payroll tax and income tax. The remainder are defined as non-labor income. Labor income is composed of wages (including subsidies) and other labor income, the former of which is strictly the wage base used for calculating the payroll tax in the formal sector. Since employees in the informal sector pay the employee pension based on the local average income, we use different concepts of income as the denominator when calculating the employee pension rate. The summary statistics are presented in Table 2.

[3] The employee pension expenses are recorded separately, even if the expenses are deducted from the posted wage by the employer.
[4] Wages before the employee payroll tax and income tax.

Table 1
Summary statistics for total income, non-zero employee payroll tax proportions and rates.

Sectors	Observations	Mean total income (S.D.)	Non-zero employee payroll tax	Employee payroll tax/Total income
	(1)	(2)	(3)	(4)
Formal sector				
(1) The SOEs and the public sector	198,195	18,377 (10,248)	63.0%	6.5%
(2) Collective-owned sector	20,987	12,700 (8725)	59.4%	8.0%
(3) Joint-equity and foreign-owned enterprises	46,470	16,872 (10,626)	67.8%	7.6%
Informal sector				
(4) Individual employers and self-employed	27,884	16,101 (11,008)	21.0%	11.6%
(5) Employees by individual employers or self-employed	41,051	11,762 (8336)	35.5%	12.6%
(6) Flexible and individual employees	16,339	10,158 (7682)	34.1%	15.0%

Notes: The nominal employee payroll tax rate is 8% in the formal sector.

3.2. Empirical strategy

The empirical specification is the DD approach, comparing the treated sector to the control sector and pre-treatment to post-treatment period:

$$log(z_{ist}) = \beta_0 + \beta_1 Post_t \times Treat_s + X_{ist}^{'}\beta_2 + \mu_s + \mu_c + \delta_t + Trend_p + \varepsilon_{ist} \tag{1}$$

where log(z_{ist}) are different concepts of income for individual *i* working in sector *s* at year *t*. $Treat_s$ is a dummy indicating whether individuals are employed in the formal sector (=1 if yes). $Post_t$ is an indicator that equals 1 for post-treatment period (2006–2009) and 0 otherwise. We include sector fixed effects, μ_s, county fixed effects, μ_c, year fixed effects, δ_t, and province trends, $Trend_p$. Control variables X_{ist}' contain age, working experience (calendar year minus the initial year of career) and its' squared, gender (=1 if male), marriage status (=1 if married), ethnicity (=1 if *Han* ethnicity), registration (*hukou*) type (=1 if urban *hukou*), and eight dummy variables for schooling (literacy class, primary school, junior high school, high school, technical secondary school, technical college, college, and graduate). ε_{ist} is the error term. The robust standard errors are clustered at the city level.

The identification assumption for the DD design is that the treatment and control groups would have behaved similarly in the absence of the 2006 pension reform. To verify the parallel-trends assumption of the DD specification and estimate policy effects in different years, we specify the "dynamic" form of Eq. (1) as follows:

$$log(z_{ist}) = \beta_0^{'} + \sum_{j=2003, j\neq 2005}^{2009} \alpha_j \boldsymbol{I}(t=j) \times Treat_s + X_{ist}^{'}\theta_2^{'} + \mu_s^{'} + \mu_c^{'} + \delta_t^{'} + Trend_p^{'} + \varepsilon_{ist}^{'} \tag{2}$$

where $\boldsymbol{I}(t = j)$ is an indicator that equals 1 for calendar year *j*, which ranges from 2003 to 2009 (excluding 2005). The parameter α_j captures the difference in outcomes between the treatment and control groups in each calendar year relative to the difference in the baseline year (2005) before the 2006 pension reform. Other variables are the same as in Eq. (1).

4. Results and robustness checks

Before proceeding to the estimation results, we present graphical evidence on total income, labor income, and non-labor income responses to the 2006 pension reform. Fig. 2 shows the evolution of total income for the treatment and control groups. Fig. 3 shows the comparisons on labor and non-labor incomes of the two groups. Two main findings emerge from the figures. First, the income trends of treatment and control groups are parallel in the years prior to the reform and then start to diverge in 2006. This provides compelling evidence of income responses to the reform, and in particular the similarity of pre-trends shows that the two groups are suitable for the DD identification. Second, compared to the control group, there is a clear decline in total income and labor income, and increase in non-labor income after the reform. Third, the effect on labor income is higher than that on total income, which is consistent with the belief that taxes distort broad income less (Gruber & Saez, 2002).

4.1. Total income responses

We first estimate the effect of the 2006 pension reform on total income, which recovers the elasticity of taxable income corresponding to the extant literature. We differ from the literature in the concepts of income. Since we study the effects of the pension reform, our "taxable" income is posted income before employee pensions and income tax, excluding employer pensions. Our definition of total income is equal to the payroll tax plus "taxable income" defined in Kleven and Schultz (2014) or "broad income" defined in Gruber and Saez (2002).

We proceed with visual evidence on estimates of Eq. (2) in Fig. 4 and the corresponding table results are presented in Table 3

Table 2
Summary statistics for the data set.

Variable	Formal sector				Informal sector			
	Obs.	Mean	Median	S.D.	Obs.	Mean	Median	S.D.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total income	259,905	17,877	15,102	11,610	83,637	12,830	9789	10,139
Labor income	261,147	17,625	14,830	11,678	59,977	10,487	8215	8589
Non-labor income	264,570	469	0	2107	81,922	4372	107	7582
Pension agency (1 = Tax bureau, 0 = Social security bureau)	259,206	0.51			81,567	0.668		
Working hours	150,020	176	176	33	38,218	201	184	56
Employee pension (extensive margin, 1 = yes)	259,905	0.633			83,637	0.303		
Employee pension rate (including 0)								
Pension/Total income	264,188	0.036	0.023	0.040	82,663	0.024	0	0.044
Pension/Labor and business income	264,104	0.039	0.024	0.045	82,571	0.028	0	0.055
Pension/Labor income	264,097	0.039	0.024	0.045	58,194	0.033	0	0.059
Pension/Wage and subsidies	263,821	0.039	0.024	0.045	56,073	0.034	0	0.060
Demographics								
Age	259,206	40.7	41	8.9	81,567	39.4	40	8.7
Work experience	259,206	20.2	21	9.8	81,567	17.2	18	9.9
Male	259,206	0.572			81,567	0.520		
Married	259,206	0.892			81,567	0.874		
Han ethnicity	259,206	0.970			81,567	0.972		
Has urban *hukou*	259,206	0.990			81,567	0.937		
Education								
Under high school	259,206	18.9%			81,567	44.5%		
High school	259,206	37.5%			81,567	40.2%		
Tertiary	259,206	43.6%			81,567	15.2%		

(columns (1)(2)). Estimates with/without controls are almost identical, which indicates that our results are less likely to be affected by omitted variables (Altonji, Elder, & Taber, 2005). Total income in the treatment and control groups exhibits parallel trends before the 2006 pension reform. After the policy reform, we document a clear decline in total income of employees in the formal sector compared to those in the informal sector. The estimated coefficients on interaction terms are −0.024, −0.037, −0.080, and − 0.074 from 2006 to 2009, which are significant at least at the 5% level. There is a relatively small initial effect of the reform in 2006, then increases in 2007, and stabilizes in 2008 and 2009. Recalling that the 2006 pension reform subtracts 3 percentage points of the DC account, the effect on total income is quite large. As presented in Table 4, the DD estimate of Eq. (1) is −0.060 (see column (2) Panel A), translating into an elasticity of taxable income of 2[5] with a 95% confidence interval of 1.9–4.1. Our estimate of ETI is above the upper bound (about 0.8) of the literature in the United States and other developed countries reviewed by Saez, Slemrod, and Giertz (2012) and Chetty (2012). Even responses to narrower income are higher than that of broader income due to income shifting or deduction items (Gruber & Saez, 2002), ETIs are relatively small as the tax system in developed countries is more efficient (Kleven & Schultz, 2014). In developing countries, however, tax evasion is more prevalent as a result of lower administrative capacity. In recent research, Bachas and Soto (2018) find that the elasticity of reported profits with respect to the tax rate is very large at roughly four in Costa Rica. Best et al. (2015) rigorously prove that the large output responses to tax are mainly from evasion rather than real output responses in Pakistan. The results of our paper are not unusual in quantity in a large developing country like China. The novelty of the results is that the elasticity of taxable income with respect to the payroll tax is also large, translating into a lower optimal payroll tax rate. Besides favoring the indirect tax system, our paper furthers the understanding of why developing countries do not extend the pension system through the payroll tax.

4.2. Labor and non-labor income responses

The above section finds that the effect of the 2006 pension reform on broader range of income (total income) is significantly large. To study the effects of the 2006 pension reform on different forms of income, we decompose total income into labor and non-labor income. Fig. 5 shows that labor income declines more after the 2006 pension reform compared to that of total income. Remarkably, Fig. 6 shows that non-labor income increases after the 2006 pension reform. Since non-labor income is not associated with the payroll tax employees have to pay, we find significant income shifting responses to the 2006 pension reform. In detail, labor income decreases by 13.4% (see column (4) Panel A in Table 4), and non-labor income increases by 60.9% (see column (6) Panel A in Table 4).

[5] $2 = -0.06/(\ln 1 - \ln(1 + 0.03))$, where we use $\ln(1 + x) \approx x$ when x is small.

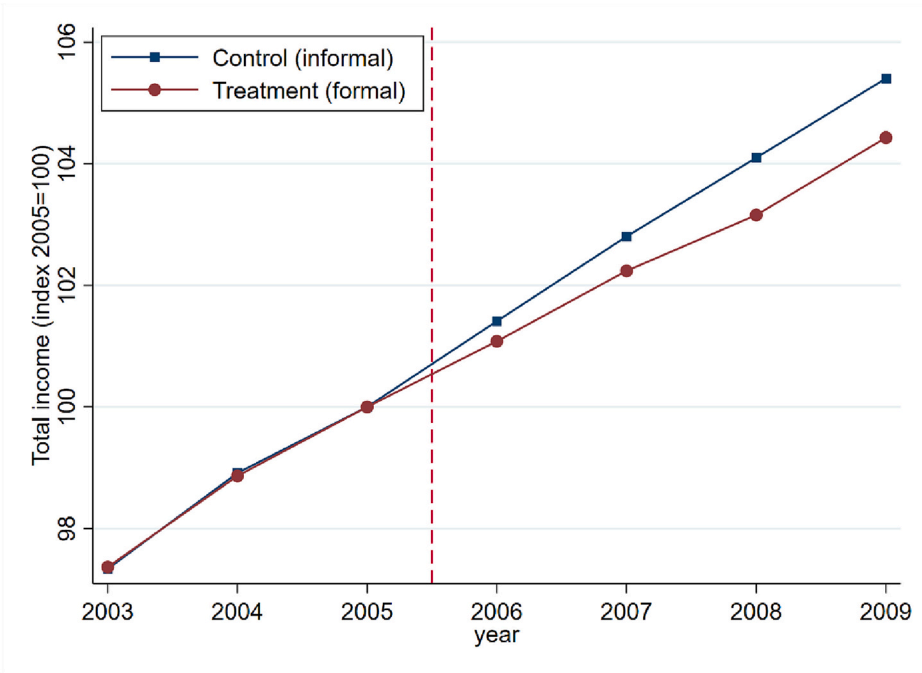

Fig. 2. Graphical evidence on total income responses to the 2006 pension reform.
Notes: This figure shows the evolution of total income for groups that are affected differently by the 2006 pension reform. Total income levels in 2005 are normalized to 100 in each group. The treatment group include individuals in the formal sector who experience a decrease in the DC account rate and an increase in the DB account rate by 3 percentage points. The control group include those in the informal sector who are less likely to be affected by the pension reform. The detailed classifications and summary statistics for the treatment and control groups are presented in Table 1.

Since labor income (Mean = 14,912, S.D. = 11,092, about 88% of total income) is of higher proportion than non-labor income (Mean = 1978, S.D. = 5214, about 12% of total income), the net effect of the 2006 pension reform on total income is still quite large.

In the baseline results, we directly compare employees in the formal and informal sectors. As presented in the summary statistics, employees in the formal sector are not fully covered by the BOIA; and some employees in the informal sector are not excluded from the BOIA. Our baseline results should be explained as intention-to-treat (ITT). We exclude employees paying zero pension in the formal sector (the treatment group) and remain the control group unchanged. Figs. B1–B3 in the Appendix plot the estimates on the three dependent variables, respectively. After excluding employees who do not pay the employee payroll tax in the treatment group, the three dependent variables satisfy the parallel-trend assumption well. Compared to results in Panel A of Table 4, Panel B of Table 4 shows that total income and labor income decline more in response to the 2006 pension reform; and the negative effect on non-labor income remains similar. Since employees who do not pay the employee payroll tax are also less likely to possess the employer payroll tax, the baseline results are the lower bound of the ETIs. To address the concerns that some employees in the informal sector also possess the employer payroll tax, we further refine the control group to exclude employees paying non-zero employee pension in the informal sector. Figs. B4–B6 in the Appendix plot the estimates on the three dependent variables and Panel C of Table 4 shows the results. Labor income reduces to a larger extent than that of total income. Non-labor income increases due to the 2006 pension reform, which is consistent with the baseline results.

4.3. Placebo tests and robustness checks

We consider a variety of robustness checks as follows.

First, we discuss the composition effect and its' impacts on the Stable Unit Treatment Value Assumption (SUTVA) of the causal inference. One possible explanation for the baseline results is that the informal sector becomes more attractive among high-income employees because of the 2006 pension reform or other shocks. For example, high-income employees in the formal sector switch to the informal sector after 2006. Another possible composition effect is that the low-income (high-income) employees in the informal (formal) sector withdraw from the labor market, or vice versa. New entrants after 2006 are less likely to confound our results since only 2% of employees start working after 2005 in our sample. We drop these individuals and the results remain almost identical. Since one third individuals are replaced in each wave of the survey, using panel data will largely diminish the sample size. As a result, the pre-trend parallel assumption cannot be testified. Also, dividing treatment and control groups by sector in 2005 will introduce the traditional mean reversion problem (Saez, Slemrod, & Giertz, 2012), that is, individuals employed in the formal sector are likely to be employed in the informal sector in other years, and vice versa. That's why Saez, Slemrod, and Giertz (2012) propose that the advantage

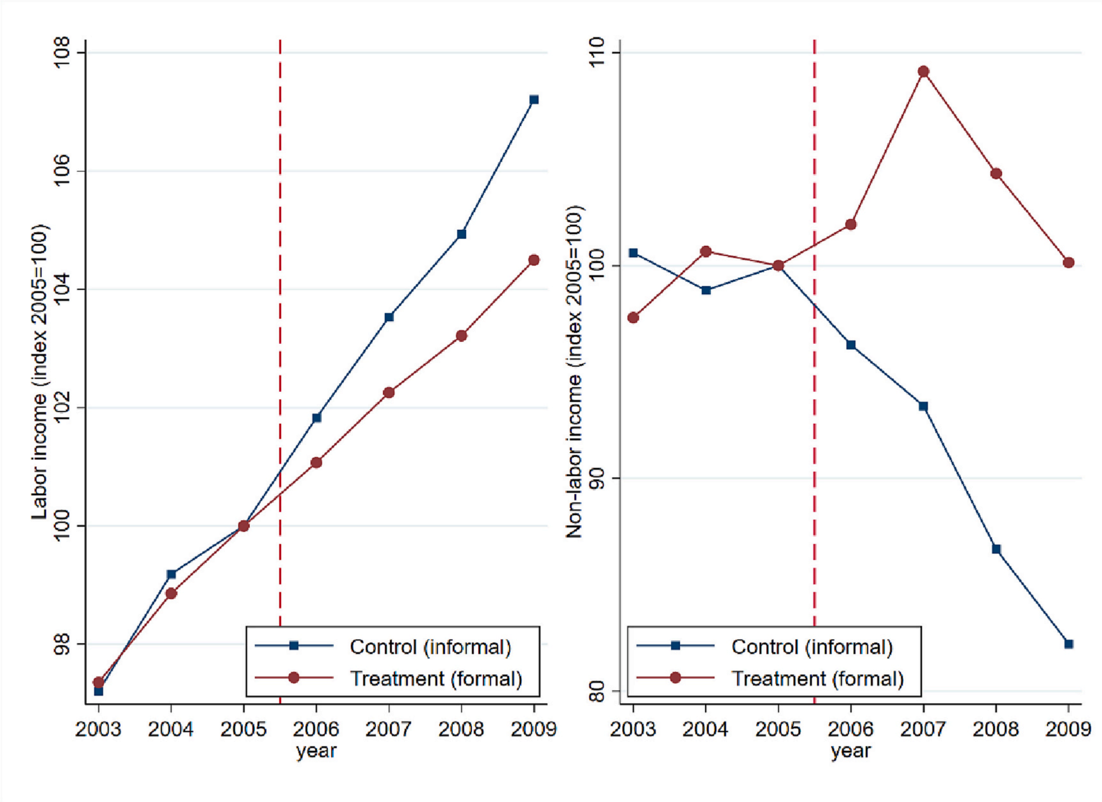

Fig. 3. Graphical evidence on labor and non-labor income responses to the 2006 pension reform.
Notes: This figure shows the evolution of labor income (left panel) and non-labor income (right panel) for groups that are affected differently by the 2006 pension reform. See the notes in Fig. 2 for more information.

of panel data over cross-sectional data has been exaggerated. It is hard to believe that a 3 percentage points elimination of the payroll tax will lead employees in the formal sector to switch to the informal sector. To address the concern of other shocks, we focus on individuals who exist in the waves of 2004, 2005, and 2006. The transition matrix of the sector is presented in Table 5. Two facts are worth mentioning. First, while there is a clear symptom of the mean reversion, transitions across sectors are more active in 2004 than that in 2005. In Panel A of Table 5, for those employed in the formal sector in 2005, 92.8% and 98.4% of them are employed in the formal sector in 2004 and 2006, respectively. In Panel B, for those employed in the informal sector in 2005, 36.5% and 4.9% of them are employed in the formal sector in 2004 and 2006, respectively. In our baseline results, we do not find significant effects in 2004, indicating that transitions across sectors are less likely to confound our results. Second, for those transit from the formal sector to the informal sector in 2006, they have relatively lower average total income (18,061 *yuan* vs. 15,695 *yuan*). For those transit from the informal sector in 2005 to the formal sector in 2006, they have relatively higher average total income (12,921 *yuan* vs. 12,145 *yuan*). Therefore, even if transitions across sectors exist, the composition effect will increase average total income of the treatment group rather than the opposite observed in the baseline results.

Second, we conduct a placebo test among individuals above the statutory retirement age—55 for female and 60 for male. Those above the statutory retirement age are entitled to the pension. Therefore, they will not be affected by the 2006 pension reform that reduces 3 percentage points of the employer payroll tax during the pension accumulation period. We focus the sample exclusively on employees of 61–65 for males and 55–60 for females. Figs. 7–9 present the estimates for the three dependent variables, which show that the 2006 pension reform has insignificant effects on total income, labor income, and non-labor income. Table 6 reports the corresponding results on Eq. (1), which are consistent with the figure results.

Third, we face the challenge of Roth (2022) who doubts that the “dynamic” DD estimates cannot separate the trend of the treatment and control groups. Roth (2022) proposes a procedure to check the robustness of the “pre-trend” as follows. First, generating a hypothesized trend according to the “dynamic” DD estimates. Next, calculating the expectation of the estimates after pre-testing. And then, comparing the expectation after pre-testing with the “dynamic” DD estimates to evaluate the robustness of the trend effect. We show the results of the three dependent variables in Figs. 10–12, which display that our DD specifications are robust to the time trend of the treatment and control groups.

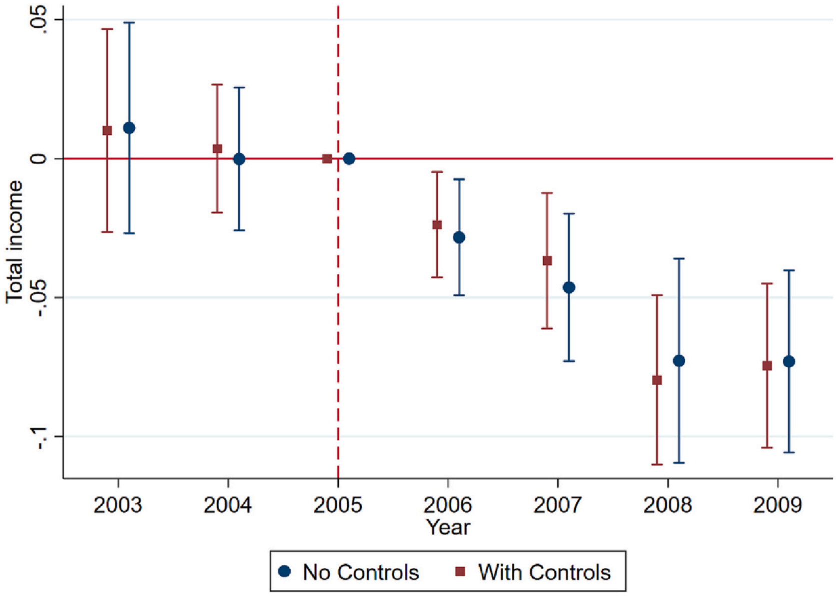

Fig. 4. Total income responses to the 2006 pension reform (formal vs. informal sectors).
Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients α_j in Eq. (2). The dependent variable is total income. Treatment and control groups are the formal and informal sectors, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level. Controls include age, working experience and its' squared, gender, marriage status, ethnicity, *hukou* type, and eight dummy variables for schooling.

Table 3
Total, labor, and non-labor income responses to the 2006 pension reform (event study).

	Total income		Labor income		Non-labor income	
	(1)	(2)	(3)	(4)	(5)	(6)
2003 × Formal	0.0110	0.0101	0.0109	0.0145	−0.0472	−0.0814
	(0.019)	(0.019)	(0.028)	(0.026)	(0.102)	(0.100)
2004 × Formal	−0.0001	0.0036	−0.0267	−0.0215	0.0714	0.0568
	(0.013)	(0.012)	(0.020)	(0.019)	(0.075)	(0.075)
2006 × Formal	−0.0283***	−0.0237**	−0.0592***	−0.0531***	0.1975***	0.2026***
	(0.011)	(0.010)	(0.016)	(0.016)	(0.057)	(0.055)
2007 × Formal	−0.0463***	−0.0367***	−0.0975***	−0.0921***	0.5232***	0.5316***
	(0.013)	(0.012)	(0.023)	(0.021)	(0.103)	(0.100)
2008 × Formal	−0.0727***	−0.0796***	−0.1346***	−0.1498***	0.7034***	0.7242***
	(0.019)	(0.015)	(0.026)	(0.023)	(0.113)	(0.112)
2009 × Formal	−0.0730***	−0.0745***	−0.2161***	−0.2246***	0.8333***	0.8811***
	(0.017)	(0.015)	(0.019)	(0.018)	(0.103)	(0.100)
Controls		Yes		Yes		Yes
Observations	343,542	340,773	321,124	318,908	346,492	343,767
adj. R^2	0.256	0.385	0.288	0.403	0.188	0.221

Notes: Controls include age, working experience and its' squared, gender, marriage status, ethnicity, *hukou* type, and eight dummy variables for schooling. Robust standard errors clustered at the city level in parentheses. $^{**}p \leq 0.05$, $^{***}p \leq 0.01$.

4.4. Heterogeneous analyses

To fully understand the effects of the 2006 pension reform on different subgroups, we examine the heterogeneous total income responses by subgroups in Fig. 13. First, we divide the subgroup by the 75th labor income percentile each year. Similar to the payroll tax system in other developed countries, there is a ceiling wage used for calculating the payroll tax in BOIA. Employees whose wages are above 300% of the local wage pay both the employer and employee payroll taxes as 300% of the local wage×payroll tax rates. For those whose wages are above the ceiling, their effective payroll tax rates diminish with respect to their real wages. Therefore, a 3 percentage points of their employer payroll tax means a lower proportion of wage. The top panel of Fig. 14 shows that individuals with labor income above the 75th percentile respond less to the 2006 pension reform compared to the remainders. In Fig. 15, non-labor income responses of individuals with higher labor income are imprecisely estimated. This phenomenon reflects the Simpson's Paradox, see Bickel, Hammel, and O'Connell (1975) for an example. The causal of the phenomenon is that non-labor income amounts

Table 4
Total, labor, and non-labor income responses to the 2006 pension reform.

	Total income		Labor income		Non-labor income	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Formal sector vs. *Informal sector*						
Post × Formal	−0.0602***	−0.0599***	−0.1278***	−0.1340***	0.5763***	0.6088***
	(0.013)	(0.011)	(0.021)	(0.019)	(0.090)	(0.088)
Controls		Yes		Yes		Yes
Observations	343,542	340,773	321,124	318,908	346,492	343,767
adj. R^2	0.256	0.385	0.288	0.402	0.188	0.221
Panel B. Formal sector with non-zero pension vs. *Informal sector*						
Post × Formal	−0.0963***	−0.0908***	−0.1636***	−0.1652***	0.5459***	0.5997***
	(0.016)	(0.013)	(0.024)	(0.021)	(0.093)	(0.091)
Controls	248,224	245,810	225,503	223,642	250,146	247,777
Observations		Yes		Yes		Yes
adj. R^2	0.308	0.406	0.350	0.428	0.190	0.222
Panel C. Formal sector with non-zero pension vs. *Informal sector with zero pension*						
Post × Formal	−0.0750***	−0.0780***	−0.1081***	−0.1228***	0.3720***	0.4277***
	(0.014)	(0.013)	(0.021)	(0.019)	(0.087)	(0.087)
Controls		Yes		Yes		Yes
Observations	222,846	220,911	204,654	203,178	225,279	223,375
adj. R^2	0.318	0.414	0.367	0.446	0.201	0.233

Notes: Controls include age, working experience and its' squared, gender, marriage status, ethnicity, *hukou* type, and eight dummy variables for schooling. Robust standard errors clustered at the city level in parentheses. $^{***}p \leq 0.01$.

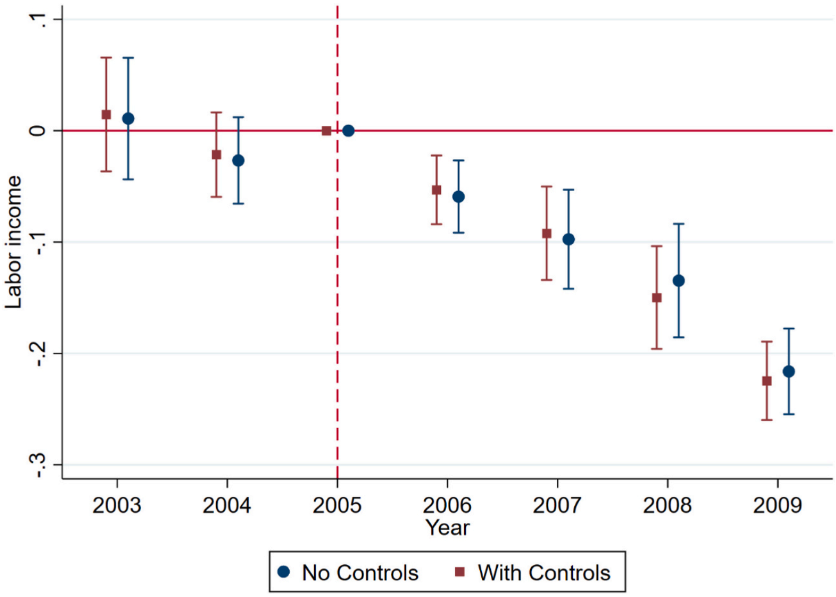

Fig. 5. Labor income responses to the 2006 pension reform (formal vs. informal sectors).
Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients α_j in Eq. (2). The dependent variable is labor income. Treatment and control groups are the formal and informal sectors, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level. Controls include age, working experience and its' squared, gender, marriage status, ethnicity, *hukou* type, and eight dummy variables for schooling.

to a larger proportion of total income among high-labor-income individuals. We conclude that individuals with higher labor income respond less to the 2006 pension reform, which is consistent with former studies.

Second, we divide the sample by gender. Figs. 13–15 show that females respond more than males to the 2006 pension reform, which is consistent with the canonical evidence that females have higher ETIs.

Third, we divide the sample by education level, including under high school (literacy class, primary school, junior high school), high school (high school, technical secondary school), and tertiary education (technical college, college, and graduate). We find that

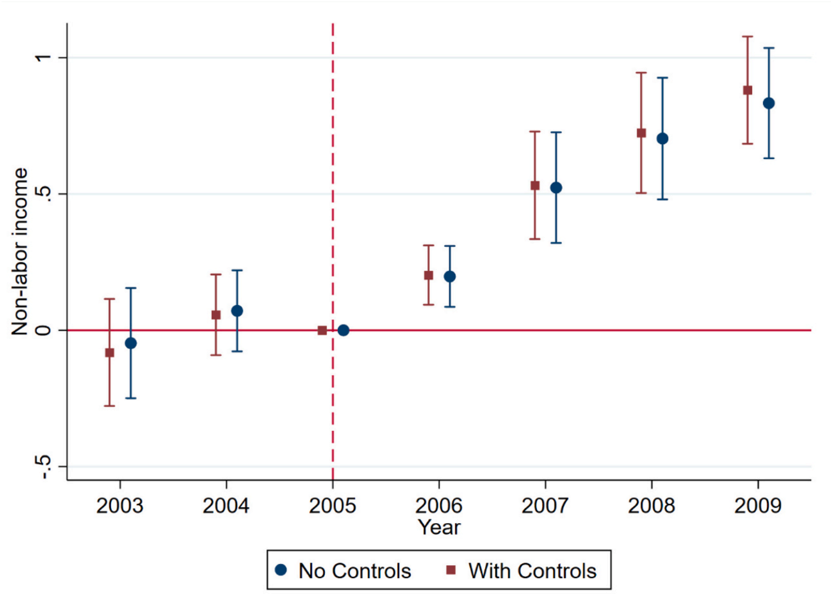

Fig. 6. Non-labor income responses to the 2006 pension reform (formal vs. informal sectors).
Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients α_j in Eq. (2). The dependent variable is non-labor income. Treatment and control groups are the formal and informal sectors, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level. Controls include age, working experience and its' squared, gender, marriage status, ethnicity, *hukou* type, and eight dummy variables for schooling.

Table 5
Transition matrix of the sector.

Observations	Proportion employed in the formal sector in 2004 (total income in 2004)	Proportion employed in the formal sector in 2006 (total income in 2006)	Proportion employed in the informal sector in 2006 (total income in 2006)
Panel A: Individuals in the formal sector in 2005			
9631	92.8% (15,983)	98.4% (18,023)	1.6% (15,695)
Panel B: Individuals in the informal sector in 2005			
2406	36.5% (12,473)	4.9% (12,183)	95.1% (13,082)

Notes: This table use the 2004–2006 balanced-panel data to describe transitions between sectors. Panel A shows that 9631 individuals are employed in the formal sector in 2005. 92.8% are already in the formal sector in 2004. In 2006, 98.4% remain in the formal sector in 2006, and 1.6% of them transit into the informal sector. Panel B can be understood analogously. The transition matrix implies that transitions between sectors from 2004 to 2005 are more active than that from 2005 to 2006. Recalling the "dynamic" DD estimates, transitions between sectors are less likely to violate the SUTVA.

the 2006 pension reform reduces more total income and labor income among individuals with tertiary education.

Finally, we divide the sample into four age cohorts, namely, 18–30, 31–40, 41–50, and 51–60. In the bottom panel of Fig. 14, we show that labor income responses are smaller for the age cohort of 18–31 and 51–60, while there are no significant age disparity on total income and non-labor income.

4.5. Explanations

4.5.1. Real labor responses

Will the income responses be explained by "real responses"? That is, individuals work more hours on non-labor income that is free from the payroll tax. We replace the dependent variable as the monthly working hours which is only available in the UHS survey before 2007. As shown in Fig. 16, the gap in working hours between the formal and informal sectors is quite stable in regards to quantity (within 2%) across years. In addition, individuals in the formal sector have marginally higher working hours after the 2006 pension reform, implying that responses on working hours is not likely to produce the negative total and labor income effects. It is summarized that the elasticity of intensive labor supply is 0.1–0.4 (Chetty, 2009a, 2009b; Saez, Slemrod, & Giertz, 2012). Since the income effect is around 0.1–0.2 (Imbens, Rubin, & Sacerdote, 2001), the compensated and uncompensated elasticities of labor supply are similar. Compared to the high level of ETIs in developing countries (Bachas & Soto, 2018; Best et al., 2015; Carrillo et al., 2017), the real labor response can be ignored.

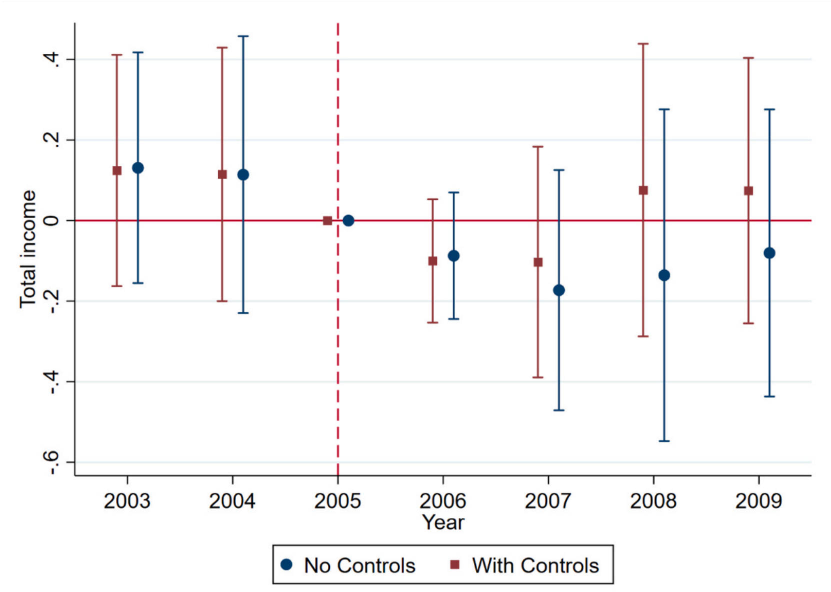

Fig. 7. Total income responses to the 2006 pension reform (retirement-age groups).
Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients α_j in Eq. (2). The dependent variable is total income. Treatment and control groups are the formal and informal sectors of retirement-age groups, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level.

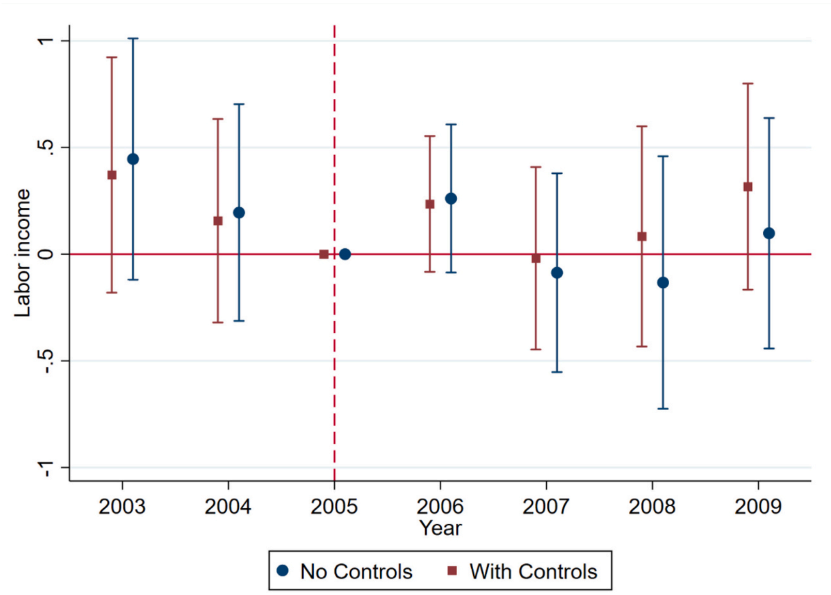

Fig. 8. Labor income responses to the 2006 pension reform (retirement-age groups).
Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients α_j in Eq. (2). The dependent variable is labor income. Treatment and control groups are the formal and informal sectors of retirement-age groups, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level.

4.5.2. Income shifting

A straightforward explanation for the bifurcating effects of the 2006 pension reform on labor and non-labor income is income shifting. Employees may change some items from labor to non-labor income in response to the 2006 pension reform as there will be no benefits from the employer payroll tax since 2006. Even if the employee payroll tax is deducted through employers, employers can underreport the wage base to the administrative agency to reduce both the employer and employee payroll taxes. Before 2006, underreporting the wage base and thus lowering the employer payroll tax may be resisted by employees since they share 3 percentage

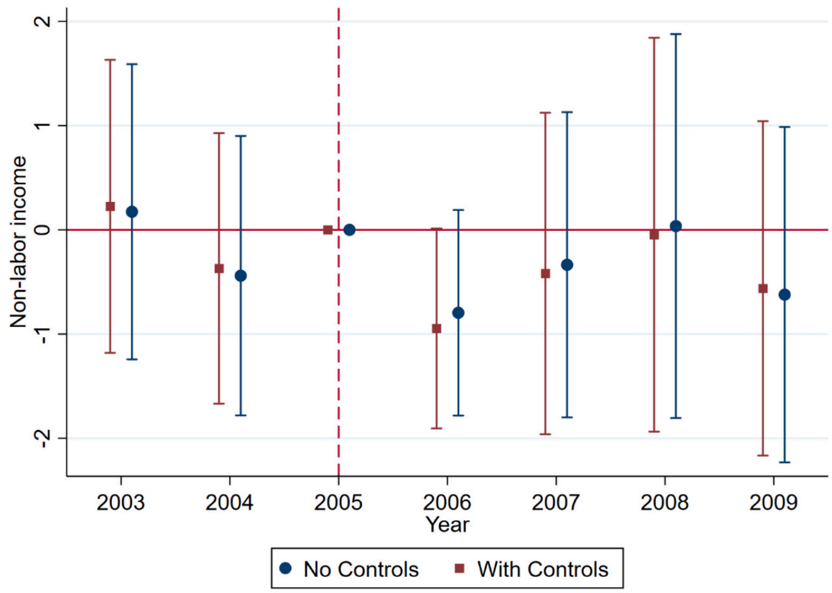

Fig. 9. Non-labor income responses to the 2006 pension reform (retirement-age groups).
Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients α_j in Eq. (2). The dependent variable is non-labor income. Treatment and control groups are the formal and informal sectors of retirement-age groups, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level.

Table 6
Total, labor, and non-labor income responses to the 2006 pension reform among individuals of retirement age.

	Total income		Labor income		Non-labor income	
	(1)	(2)	(3)	(4)	(5)	(6)
Post × Formal	−0.1750*	−0.1216	−0.0502	0.0489	−0.5166	−0.6576
	(0.098)	(0.093)	(0.162)	(0.143)	(0.413)	(0.412)
Controls		Yes		Yes		Yes
Observations	1674	1653	1396	1380	1694	1673
adj. R^2	0.379	0.515	0.401	0.513	0.342	0.360

Notes: Retirement age denotes 55–60 for women and 60–65 for men. Controls include age, working experience and its' squared, gender, marriage status, ethnicity, *hukou* type, and eight dummy variables for schooling. Robust standard errors clustered at the city level in parentheses. $^*p \leq 0.1$.

points of the employer payroll tax. After the 2006 pension reform, employers may shift some labor income to non-labor income to avoid labor costs. What are the possible shifted income items? In the UHS survey, labor income includes wages, the employee payroll tax, bonuses, subsidies, and fringe benefits from the primary and secondary jobs. It is possible that employers pay more dividends in non-labor income when reducing labor income.

4.5.3. Employee payroll tax avoidance and evasion

While income shifting may be attributable to the baseline results, there may be other explanations. One possible explanation is the payroll tax avoidance and evasion. As identifying compelling evasion behaviors is difficult, we provide suggestive evidence based on different administrative capacities among the two administrative agencies. In the payroll tax administration process, employers pay the payroll tax to the administrative agencies based on the self-reported employee wages. Since the Tax bureau can cross-check the reported wages and real wages, the enforcement of the payroll tax is higher in provinces administrated by the Tax bureau than provinces administrated by the Social security bureau. One common method to evade the payroll tax is to underreport wage base.[6] As long as employers do not pay the payroll tax with a wage base under 60% of the local wage,[7] the payroll tax evasion would not be

[6] *White Paper on Social Security of Chinese Enterprises 2018,* available at: https://www.51shebao.com/news/industry_report.
[7] Since the lower bound of wages used to calculate the payroll tax is 60% of the local wage.

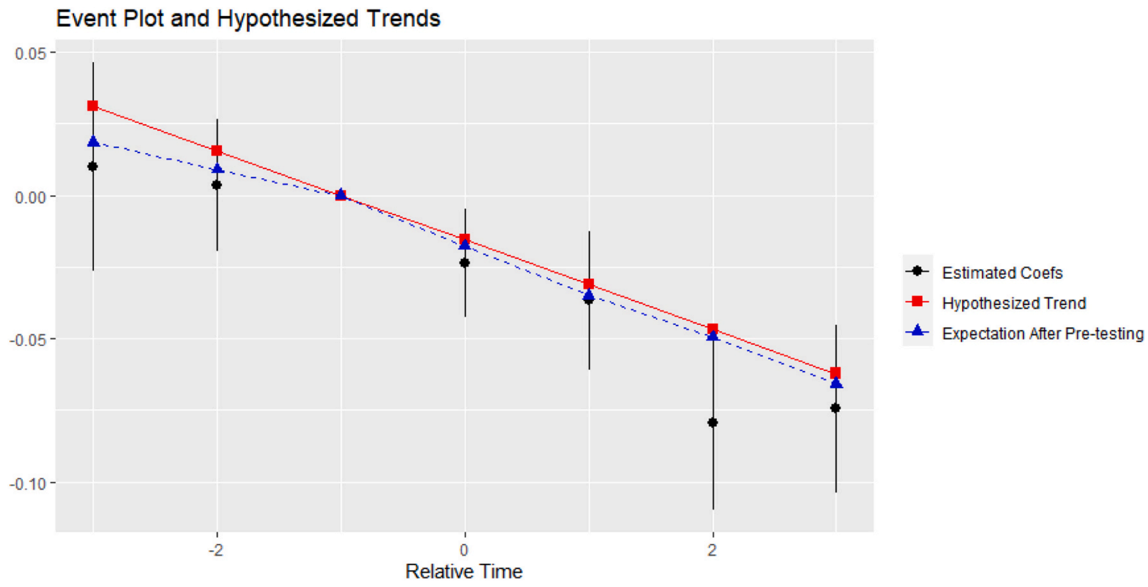

Fig. 10. Screen-shot of Shiny application on total income.
Notes: This figure illustrates the pre-trends test proposed by Roth (2022). The estimated coefficients are the same as in Fig. 4. The hypothesized trend is the stochastic violations of parallel trends that conventional pre-tests have 50% power. Expectation after pre-testing is the hypothesized trend conditional on passing the pre-test.

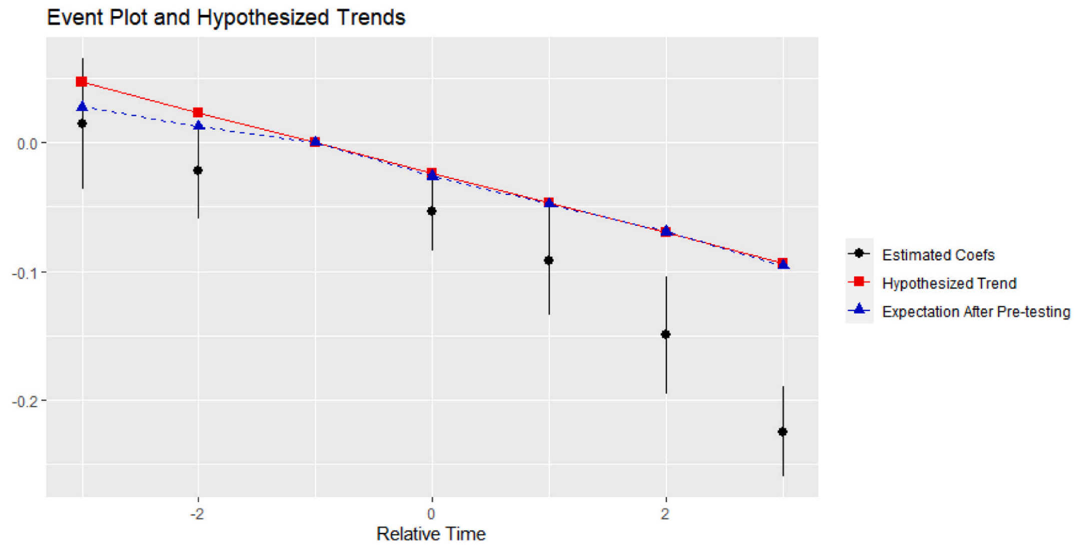

Fig. 11. Screen-shot of Shiny application on labor income.
Notes: This figure illustrates the pre-trends test proposed by Roth (2022). The estimated coefficients are the same as in Fig. 5. The hypothesized trend is the stochastic violations of parallel trends that conventional pre-tests have 50% power. Expectation after pre-testing is the hypothesized trend conditional on passing the pre-test.

audited by the administrative agencies easily.[8]

We divide the sample by the two administrative agencies. It is worth mentioning that the administrative agency in each province was stable after 1997. Provinces will not randomly change administrative agencies. Table 7 shows the results by administrative

[8] The Tax bureau covers Liaoning, Heilongjiang, Jiangsu, Zhejiang, Hubei, Guangdong, Chonqing, and Yunnan, whose *de facto* employee payroll tax rate is 6.7% in the formal sector and 12.6% in the informal sector. The Social security bureau convers Beijing, Shanghai, Shandong, Henan, Jiangxi, Shanxi, and Sichuan, whose *de facto* employee payroll tax rate is 5.9% in the formal sector and 10.8% in the informal sector, indicating a stricter payroll tax enforcement of the Tax bureau.

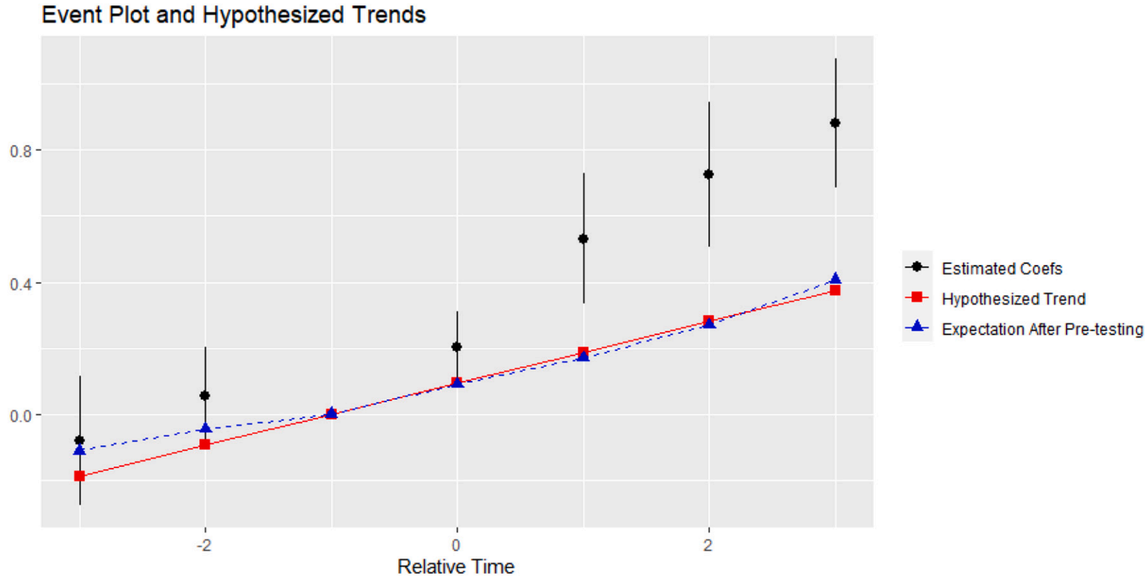

Fig. 12. Screen-shot of Shiny application on non-labor income.
Notes: This figure illustrates the pre-trends test proposed by Roth (2022). The estimated coefficients are the same as in Fig. 6. The hypothesized trend is the stochastic violations of parallel trends that conventional pre-tests have 50% power. Expectation after pre-testing is the hypothesized trend conditional on passing the pre-test.

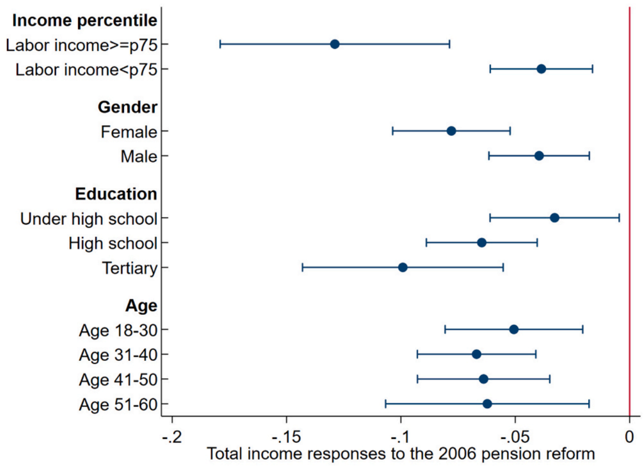

Fig. 13. Heterogeneous analyses on total income responses to the 2006 pension reform.
Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients β_1 in Eq. (1). The dependent variable is total income. Treatment and control groups are the formal and informal sectors, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level.

agencies. It is clear that provinces whose social security contributions collected by the Social security bureau react more fierce to the pension reform than those collected by the Tax bureau. These results indicate that lower administrative capacity is associated with higher payroll tax evasion by income shifting.

In addition, we further examine the effect of the pension reform on the effective employee payroll tax. Since individuals in the informal sector without an employer can attend the BOIA voluntarily, we apply different concepts of income as the denominator to construct four employee pension rates. Fig. 17 plots the estimates by using these pension rates as dependent variables in Eq. (2). We consistently find that the employee pension rate among individuals in the formal sector declines relative to those in the informal sector after the 2006 pension reform. The corresponding table results are reported in Table 8. The DD estimates are 0.49%–0.77%, translating into a 1.63%–2.57% payroll tax evasion when pension rate increases by 10 percentage points.

To sum up, the effect of the 2006 pension reform on working hours is not significant. Employers may shift some labor income to non-labor income to avoid the employer payroll tax. In addition to reducing labor income, the employee payroll tax will also likely to

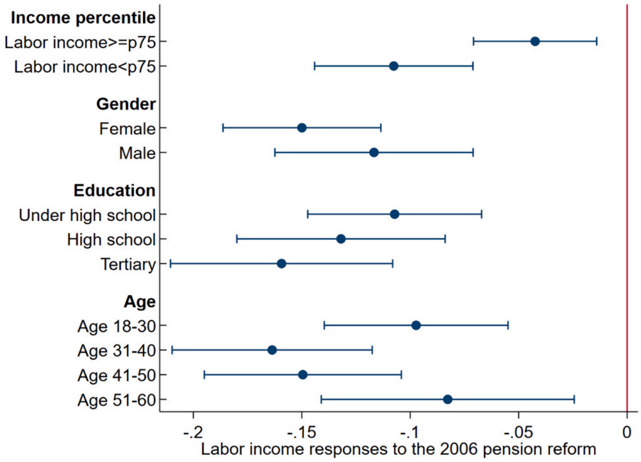

Fig. 14. Heterogeneous analyses on labor income responses to the 2006 pension reform.
Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients β_1 in Eq. (1). The dependent variable is total income. Treatment and control groups are the formal and informal sectors, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level.

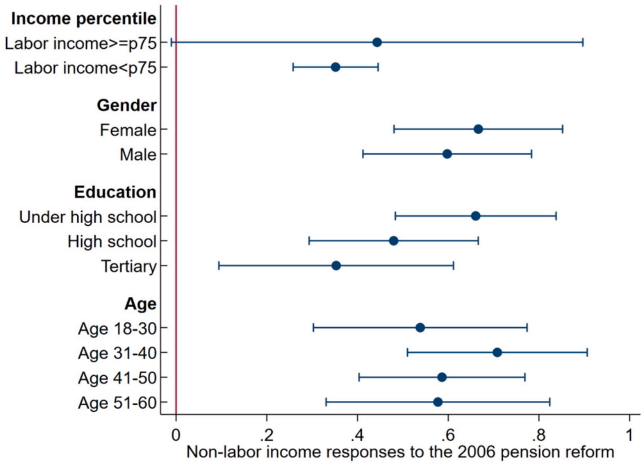

Fig. 15. Heterogeneous analyses on non-labor income responses to the 2006 pension reform.
Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients β_1 in Eq. (1). The dependent variable is total income. Treatment and control groups are the formal and informal sectors, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level.

be evaded by channels such as underreporting wages to the administrative agencies, especially the Social security bureau.

4.5.4. Alternative explanations

Besides the split of the employer payroll tax, the 2006 pension reform included other reformations that may confounds our policy evaluation. We discuss some alternative explanations. First, encouraging participations of the flexible employees. Employees without an employer and the self-employed could participate in the BOAI voluntarily by contributing 20% of the local wage,[9] 8% of which were accrued to the DC account and the remainder were contributed to the DB plan. As flexible employees lacked the employer payroll tax, the reform incentivized their participation by reducing their total payments to the pension system than that of employees with employers (28%). During 2003–2009, 90% (10%)[10] of BOAI participants were employees with (without) an employer. Therefore, this

[9] In recent years, the wage base can be chosen as 60%–300% of the local wage. Higher chosen wages will naturally lead to higher benefits from the DB plan with a dependency ratio. 60% and 300% are also the lower and upper bounds of the wage base for employees in the formal sector. That is, employees whose wages below 60% (above 300%) of the local wage should pay the payroll tax by 60% (300%) of the local wage.
[10] Calculated from the 2020 China' Statistical Yearbook, available at http://www.stats.gov.cn/tjsj/ndsj/2020/indexch.htm.

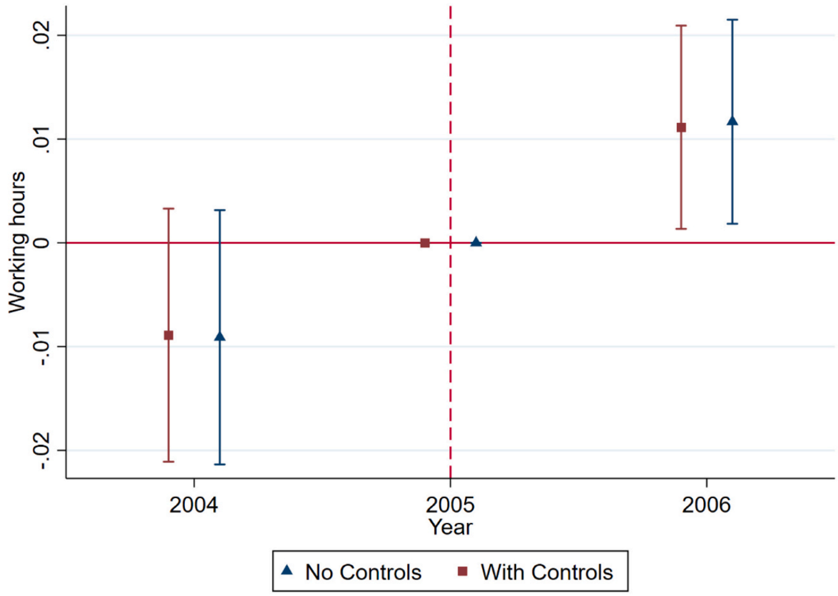

Fig. 16. Working hours responses to the 2006 pension reform.
Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients α_j in Eq. (2). The dependent variable is working hours in logarithm. Treatment and control groups are the formal and informal sectors, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level.

Table 7
Total, labor, and non-labor income responses to the 2006 pension reform regarding administrative agencies.

	Total income		Labor income		Non-labor income	
	Tax bureau	Social security bureau	Tax bureau	Social security bureau	Tax bureau	Social security bureau
	(1)	(2)	(3)	(4)	(5)	(6)
Post×Formal	−0.0450***	−0.0803***	−0.0943***	−0.2095***	0.4858***	0.8779***
	(0.014)	(0.016)	(0.022)	(0.032)	(0.085)	(0.146)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	186,862	153,911	172,403	146,505	188,098	155,669
adj. R^2	0.381	0.388	0.400	0.402	0.207	0.225

Notes: Controls include age, working experience and its' squared, gender, marriage status, ethnicity, *hukou* type, and eight dummy variables for schooling. Robust standard errors clustered at the city level in parentheses. $^{***}p \leq 0.01$.

reformation was less likely to confound our results. Secondly, improving the benefit-rule of the DB plan. Before the 2006 pension reform, after contributing to the pension system for >15 years, the retirees could claim the retirement pension, which is composed of the DB plan (about 20% of the local monthly wage one year before) and benefits from the DC account (total DC account savings divided by 120). After the 2006 pension reform, the benefits from the DB plan was based on the local monthly wage one year before and individual's indexed wage base, multiplying the years of payment×1%. The main rationale behind the policy evaluation is that employees value more on the DC account than the DB account. If the reform indeed improved the incentive of the DB account, our results would be reinforced: Since we attribute the income responses to a 3 percentage points tax rate increase, the real tax rate increase was <3 percentage points if the DB account was more valued than before. Therefore, we will get a even higher estimated ETI if the tax-benefit linkage improvement made a difference. More insights can be derived from the model in Appendix A.

5. Implications and welfare analysis

To wrap up the main findings, we build a parsimonious theoretical model in Appendix A. Suppose the employee value more on the DC account than the DB account, either for tax-benefit linkage (Bozio, Breda, & Grenet, 2019; Summers, 1989) or for tax salience (Iturbe-Ormaetxe, 2015). The employer can underreport the wage base to reduce social security costs. The key insight of the model is that the employee is incentivized to scrutinize the reported wage base since she shares a part of the payroll tax paid by the employer. We denote by τ_1 and τ_2 the payroll tax rates accuring to employees' DC and DB accounts, respectively. In our setting, the DB account revenue maximizing tax rate is equal to $\tau_2^* = \frac{1}{(\varepsilon_2 - 1)}$ (formula (A7) in Appendix A), where ε_2 (formula (A6) in Appendix A) is the elasticity of the reported wage base, $(y - e)$, with respect to one plus the DB account rate, $(1+\tau_2)$. Since τ_2 increase from 17% to 20% after the

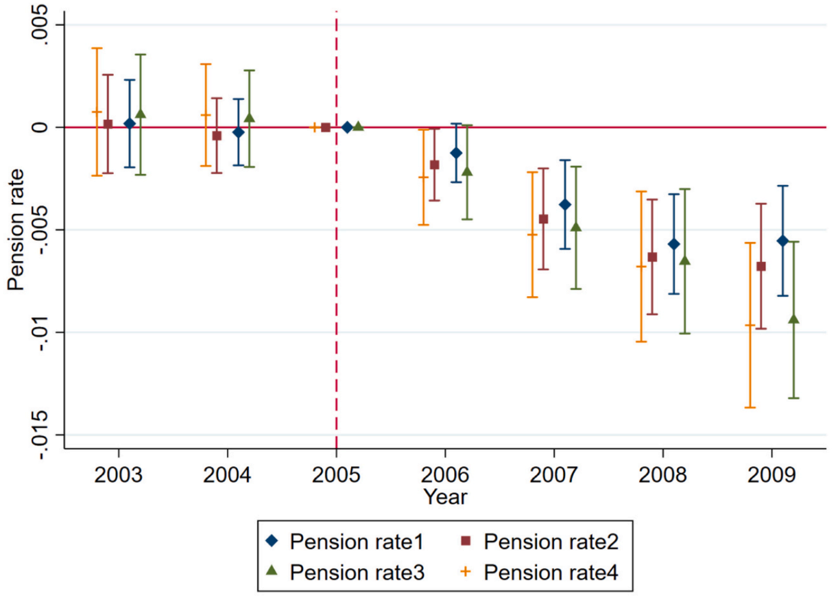

Fig. 17. Pension rate responses to the 2006 pension reform.
Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients α_j in Eq. (2). The dependent variable is the employee pension divided by (1) total income, (2) labor and business income, (3) labor income, and (4) wage and subsidies, denoted by rate1, rate2, rate3, rate4, respectively. Treatment and control groups are the formal and informal sectors, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level.

Table 8
Employee pension rates income responses to the 2006 pension reform.

	Pension/Total income		Pension/Labor and operating income		Pension/Labor income		Pension/Wage and subsidies	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post × Formal	−0.0051***	−0.0059***	−0.0072***	−0.0077***	−0.0042***	−0.0049***	−0.0064***	−0.0067***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Controls		Yes		Yes		Yes		Yes
Observations	349,629	349,450	324,503	321,937	346,851	346,675	322,291	319,894
adj. R^2	0.145	0.128	0.122	0.121	0.169	0.151	0.147	0.146

Notes: Controls include age, working experience and its' squared, gender, marriage status, ethnicity, *hukou* type, and eight dummy variables for schooling. Robust standard errors clustered at the city level in parentheses. $^{***}p \leq 0.01$.

2006 pension reform, the implicated ε_2 is equal to 5.29 $\left(-\frac{-0.134}{ln(1+20\%)-ln(1+17\%)}\right)$. Given the above analyses, the revenue-maximizing tax rate is about 23.3%, which is significantly lower than the results in developed countries (Saez, 2001). The employer pension rate, excluding other social security contributions and income tax, is already 20% in China during the sample period. The non-salary costs such as social insurance and housing contributions reach >40% of employees' wages in China and cause a huge burden among firms (Fang & Feng, 2018; Nielsen & Smyth, 2008). Even choosing the estimated ETI prudently, the social security contribution rate is above the Laffer rate in China. We provide an explanation for the reason why developing countries do not extend the pension system through the payroll tax: Given higher ETIs of the pension as a result of informal sector or state capacity, the extension of the payroll tax is associated high enforcement costs and excess burden.

We further provide some back-of-the-envelope calculations of the 2006 pension reform. According to the formula (A11) in Appendix A, the deadweight loss per *yuan* of extra DB account collected is $\frac{\varepsilon_2\tau_2}{1+\tau_2-\varepsilon_2\tau_2}$. With caution, we treat the real employer pension rate as half of the statutory rate (10%). The deadweight loss per *yuan* (RMB) of additional pension revenue is 0.8 *yuan* (taking ε_2 as 5.29). Referring to Chetty (2009a), the elasticity of total income should be applied in the calculation of deadweight loss if there are transfer costs in income shifting. Taking the elasticity of total income with respect to the pension rate as 2, the deadweight loss is 0.21 *yuan*.

6. Conclusions

By estimating the 2006 pension reform that subtracts 3 percentage points of the employee's DC account in China, we provide new evidence on income responses to the payroll tax. The income elasticity with respect to the pension rate is larger than 2. Employees shift labor income to non-labor income free from the pension when pension rate increases. In addition, pension evasion is associated with pension rate increases.

This paper has the following implications. First, this paper furthers our understanding of why developing countries do not extend the pension system through payroll taxes. Payroll taxes are found to have a less negative incentive on labor income than income taxes in developed countries (Lehmann et al., 2013; Sicsic, 2022; Tazhitdinova, 2015). We, however, document large elasticity of taxable income with respect to the payroll tax in a large developing country. Extending the pension system through the payroll tax may cause a huge deadweight loss. Second, we find that total income responses to the payroll tax are less than that of labor income, which is similar to Gruber and Saez (2002). To avoid labor costs, employers may shift labor income to non-labor income that is free from the payroll tax. Developing countries favor more on indirect taxes such as the value-added tax because its' self-enforcement mechanism (Pomeranz, 2015). Before the 2006 pension reform, employees shared a proportion of the employer payroll tax, which acted as an enforcement mechanism of the payroll tax. Employees are incentive-compatible with the administrative agency to curb the employer from underreporting the wage base. After the 2006 pension reform, however, employees may be incentive-compatible with employers to evade social security contributions. Therefore, this paper provides a novel explanation for the high ETIs estimated from the 2006 pension reform. Third, this paper also highlights the administrative capacity as a solution to the low compliance of the payroll tax, which is similar to that of the income taxes. In provinces where the payroll tax is administrated by the Tax bureau, income shifting is to a lesser extent than that of provinces administrated by the Social security bureau. If other developing countries try to extend the pension system, an effective administrative agency may be necessary to cope with the income-shifting responses. In specific, an effective administrative agency should be able to cross-check wages and the payroll tax. Remarkably, items free from the payroll tax such as dividends may be frequently used to shift income.

Data availability

Data will be made available on request.

Acknowledgments

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Appendix

A.1. A parsimonious theoretical model

We denote by y posted income paid by the employer to the representative employee. Deducting social security contributions paid by the employee from y yields taxable income. While we focus on the pension only, other items in the social security contributions such as the medical and unemployment insurances are ignored. The employer pays the posted income y and the employer payroll tax $(\tau_1 + \tau_2)(y - e)$, where τ_1 and τ_2 are payroll tax rates accuring to the employee's Defined Contribution account and the government Defined Benefit plan, respectively. $(y - e)$ is the wage base that the employer reports to the pension administrative agency. The employer can shelter the wage base e by paying a resource cost $g(e)$. Referring to Chetty (2009a), the cost $g(e)$ reflects the economic opportunity cost of sheltering e. In order to achieve the participation constraint, the employer should transfer $p(e)$ to the employee. The employee value the DC account more than the DB account for two reasons. First, the DC account has higher tax-benefit linkage than that of the DB account (Bozio et al., 2019; Summers, 1989). Second, the DC account is more salient than the DB account (Iturbe-Ormaetxe, 2015). For simplicity, while we assume the employee value the benefit the same as the DC account in quantity, she ignores the benefit of the DB account for meager tax-benefit linkage and less salience. The employee's problem is to

$$\begin{aligned} &\max_{y} u(c, y, \tau_1, e) = c - h(y) + p(e) \\ &\qquad \text{s.t.}\, c = y + \tau_1(y - e) \\ &\qquad\qquad p(e) \geq \tau_1 e \end{aligned} \tag{A1}$$

The employee chooses earning y to maximize utility, given $h(y)$ the disutility of earning y and $p(e)$ the transfer from the employer for underreporting the wage base that calculates the payroll tax. $p(e) \geq \tau_1 e$ is the employee's participation constraint, which indicates that the transfer from the employer ($p(e)$) should compensate the employee's loss on the DC account due to underreporting the wage base.

The employer's problem is to

$$\min_e f(y, \ \tau_1, \tau_2, e) = y + (\tau_1 + \tau_2)(y – e) + g(e) + p(e) \tag{A2}$$

The employer shelters the wage base e to minimize cost $f(y, \tau_1, \tau_2, e)$, given $g(e) + p(e)$ the total sheltering costs. Assume that $g(e)$ is a strictly convex function of e. Suppose the sheltering follows a Stackelberg-style process, in which the employer is the leader and the employee is the follower. The first-order condition of the employee is

$$1+\tau_1 = h'(y) \tag{A3}$$

While minimizing the cost, the employer will satisfy the employee's participation constraint by transferring the minimum amount, i.e., $p(e) = \tau_1 e$. The employer's first-order condition is simplified to

$$\tau_2 = g'(e) \tag{A4}$$

Since both $h(y)$ and $g(e)$ are strictly convex, we have

$$\frac{dy}{d\tau_1} > 0, \frac{de}{d\tau_2} > 0 \tag{A5}$$

The intuition of Eq. (A5) is straightforward: While a higher payroll tax rate for the DC account incentivizes more earning, a higher payroll rate for the DB account stimulates more wage base sheltering. Another implicit result is worth emphasizing: $\frac{de}{d\tau_1} = 0$, which indicates that the payroll tax accuring to the employee's DC account will not stimulate sheltering. It is interesting why different accounts result in different sheltering behaviors. Given the sharing rule of the employer's payroll tax, sheltering wage base will reduce the DB and DC accounts, simultaneously. Since the employee value more on the DC account, she has the motivation to curb the employer from underreporting the wage base.

We next consider the optimal payroll tax rate in the context of the pension plan and a reform that increases τ_2, while keeping $\tau_1 + \tau_2$ constant. The elasticity of the reported wage base, $(y - e)$, with respect to one plus the DB account rate, $(1+\tau_2)$, is defined as

$$\varepsilon_2 = -\frac{1+\tau_2}{y-e}\frac{d(y-e)}{d(1+\tau_2)} \tag{A6}$$

The optimal DB account rate maximizing the DB account revenue is given by

$$\tau_2^* = \frac{1}{(\varepsilon_2 - 1)} \tag{A7}$$

The proof of formula (A7) is similar to that of the classic result (see Piketty, Saez, & Stantcheva, 2014). The government chooses τ_2 to maximize the DB account revenue, $T = \tau_2(y - e)$. The first order condition is $(y - e) + \tau_2\frac{d(y-e)}{d(1+\tau_2)} = 0$, which can be immediately rearranged as (A7) using the definition of ε_2 from (A6). Referring to Saez, Slemrod, and Giertz (2012), there is another approach to derive (A7) as well as decomposing effects on the payroll tax change. Suppose the government increases τ_2 by a small amount, $d\tau_2$, the mechanical effect on the payroll tax increase is

$$dM = (y-e)d\tau_2 > 0 \tag{A8}$$

The income responses that reduce the reported wage base by $d(y - e) = -\varepsilon_2\frac{y-e}{1+\tau_2}d\tau_2$. The change in the DB account revenue due to the income responses is equal to

$$dB = -\varepsilon_2(y-e)\frac{\tau_2}{1+\tau_2}d\tau_2 < 0 \tag{A9}$$

The total change in the DB account revenue due to tax change is

$$dR = dM + dB = (y-e)d\tau_2\left(1 - \varepsilon_2\frac{\tau_2}{1+\tau_2}\right) \tag{A10}$$

The marginal excess burden per dollar of extra tax collected is defined as

$$-\frac{dB}{dR} = \frac{\varepsilon_2\tau_2}{1+\tau_2-\varepsilon_2\tau_2} \tag{A11}$$

Finally, we calculate the excess burden of the DB plan as the standard framework (Chetty, 2009a). We define social welfare as the employee's utility minus the employer's cost, plus the DB account revenue

$$W(\tau_2) = \{(y+\tau_1(y-e)-h(y)+p(e)) - (y+(\tau_1+\tau_2)(y-\mathrm{e})+g(e)+p(e))\} + \tau_2(y-e) \tag{A12}$$

Since the agents have chosen y and e to maximize utility and minimize cost, respectively. The envelope theorem implies that the behavioral responses can be ignored when differentiating the term in the curly brackets, yielding the following expression for the marginal excess burden of the DB plan

$$\frac{dW}{d\tau_2} = -(y-e) + (y-e) + \tau_2\frac{d(y-e)}{d\tau_2} = \tau_2\frac{d(y-e)}{d\tau_2} \tag{A13}$$

Thus, the reported wage base elasticity with respect to the DB account rate is a sufficient statistic to calculate deadweight loss, which is equivalent to (A9).

A.2. Additional figures

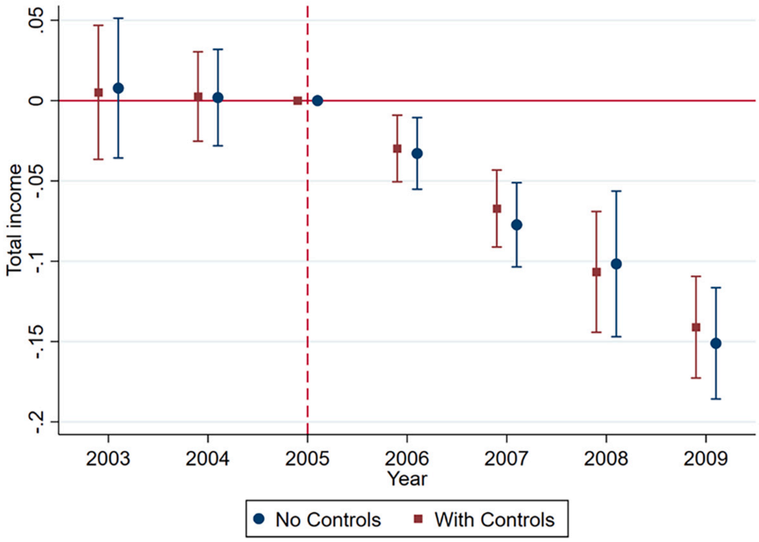

Fig. B1. Total income responses to the 2006 pension reform.

Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients α_j in Eq. (2). The dependent variable is total income. We drop individuals with zero employee pension in the treatment group. Treatment and control groups are employees with employee pension in the formal sector and employees in the informal sector, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level.

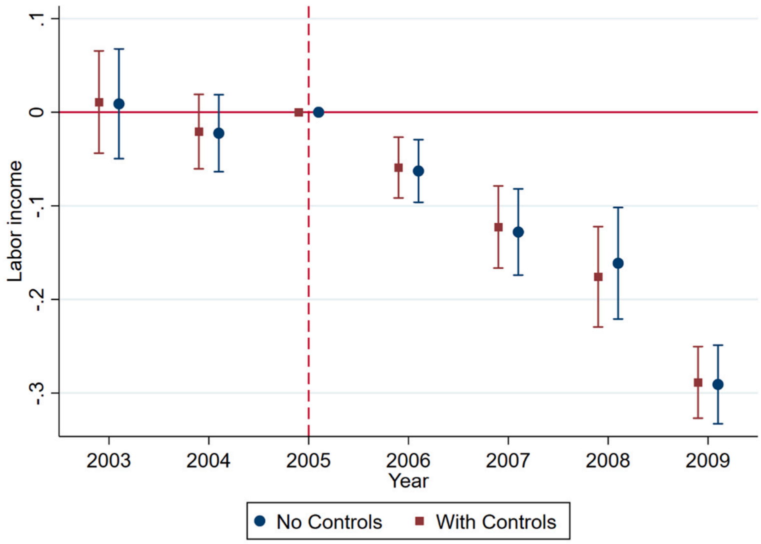

Fig. B2. Labor income responses to the 2006 pension reform.

Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients α_j in Eq. (2). The dependent variable is labor income. We drop individuals with zero employee pension in the treatment group. Treatment and control groups are employees with employee pension in the formal sector and employees in the informal sector, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level.

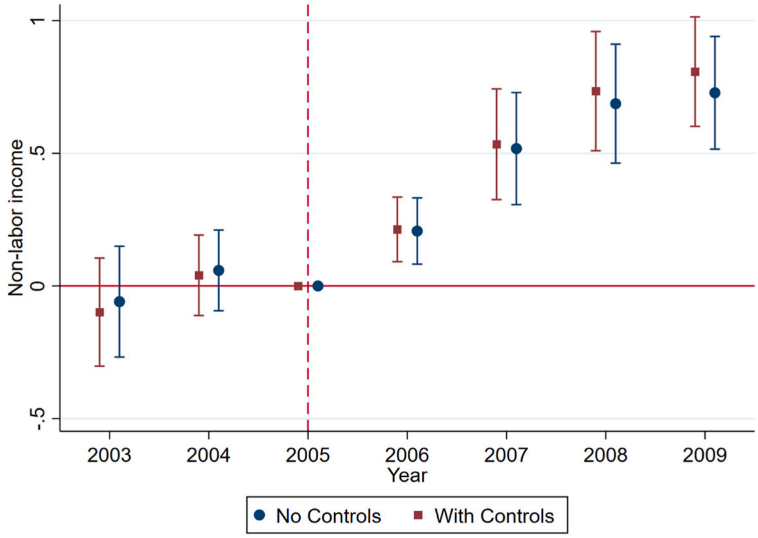

Fig. B3. Non-labor income responses to the 2006 pension reform.
Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients α_j in Eq. (2). The dependent variable is non-labor income. We drop individuals with zero employee pension in the treatment group. Treatment and control groups are employees with employee pension in the formal sector and employees in the informal sector, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level.

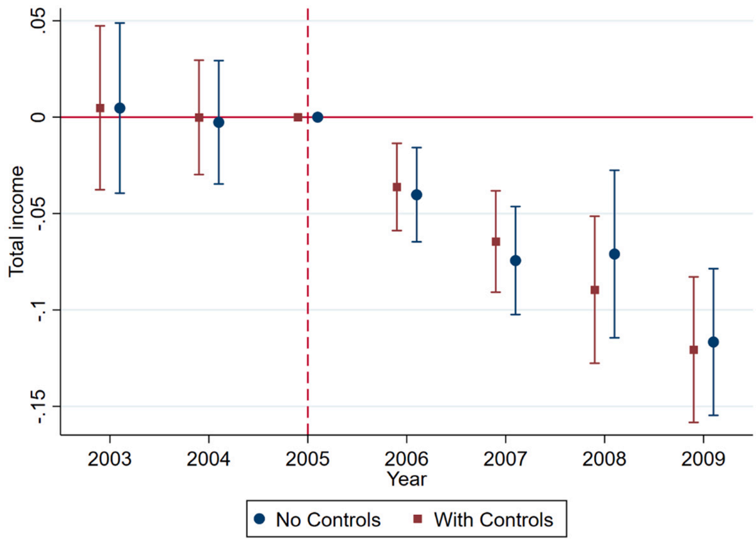

Fig. B4. Total income responses to the 2006 pension reform.
Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients α_j in Eq. (2). The dependent variable is total income. We drop individuals with zero employee pension in the treatment group and individuals with non-zero employee pension in the control group. Treatment and control groups are employees with employee pension in the formal sector and employees without employee pension in the informal sector, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level.

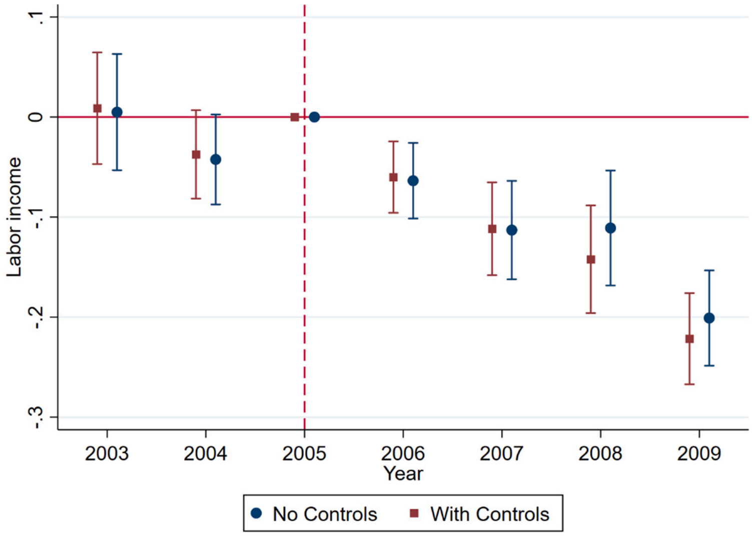

Fig. B5. Labor income responses to the 2006 pension reform.
Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients α_j in Eq. (2). The dependent variable is labor income. We drop individuals with zero employee pension in the treatment group and individuals with non-zero employee pension in the control group. Treatment and control groups are employees with employee pension in the formal sector and employees without employee pension in the informal sector, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level.

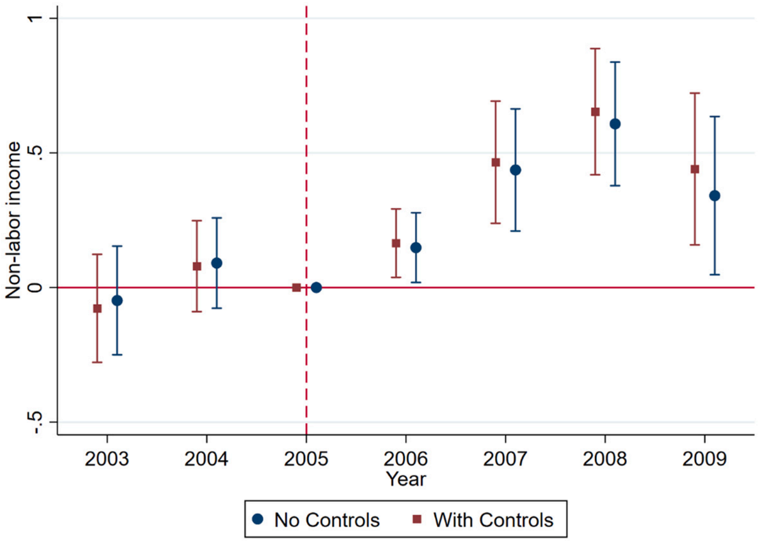

Fig. B6. Non-labor income responses to the 2006 pension reform.
Notes: This figure shows OLS point estimates and 95% confidence intervals of the coefficients α_j in Eq. (2). The dependent variable is non-labor income. We drop individuals with zero employee pension in the treatment group and individuals with non-zero employee pension in the control group. Treatment and control groups are employees with employee pension in the formal sector and employees without employee pension in the informal sector, respectively. All coefficients are plotted relative to 2005. Standard errors are clustered at the city level.

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