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Discrete earnings responses to tax incentives: Empirical evidence and implications

Tuomas Kosonen*
Tuomas Matikka**

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* Labour Institute for Economic Research (Helsinki, Finland), Academy of Finland and CESifo, tuomas.kosonen@labour.fi
** VATT Institute for Economic Research (Helsinki, Finland) and CESifo, tuomas.matikka@vatt.fi

Abstract

We study the consequences of discrete rather than continuous earnings choice sets on individual responses to income taxes. In our empirical application, we utilize an income notch created by the study subsidy system for higher education students in Finland and a reform that shifted out the location of this notch. We find that the reform, which changed the income tax schedule by increasing the location of the notch from 9,000 euros to 12,000 euros, affected the income distribution from earnings of about 2,000 euros onward. Because the tax schedule did not change around these lower incomes, the wide-ranging response to the reform constitutes a puzzle from a standard model point of view. We develop further results, theoretical arguments and a simulation model that all suggest that the shifting of the distribution can be explained with discrete earnings choices. Moreover, we discuss the welfare implications of discrete earnings choices, and find that welfare losses can be greater than empirically estimated if the underlying behavior is constrained by discrete earnings and they are thought to be represented by continuous earnings choices.

Keywords: tax incentives, optimization frictions, discrete earnings choices
JEL Classification Codes: H21, H24, J22

Tiivistelmä

Tässä tutkimuksessa tutkitaan diskreettien valintajoukkojen vaikutusta palkansaajien työn tarjonnan reagoimiseen tuloveroihin. Artikkelin empiirisessä osiossa hyödynnetään opintotuen tulorajojen aiheuttamaa tuloveroissa tapahtuvaa äkillistä nousua, ja reformia, jossa tulorajoja nostettiin. Tulosten mukaan vuoden 2008 reformi, jossa tulorajaa nostettiin 9 opintotukikuukautta nostaneille 9 000 eurosta 12 000 euroon, aiheutti merkittäviä muutoksia opiskelijoiden tulojakaumassa. Tulojakauma siirtyi korkeammalle tasolle lähtien noin 2 000 euron tuloista. Koska opiskelijoiden verojärjestelmässä ei tapahtunut muutoksia näin alhaisella tasolla vuoden 2008 reformissa, ei normaalit taloustieteen työn tarjonnan mallit pysty selittää tätä siirtymää. Artikkelissa esitetään empiirisiä lisätuloksia, teoreettisia argumentteja ja simulaatiomalli, jotka kaikki viittaavat siihen, että tuloksen pystyy selittämään diskreettien valintajoukkojen mallilla. Lisäksi artikkelissa esitetään, että verotuksen hyvinvointitappiot voivat olla suuremmat kuin empiirisesti estimoidut, jos valintajoukot ovat diskreettejä, mutta niiden ajatellaan olevan jatkuvia.

Avainsanat: verokannustimet, optimoinnin kitkatekijät, diskreetit valintajoukot

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Labour Institute for Economic Research
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1 Introduction

In all developed countries, a major part of the population receives their income through wage earnings. Consequently, these individuals are also subject to various and often complex income tax schedules. Thus, one very important question in economics is to understand how taxpayers respond to these tax systems in their behavior, a question that has received extensive attention in economic research (see e.g. Saez et al. 2012 for a literature survey). A standard empirical analysis simply measures the responsiveness of income or labor supply to changes in taxes applied to a particular group of people. In recent empirical work, the focus has turned to understanding on a more nuanced level the factors that determine responses to taxes (see e.g. Kleven 2016 for a survey of the bunching literature), or to uncovering reasons that prevent taxpayers from responding, labeled with a common term as optimization frictions (see e.g. Chetty *et al.* 2011, Chetty 2012, Chetty *et al.* 2013, Chetty and Saez 2013, Kleven and Waseem 2013, Gelber et al. 2017b). Despite these recent advancements, we still lack knowledge on why labor supply or reported incomes respond to taxes in some cases but not in others, and how different types of responses affect the welfare analysis of taxation. Thus, we need more empirical evidence on the determinants of the wage earners' responses to taxes.

In this paper, we analyze responses to taxes and make an effort to distinguish between different mechanisms that determine how individuals respond to tax incentives. We utilize a novel empirical design: a combination of an income notch, a jump in the average tax rate, and a reform that shifted out the location of the notch. Using the relocation of the notch, we can detect "global" responses to a local incentive, revealing how the notch affects the earnings choices further away from the discontinuity. In addition, we provide further and more detailed empirical evidence of earnings responses, develop theoretical considerations and match our empirical results with a theoretical simulation model. These analyses point to the direction that the key mechanism that allows us to explain our empirical results is discrete earnings responses to tax incentives. Moreover, we discuss the implications of discrete earnings choices on estimating the elasticity of taxable income in different contexts, and on measuring the welfare losses to taxes in general.

In the empirical part of the paper, we utilize an income tax notch that shifted location due to a reform in 2008. The notch is created by an income threshold in a study subsidy program for higher education students in Finland. One month of subsidy is approximately 500 euros, and a student loses eligibility for it if her earnings exceed an income threshold, thus reducing her disposable income sharply. The shifting out of the notch was caused by a reform in 2008 that increased the income threshold by approximately 30%, allowing students to earn more without losing benefits.

The study subsidy system and the 2008 reform are equivalent to a notched income tax schedule, where the notch changes location. This institution enables us to identify two moments in the data. First, the cross-sectional notch allows us to distinguish whether or not individuals respond to it but does not allow us to distinguish which taxpayers do respond, and more importantly, where they would have been located in the income distribution in the absence of the notch. Second, the change in the location of the notch allows us to determine through contemporary changes in the income distribution which individuals respond to the notch, and especially where they are located in the pre-reform income distribution.

On top of a setup that allows us to estimate two empirical moments, we believe that our context we analyze has other advantages. University students are an excellent population to study the presence of frictions stemming from the labor market. In the Finnish context, students typically participate in the flexible part-time labor market during their studies and breaks between semesters, and often work for many employers within a year. Therefore, any frictions affecting the responses of students in this flexible part-time labor market are also likely to be present for other taxpayers in more permanent or full-time labor market environment. In addition, the extensive register-based panel data on all Finnish taxpayers allow us to follow the same students over time and link their earnings to the firm they work for. These features allow us to shed light on various mechanisms explaining our results.

Our analysis of the 2008 reform reveals that students respond to the change in the location of the notch by increasing their income in a wide income range. The visible excess mass from immediately below the old notch disappear and a new, somewhat smaller, excess mass appears below the new location of the notch. More importantly, we observe that many students that were located far below the old notch significantly increased their annual earnings precisely at the year of the reform. As a result, the income distribution of students changed its shape in the reform, and the average income of students increased.

To support the causality of these findings, we do not detect any changes in the shape of the earnings distribution of other young part-time workers at the time of the reform. This indicates that the earnings responses of students did not arise from other contemporary changes in the part-time labor market in Finland. Another concern is that although other groups of young taxpayers do not seem to increase income, students tend to do so even in the absence of the reform. However, we show that although there are some minor changes in the distribution of students over time, the approximate location of the distribution remains rather constant in the years absent the reform. Thus, also this robustness check implies that the 2008 reform caused shifting of the earnings distribution of students.

Next, we develop a theoretical framework that illustrates how different variants of the canonical labor supply model could explain responses to a local tax incentive. We start from a standard static model, where the behavior of a taxpayer is represented by a utility function over consumption and leisure, and the budget constraint including income taxes. The key to understanding responses to local tax incentives in this model is that the initial location of an individual is determined by her type (e.g. productivity) and responses to initial taxes.Bunching and similar relocation choices can be explained in this framework by having sharp changes in tax incentives. However, in general the model cannot explain large relocation choices as a response to small tax changes that do not cross the indifference curves of individual having chosen a particular location. Furthermore, adding simple optimization frictions that prevent taxpayers from responding to tax incentives does not fundamentally change the implications of this model regarding the location choices of individuals.

Previous literature has considered also discrete earnings choices, for example Dickens and Lundberg (1993), Saez (1999 and 2002), as well as the structural labor supply literature assumes discrete choices (see e.g. Löffler et al. 2018 for a survey). In contrast to standard labor supply model, discrete earnings choices are an example of a model where individuals consider locations different from where they are initially are located. In the discrete choice model, the rule determining the location of an individual relates to the relative utility derived from different discrete locations. For example, if the initial choice is point A, and the tax schedule changes such that the next point B above becomes better, the individual changes location in this model. In our empirical example point A could have been located far below the old notch and point B above it. In the reform point B became relatively better, because the new notch is on a higher location than B. Thus, it appears that the discrete choice model is able to explain our main empirical results, whereas the standard continuous choice labor supply model cannot.

To empirically support the discrete choice mechanism, we show that students at the individual-level increase their earnings by a large share after the relocation of the notch. For example, at the time of the reform, it became much more likely that a student originally below the income threshold increased her earnings by 50% or more, compared to the period before 2008. This result supports the notion that the shifting of the income distribution arises because of individual-level discrete earnings responses of students along the intensive margin rather than, for example, through a selection of new kinds of students participating into the income distribution.

Moreover, we build a simulation model to further study the underlying mechanisms and their implications. Using the model, we generate earnings distributions under the standard continuous model and our discrete earnings choices model discussed above, and study how well different variants of the model can explain observed empirical patterns. The baseline model predictably generates extensive and sharp bunching below the income threshold, but no earnings responses from a wider income interval when the threshold is increased. We add adjustment frictions and i.i.d. income shocks to the baseline model, but these frictions do not generate the observed shifting of the income distribution from a wider income range.

We then add discrete earnings choices to the baseline model by assuming that individuals have a discrete choice set of potential earnings from which they need to choose the one that maximize their utility. Because the choice sets are random draws and are in different locations across different draws, aggregating over individuals still produces a smooth income distribution. However, when using a relatively sparse choice set of 10–30 choices (600–2,000 euro jumps in earnings), we can qualitatively match two key empirical features: shifting of the income distribution from a wide income range and dispersed local bunching.

The discrete earnings choices have implications to estimates of welfare losses. First, when estimating empirically the elasticity of income with respect to income taxes, the independent variable is according to the standard model the change in the log of tax rate and the dependent variable the change in log income. Under the discrete model, the independent variable relates to change in the tax in one location relative to another and the dependent variable is the share of individuals changing location (and to where they relocate). Thus, if one estimates to what extent log incomes on average respond to average change in taxes, but the underlying model is discrete, one cannot uncover the true elasticity estimate, or the sufficient statistics, as intended. The structural welfare loss can then be greater than thought when using the conventional elasticity estimate.

We contribute to the literature using the bunching method to estimate elasticity of taxable income, ETI (see Kleven 2016 for a survey of this literature). Our results suggest that individuals that are located far below the initial location of the notch respond to the notch. This implies that the surrounding distribution cannot be used as a credible counterfactual distribution, as the distribution even far away from the location of the notch does not represent the shape of the distribution in the absence of the notch.

In addition, our study contributes to the literature analyzing various optimization frictions. In particular, our paper relates to studies discussing the role of earnings adjustment frictions and estimated elasticities, such as Gelber *et al.* (2017a). In addition, our study adds to the recent literature that critically analyzes the bunching methodology. For example, Blomquist and Newey (2017) address the fact that the shape of the underlying distribution can drastically affect the elasticity estimates derived from observed bunching. We contribute to this literature by using a unique empirical application to illustrate how discrete earnings choices can invalidate the local bunching estimator in terms of recovering unbiased earnings elasticity estimates. Finally, we also contribute to the structural labor supply literature that often assumes discrete choices, recently summarized in Löffler et al. (2018), by showing that in addition to discrete working hours individuals can also face discreteness in available earnings choices.

This paper proceeds as follows: Section 2 presents the relevant institutions and empirical methods. Section 3 presents the main results. In Section, 4 we discuss the mechanisms and present our simulation models and discuss their implications. Section 5 concludes the study.

2 Institutions, data and empirical methods

2.1 The study subsidy for higher education students

In Finland, all students who are enrolled in a university or polytechnic can apply for a monthly-based study subsidy, administered nationally by the Social Insurance Institution of Finland (hereafter SII). The subsidy is intended to enhance equal opportunities to acquire higher education, and to provide income support for students who often have low disposable income. In Finland, university education is publicly provided and there are no tuition fees. A large proportion of individuals receive higher education in Finland (approximately 40% of individuals aged 25-34 have a degree), and the study subsidy program is widely used among students.

The maximum amount of the study subsidy was 461 euros per month in 2007. The default number of subsidy months per year is 9, which the bulk of the students also choose. The eligibility for the study subsidy depends on personal annual gross income (labor income + capital income), and completing a certain predefined number of credit points per academic year. Parental income or wealth does not affect eligibility nor the amount of the benefit for students not living with their parents.[1]

The discontinuity in labor supply incentives is created by an income threshold. If annual gross income is higher than the threshold, the study subsidy of one month is reclaimed by the SII. This results in an implied marginal tax rate of over 100% in a region just above the threshold, creating a *notch* in the budget set of students. With the default 9 months of the subsidy, the annual gross income limit was 9,260 euros in 2007. An additional month of the subsidy is reclaimed for an additional 1,010 euros of income above the threshold. This implies that the schedule ultimately comprises of multiple notches. Students can deviate from the default of 9 months and alter the number of subsidy months by application, or by returning already granted subsidies by the end of March in the next calendar year. Having more study subsidy months reduces the income limit, and vice versa.[2]

The study subsidy program was reformed in 2008. The main outcome of the reform was that the income threshold was increased by approximately 30%. For a typical student with 9 study subsidy months, the annual income threshold increased from 9,260 to 12,070

[1] The full study subsidy includes a study grant and a housing benefit. The standard study grant was 259€/month and the maximum housing benefit 202€/month in the academic year 2006/2007. Housing benefits are granted only for rental apartments, and the housing allowance is reduced if spousal gross income exceeded 15,200 per year (in 2007). In addition to the study subsidy, students could apply for repayable student loans which were secured by the central government.

[2] In 2007, the formula for the annual income threshold was the following: 505 euros per study subsidy month and 1,515 euros per month without the study subsidy, plus a fixed amount of 170 euros.

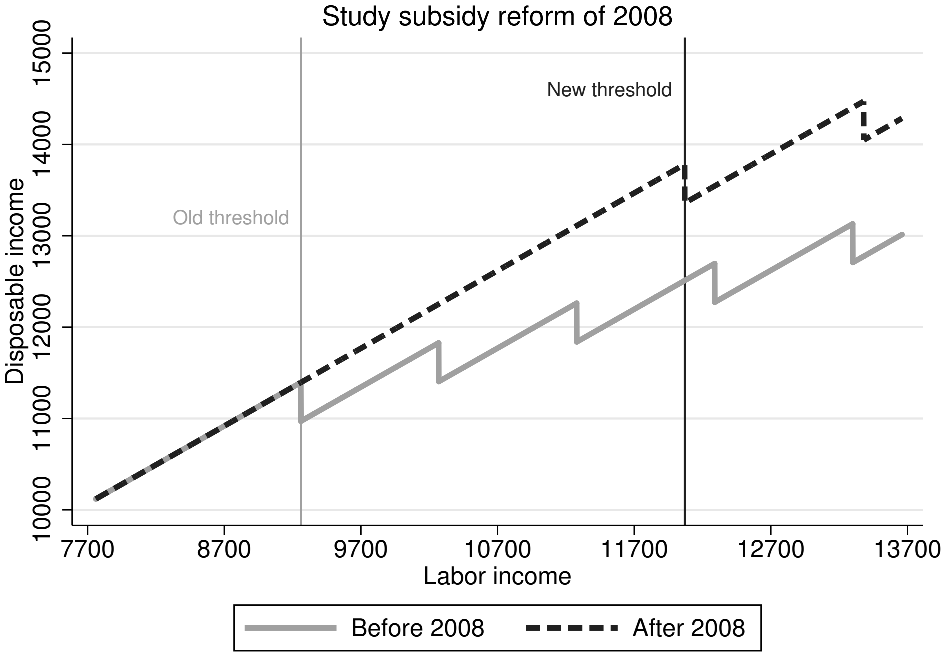

Figure 1: Disposable income at different gross income levels, students with 9 subsidy months in 2007 and 2008

euros. In addition, the monthly study subsidy was slightly increased from 461 to 500 euros per month. As with the old regime, an additional month of the subsidy is reclaimed after an additional 1,310 euros of gross income above the threshold. Other details of the system were not changed, including the academic criteria.[3]

Figure 1 illustrates the study subsidy schedule before and after 2008 for a student who collects the default 9 subsidy months. The vertical axis denotes disposable income, and horizontal axis labor income. First, the figure shows that students face large local incentives not to exceed the income threshold. Once the income threshold is exceeded, losing one month of study subsidy causes a significant dip in disposable income. Therefore, the study subsidy notch induces a strictly dominated region just above the threshold where students can earn more disposable income by reducing their gross earnings. Furthermore, the figure underlines the distinctive change in incentives caused by the increase in the income threshold in 2008, highlighting that the reform encouraged to increase earnings above the old income threshold. Finally, Table A1 in Appendix A shows the income thresholds in numbers before and after 2008, and presents the relative loss in disposable income that incurred when the income threshold is exceeded.

[3]After 2008, the formula for the annual gross income limit was the following: 660 euros per study subsidy month and 1,970 euros per month when no study subsidies are collected, plus a fixed amount of 220 euros.

2.2 Data and descriptive statistics

Despite the fact that the majority of students have access to the study subsidy and repayable student loans, most higher-education students in Finland also work part-time during studies and study breaks. Therefore, the means-testing of the study subsidy creates a binding budget constraint for a majority of students. In our analysis, we use panel data on all working-age individuals (15–70 years) living in Finland in 1999–2013 provided by Statistics Finland. These data include a variety of register-based variables, such as detailed information on tax register and social benefit items, including information on the study subsidy program. With these data, we can analyze responses to incentives created by the program and learn how various individual characteristics affect behavioral responses.

Table 1 shows the descriptive statistics for all students in 1999–2013. Average annual labor income among all students is 9,130 euros. We observe that 77% of students earned more than 500 euros of labor income in a year. In addition, less than 60% of students received labor earnings from only one employer, indicating that students tend to work in different types of jobs during the year. Overall, these observation indicate that many students work in part-time jobs during their studies and breaks between semesters in order to increase their disposable income and/or to gain work experience while studying. Also, 18% of students work in manufacturing (including construction), 15% in the service sector (mainly restaurants and hotels), and 37% in administrative and support services or in the public sector.

	Individual characteristics			
	Age	Female	Labor income	Labor income > 500
Mean	23.7	.56	9,130	.77
Median	23	1	6,325	1
sd	5.128	.496	9,524	.28
N	5,126,594	5,126,594	4,351,213	5,126,594
	One employer	Study subsidy months	9 subsidy months	Years studied
Mean	.57	6.7	.32	2.1
Median	1	8	0	2
sd	.50	3.05	.462	1.91
N	3,557,732	5,126,594	5,126,594	3,933,607
	Field of industry			
	Manufacturing	Services	Admin. & Publ. Sector	Other/missing
Mean	.18	.15	.37	.29
sd	.39	.36	.48	.45
N	5,126,594	5,126,594	5,126,594	5,126,594
	Field of study			
	Arts & Humanities	Business & Soc. Science	Tech., Health & Soc. Serv.	Other/missing
Mean	.13	.16	.30	.37
sd	.33	.36	.46	.48
N	5,126,594	5,126,594	5,126,594	5,126,594

Table 1: Descriptive statistics, all students 1999–2013

The average number of study subsidy months collected per year is 6.7. The share of students receiving the default subsidy of 9 months is 32%. Overall, the group receiving the default subsidy is very similar to the overall student population, expect that they are slightly younger (22.4) and have less labor income (5,633) than all students (on average). An average student in the data has been studying for approximately 2 years. Finally, 13%, 16% and 30% of students in our data study arts and humanities, business and social sciences, and technology or health and social services, respectively.

2.3 Empirical methods

Behavioral responses to discontinuous changes in the budget set, such as tax rate kinks or notches, are in the recent literature estimated using the bunching methodology (see Kleven 2016 for a summary). Intuitively, if a discontinuous jump in incentives affects behavior, we should find an excess mass of individuals located just below the threshold in the earnings distribution. This local excess bunching thus captures the output distortions created by the threshold. In the local bunching approach, the behavioral response caused by threshold is estimated by relating the observed excess mass in the earnings distribution below the threshold to the counterfactual density that would exist in the absence of the discontinuity. Typically, the counterfactual density is estimated by fitting a flexible polynomial function to the observed earnings distribution, excluding a small area of the observed distribution around the threshold. Saez (2010) and Kleven and Waseem (2013) show that under certain restrictions, this local bunching measure can be translated to an average earnings elasticity, representing a relevant parameter for welfare analysis of taxes and income transfers. We discuss the local estimation approach in more detail in Appendix B.

However, the local bunching method could produce biased estimates of the extent of behavioral responses if the threshold affects the earnings distribution further away from the threshold. In this case, the local bunching estimate does not sufficiently capture the distortions caused by the discontinuous change in incentives. One potential cause for responses within larger income intervals are constraints that limit the possibility to continuously adjust earnings. Under this constraint, individuals can adjust their earnings only in a discrete manner, in contrast to marginal earnings adjustments as in the underlying local bunching model (Saez 2010, Kleven and Waseem 2013). Consequently, discrete earnings responses can affect the earnings across the distribution. We discuss the welfare implications of these types of responses in more detail in Section 4.

In order to detect and estimate discrete earnings responses, we evaluate the effects of the study subsidy income threshold on the overall shape of the earnings distribution further away from the notch. In the analysis, we use the pre-2008 density as the counterfactual when numerically illustrating changes in the distribution caused by the increase in the income threshold after 2008. The method follows the lines of the local bunching approach, except that we denote the distributions in relative terms in order to take into account the fact that the number of students at certain income levels might differ between the years.[4]

The change in the shape of the overall distribution below the location of the old threshold (prior to 2008) can be numerically characterized as

$$\hat{b}(z) = \frac{\sum_{i=z_1}^{z^L} \left[(c_j^A/N_A) - (c_j^B/N_B) \right]}{\sum_{i=z_1}^{z^L} (c_j^B/N_B)/N_j} \tag{1}$$

where $\sum_{i=z_1}^{z_L}(c_j^A/N_A)$ is the relative share of students after 2008 within an income range of $[z_1 - z_L]$, where c_j is the count of individuals in bin j, and z denotes the income level in bin j. In our baseline analysis, we use 200 euro bins and set z_1 to zero and z_L equal to the income threshold, thus including the whole distribution below the income threshold when analyzing broader changes in the income distribution. N_A denotes the overall number of students earning less than 18,000 euros per year after the reform. Similarly, $\sum_{i=z_1}^{z_L}(c_j^B/N_B)$ is the relative share of students in the income range $[z_1, z_L]$ before the reform. N_j denotes the number of bins within $[z_1, z_L]$.

We study the years right before and after 2008 in order to focus on the effects of the reform. As the estimate for the change in the overall shape of distribution cannot be directly interpreted in terms of welfare analysis, we use this numerical estimate to characterize the extent of the change in the earnings distributions over time, and to compare the observed change in the distribution between different subgroups and changes in simulated earnings distributions using various assumptions of the number of available earnings choices and the disutility of labor. We discuss these in more detail below.

Nevertheless, it could be that other factors than the change in the income threshold inflict changes in the shape of the income distribution, such as overall changes in the economic environment and the labor market. In order to take these issues into account, we utilize changes in the distribution of young, part-time non-student workers who match students' job and age characteristics. These individuals are not subject to the income threshold, but are of same age as students and work in similar types of jobs. Intuitively, even though current students might differ from current non-student part-time workers in some relevant non-observed characteristics, the income development of other part-time workers still captures the underlying general economic trend that affects the overall earnings potential of the part-time labor force.

In order to take the general economic development into account, we utilize a difference-in-differences type of a setup where we account for the changes in the non-student distri-

[4] In the standard cross-sectional local bunching analysis, using relative distributions instead of frequency distributions produces identical estimates of the relative local excess bunching around the discontinuity in tax incentives.

bution. In this estimation, we simply subtract the change in the non-student part-time worker earnings distribution from the students' distribution, $\hat{b}(z)^S - \hat{b}(z)^P$, where the superscript S denotes students and P non-student part-time workers.

3 Main results

Our main empirical results utilize the reform in 2008 that shifted out the income thresholds by approximately 30%. We are interested in investigating whether local tax incentives, such as notches, affect income distributions outside of the immediate bunching and dominated regions. Thus, we examine the shape and location of the whole income distribution before and after the reform. In addition, we contrast the income distribution of students affected by the reform in 2008 with other young adults in the part-time labor market and students in other years to see how income distributions tend to change in the absence of changes in the local tax incentive.

In the analysis, we focus on students that have 9 months of subsidy before and after 2008. For this group, the income threshold increased from 9,260 to 12,020 euros in 2008. This restriction is not very selective, because a bulk of students receive 9 months of the study subsidy, in part because it is the default choice and in part because it presumably creates a good balance between subsidies and allowed earnings for many students. The advantage we gain by fixing the number of subsidy months is that we can isolate the effect of the change in the location of the threshold on the earnings distribution for a large part of the student population.

Figure 2 shows the relative labor income distributions of students in bins of 100 euros in 2006–2007 and 2008–2009, denoting the pre- and post-reform years, respectively. The solid vertical lines in the figure denote the old and new income thresholds of the study subsidy system. The vertical axis denotes the percentage share of individuals in each 100 euro bin within an income interval of 0–18,000 euros of annual labor income.[5]

Remarkably, the figure illustrates that the earnings distribution after 2008 has a significantly different shape than before the reform, implying that the income threshold affects the shape of the whole labor earnings distribution, not just the region close to the notch point. Under the conservative hypothesis that the notch creates only local responses, we would have expected the excess mass to be relocated to the new notch, which indeed has occurred. However, we would have not expected other significant changes in the shape of the distribution that we nonetheless observe. The figure illustrates that in fact the income distribution shifted to the right from a large region below the threshold, from about earnings of 2,000 euros onward.

In order to numerically illustrate the significance of the change in the distribution,

[5]The figure includes only labor earnings as receiving capital income is very rare among university students.

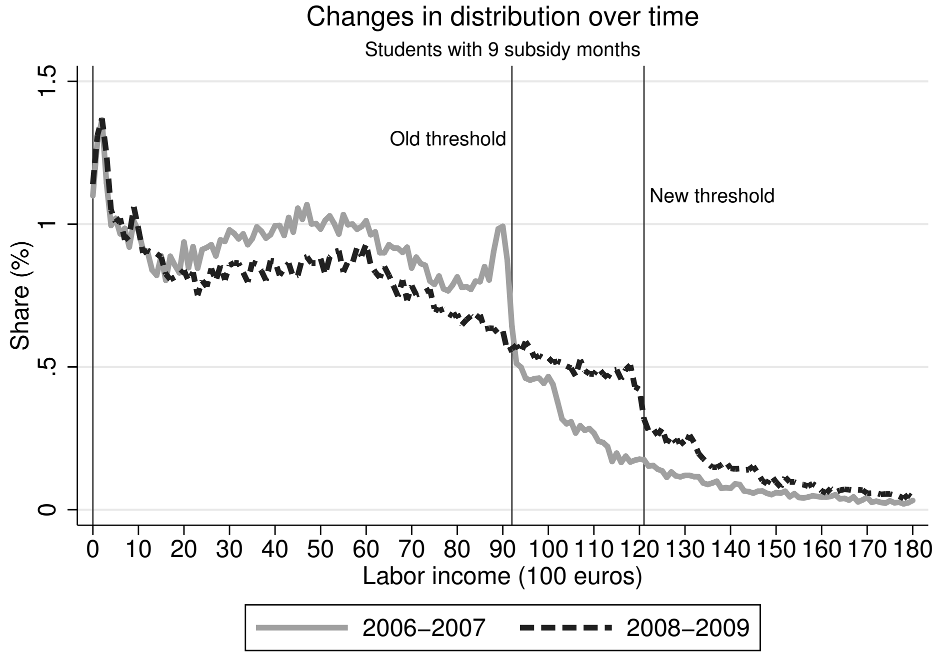

Figure 2: Labor income distributions of students (9 months of subsidy) before and after the reform of 2008

we estimate equation (1), the relative change in the mass of students below the notch, between 2006–2007 and 2008–2009 within an income range of 0–9,200 euros. The estimate for the relative difference of the distributions below the old income threshold between the periods is large (10.970, with standard error of 0.846), suggesting that the magnitude of the change in the overall earnings distribution is significant. This estimate is over three times larger than the standard local bunching estimate before 2008 derived from the income range 8,100–9,200 euros (2.931 (0.875)).[6] Furthermore, in order to further characterize the general magnitude of the overall income response, we estimate an average income increase of 550 euros per student when accounting for the overall changes in the shape of the earnings distribution, which corresponds to a roughly 10% increase in labor earnings.

The identification challenge here is that the change in the shape of the distribution might have occurred for other reasons than the 2008 reform. To defend the idea that the changes in incentives indeed created the changes in the earnings distribution, we show that there were no other contemporary changes in earnings among other young part-time workers. In order to do that, we plot the earnings distributions of young, part-time workers who are not students in Figure 3. This control group resembles the treated students, because they have similar average labor earnings as students, and many of these workers have more than one employer within a year, very similarly as the student

[6]The local bunching estimate is calculated following the procedures in Kleven and Waseem (2003), explained in detail in Appendix B.

population. The characteristics of young, part-time workers included in Figure 3 are described in Table A3 in Appendix A.[7]

In comparison to students, the earnings distribution of non-student part-time workers remained practically constant between 2006–2007 and 2008–2009, indicating no significant changes in the earnings of other young part-time workers who are not subject to the income threshold nor changes in its location. This lack of change in the control group income distribution builds confidence in that the observed change for students is a causal response to the 2008 reform.

In order to measure these changes more precisely, we develop a difference-in-differences estimate for the change in the relative density below the old income threshold. The estimate subtracts the relative change in the distribution of non-student part-time workers from the change in the students distribution within the same income range (0-9,200e). As the changes in the earnings distribution for non-students are small, this estimate (9.809 with standard error 1.01) does not significantly differ from the simple comparison of pre- and post-reform distributions of students presented above.

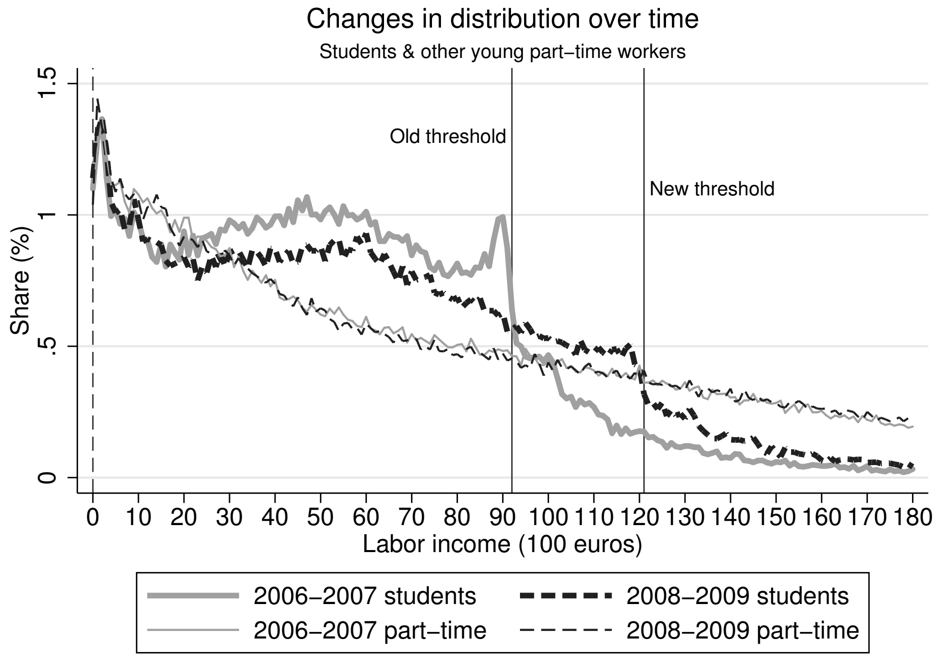

Figure 3: Labor income distributions of students (9 months of subsidy) and non-student part-time workers before and after the reform of 2008

Another threat to identification is that the income distribution of students keeps on

[7]The group of non-student part-time workers is selected to roughly match students' job and age characteristics. Students typically work in part-time jobs or in full-time jobs for a part of the year, i.e. they work less than 12 months a year. In addition, students tend to be young. Thus, the control group comprise of individuals who we observe to have less than 12 working months per year, and who are 19–24 years old. The age interval is chosen to match between the 25–75 percentile points of the students age distribution. Our results are not sensitive to small changes in the composition of the non-student group.

changing all the time, and the observed change around the year 2008 is not attributable to the reform. However, empirical evidence is not consistent with this hypothetical threat. In Figure 4, we plot earnings distributions from a longer period before and after 2008. The figure shows that the change in earnings occurred exactly at the time of the relocation of the income threshold, indicating that any gradual shifting of the distribution does not explain the observed pattern. In addition, Figure A1 in Appendix A shows the distributions in 2006–2007 and 2008–2009 when we re-weight the student population in the latter period to match pre-reform characteristics in terms of age, field of study and field of industry. This bin-level inverse probability weighting procedure accounts for potential differences in key characteristics between the periods. However, re-weighting does not change the outcomes in a significant manner, suggesting that potential changes in the characteristics of student population over time does not explain the results either.

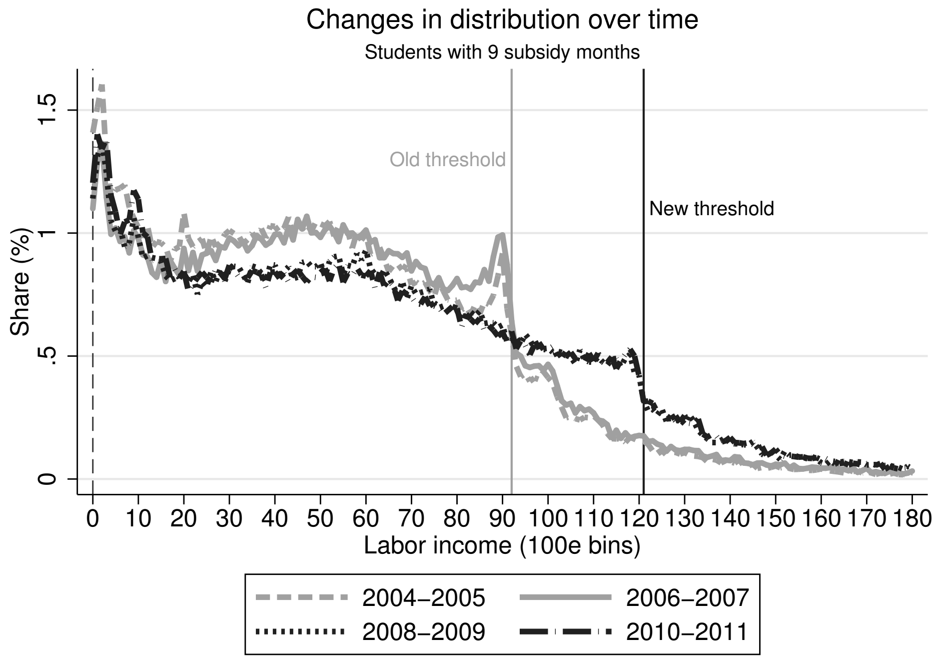

Figure 4: Labor income distributions in different years before and after the reform, students with 9 subsidy months

Finally, we study other potential changes at the time of the reform that might affect observed changes in the shape of the earnings distribution. First, there were no significant changes in the distribution of subsidy months associated with the reform, and 9 months is the most typical choice in all of the years around the reform. This indicates that students responded to the reform by changing their earnings, but not, on average, by claiming more or less subsidies per year. Second, we looked at whether the reform is accompanied by extensive margin responses, but the share of students not working at all (earning less than 500 euros per year) did not change significantly at the time of the reform. Therefore, these types of responses do not explain the change in the shape of the observed earnings distributions around the 2008 reform.

4 Conceptual framework and implied mechanisms

4.1 Conceptual framework

Here we discuss different conceptual frameworks that could explain the main empirical results presented above. The feature of the main result that we want to be able to explain is the shifting of the income distribution from a wide income range following the change in the location of the notch. We start with a standard model and extend that to attenuating optimization frictions and discrete choice sets. In the analysis our focus is on what determines the income location choices of individuals under different assumptions and the contrast between the standard model and discrete choices model regarding the location choices.

A standard framework to analyze taxpayers' responses to taxes is to consider utility function over consumption and leisure and a linearized budget set consisting of earnings, consumption and taxes. The bunching method utilizes this framework to estimate the amount of excess mass at a discontinuous change or jump in tax incentives, and relate this behavioral response to the size of the incentive change to recover an elasticity estimate (see Saez 2010 and Kleven 2016). A key assumption for our interests is that in this model one assumes exogenous preferences, for example productivity, according to which individuals are heterogenous. From an individual point of view, the exogenously given preferences and taxes determine the location individual chooses in the income distribution.

Formally, utility function is $u(c, z)$, where c denotes consumption and z earnings, and $u_c>0$ and $u_z<0$. The budget set is described as $c = (1-\tau)z + R$, where $(1-\tau)$ is the net-of-tax rate and R is virtual income. In our analysis, we parameterize the utility function to a quasilinear form as follows:

$$u(c,z) = c - \frac{w^i}{1+\frac{1}{e}}\left(\frac{z}{w^i}\right)^{1+\frac{1}{e}} \tag{2}$$

where w^i is an ability parameter. Thus, the utility maximization with respect to z gives $z = w\left(1-\tau\right)^e$, where e is the earnings elasticity parameter with respect to τ, capturing the behavioral responses to taxes and describing the relative magnitude of welfare losses in an optimal income tax setting. Note that the parameter e captures the elasticity with respect to taxes, defined as $\frac{dz}{d(1-\tau)}\frac{1-\tau}{z} = e$, only within this parameterized utility function. In general responses to taxes in this model are measured as a marginal change in earnings as a response to marginal change in taxes.

As discussed above, the income location choices of an individual in this model for individual i are determined by innate productivity w^i, and the response to taxes determined by the utility function in equation (2). If we start from an initial optimal location (from the point of view of the individual), z^*, and do not change the taxes so that any new tax location does not alter the optimal choice for the individual, the individual will not respond to the tax schedule change by changing her income. Similarly, the individual would not respond to any change in the tax schedule far above her current location.

An increasingly popular extensions to this basic framework are optimization frictions (see Chetty *et al.* 2011, Chetty 2012, Chetty *et al.* 2013, Chetty and Saez 2013, Kleven and Waseem 2013). The optimization frictions typically considered include job switching costs, salience or complete unawareness of tax incentives. A common feature with these types of optimization frictions is that they attenuate responses. For example, as we will see below, in the bunching framework they would reduce the amount of bunching. The above framework could be augmented for having this kind of optimization friction by adding a parameter $a \in (0, 1)$ to the utility function. If a is close to one, responses to taxes would be minimal, and if a is close to zero, responses to taxes would be according to the frictionless model. The utility function becomes as follows.

$$u(c, z) = c - \frac{w^i}{1 + \frac{1}{e(1-a)}} \left(\frac{z}{w^i} \right)^{1+\frac{1}{e(1-a)}} \tag{3}$$

From the above formulation it becomes clear that considering these kind of optimization frictions do not alter the location choices as a response to taxes in a fundamental manner, but merely reduces the responsiveness to taxes. The responsive to taxes becomes $\frac{dz}{d(1-\tau)} \frac{1-\tau}{z} = (1 - a)e$. Location choices continue to be determined through similar preference relation as above, and changes in taxes that do not cross the indifference curves of the individual would not affect the location choices. Moreover, considering heterogeneous adjustment costs across individuals does not change the general intuition, but would explain that simultaneously some taxpayers respond to taxes while others would not.

If one alters the basic framework further by adding optimization errors to the model, the behavior regarding location choices changes slightly. The error could arise from an unanticipated change to initially chosen income, be it reduced earnings through sick-leaves, or increased earnings through bonuses. An important aspect of optimization errors are that they are unanticipated and thus not enter the decision on how to respond to taxes, if they were anticipated they would be included in the optimization framework with perhaps some expectation. The simplest method to include optimization errors is to consider an error parameter drawn from some distribution: $r \in f(r)$. The distribution could be, for example, normal distribution with mean zero and a standard deviation of 1,000 euros. It is unlikely that a large fraction of individuals would have very large unanticipated changes in their earnings, thus the standard deviation would not likely be very large. First a taxpayer makes an optimal income choice z^*, and then the optimization error alters the choice by r, so that the final choice is $z^* - r$. These kind of optimization errors would cause small deviations in income and lead to, for example, some taxpayers to be located in the dominated range above a notch. On top of this kind of small deviation in incomes, optimization errors cannot explain large changes in income distribution.

Next we consider a model that can easily explain large changes in income location choices: discrete choice sets. They are defined as having non-continuous and small number of alternative income points from which the taxpayer must choose. The motivation for discrete choice sets is, for example, that taxpayers must choose between different employers that offer jobs with a fixed monthly salary. Empirically, a taxpayer has often only few job offers constituting a choice set that is rather sparse. A more nuanced example is that an individual works for the same employer, but the work-contract is made always a month at a time. The need for such contracts, formal or informal, arises from uncertainty for both parties without a contract. Discrete choices have been analyzed in the labor supply literature before, for example, they were part of explanation for the lack of bunching in Saez (1999), Lundberg and Dickens (1993) analyzed them, and structural labor supply models often assume that choices are discrete (see e.g. Löffler et al. 2018).

Discrete earnings could be modeled through a constraint that an individual chooses from discrete earnings locations even conditional on them being intensive responses, i.e. conditional on participating to labor markets, following Saez (2002). The preferences and underlying wage distribution are continuous. Thus, the utility function would be as above, but indexing the discrete earnings and consumption choices with j.

$$u(c_j, z_j) = c_j - \frac{w^i}{1+\frac{1}{e}}\left(\frac{z_j}{w^i}\right)^{1+\frac{1}{e}}$$

The constraints include the budget constraint as above, but now also a constraint that individual must choose between alternatives $u(c_{j-1}, z_{j-1}),\ u(c_j, z_j),\ u(c_{j+1}, z_{j+1})$. A parameterized version of the constraint is such that there is a fixed cost q determining whether or not an individual wants to change the earnings location. The fixed costs are predetermined and heterogeneous, and are drawn from a distribution, $q \in f(q)$ and a cumulative distribution $F(q)$. The decision to respond to taxes then becomes as follows.

$$u(c_j, z_j) \geq u(c_{j-1}, z_{j-1}) - q^i \tag{4}$$

Individual i then switches location if $q^i > u(c_{j-1}, z_{j-1}) - u(c_j, z_j)$. Thus, there is a threshold value $\bar{q} = u(c_{j-1}, z_{j-1}) - u(c_j, z_j)$, and if the fixed cost is higher than the threshold value, the individual does not switch income location between states $j-1$ and j. The amount of individuals that would rather switch to location j is the cumulative value $F(\bar{q}_j)$. The responsiveness to taxes could then be calculated through how many individuals there are having low enough q that they would change location as a response to a change to tax incentives, relative to the number of people in the initial location. This type of change is captured through a mobility elasticity η instead of income elasticity ϵ.

$$\eta \equiv \frac{\partial F(q_j)}{\partial \bar{q}_j} \frac{\partial \bar{q}_j}{\partial z_j} \frac{z_j}{F(q_j)}$$

Thus the mobility elasticity captures the fraction of individuals changing location whereas the income elasticity captures the average (marginal) change in income of all taxpayers that have income z as a response to changes in taxes. The difference is important when considering what different measures are estimating empirically.

The conceptually different response between this model and the continuous model is that individuals consider their utility in both states, z_{j-1} and z_j. If the tax schedule in general changes at either $T(z_{j-1})$ or $T(z_j)$, this affects the location choices of an individual, even if the change in the schedule does not cross with the indifference curves of individual located at z_{j-1}. Thus, tax changes from far above of the current location of individual can induce income responses. The discrete model can rationalize much larger jumps in earnings locations as a response to small tax changes compared to any of the continuous models considered above. The essential constraint is that individuals cannot choose income locations that are marginally close to where they are located, i.e. that the choice sets are discrete.

4.2 Empirical support for different mechanisms including discrete earnings

Next, we present empirical support for different mechanisms that could explain the main result presented above. First, a typical explanation for the lack of bunching or lack of missing mass in the dominated region related to notches is salience, i.e. that taxpayers are not aware of the income threshold. Similar optimization frictions relate to adjustment frictions preventing students to respond to the threshold. However, Figure 2 suggest that at least some fraction of students are aware of the location of the income thresholds, as bunching at the threshold is clearly visible in both before 2008 (excess bunching 2.932, standard error 0.875) and after 2008 (1.71 (0.882)). Furthermore, local bunching response fully disappeared below the old threshold immediately after the reform, and a new excess mass appeared below the new threshold within the year of the reform in 2008. Since these changes occurred in the same year as the reform, we find no evidence of some students still believing that there is a notch at the old location, nor that there would be a sluggish response to the relocation of the threshold.[8]

Next, we present more detailed evidence supporting discrete income jumps at individual level that are consistent with the discrete earnings responses model. First, Figure 5 presents the average individual-level changes in labor income in base-year income bins of 3,000 euros for students with 9 subsidy months in 2005–2006, 2006–2007 and 2007–2008. Overall, the figure shows that average changes in individual income are very similar in the years before the reform, and that there is a visible pattern of mean reversion (starting from a low income leads to larger income on average in the next year, and vice versa). Consistent with the hypothesis of discrete earnings responses, the figure shows that labor income increased significantly in 2007–2008 compared to the years before the reform, particularly for those students below the new income threshold in base-year bins of 6,000–9,000 and 9,000–12,000 euros. The change in the pattern is observable even in the 3,000–6,000 euro bin that is well below the old threshold. However, we find no significant difference between the years for income bins above the new threshold, suggesting that the rapid increase in earnings in other bins stems from the increase in the income threshold.

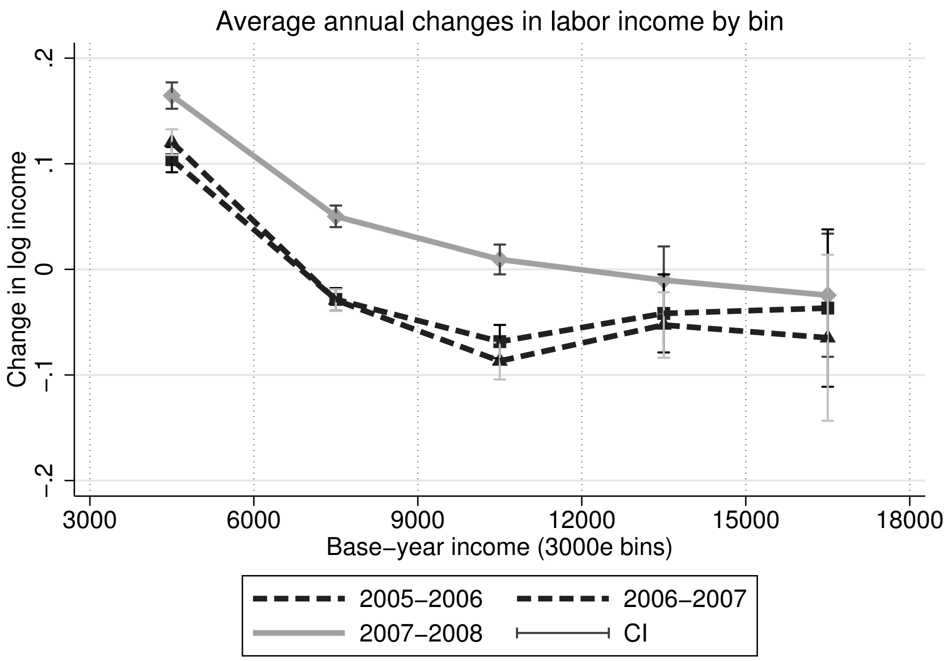

Figure 5: Average individual-level changes in labor income in base-year bins of 3,000 euros, students with 9 subsidy months in 2005–2006, 2006–2007 and 2007–2008

[8]Additional examination of the excess masses before and after the reform reveals, as further illustrated in Figure B2 in Appendix B, that bunching is slightly larger before the reform than after it. One explanation for this is that local incentives not to exceed the notch are somewhat smaller after 2008, since the relative significance of losing one month's subsidy in terms of disposable income is now smaller than before 2008 when the threshold was at a lower income level.

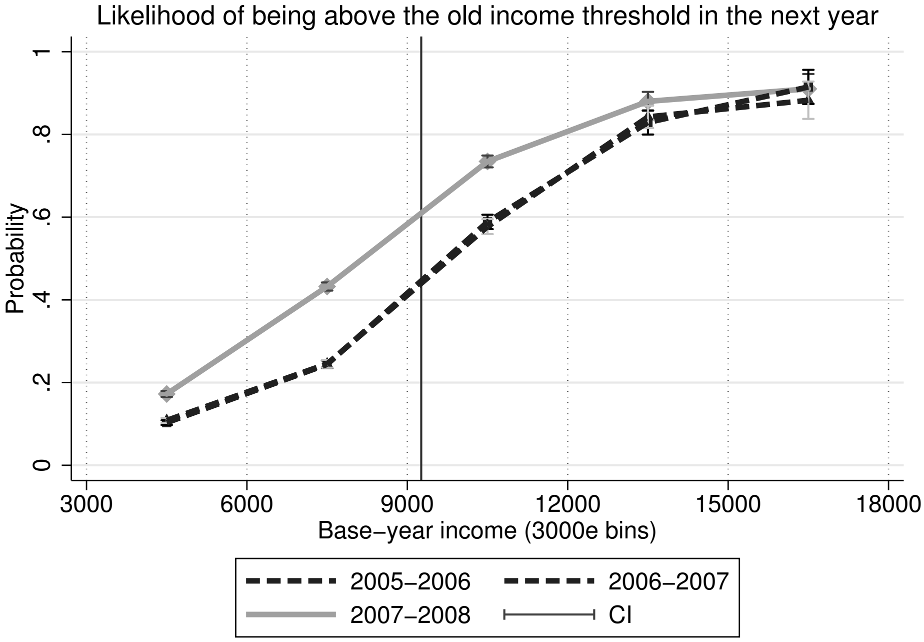

Figure 6: Likelihood of locating above the old income threshold (9,200 euros) in the next year (in 3,000 euro bins)

Second, Figure 6 shows that the likelihood of locating above the old income threshold (9,200 euros) in the next year increased significantly in the reform in the bins below the new threshold, compared to the years prior to 2008. Again, the fact that the likelihood of being located above the old notch increased in income bins far below the old notch illustrates that a notable share of students responded to the reform with a large increase in their earnings.

Third, Figure 7 shows the likelihood of increasing earnings by 50% or more relative to base-year income in bins of 3,000 euros for students with 9 subsidy months. We observe that large increases in earnings are significantly more likely when the threshold was increased (2007–2008) compared to previous years (2005–2006 and 2006–2007). For example, the prevalence of annual earnings increases larger than 50% doubled from 5% to 10% in the bin just below the old income threshold. In contrast, there are no significant differences in large earnings increases between the pre- and post-reform years in bins above the new income threshold (12,100 euros).

Overall, Figures 5–7 provide compelling evidence that many students responded to the relocation of the income threshold with a large increase in their income. These individual-level jumps in income are consistent with discrete earnings responses rather than marginal earnings adjustments implied by standard labor supply model. These findings strengthen the conception that there are frictions in the labor market that allow a significant proportion of students in the part-time labor market to adjust their earnings only in a discrete manner.

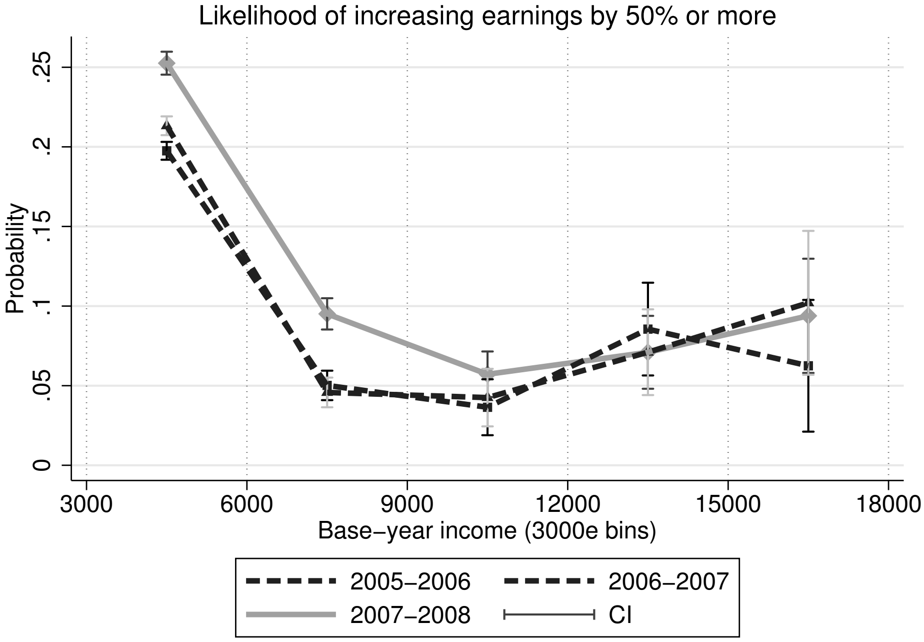

Figure 7: The likelihood of increasing earnings by more than 50% compared to base-year (in 3,000 euro bins)

Heterogeneous responses

Studying the heterogeneity of responses among different subgroups of students can potentially reveal additional information on the relevance of various labor market frictions. We are interested in particular in finding evidence that would relate to discreteness of earnings choices.

Figure 8 presents the earnings distributions of students with 9 subsidy months before and after 2008 for four groups: those with one employer and those with many employers during the year, and those with the same employer in both 2007 and 2008 and those with a different employer. As discussed above, students typically participate in the flexible part-time labor market during their studies and often work for many employers within the year, and very often change their employers between two years. As an example, compared to all workers aged 19-50 years, students are much less likely to have only one employer during a year (59% of students vs. 80% of all workers).[9]

Figure 8 illustrates that overall changes in the earnings distribution were larger for those with more than one employer during the year, compared to those with only one employer. This suggests that discrete earnings frictions stemming from the labor market are likely to be present even for those workers who are more likely to hold multiple jobs within a year. However, local bunching responses at the threshold are clearly visible for both of these groups, suggesting that a relevant fraction of students were able to precisely

[9]Table A2 in Appendix A presents the descriptive statistics for all workers (excluding students) aged 19-50 years.

adjust their earnings close to the notch despite the differences in the number of employers during the year.

Second, we find that changes in the distribution are more prevalent for those who have the same principal employer, compared to those who are more likely to change jobs between 2007 and 2008.[10] This suggests that notable discrete earnings frictions exist also for those who do not change their job, and that the effect is not driven by those who search for a new employer after the reform. In fact, changes in the distribution appear to be smaller for those with a different employer after 2008. Also, the figure shows that local bunching is much smaller for those who are more likely to have a new job, suggesting that precise earnings adjustment to exactly match the threshold is more challenging for new workers compared to other workers in the firm.

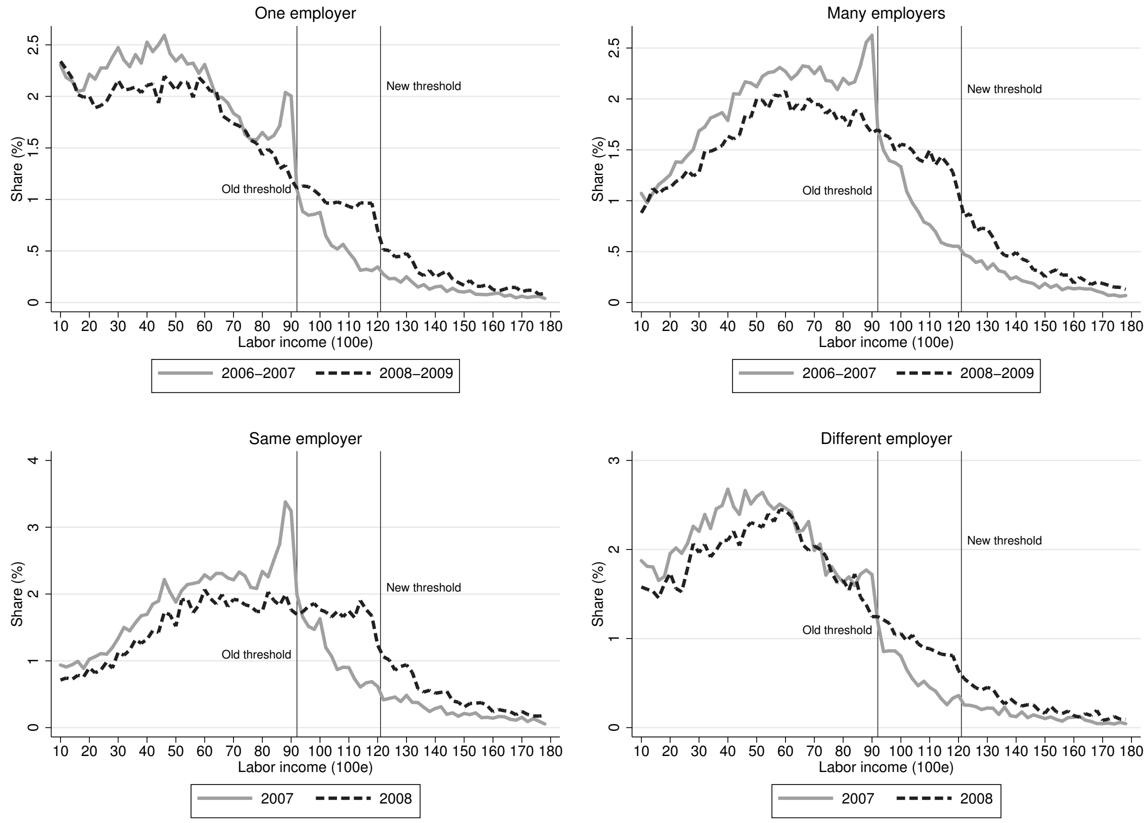

Figure 8: Labor income distributions before and after 2008 for four groups: students with one employer during the year (upper-left), students with more than one employer (upper-right), students with the same employer in 2007 and 2008 (lower-left) and students with different employer in 2007 and 2008

Finally, Figures A2 and A3 in Appendix A present the changes in the distribution for students working in different industries and in firms of different size. Overall, there

[10]In the case of many employers within a year, the principal employer is defined as being the one that the student has the longest active working contract with. We define the change in employer as the change in the principal employer.

are no large differences in responses between students in different industries, but changes in the distribution appear to be smaller for administrative and public sector workers compared to manufacturing and the service sector. Also, responses are rather similar in firms with different size, but changes in the earnings distribution tend to be slightly larger for workers in smaller firms.

4.3 Baseline simulation model and optimization frictions

In this section, we present a simulation model that we use to generate income distributions under different assumptions about taxpayers' behavior. We start from the standard continuous choice model and then add different extensions to that model.

Baseline framework and the simulation model

In order to have a budget set that resembles the empirical one for students under the study subsidy system, we assume parameters given in Table 2. The marginal income tax rate is set to 22% below the notch. To simplify the analysis, the high marginal tax rate of 61% above the notch linearizes the budget set with many subsequent notches above the income threshold. The size of the notch is 500 euros, which corresponds to the change in virtual income at the notch.

The model utilizes an underlying ability distribution that translates into an income distribution in the absence of taxes or other constraints. Each individual receives a draw from this distribution, which cannot be changed. Our parameterized ability distribution is presented in Figure A4 in Appendix A.[11]

In the baseline simulation model, we assume that the preferences of individuals are represented by a parameterized utility function in equation (2). Individuals face a budget set where the location of the notch changes according to the parameters presented in Table 2.

Figure 9 shows the simulated distribution when using the baseline model and a baseline earnings elasticity parameter e of 0.5. The two distributions in the figure correspond to those simulated using the budget set before (solid gray line) and after (dashed black line) the relocation of the income threshold in 2008. Bunching at the income threshold is clear, very sizable and sharp in both cases, in contrast to a more diffuse bunching in the empirical distribution (see Figure 2 above). Also, there is a distinctive hole in the distribution just above the notch, corresponding to the fact that in the baseline theoretical model, no taxpayer wants to locate in the dominated region, in contrast to the empirical case where many students are located in the dominated range. Importantly,

[11] The distribution is a combination of power distributions and normal distributions, which gives an approximate match for the shape of the empirical earnings distribution of students in our empirical case. In our setting, the amount of bunching is not very sensitive to different underlying ability distributions that roughly match the empirical earnings distribution.

Parameter	Value
Marginal tax rate (τ)	
Below the notch	0.22
Above the notch	0.61
Size of the notch	500e
Virtual income (R)	
Before	4,100e
After	3,600e
Location of the notch (income threshold)	
Before	9,000e
After	12,000e

Table 2: Parameter values in the simulation model

outside the bunching and dominated regions, the simulated distributions are directly on top of each other, implying that the baseline model cannot produce the observed shifting of the earnings distribution from a broader income range.

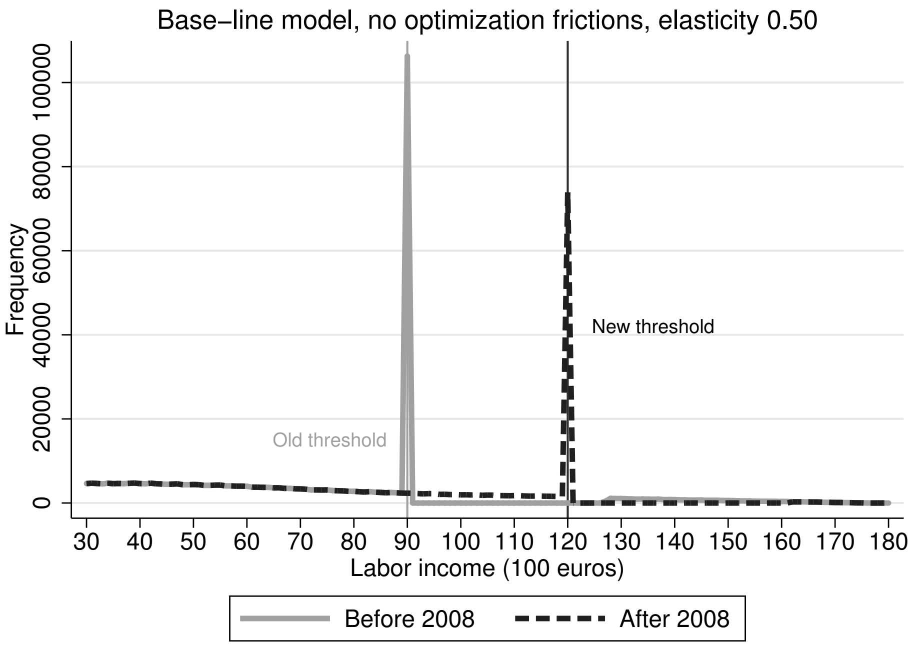

Figure 9: Bunching response to notches in the baseline simulation model

Optimization frictions

Next, we add optimization frictions discussed in the previous literature (see for example Chetty *et al.* 2011, Chetty 2012 and Kleven and Waseem 2013) to the model. First, we first add to the model adjustment frictions following the model presented in equation

(3). We assume heterogeneous adjustment frictions represented by uniformly distributed parameter a in the unit interval. We multiply the elasticity parameter with $(1 - a)$. Consequently, when a is close to one, an individual is not very responsive to taxes, whereas the individual follows the baseline frictionless model if a equals zero. Each individual has a different and independent draw from uniform distribution.

Figure 10 shows the simulated income distributions with the adjustment frictions. Overall, adding adjustment frictions does not significantly alter the overall shape of the distribution compared to the baseline model. Adjustment frictions mainly reduce local bunching and somewhat increase the mass in the dominated range. Outside the bunching region and the dominated range, the two distributions are very similar. Therefore, a simple adjustment friction does not appear the explain the observed empirical patterns (shifting of the whole distribution, diffuse local bunching response) presented above.

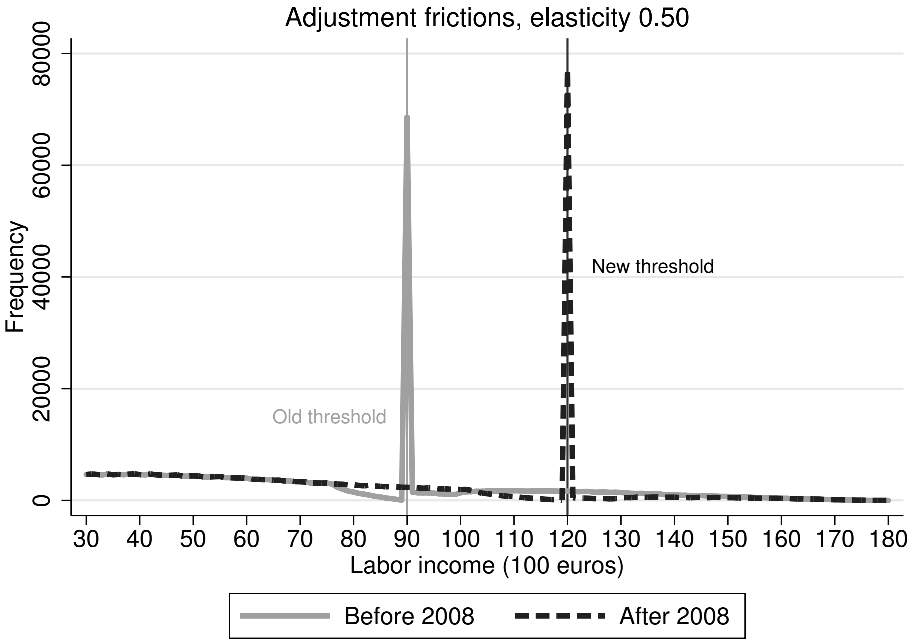

Figure 10: Simulated income distribution with adjustment frictions

Another friction discussed in the literature is that some taxpayers face idiosyncratic shocks to their earnings. In our simulation, we model idiosyncratic shocks as i.i.d. normal distributed mean zero earnings shocks with a standard deviation of 800 euros. In the model, the shocks occur after individuals have made their optimal earnings choices.

After adding i.i.d shocks to the model, local bunching is now more diffuse and more individuals are located in the dominated region (Figure 11). Therefore, i.i.d. shocks combined with adjustment frictions could at least qualitatively explain these features in the empirical distribution near the income threshold.[12] However, these simulated distributions still do not match the empirical distribution. The main missing feature is

[12]If we were to assume only negative income shocks, we would get diffuse bunching only below the

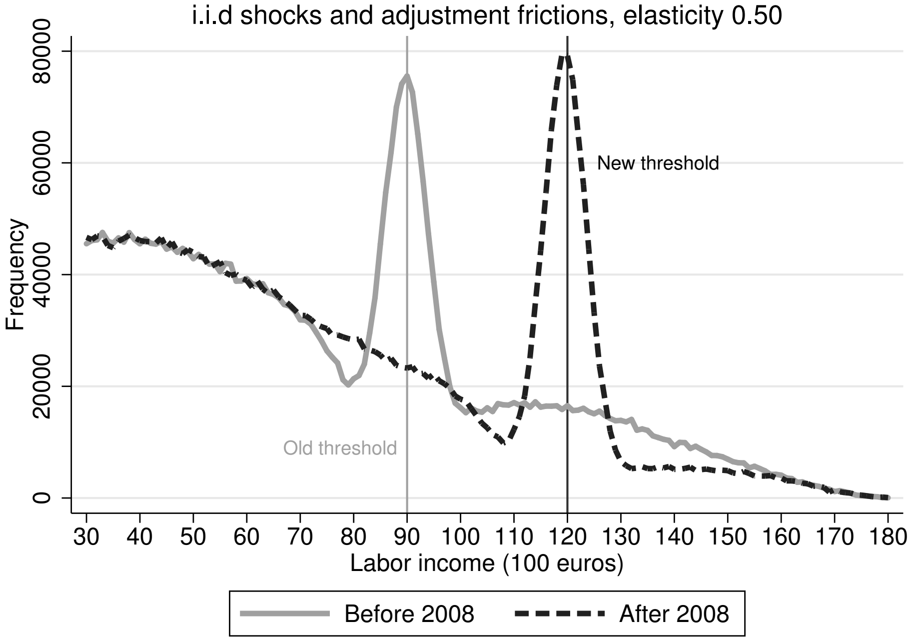

Figure 11: Simulated income distribution with i.i.d. earnings shocks and adjustment frictions

the change in the shape of the overall earnings distribution following a change in the location of the notch.

Discrete earnings choices

Next, we add to the baseline model discrete earnings choices as a constraint to individuals' behavior. In our model, we start from the baseline framework presented above, but limit the earnings choices of each individual to a discrete set of available earnings. The model thus follows the structure presented in equation (4).

The earnings choices are drawn from a power distribution weighing the lower income choices but spanning the whole income range, presented in Figure 12. The large mass in the probability distribution at small earnings ensures that each individual has at least one choice that gives positive utility with positive earnings. The thick tail in the distribution ensures that there is another available choice at a higher income level, although the specific location of this choice can vary significantly across different draws.

We iterate the model multiple times, and in each round draw new available earnings choices. Thus, the resulting earnings distribution for the full population is continuous, although one individual faces only discrete and limited number of possible earnings choices.

Figure 13 illustrates the properties of the model by showing the income distribution using 30, 15, 10 and 5 available choices for each individual and the elasticity to disutil-

notch, similarly as in the empirical distribution. However, modeling shocks such that they affect earnings only to a certain direction is more difficult to justify from a theoretical perspective.

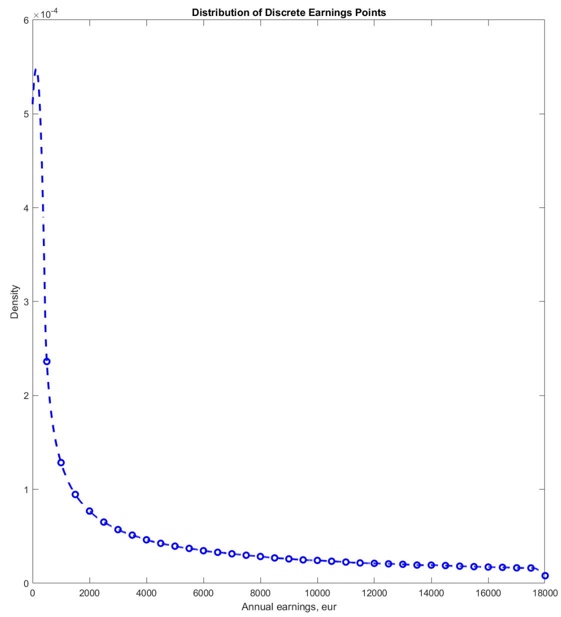

Figure 12: The underlying probability distribution of earnings choices

ity of income supply parameter, e, of 0.7. The upper-right graph shows that using 30 available choices produces somewhat diffuse but still quite pronounced local bunching. The distributions with 30 discrete choices are already of quite different shape than those obtained in the adjustment friction and i.i.d. shock model presented above. When the number of discrete choices are reduced to 15 or 10 (upper-left and lower-right graphs), the qualitative shape of the distribution starts to resemble the empirical one in that the amount of excess mass below the threshold relative to the rest of the distribution seems to be on the same order of magnitude, and more importantly, that the distribution shifts in the simulated reform to the right from relatively wide income range. For example, with 10 available choices the average space between two discrete earnings choices would be slightly more than 2,000 euros (in the income range of 0–25,000 euros). This roughly corresponds to the monthly wage a typical student would receive from working 40 hours a week. These findings suggest that in order to be able to simulate an income distribution that matches the shape of the empirical distribution and the change following the shifting out of the notch, we need relatively sparse earnings choices. This supports the role of discrete earnings choices in explaining our empirical findings. However, when further cutting down the number of choices to 5, we observe hardly any local bunching and only limited changes in the shape of the distribution. This intuitively suggests that a very small number of available choices attenuates any types of observed responses to tax incentives, and in our simulation turn out to be too sparse choice set.

Table 3 collects the estimates for the overall change in the earnings distribution using different assumptions on the number of available discrete earnings choices and the elas-

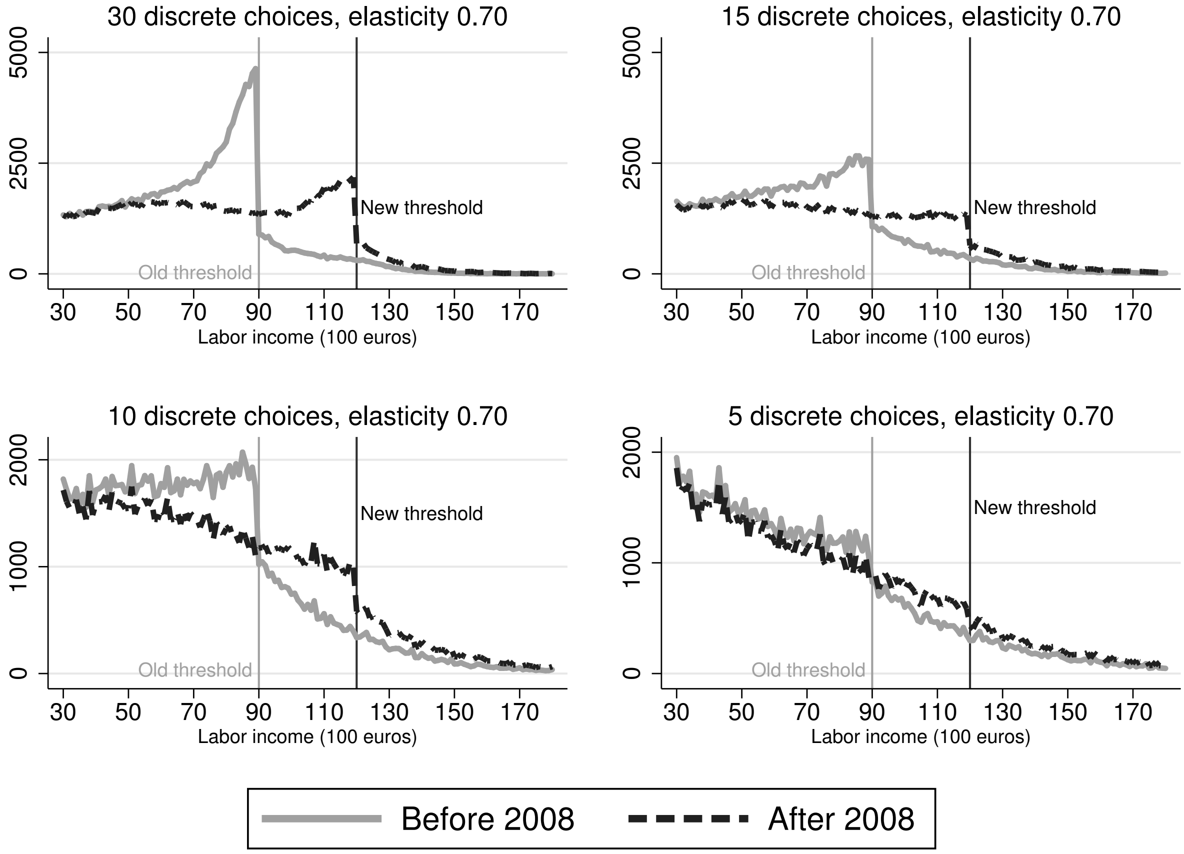

Figure 13: Simulated income distributions with different numbers of discrete earnings choices

ticity parameter. When estimating broader changes in the distribution for the simulated observations, we set the upper limit of the earnings distribution to be 2,000 below the old income threshold, at 7,200 euros, thus capturing potential changes in the shape of the distribution below the local bunching region. Thus, we consider the amount of change in the density of income distribution according to equation (1) from before to after the simulated reform in the income range of 0-7,200 euros. Overall, the table shows that there is a larger overall shift in the distribution when the number of discrete choices is increased to 15, but starts to decline with 20 or more earnings choices. Intuitively, a larger number of available choices increases local bunching but decreases responses that we observe further below the threshold. The table shows that we can assume quite large elasticity parameter for disutility of income supply, e, in order to maximize the amount of shifting. However, with very high parameter values makes the distribution becomes concentrated at low incomes, and thus the resulting distribution does not seem credible in that regard anymore.

Of course, the simulated distributions above do not provide a perfect match for the empirical distribution, and it is difficult to assign an unambiguous number of discrete

Simulated distributions	*Discrete choices:5*	*Discrete choices:10*	*Discrete choices:15*	*Discrete choices:20*	*Discrete choices:30*
Elasticity: 0.4	2.18 (5.30)	3.60 (4.09)	4.04 (3.85)	3.91 (3.88)	3.17 (4.28)
Elasticity: 0.5	2.67 (5.00)	4.33 (4.03)	4.83 (3.80)	4.67 (3.83)	3.78 (4.37)
Elasticity: 0.6	3.11 (5.04)	4.96 (3.70)	5.51 (4.00)	5.31 (3.82)	4.28 (4.42)
Elasticity: 0.7	3.49 (5.23)	5.49 (3.70)	6.07 (3.91)	5.83 (3.73)	4.69 (4.58)
Elasticity: 0.8	3.81 (5.08)	5.94 (4.03)	6.53 (3.78)	6.25 (3.70)	5.01 (4.24)
Elasticity: 0.9	4.08 (4.77)	6.29 (3.63)	6.89 (3.26)	6.59 (3.65)	5.26 (4.35)
Elasticity: 1.10	4.46 (4.78)	6.73 (3.52)	7.35 (3.58)	7.02 (3.44)	5.59 (3.99)
Elasticity: 1.25	4.61 (4.64)	6.87 (3.51)	7.50 (3.18)	7.15 (3.30)	5.71 (3.93)

Table 3: Estimates in different specifications (standard errors in parenthesis)

choices and a disutility parameter that would perfectly match our empirical distribution. In order to do that, we would perhaps need to include additional features to the model, such as uncertainty over future earnings, income effects, adjustment frictions and random income shocks. However, our main point in this section is not to build a model that would perfectly match the income distribution we observe, but to show that discrete choices are an essential element of the model if we want to achieve even a qualitative match with our empirical findings. In our view, the key finding is that the number of discrete choices that best matches the empirical distribution is low indicating a relatively sparse choice set.

5 Discussion

In this paper, we studied the income responses of taxpayers facing an income notch and shifting of the notch to a higher income level. The analysis reveals that individuals can face significant restrictions in their available earnings choices.

The notch is created by income thresholds in study subsidy system for Finnish university students working in the part-time labor market. The shifting of the notch occurred in the 2008 reform, where the income thresholds were increased by 30% while keeping the subsidies otherwise constant. We find clear and immediate earnings responses in a wide income range below the study subsidy income notch when the location of this income threshold was increased. Robustness checks utilizing other groups of taxpayers not affected by the reform suggest that the shifting of the income distribution was causally affected by the shifting of the notch, as we do not detect any changes in the shape of the earnings distribution for other young part-time workers at the time of the reform. Thus, earnings responses of students are caused by changes in incentives rather than other changes in the overall part-time labor market in Finland.

This finding is consistent with discrete earnings choices that prevent taxpayers from responding to incentives by marginally adjusting their earnings. We shows that these findings cannot be explained with inattention, salience or optimization errors that are typically discussed in the literature. We develop a simulation model that includes discrete earnings choices as a constraint to the behavior of taxpayers. We calibrate the model to the empirical income distribution and it's shifting in the reform. The calibrated model that best fits the data has relatively sparse number of discrete earnings locations, only 15 in the income range between 0 and 25 000 euros. Thus, the discreteness seems to be a serious constraint even in the relatively flexible part-time labor market where university students earn their income.

References

[1] Bastani, S. and H. Selin (2014). Bunching and non-bunching at kink points of the Swedish tax schedule. Journal of Public Economics, 109: 36–49.

[2] Blomquist, S. and W. Newey (2017). The Bunching Estimator Cannot Identify the Taxable Income Elasticity. NBER Working Paper 24136.

[3] Blundell, R. and A. Shepard (2012). Employment, hours of work and the optimal taxation of low income families. Review of Economic Studies, 79: 481-510.

[4] Blundell, R. and H. Hoynes (2004). Has in-work benefit program helped the labor market?, in Blundell, R. D. Card and R. Freeman (eds.)., Seeking a Premier Economy: The Economic Effects of British Economic Reforms, 1980-2000. Chicago: Chicago University Press, 2004.

[5] Chetty, R., J. Friedman and E. Saez (2013). Using differences in knowledge across neighborhoods to uncover the impacts of the EITC on earnings. American Economic Review, 103(7): 2683-2721.

[6] Chetty, R. and E. Saez (2013). Teaching the tax code: Earnings responses to an experiment with EITC recipients. American Economic Journal: Applied Economics, 5(1): 1–31.

[7] Chetty, R. (2012). Bounds on elasticities with optimization frictions: A synthesis of micro and macro evidence on labor supply. Econometrica, 80(3): 969-1018.

[8] Chetty, R., J. Friedman, L. Pistaferri and T. Olsen (2011). Adjustment costs, firm responses, and micro vs. macro labor supply elasticities: Evidence from Danish tax records. Quarterly Journal of Economics, 126(2): 749-804.

[9] Chetty R., A. Looney and K. Kroft (2009). Salience and taxation: Theory and evidence. American Economic Review, 99(4): 1145-1177.

[10] Dickens, W., T., and S.J. Lundberg (1993). Hours Restrictions and Labor Supply. International Economic Review, 34 (1), 169–192.

[11] Gelber, A., D. Jones and D.W. Sacks (2017a). Estimating Earnings Adjustment Frictions: Method and Evidence from the Social Security Earnings Test. GSPP Working Paper.

[12] Gelber, A., D. Jones, D.W. Sacks and J. Song (2017b). Using Kinked Budget Sets to Estimate Extensive Margin Responses: Method and Evidence from the Social Security Earnings Test. Working Paper.

[13] Gruber, J. and D. Wise (1998). Social security and retirement: An international comparison. The American Economic Review, 88(2) Papers and Proceedings of the Hundred and Tenth Annual Meeting of the American Economic Association: 158-163.

[14] Kleven, H. (2016). Bunching. Annual Review of Economics, Vol. 8, 2016.

[15] Kleven, H. and M. Waseem (2013). Using notches to uncover optimization frictions and structural elasticities: Theory and evidence from Pakistan. Quarterly Journal of Economics, 128: 699-723.

[16] Löffler, M., A. Peichl and S. Siegloch (2018). The Sensitivity of Structural Labor Supply Estimations to Modeling Assumptions. ifo Working Papers 259/2018.

[17] Manoli, D. and A. Weber (2012). Nonparametric evidence on the effects of financial incentives on retirement decisions. NBER Working Paper 17320.

[18] Reck, D. (2014). Taxes and Mistakes: What's in a sufficient statistic? Working Paper.

[19] Saez, E. (1999). Do Taxpayers Bunch at Kink Points? NBER Working Papers 7366, National Bureau of Economic Research.

[20] Saez, E. (2002). Optimal Income Transfer Programs: Intensive Versus Extensive Labor Supply Responses, Quarterly Journal of Economics, 117: 1039-1073.

[21] Saez, E. (2010). Do taxpayers bunch at kink points? American Economic Journal: Economic Policy, 2(3): 180-212.

[22] Saez, E., J. Slemrod and S. Giertz (2012). The elasticity of taxable income with respect to marginal tax rates: A critical review. Journal of Economic Literature, 50(1): 3-50.

[23] Sallee, M. and J. Slemrod (2012). Car notches: Strategic automaker responses to fuel economy policy. Journal of Public Economics, 96: 981-999.

[24] Slemrod, J. (2010). Buenas notches: Lines and notches in tax system design. Working Paper.

[25] Yelowitz, A. (1995). The Medicaid notch, labor supply and welfare participation: Evidence from eligibility expansions. Quarterly Journal of Economics, 110: 909-939.

[26] Zaresani, A. (2017). Adjustment Costs and Incentives to Work: Evidence from a Disability Insurance Program. Working Paper.

Appendix A

	Before 2008 (academic year 2006/2007)		After 2008 (academic year 2008/2009)	
Study subsidy months	Income limit	Relative income loss at the margin if income limit is exceeded	Income limit	Relative income loss at the margin if income limit is exceeded
1	17,340	3.1%	22,550	2.5%
2	16,330	3.2%	21,190	2.7%
3	15,320	3.5%	19,930	2.9%
4	14,310	3.7%	18,620	3.1%
5	13,300	4.0%	17,310	3.3%
6	12,290	4.3%	16,000	3.6%
7	11,280	4.7%	14,690	3.9%
8	10,270	5.2%	13,380	4.3%
9	9,260	5.7%	12,070	4.8%

Note: The relative loss from marginally exceeding the income limit is calculated using the full study subsidy (461 euros and 500 euros before and after 2008, respectively) plus 15% interest collected by the Social Insurance Institution.

Table A1: Income limits in the study subsidy system and the relative marginal loss if the income limit is exceeded (in proportion to gross income at the limit)

	Individual characteristics				
	Age	Female	Labor income	Share with labor income > 500	Share with one employer
Mean	36.4	.48	25,912	.60	.81
Median	37	0	24,152	1	1
sd	8.914	.499	29,241	.49	.39
N	29,261,269	29,261,269	24,634,474	39,206,269	31,383,598
	Field of industry				
	Industry	Services	Admin. & Publ. Sector	Other/missing	
Mean	.27	.13	.42	.17	
sd	.44	.34	.49	.37	
N	39,206,521	39,206,521	39,206,521	39,206,521	

Table A2: Descriptive statistics, non-students aged 19–50, 1999–2013

	Individual characteristics				
	Age	Female	Labor income	Share with labor income > 500	Share with one employer
Mean	21	.56	8,318	.93	.62
Median	21	1	6,741	1	1
sd	1.710	.496	7,229	.25	.48
N	940,786	940,786	932,572	940,786	940,786
	Field of industry				
	Industry	Services	Administration & Publ. Sector	Other/missing	
Mean	.31	.22	.41	.06	
sd	.46	.41	.49	.24	
N	940,786	940,786	940,786	940,786	

Table A3: Descriptive statistics, non-student part-time workers aged 19–24, 1999–2013

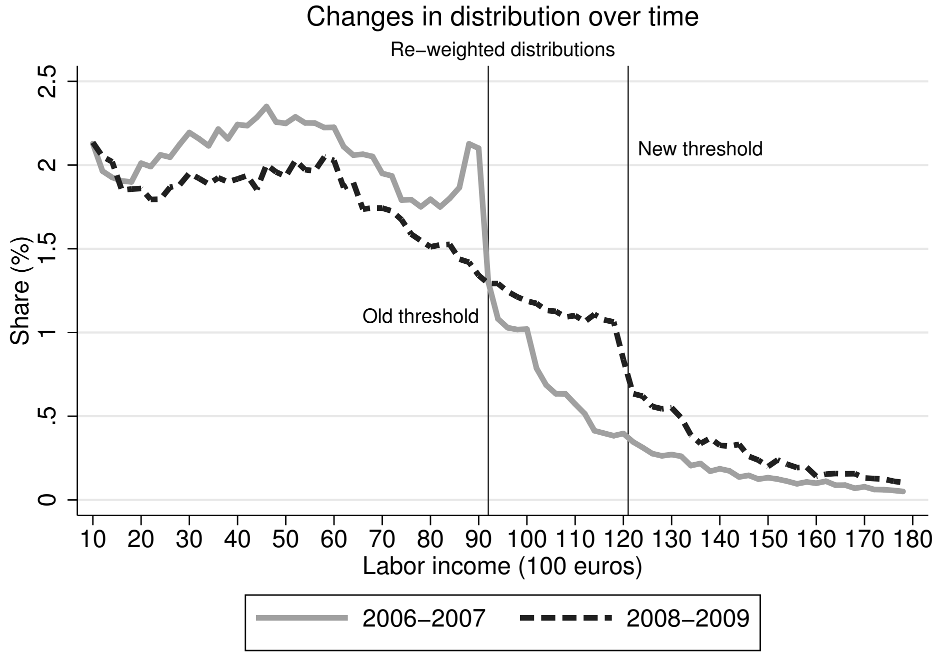

Figure A1: Labor income distributions before and after the reform, re-weighted distribution in 2006–2009. Bin-level inverse probability weighting using age, field of study and field of industry. The base-year is set to 2006.

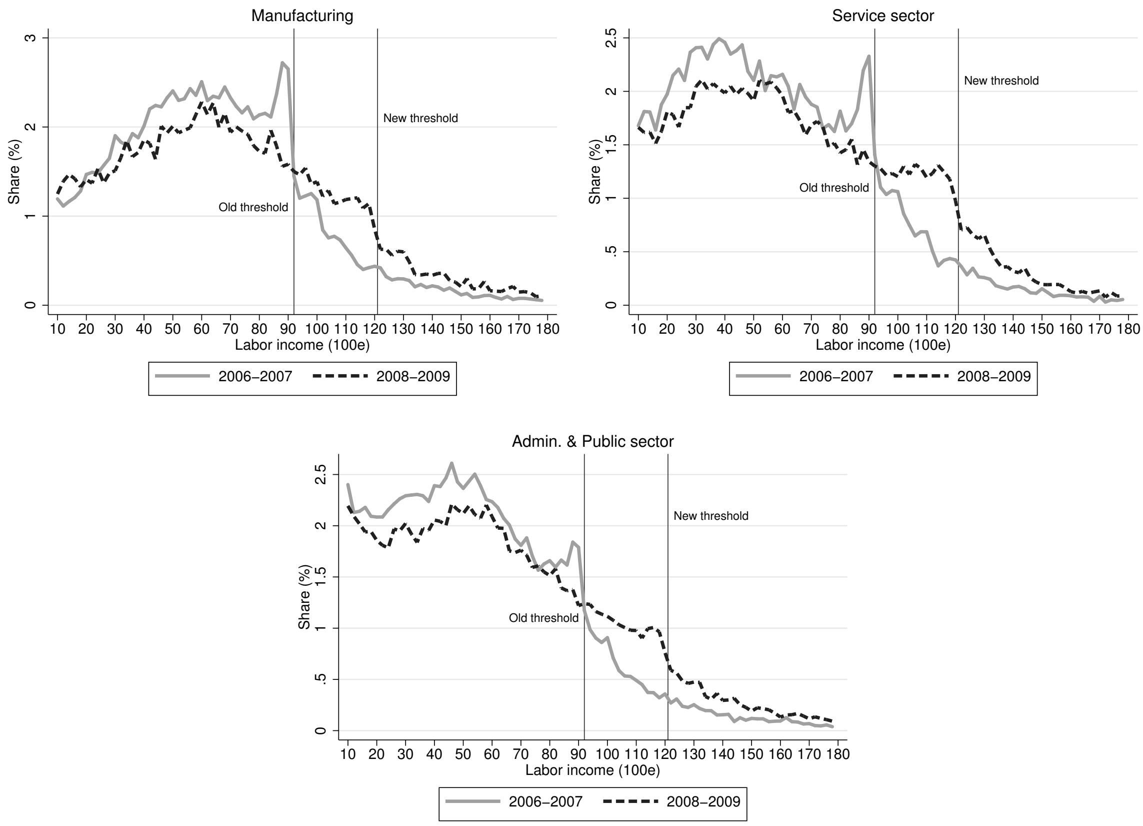

Figure A2: Labor income distributions before and after 2008 for students working in different industries

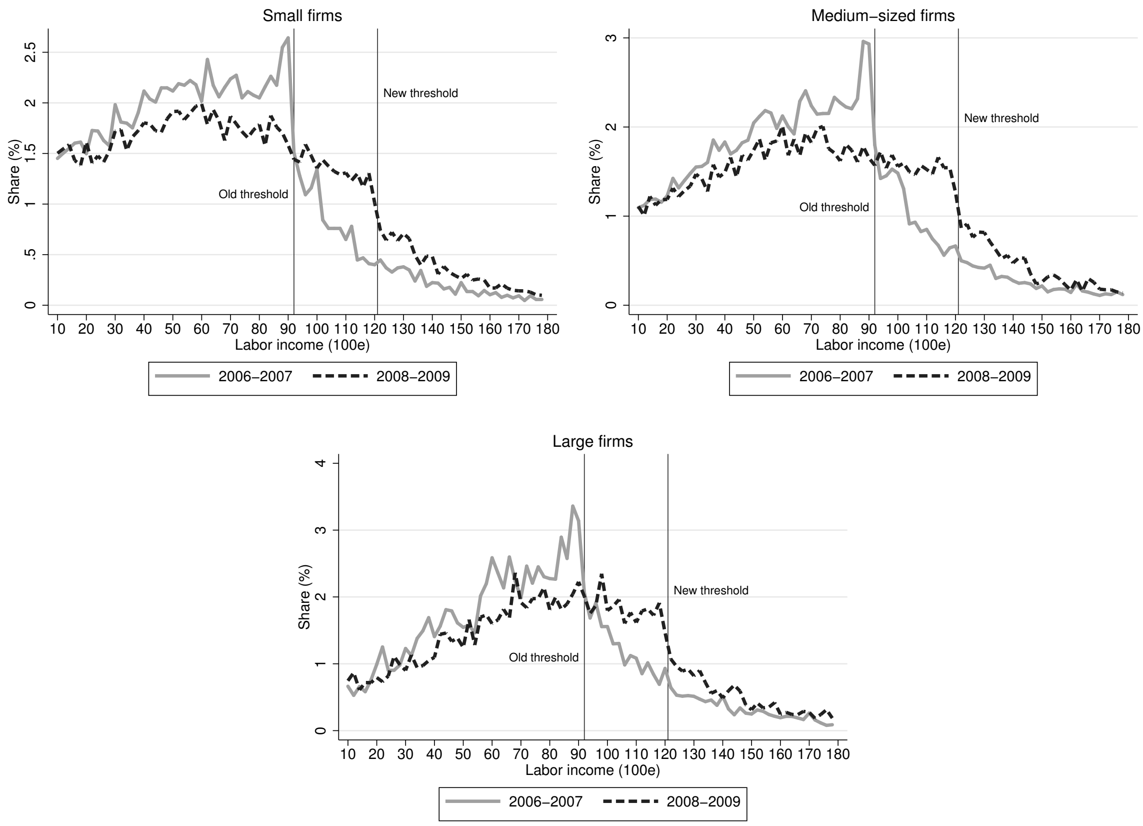

Figure A3: Labor income distributions before and after 2008 for students working in different sized firms (terciles based on firm turnover)

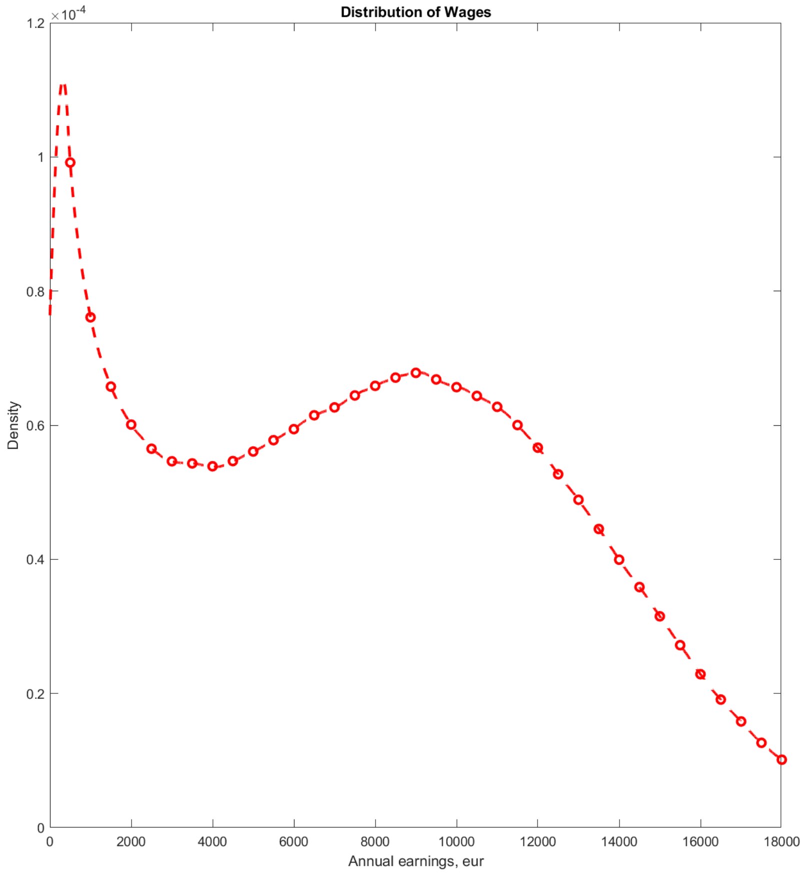

Figure A4: Underlying earnings distribution in the absence of taxes

Appendix B

Local bunching

Estimating local bunching.

We measure local responses to the notch caused by the income threshold following the standard bunching approach in Kleven and Waseem (2013). The local counterfactual density is estimated by fitting a flexible polynomial function to the observed distribution, excluding an area around the study subsidy income threshold z^* from the observed income distribution, and group students into income bins of 100 euros. We then estimate a counterfactual density by excluding the region $[z_L, z_H]$ around the threshold from the regression:

$$c_j = \sum_{i=0}^{p} \beta_i (z_j)^i + \sum_{i=z_L}^{z_H} \eta_i \cdot \mathbf{1}(z_j = i) + \varepsilon_j \tag{5}$$

where c_j is the count of firms in bin j, and z_j denotes the income level in bin j. The order of the polynomial is denoted by p. Thus the fitted values for the counterfactual density are given by $\hat{c}_j = \sum_{i=0}^{p} \beta_i (z_j)^i$. The local excess bunching is then estimated by relating the actual number of firms close to the threshold within (z_L, z^*) to the estimated counterfactual density in the same region:

$$\hat{b}(z^*) = \frac{\sum_{i=z_L}^{z_L} (c_j - \hat{c}_j)}{\sum_{i=z_L}^{z_L} \hat{c}_j / N_j} \tag{6}$$

where N_j is the number of bins within $[z_L, z^*]$.

Following Kleven and Waseem (2013), we set the lower limit of the excluded region (z_L) based on visual observations of the income distribution to represent the point in the income distribution where the bunching behavior begins, that is, when the density begins to increase. We determine z_H such that the estimated excess mass, $\hat{b}_E(z^*) = (\sum_{i=z_L}^{z^*} c_j - \hat{c}_j)$, equals the estimated missing mass above the threshold, $\hat{b}_M(z^*) = (\sum_{i=z>z^*}^{z_H} \hat{c}_j - c_j)$, stemming from individuals above the income threshold responding to the notch by bunching below it. We apply this convergence condition by starting from a small value of z_H, and increasing it gradually until $\hat{b}_E(z^*) \approx \hat{b}_M(z^*)$. This convergence condition also defines the marginal buncher student with income $z^* + \triangle z$, representing the student with highest earnings in the absence of the notch who responds by locating below the income threshold.

Following Kleven and Waseem (2013), we calculate standard errors for all the estimates using a residual-based bootstrap procedure. We generate a large number of income distributions by randomly resampling the residuals from equation (5) with replacement, and generate a large number of new estimates of the counterfactual density based on the resampled distributions. Based on the bootstrapped counterfactual densities, we evaluate variation in the estimates of interest. The standard errors for each estimate are defined as the standard deviation in the distribution of the estimate.

Local bunching responses.

We find clear local responses to the income threshold of the study subsidy program. Figure B1 shows the gross income distribution and the counterfactual distribution relative to the notch in bins of 100 euros in the range of +/- 6,000 euros from the notch in 1999–2013. The dashed vertical line denotes the notch point above which a student loses one month of the subsidy. The solid vertical lines denote the excluded range used in the estimation of the counterfactual, which is estimated using a 7th-order polynomial function. The dash-point vertical line above the notch shows the upper limit for the dominated region just above the notch where students can increase their net income by lowering their gross income.

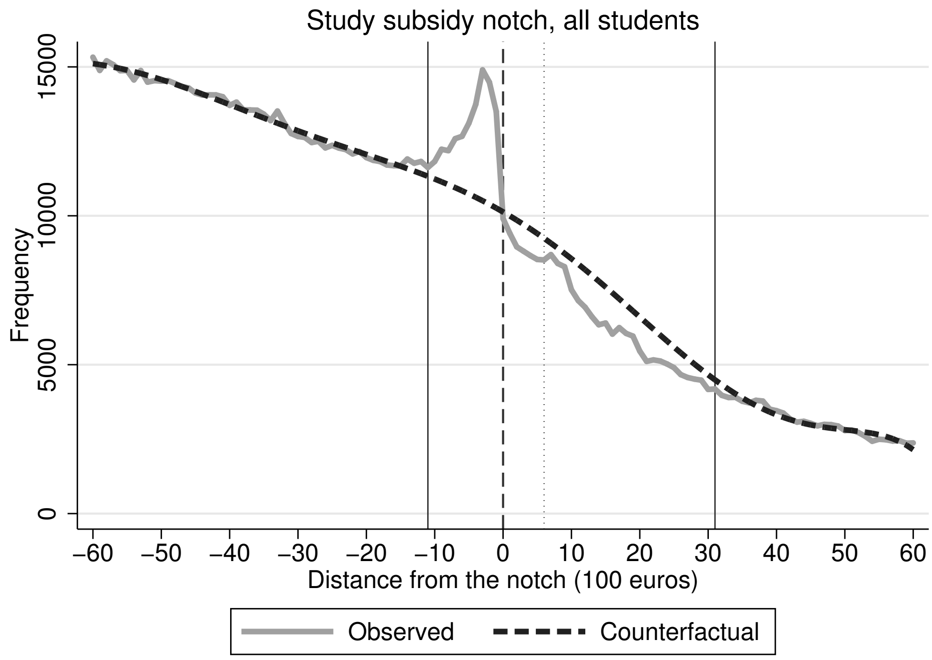

Figure B1: Local bunching at the study subsidy notch, 1999–2013

Figure B1 indicates a visually clear and statistically significant excess mass (estimate 2.19 (0.189)) below the income threshold for all students. This implies that students are both aware of the notch and respond to the strong local incentives created by it. In addition, there is clear evidence of the existence of some types of frictions. There is an economically and statistically significant mass of students – .915 (.027) of the mass compared to the counterfactual – at the locally dominated region where no students should locate in the absence of any types of frictions (Kleven and Waseem 2013). Furthermore, even though the study subsidy schedule ultimately consists of multiple notches, we observe a distinctive response only to the first income threshold they face.

Figure B2 shows the local bunching responses before (1999–2007) and after (2008–2013) the 2008 reform.The figure shows that local excess bunching is slightly larger before (2.55 (0.228)) than after (1.71 (0.882)) the reform. One explanation for this is that local incentives not to exceed the notch are somewhat smaller after 2008, since the relative significance of losing one month's subsidy in terms of disposable income is now smaller than before 2008 when the threshold was at a lower income level.

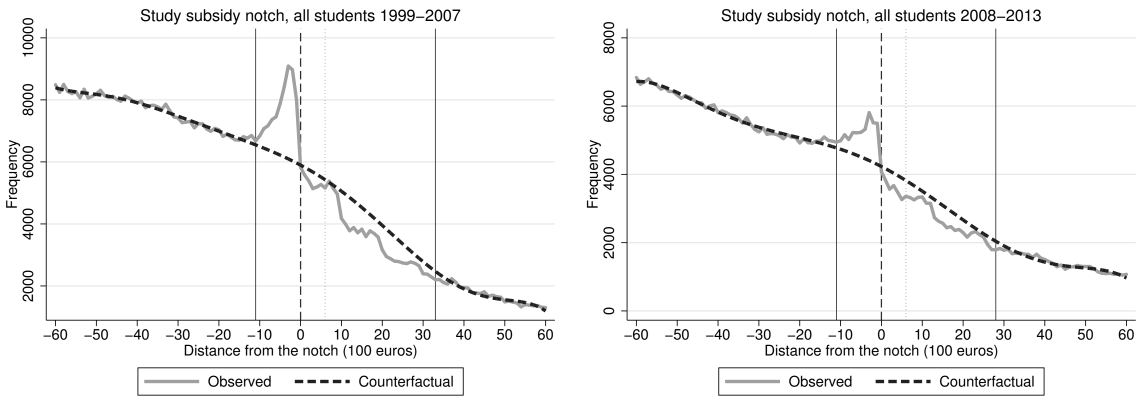

Figure B2: Bunching at the study subsidy notch: Before and after the reform of 2008