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Philippe Ruh
University of Zurich

Stefan Staubli
University of Calgary, CEPR, IZA and NBER

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IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Financial Incentives and Earnings of Disability Insurance Recipients: Evidence from a Notch Design*

Most countries reduce Disability Insurance (DI) benefits for beneficiaries earning above a specified threshold. Such an earnings threshold generates a discontinuous increase in tax liability – a notch – and creates an incentive to keep earnings below the threshold. Exploiting such a notch in Austria, we provide transparent and credible identification of the effect of financial incentives on DI beneficiaries' earnings. Using rich administrative data, we document large and sharp bunching at the earnings threshold. However, the elasticity driving these responses is small. Our estimate suggests that relaxing the earnings threshold reduces fiscal cost only if program entry is very inelastic.

JEL Classification: H53, H55, J14, J21

Keywords: disability insurance, labor supply, benefit notch, bunching

Corresponding author:
Stefan Staubli
University of Calgary
Department of Economics
2500 University Dr. N.W.
Calgary, AB, T2N 1N4
Canada

E-mail: sstaubli@ucalgary.ca

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1 Introduction

Disability Insurance (DI) programs are among the largest social insurance programs. In OECD countries, total expenditures on disability benefits account for approximately 2.5 percent of GDP (OECD, 2010). In many DI programs, beneficiaries lose part or all of their benefits if earnings exceed a substantial gainful activity (SGA) threshold. This policy induces a discontinuous increase in the (implicit) tax liability—a notch—and creates an incentive for beneficiaries to keep their earnings just below the SGA threshold to retain benefits. If bunching at the SGA threshold is widespread, then policies that relax the notch could increase work effort among DI beneficiaries, potentially improving their economic well-being and their autonomy while reducing dependency on benefits.[1] Yet, these policies could create unintended costs if they induce more individuals to seek disability benefits. Despite numerous anecdotes on the work disincentives induced by the SGA threshold, there is little empirical evidence on the impact of the SGA threshold, and financial incentives in general, on the labor supply of beneficiaries.[2]

This paper helps to close this gap by investigating whether earnings thresholds induce DI recipients to adjust their labor supply. Our estimation strategy exploits quasi-experimental variation in the implicit tax on work in Austria's DI program. Specifically, DI beneficiaries in Austria can earn up to an SGA threshold of €439 per month (around USD 500) without losing benefits. However, if monthly earnings exceed the SGA threshold by €1, then DI benefits are reduced by up to 50 percent in that month. This notch creates a strong incentive for many DI beneficiaries to bunch on the low-earnings side of the SGA threshold. As shown by Saez (2010), the amount of bunching can be used to estimate an elasticity of earnings with respect to the net-of-tax rate. However, observed bunching might be attenuated if some individuals do not respond because of optimization frictions such as adjustment costs and inattention. The structural earnings elasticity, the elasticity absent frictions, is likely to be larger. Kleven and Waseem (2013) show that one advantage of a

[1] Many countries are considering or have recently implemented policy reforms designed to increase work incentives for DI recipients. For example, the U.S. is currently testing a benefit offset policy that reduces benefits by $1 for every $2 of earnings above the SGA threshold, rather than fully suspend benefits. Switzerland tested a conditional cash program that offered DI recipients a cash payment if they take up or expand employment and reduce disability benefits (see Bütler et al., 2015, for an evaluation of the program). Other recent examples include the United Kingdom and Norway (see Kostol and Mogstad, 2014).

[2] For example, the article "Disability Insurance: Not Working" in the magazine *the Economist* (issue from January 24, 2015) provides anecdotal evidence for such behavior in the U.S. Social Security Disability Insurance. Empirical evidence is provided by Schimmel et al. (2011); Weathers and Hemmeter (2011); Campolieti and Riddell (2012); Kostol and Mogstad (2014) (discussed in detail below).

notch design, as opposed to a kink design, is the ability to estimate a structural elasticity because a notch creates a region of strictly dominated choices on the high-earnings side of the SGA threshold. In this range, beneficiaries can increase both total net income and leisure by moving to the SGA threshold. Thus, we can use the number of people who locate in the dominated region to recover the structural elasticity, because in a frictionless world this region should be empty.[3]

Two features make the SGA threshold in Austria advantageous for studying how earnings respond to financial incentives. First, the increase in tax liability at the SGA threshold is salient and large in magnitude. The average DI beneficiary loses around 10 percent of his or her total after-tax income if earnings exceed the SGA threshold by €1. Having large variation in tax liability allows us to identify behavioral responses even if they are small. Detecting behavioral responses would be more difficult in other contexts because earnings rules are typically more complex and therefore less salient.[4] Second, bunching below the SGA threshold can be difficult to detect in administrative data, because earnings are measured at the annual level while the SGA threshold is specified at the monthly level. Hence, recipients who bunch at the SGA threshold only for some months of the year would not appear to bunch in annual data. In contrast, our administrative data from social security and tax registers allow us to measure earnings and DI benefits at the monthly level. Moreover, since sample sizes are large, we can graphically demonstrate bunching, providing transparent evidence of the behavioral response.

A notch may also create behavioral responses along the extensive margin, i.e. the decision of whether to participate in the labor force. We identify the causal impact of the SGA threshold on the extensive margin decision by exploiting a policy change that relaxed earnings restrictions significantly. Since the change in law affected only a subsect of DI beneficiaries, we can estimate

[3]Recent studies relying on notches in the budget set examine such diverse topics as earnings adjustments to income and payroll taxes (Kleven and Waseem 2013; Tazhitdinova 2017), automaker responses to fuel economy regulations (Sallee and Slemrod 2012; Ito and Sallee 2016), the impact of transfer taxes on the real estate market (Kopczuk and Munroe, 2015; Best and Kleven, 2016), the effect of tax credits on retirement savings and income (Ramnath, 2013), the labor supply effects of social security (Brown, 2013; Manoli and Weber, 2016), and firm responses to stricter tax enforcement (Almunia and Lopez Rodriguez, 2017). See Kleven (2016) for a review of the bunching approach and the related literature. Our paper contributes to this literature by studying behavioral responses at a notch in the disability benefit schedule.

[4]For example, beneficiaries in the public DI program in the U.S. can earn above the SGA for nine months (not necessarily consecutive) over any five-year period. After exhausting the nine-months period, beneficiaries enter the extended period of eligibility (EPE). If earnings are above the SGA threshold during the EPE, benefits are paid for three additional months, but are suspended in full thereafter during each month that beneficiaries earn above SGA. If earnings are above the SGA three years after entering the EPE, benefits are terminated. Abeler and Jäger (2015) provide evidence that individuals underreact to complex tax rules relative to less complex ones.

the extensive margin response using a difference-in-differences approach. Such responses could also introduce a bias in our estimate of the earnings elasticity, because they lower the observed earnings distribution above the SGA threshold. To investigate the impact of extensive margin responses on the earnings elasticity, we perform Monte Carlo simulations in which the data are generated by a utility function allowing for extensive margin responses.

The insights from our empirical analysis can be summarized by six broad conclusions. First, there is large and sharp bunching in DI beneficiaries' earnings just below the SGA threshold. If the SGA threshold did not exist, beneficiaries who bunch at the SGA threshold would earn on average €196 more per month. This represents a 45 percent increase relative to the SGA earnings level. Bunching is very persistent over time; almost 60 percent of those who bunch after entering the program continue to do so five years later. Second, we observe that many beneficiaries locate in the dominated region, implying that observed bunching is attenuated by frictions. Over time beneficiaries leave the dominated region quickly and most move to the SGA threshold. Third, even though the estimated earnings response is large, the implied structural earnings elasticity is small. We estimate an earnings elasticity of 0.27. Our elasticity is higher than estimates found in studies that examine bunching in the income tax schedule, but it is in line with estimates found in studies that examine bunching in contexts other than the income tax.[5] We also find significant heterogeneity in the responsiveness to financial incentives across subgroups. Women, younger age groups, and beneficiaries with low benefits are more responsive to financial incentives than men, older age groups, and beneficiaries with high benefits. Fourth, we find that the SGA threshold creates sizeable extensive margin responses. DI beneficiaries who face relaxed earnings restrictions after the reform increase their labor force participation by 6.7 percentage points. In contrast, only 2.3 percent of beneficiaries participate in the labor force before the reform. Fifth, the Monte Carlo simulations reveal that the bunching estimator performs well in our application. Even though we study a large notch, the bias from extensive margin responses is small. Sixth, the magnitude of our estimates implies that relaxing the earnings restrictions would increase labor force participation and earnings among current beneficiaries. However, overall government expenditures would likely

[5] Saez (2010), Chetty et al. (2011), le Maire and Schjening (2013), Kleven and Waseem (2013), and Bastani and Selin (2014) find elasticities between 0-0.05 for wage earners using kinks and notches in the income tax schedule. Gelber et al. (2013), Tazhitdinova (2017), and Le Barbanchon (2016) estimate earnings elasticities between 0.1-0.35 relying on kinks in the U.S. Social Security program, notches in the "Mini-Job" program for low-income earners in Germany, and kinks in the U.S. unemployment insurance, respectively.

increase as more individuals would seek DI benefits.

Our paper is primarily related to the literature on policy reforms that provide financial work incentives for DI beneficiaries. Hoynes and Moffitt (1999) simulate the financial impacts of potential reforms to the DI program and conclude that the effects on work effort are often not as strong as expected. Consistent with this view, Schimmel et al. (2011) find that the increase in the monthly SGA threshold from USD 500 to USD 700 in the U.S. had only a small impact on beneficiaries' earnings. However, more recent evidence suggests that some policies can be effective at increasing employment. Campolieti and Riddell (2012) find that the introduction of an annual earnings exemption of CAD 3,800 in Canada increased disability beneficiaries' propensity to work, but did not influence program inflow or outflow. Weathers and Hemmeter (2011) find that a pilot project in the U.S. that replaced the notch at the SGA threshold with a gradual reduction in benefits led to a 25 percent increase in the number of beneficiaries with earnings above the SGA amount. Kostol and Mogstad (2014) also document that financial incentives in Norway's DI program increased earnings and disposable income of beneficiaries.

Our paper is also related to the literature on the work potential of DI beneficiaries, documenting that DI receipt reduces labor force participation and earnings (e.g., Bound, 1989; Chen and van der Klaauw, 2008; von Wachter et al., 2011; Maestas et al., 2013; French and Song, 2014). Since these studies use rejected applicants as a control group, they provide a good estimate for the employment potential of beneficiaries at the time of applying. There is less evidence on the employment potential of beneficiaries who have been on the program for some time with the exception of Borghans et al. (2014), Moore (2015), and Gelber et al. (2017). Using administrative data from the Netherlands, Borghans et al. (2014) find that more stringent DI rules increase earnings by €0.62 per euro of lost DI benefits among existing DI recipients. Moore (2015) documents a strong increase in earnings among individuals in the U.S. who lost DI eligibility after the removal of drug and alcohol addictions as qualifying conditions. Approximately 22 percent of terminated beneficiaries started working at levels above the SGA threshold. Gelber et al. (2017) find that an income effect accounts for most DI-induced reductions in earnings among beneficiaries.

This paper proceeds as follows. Section 2 describes Austria's DI program. Section 3 outlines the bunching methodology and summarizes the data. Section 4 shows descriptive evidence for bunching at the SGA threshold and presents estimates for the earnings elasticity. Section 5 presents estimates for the extensive margin response. Section 6 describes our Monte-Carlo exercise to assess the performance of the bunching approach. Section 7 calculates the fiscal effects of hypothetical policy reforms. Section 8 concludes.

2 Institutional Background

2.1 The Austrian DI Program

The DI program is one of the largest transfer programs in Austria and part of the larger social security system, financed by a payroll tax on earned income. The program provides partial earnings replacement to workers who are unable to engage in substantial gainful activity due to a medically determinable health impairment that has lasted for at least six months. From 1985 to 2012, the percentage of the working age population receiving DI benefits in Austria has been stable between 4.3 and 5.3 percent, as shown in Figure 1. In contrast, over the same period, the rate of DI receipt in the U.S. increased from 2.2 to 5.3 percent.[6]

Figure 1

To apply for DI benefits, individuals must submit an application to the local DI office. Employees at the DI office first check the non-medical eligibility criteria for DI benefits. Only individuals who have contributed to the program for at least 5 years in the past 10 years and are not yet eligible for retirement benefits can apply for DI benefits. DI eligibility in Austria is not conditioned on earnings; individuals can continue to work while they apply for and receive benefits. If an applicant meets the nonmedical criteria, a team of disability examiners and physicians assesses the applicant's overall ability to work and the medical severity of the disability. A disability award is made to individuals whose earnings capacity, due to a physical or mental health impairment, has been reduced by more than 50 percent relative to that of a healthy person with comparable education.[7]

[6]Other countries have experienced similar or even more striking increases in disability recipiency rates as the U.S., from 2 percent to around 6 percent in Australia and Ireland, from 3 to 6 percent in the U.K., and from 6 to 10 percent in Norway.

[7]Medical criteria for disability classification are relaxed starting at age 57. See Staubli (2011) for the impact of this relaxation on labor force participation of older workers.

In 2012, the DI exit rate was 4.2 percent, which is lower than in many other countries.[8] There are three main ways to exit the program. First, DI claimants may no longer meet the medical or non-medical eligibility criteria for disability benefits. For example, their health status may improve such that the DI recipient is no longer disabled. In 2012, medical improvements and return to work accounted for 36.7 percent of program exits. Second, DI claimants may reach the full retirement age, at which point they can ask to be transferred to the old-age pension program. However, few beneficiaries do so because in most cases the old-age pension would be lower than the disability pension. In 2012, 12.8 percent of those who left the DI program were shifted to the old-age pension program. Third, the DI recipient may die. Death accounted for 50.5 percent of program exits in 2012.

DI benefits replace about 60 percent of pre-disability earnings up to a maximum of about €2,800 per month (around USD 3,190). Benefits are subject to income tax and mandatory health insurance contributions. The level of benefits depends on an assessment basis and a pension coefficient. The assessment basis corresponds to the average earnings over the best 20 years after applying a cap to earnings in each year. The pension coefficient is the percentage of the assessment basis that is received in the pension. The pension coefficient increases with the number of contribution years up to a maximum of 80 percent (roughly 45 contribution years). Applicants under age 60 qualify for a special increment if their pension coefficient is below 60 percent (around 25 percent of beneficiaries get a special increment).

2.2 The Substantial Gainful Activity Threshold

DI beneficiaries in Austria can earn each month up to a Substantial Gainful Activity (SGA) threshold without losing any benefits. That is, $\Delta s = 0$ if $z \leq z^*$ where s is gross monthly DI benefits, z is gross monthly labor earnings, and z^* is the monthly SGA threshold. However, DI recipients may lose a share of benefits in each month in which $z > z^*$, depending on the gross

[8] For example, the exit rate in the U.S. Social Security Disability Insurance is roughly double (Moore, 2015).

monthly income $(s+z)$. The loss in benefits if $z > z^*$ is calculated as follows:

$$\triangle s = \begin{cases} 0 & \text{if } s+z \leq K_1 \\ \min(0.3(s+z-K_1), z, 0.5s) & \text{if } K_1 < s+z \leq K_2 \\ \min(0.3(K_2-K_1)+0.4(s+z-K_2), z, 0.5s) & \text{if } K_2 < s+z \leq K_3 \\ \min(0.3(K_2-K_1)+0.4(K_3-K_2)+0.5(s+z-K_3), z, 0.5s) & \text{if } s+z > K_3. \end{cases} \quad (1)$$

The values for z^*,K_1, K_2, and K_3 are adjusted each year to account for inflation. In 2012, the last year of our data, the monthly SGA threshold in Austria was €439 (around USD 500), which was about half of the SGA threshold for non-blind DI recipients in the U.S, the corresponding values for K_1, K_2, and K_3 were €1,258, €1,887, and €2,515, respectively, and the average monthly DI benefits were €1,053. Equation 1 highlights several important points: First, individuals do not lose benefits even if $z > z^*$ as long as $s+z \leq K_1$. Second, the marginal loss in benefits from earning an additional euro is increasing in income and equal to €0 if $s+z \leq K_1$, €0.3 if $K_1 < s+z \leq K_2$, €0.4 if $K_2 < s+z \leq K_3$, and €0.5 if $s+z > K_3$. Third, the loss in benefits is capped by z and $0.5s$, whichever is lower. Thus, DI beneficiaries always keep at least half of their benefits no matter how much they earn.[9]

It is important to note that the SGA threshold coincides with the earnings threshold above which workers are automatically insured by the public pension system. This implies that DI beneficiaries are required to pay 18 percent social security tax on *all* earnings as soon as their earnings exceed the SGA threshold. The rules are different for employers and depend on the number of employees with earnings below the SGA threshold. Employers with one employee who earns less than the SGA threshold pay 21 percent social security tax as soon as the employee's earnings cross the SGA threshold. Employers with several employees who earn less than the SGA threshold pay social security taxes if the total earnings of those employees are 1.5 times larger than the SGA threshold.

Together, these rules change the implicit tax on earnings at the SGA threshold in two ways. First, there is a discrete jump in tax liability—a notch—because beneficiaries lose a share of both

[9]The hassle costs associated with changing earnings is low. The only requirement is that DI beneficiaries notify the social security agency within seven days of any change in earnings. Firms also report earnings above the SGA threshold directly because these earnings are subject to social security taxes. The social security administration automatically deducts disability benefits if earnings exceed the SGA threshold and reinstates the original benefits if earnings drop below the SGA threshold.

benefits and earnings on the first euro of earnings above the SGA threshold. The average beneficiary loses about €125, or 10 percent of the monthly after-tax income, of which 60 percent is due to the loss in benefits and 40 percent is due to social security contributions. Second, there is a discrete change in the implicit marginal tax—a kink—because for each euro of earnings above the SGA threshold beneficiaries have to pay 18 cents in payroll taxes and they lose up to 50 cents in benefits, depending on whether the gross income exceeds K_1, K_2 or K_3. If all DI beneficiaries in our data earned z^*, then 36 percent would have gross income (z^*+s) between K_1 and K_2, 10 percent between K_2 and K_3, and 3 percent above K_3. Thus, for 49 percent of DI beneficiaries, gross income at the SGA threshold exceeds K_1 and at least 30 cents of benefits are deduced for each euro of earnings above the SGA threshold.[10]

The notch and the kink create a strong incentive for DI recipients to bunch just below the SGA threshold to avoid the high implicit tax on work and retain full DI benefits. In the next section, we will describe how we combine the amount of bunching with the change in the implicit tax to estimate an elasticity of earnings with respect to the implicit net-of-tax rate.

3 Methodology and Data

3.1 Theoretical Framework

Saez (2010) has shown that the amount of bunching at kinks of the tax schedule can be used to estimate an elasticity of taxable income with respect to the net-of-tax rate. However, the amount of bunching might be attenuated if some individuals do not respond because of optimization frictions such as adjustment costs and inattention.[11] Kleven and Waseem (2013) have extended the bunching approach to the context of notches, created by discontinuities in tax liability. An advantage of notches is the possibility to identify the structural elasticity, the elasticity absent frictions, because they generate an additional empirical moment besides bunching at the notch, specifically a hole in the earnings distribution just above the notch. This moment can be used to measure the attenuation bias from frictions.

[10]Figure A.2 in Online Appendix A shows the distribution of gross income around the kink points K_1, K_2 and K_3 for our sample. There is no evidence of bunching at any of the kinks.

[11]Gelber et al. (2013) show that it is possible to estimate a structural earnings response from kinks by exploiting policy-changes in the magnitude or the location of the kinks. More specically, they estimate adjustment costs using the speed by which earnings adjust to policy changes.

Our theoretical model follows Kleven and Waseem (2013) but focuses on a notch in disability insurance as opposed to a notch in the income tax schedule. Specifically, we assume that individuals maximize the following quasi-linear utility function

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

subject to the budget constraint $c = s + z - T(s,z)$. $T(s,z)$ is the tax liability which depends on disability benefits s and before-tax earnings z, n is an ability parameter, and e is the elasticity of earnings with respect to the marginal net-of-tax rate $1-t$. The quasi-linearity assumption simplifies the presentation, but rules out income effects of tax changes on earnings. As a robustness test, we also implement an estimation approach following Tazhitdinova (2017) that does not depend on the structure of the underlying utility. A key assumption is that the distribution of ability in the population is smooth. This assumption implies that, given a linear tax system $T(s,z) = t \cdot (s+z)$, the smooth ability distribution translates into a smooth earnings distribution.

Now suppose that a notch and a kink are introduced at the earnings threshold z^*, representing the SGA threshold. The tax schedule with the notch and the kink can be written as $T(s,z) = t \cdot (s+z) + [\Delta T + \Delta t \cdot (z - z^*)] \cdot \mathbf{1}(z > z^*)$ where ΔT is the size of the notch, Δt is the size of the kink, and $\mathbf{1}(z > z^*)$ is an indicator for earning above the SGA threshold.[12] Panel (a) of Figure 2 shows that the notch shifts the budget constraint downward above z^* while the kink rotates the budget constraint. The notch creates a region of strictly dominated choices between $z^*$and z^D. In this region, it is possible to increase consumption and leisure by moving to the SGA threshold z^*. DI beneficiaries who earned in the interval $(z^*, z^* + \Delta z^*)$ before the introduction of the SGA threshold will move to z^*. This implies that the earnings distribution with the SGA threshold exhibits bunching at z^*, as shown in Panel (b) of Figure 2. Individual H is the marginal bunching individual: this individual chooses earnings $z^* + \Delta z^*$ before the SGA threshold is introduced and is exactly indifferent between z^* and the interior point z^I with the SGA threshold. The earnings distribution with the SGA threshold should feature a hole because no individual is willing to locate between z^* and z^I. There is also a leftward shift in the earnings distribution above z^*, as the kink induces all DI recipients above z^* to earn less.

[12] The notch ΔT measures the loss in income when earnings exceed the SGA threshold by €1 and consists of two parts: the loss in benefits $\Delta s(z^* + 1)$ and the social security contributions $0.18 \cdot (z^* + 1)$.

Figure 2

The key idea of the empirical approach is that the elasticity e can be inferred from Δz^*, the earnings response of the marginal bunching individual. More specifically, we exploit the fact that the marginal bunching individual is indifferent between the SGA threshold z^* and the interior point z^I, as shown in Figure 2. Hence, we can set $u(z^I) = u(z^*)$ using equation (2) and rearrange terms to obtain an expression which defines the elasticity e as an implicit function of the tax parameters, the SGA threshold z^*, and the earnings response Δz^* (see Online Appendix C for derivation):

$$\frac{1}{1+\Delta z^*/z^*}\left[1+\frac{\Delta T/z^* - \Delta t}{1-t}\right] - \frac{1}{1+1/e}\left(\frac{1}{1+\Delta z^*/z^*}\right)^{1+1/e} - \frac{1}{1+e}\left(1-\frac{\Delta t}{1-t}\right)^{1+e} = 0. \tag{3}$$

Equation (3) cannot be solved explicitly for e, but it can be solved numerically after we have estimated Δz^*; the values of the tax parameters and the SGA threshold are observed. In the next section, we describe how we determine the earnings response Δz^*.

3.2 Empirical Implementation

The approach to estimate the earnings response Δz^* relies on the identification of the counterfactual earnings density—the distribution of earnings under a linear tax system without any notch or kink. Following Kleven and Waseem (2013), we begin by grouping DI recipients into earnings bins of €8 based on their monthly earnings. We proceed by estimating a flexible polynomial to the observed earnings distribution, excluding observations in a range $[z^L, z^U]$ below and above z^*:

$$C_j = \sum_{i=0}^{p} \beta_i (z_j)^i + \sum_{k=z^L}^{z^U} \gamma_k \mathbf{1}(z_j = k) + \varepsilon_j, \tag{4}$$

where C_j is the number of individuals in bin j, z_j is the earnings level in bin j, and p is the order of the polynomial. The excluded range $[z^L, z^U]$ corresponds to the area that is affected by the SGA threshold either because of bunching or missing mass. Because we include indicator variables for each bin in the excluded range, the polynomial is estimated without considering data from the excluded range. The counterfactual distribution is given by the predicted values from equation

(4) omitting the dummies in the excluded range: $\hat{C}_j = \sum_{i=0}^{p} \hat{\beta}_j (z_j)^i$. Bunching is estimated as the difference between the observed and counterfactual earnings distribution in the range $[z^L, z^*]$: $\hat{B} = \sum_{k=z^L}^{z^*} (C_k - \hat{C}_k)$. Missing mass is estimated as the difference between the observed and counterfactual earnings distribution in the range $(z^*, z^U]$: $\hat{M} = \sum_{k>z^*}^{z^U} (\hat{C}_k - C_k)$.

Since bunching below the SGA threshold is very sharp, we can determine the lower bound of the excluded range z^L by visual inspection. A similar approach is not feasible for the upper bound z^U because missing mass is fuzzier and cannot be easily determined visually. Instead, we exploit the fact that the missing mass above the SGA threshold must be equal to the bunching mass below the SGA threshold. More specifically, we start by setting z^U equal to the first bin on the right of z^* and estimate the counterfactual earnings density using equation (4). The resulting bunching mass in this case will exceed the missing mass. We then increase the upper bound in small increments and re-estimate equation (4) until the estimated missing mass is equal to the estimated bunching mass. Importantly, the resulting upper bound z^U is the point of convergence between the observed and the counterfactual earnings distribution and directly represents our estimate for the long-run earnings response Δz^*. Plugging this estimate into equation (3) allows us to uncover the structural elasticity e.

This method to pin down Δz^*, coined the "convergence method" by Kleven and Waseem (2013), assumes that the observed mass in the segment $(z^*, z^* + \Delta z^*)$ is driven by frictions and that the excess mass at the SGA threshold is coming from the area between the observed and the counterfactual distribution. With heterogeneity in elasticities, it is possible that some of the mass between z^* and $z^* + \Delta z^*$ is explained by low elasticities and not frictions, in which case the convergence point overestimates the true Δz^*.[13] Moreover, in a dynamic setting the loss in current income from residing in the bunching segment may be compensated by higher future earnings through career effects. In the empirical application, we will shed light on the size of the bias created by low elasticities and career effects by examining the dynamics of earnings adjustment.

[13] On the other hand, Kleven and Waseem (2013) argue that the "bunching-hole method" provides a lower bound estimate of the earnings response Δz^*. This method estimates Δz^* by rescaling the amount of bunching $\hat{B}$ with the factor $\frac{1}{(1-f)}$ to account for the fact that only a fraction $(1-f)$ of individuals can bunch due to optimization frictions. The fraction $1-f$ can be estimated by the amount of missing mass in the dominated region $(z^*, z^* + z^D)$ relative to the counterfactual. The idea is that without optimization frictions, no individual should choose an earnings level in the dominated region and any mass in this region must therefore be the result of frictions. Our main estimates are based on the convergence method, but as a robustness check we also present estimates using the bunching-hole method.

More specifically, we expect that over time individuals subject to optimization frictions or career effects will move away from the bunching segment while those with low elasticities will stay.

Since we observe the same individual many times, standard errors may be clustered at the individual level. We calculate standard errors using a pairs-cluster bootstrap that accounts for clustering of errors at the individual level (Cameron and Miller, 2015). We first generate many earnings distributions by random resampling with replacement over individuals, keeping all observations of each individual that we resample. We then re-estimate the parameters for each new sample. We define the standard error for each parameter as the standard deviation of the distribution of estimates.

3.3 Data and Sample Selection

We combine register data from two different sources. First, the Austrian Social Security Database (ASSD) contains very detailed longitudinal information for the universe of workers in Austria between 1972 and 2012. At the individual level, the data include gender, nationality, month, and year of birth, blue-collar or white-collar status, and labor market history. Labor market histories are summarized in spells. Specifically, the start and end dates of all employment, unemployment, disability, sick leave, and retirement spells are recorded. The data contain several firm-specific variables: geographical location, industry affiliation, and firm identifiers that allow us to link both individuals and firms. Second, we use individual income tax reports that firms and the social security administration are required to submit to the tax office at the end of each year. These reports contain detailed information on benefits from the various social insurance programs, earnings, social security contributions, and income tax withholdings for the tax office. We have access to the tax records for the years 1994 to 2012 and they can be linked with the ASSD via an identifier variable.

Our sample includes all DI spells that were initiated between 2001 and 2012 by individuals younger than age 57 at the time of entry into the program. We exclude spells that started prior to 2001 because earnings restrictions were not uniformly regulated for these spells. We focus on DI recipients who are younger than age 57 because individuals who start claiming benefits after age 57 face stricter earnings restrictions. These individuals lose all benefits if earnings exceed the SGA threshold and they are not allowed to work in the same occupation as before the onset of the disability.

We construct monthly earnings by dividing the annual earnings associated with an employment spell by its duration (in months). For individuals with multiple employment spells, monthly earnings are the total earnings over all employment spells in a month. This approach implicitly assumes that an individual's monthly earnings in a job are constant within a year, which is not necessarily the case. Monthly earnings will be measured with error for spells in which earnings fluctuate across months.[14] Similarly, we calculate an individual's full monthly DI benefits by dividing annual DI benefits in the absence of any work by the duration of the DI spell within a year. Since DI benefits are only adjusted for inflation from one year to the next, there should be no measurement error in monthly DI benefits. Having data at the monthly level is important given that the SGA limit applies monthly.[15] We observe individuals up to eight years before they enter the DI program and while they are on the DI program.

Table 1 provides summary statistics for our analysis samples. Column 1 shows summary statistics for all DI recipients in our sample, column 2 shows summary statistics for DI recipients who work at least once during the observation period, and column 3 shows summary statistics for the subset of DI recipients who are working just below the SGA threshold. DI recipients are on average 48.2 years old at program entry and 59 percent suffer from a musculoskeletal disease or a mental disorder, both typically difficult to verify. A comparison of columns 1 and 2 shows that only about 15 percent of DI beneficiaries are working while receiving benefits. Compared to all DI recipients, working DI recipients are younger, have more labor market experience, have lower DI benefits, had a lower wage in their last job, and suffer less from difficult-to-verify disorders. On average, they earn about 50 percent less than what they earned before entering the DI program. This drop is largely explained by the fact that many DI beneficiaries are earning just below the SGA threshold: column 3 illustrates that over 25 percent of working DI beneficiaries are located just below the SGA threshold. We do not observe hours of work and whether individuals work part-time or full-time, but a recent study by Riesenfelder et al. (2011) documents that almost all individuals with earnings below the SGA threshold work part-time with an average work load of 7.9 hours per week. Thus,

[14] If measurement error is present, we would expect bunching at the notch to be attenuated, in which case our elasticity estimate represents a lower bound.

[15] It would be harder to detect bunching with annual earnings data because beneficiaries who earn just below the SGA threshold for several months (but not the whole year) would not appear to bunch in annual data. Figure A.1 in Online Appendix A shows the distribution of annual earnings around the annual SGA threshold. While there is clear evidence for bunching at the annual SGA threshold, the amount of bunching is an order of magnitude lower than in the monthly data (see Figure 3).

individuals who bunch earn €14 per hour (in 2012 euros), assuming they work the same number of hours as the average.

Table 1

4 Empirical Analysis of Earnings Response

4.1 Descriptive Evidence of Behavioral Responses

Evidence for Bunching in Pooled Data. We start our analysis by providing graphical evidence for bunching at the SGA threshold. We pool all years of data and calculate the difference between earnings and the SGA threshold in each year, because the SGA threshold increases year by year to account for inflation and wage growth. We then group individuals into €8 bins and quantify excess mass and missing mass by estimating a sixth-degree polynomial to the observed earnings distribution using equation (4).[16] Figure 3 shows the normalized earnings distributions around the SGA threshold as well as our estimate of the counterfactual earnings density (black line). The vertical solid line denotes the SGA threshold and the vertical short-dashed lines denote the excluded range $[z^L, z^U]$.

Several things can be observed from the figure. First, there is large and sharp bunching at the SGA threshold. Second, the earnings distribution exhibits significant missing mass, as the density falls discretely above the SGA threshold. However, there are no visible holes because the distribution of earnings is relatively flat above the SGA threshold, suggesting that frictions are an important factor that prevents DI beneficiaries from adjusting their earnings. Third, the SGA threshold significantly reduces earnings of DI beneficiaries. The point of convergence z^U where missing mass equals bunching mass is €464, suggesting that without the SGA threshold the marginal bunching DI recipient would earn €464 more.

Figure 3

The identification assumption underlying our estimates for excess bunching and missing mass is that the earnings distribution would be smooth if there were no jump in the tax liability at the SGA

[16] Figure A.5 in Online Appendix A plots the counterfactual earnings distribution for lower and higher polynomial degrees, showing that the results are not very sensitive to the choice of the degree of polynomial.

threshold. We can shed light on this assumption by exploiting the movement of the SGA threshold across years. Figure A.3 in Online Appendix A displays the distribution of earnings around the SGA threshold for the years 2003, 2006, 2009, and 2012. The figures show that the excess mass follows the movement of the SGA threshold closely.

Persistency of Bunching and Dominated Behavior. Taking advantage of the longitudinal aspect of our data, we next investigate the dynamics of bunching and dominated behavior over time. More specifically, we group beneficiaries in each quarter into one of four segments as a function of their earnings z: (i) bunching segment ($z^L \leq z \leq z^*$), (ii) dominated segment ($z^* < z \leq z^U$), (iii) below segment ($0 < z < z^L$), and (iv) above segment ($z^U < z$). Figure 4 illustrates the fraction of beneficiaries in each segment over time for beneficiaries who in the first quarter after DI entry are in the bunching segment (Panel a) or in the dominated segment (Panel b).

Panel (a) shows that bunching is highly persistent over time. Around 60 percent of DI beneficiaries who are in the bunching segment in the first quarter after DI entry are still bunching five years later. On the other hand, the fraction of beneficiaries in the dominated and above segments is always very low (about 10 percent). Some beneficiaries move to the dominated segment, presumably because it is difficult to control earnings perfectly. Over time there is an increase in the fraction of beneficiaries in the below segment, perhaps reflecting that some beneficiaries reduce their earnings as results of deteriorating health.

Panel (b) shows that there is a drastic and fast decline in the fraction of beneficiaries in the dominated segment. Five quarters after DI entry, only about 30 percent of beneficiaries are still located in the dominated segment and this fraction declines further to about 20 percent. The beneficiaries who remain in the dominated segment in the long run are likely those with a low earnings elasticity. About 30 percent of beneficiaries in the dominated segment move to the bunching segment, suggesting that adjustment frictions prevent many beneficiaries from bunching in the short run. About 25 percent of beneficiaries move to the above segment, indicating the importance of career effects. As in Panel (a), there is an increase in the fraction of beneficiaries in the below segment, likely as results of deteriorating work capacity over time.

Figure 4

4.2 Earnings Elasticity Estimates from Bunching

Main Results. In this section, we present estimates of earnings elasticities by combining the nonparametric evidence on bunching presented above with the empirical framework in Section 3. Table 2 displays the amount of bunching (column 2), the earnings response of the marginal buncher using the point of convergence z^U (column 3), the average earnings response of individuals who bunch (column 4), and the structural elasticity based on equation (3) using a quasi-linear utility function (column 5). The amount of bunching is measured relative to the average counterfactual density between z^L and z^*.

Panel A shows that the earnings response is large and statistically significant. The marginal bunching DI recipient would increase monthly earnings by €464 or 112 percent of the SGA threshold in the absence of the notch. The average earnings response of recipients who bunch is roughly half as large. Even though the estimated earnings response is sizeable, the implied earnings elasticity is small at 0.27. Panel B shows that the earnings elasticity is stable over time and varies between 0.15-0.27 in the first seven years after DI entry.[17] Studies exploiting kinks and notches in the income tax schedule find an even smaller elasticity (5 to 10 times) among wage earners (Saez 2010; Chetty et al. 2011; le Maire and Schjening 2013; Kleven and Waseem 2013; Bastani and Selin 2014). Yet, papers using bunching in other contexts find elasticities that are in the range of our estimate. Gelber et al. (2013), Tazhitdinova (2017), and Le Barbanchon (2016) estimate earnings elasticities between 0.1-0.35 exploiting kinks or notches in the U.S. Social Security program, the Mini-Job program for low-income earners in Germany, and the U.S. unemployment insurance, respectively.

It is important to keep in mind that our approach relies on local moments around the SGA threshold and therefore provides a good estimate of the work capacity of beneficiaries located around the SGA threshold. The earnings elasticity might differ in countries with a different SGA threshold than in Austria if the elasticity is heterogeneous across subgroups of beneficiaries, and if characteristics of beneficiaries around the SGA threshold vary with its level. Since Austria's earnings threshold is quite low, it is likely that beneficiaries around the SGA threshold have limited

[17] Even though bunching is increasing over time, the elasticity remains fairly stable because the additional bunching mass is coming primarily from the dominated region, as shown in Panel (b) of Figure 4. This implies that there is more missing mass in the dominated region and therefore the point of convergence z^U is unchanged despite the increase in bunching.

work capacity, in which case our earnings elasticity represents a lower bound.[18]

Table 2

Speed of Earnings Adjustment. The jump in implicit tax liability at the SGA threshold is much larger for individuals on the DI program than those not on the program. Individuals on DI lose a portion of their benefits and have to pay social security contributions while those not on DI only have to pay social security contributions. Therefore, we would expect to see less bunching before individuals enter the program and more after. The availability of data before individuals enter the DI program allows us to examine how fast bunching adjusts to changes in tax liability at the SGA threshold.[19]

Figure 6 plots estimates of bunching b (Panel a) and the earnings elasticity e (Panel b) for each year before and after DI entry for beneficiaries who work at least once in the first four years on the program. The earnings distribution around the SGA threshold in each year is shown in Figure A.7 in Online Appendix A. Four years before program entry, bunching b is 1.9 and steadily increases to 7 in the year of program entry. Bunching b jumps significantly in the first year on the program to 17.1 and continues to increase to 19.1 four years after program entry.[20] Panel (b) shows that the earnings elasticity e is relatively stable across years and varies between 0.1-0.33.[21]

Figure 6

Heterogeneity in Responses. We next examine heterogeneity in earnings elasticities by dividing the population into several subgroups. Table 3 presents estimates of the labor supply responses for different subgroups of the population. There is significant heterogeneity in the responsiveness to the SGA threshold among certain groups. Panel A illustrates that elasticities for DI beneficiaries below age 50 are larger than for DI beneficiaries above age 50. This finding is consistent

[18]Consistent with this view, Table 1 shows that beneficiaries around the notch had lower earnings in their last job compared to the full population of beneficiaries.

[19]A similar analysis is not possible for beneficiaries who exit the DI program due to medical recovery because there are too few exits to be able to estimate a counterfactual earnings density.

[20]The results are similar when we focus on the years before and after the DI application year instead of the DI entry year (see Figure A.8 in Online Appendix A), suggesting that the increase in bunching before DI entry is not driven by earnings adjustments in anticipation of DI receipt, but may reflect reductions in earnings due to deteriorating health.

[21]The elasticity estimates tend to be less precise before relative to after DI entry. The reason is that the earnings distributions before DI entry show little missing mass above the SGA threshold, which increases the standard deviation of the distribution of z^U estimates in the boostrap procedure.

with existing evidence that younger DI beneficiaries exhibit the highest responsiveness to financial work incentives (Kostol and Mogstad, 2014). Panel B shows that female DI recipients are more responsive to financial incentives than their male counterparts. There are also differences across impairment types, as illustrated in Panel C: DI recipients with mental and physical disorders are less responsive compared to DI recipients with other impairments. Panel D shows that white-collar workers are more responsive than blue-collar workers. A potential explanation is that white-collar workers are better educated and hence are more aware of program rules and incentives.[22] We next split the sample depending on whether the number of days spent on sick leave prior to DI entry was greater than the median. As Panel E shows, DI recipients with sick leave below the median are more responsive than those with sick leave above the median. Panel F shows that DI recipients who did not switch firms within six months before and after DI entry have greater abilities to respond to the SGA threshold than those who did switch firms.[23] As illustrated in Panel G, the earnings elasticity is slightly higher in the primary/secondary sector and somewhat lower in the tertiary and public sectors. Finally, we divide the sample in three terciles according to the size of the notch relative to gross DI benefits. Panel H shows that the earnings elasticity is highest in the bottom tercile and decreases for higher terciles.

Table 3

Firm Bunching. It is possible that observed behavioral responses are driven by "firm bunching" (Chetty et al., 2011) rather than genuine responses of DI beneficiaries. More specifically, firms may help beneficiaries to bunch by offering jobs at the SGA threshold, in which case our elasticity estimates represent an upper bound on the individual response. The results in Table 3 suggest that observed bunching could be partially driven by firm incentives, because some groups of recipients that have less incentive to bunch still exhibit significant bunching. For example, women lose on average 8.8 percent of after-tax income at the SGA threshold while men lose 11.1 percent, yet the amount of bunching is similar for both groups.

We perform two analyses to shed light on the role of firms. First, we follow Tazhitdinova

[22]Unfortunately, we are not able to examine heterogeneity by education directly because we cannot observe individuals' education in our data.

[23]We focus on a window of six months before and after DI entry because many DI recipients change firms upon entry into the DI program, as documented in Figure A.4 in Online Appendix A.

(2017) and focus on DI recipients with multiple jobs where at least one of the jobs pays more than the SGA threshold. Since the SGA threshold applies to cumulative earnings, DI recipients with earnings above the SGA threshold in one job have no incentive to bunch in the other jobs. Thus, any bunching in the secondary job would be direct evidence of firm responses to the SGA threshold. Panel (a) of Figure 5 shows that earnings in the secondary job are often below the SGA threshold, as there is a drop in the earnings distribution above the SGA threshold, but there is very little bunching at the SGA threshold.[24] Second, there is a special rule for firms that employ two or more workers with earnings below the SGA threshold. For the workers below the SGA threshold, the firm pays social security taxes if these workers' total earnings exceed 1.5 times the SGA threshold. If bunching is driven by the firm, we would expect to see bunching of total earnings of these workers at 1.5 times the SGA threshold. Panel (b) of Figure 5 shows no evidence of bunching at this new SGA threshold (solid line), again suggesting that firm bunching is small. There is a peak in the sum of earnings at twice the SGA level because most of the firms in our sample have exactly two workers with earnings below the SGA threshold. In sum, while we cannot completely rule out firm responses to the SGA threshold, such responses do not seem to be strong in our context.

Figure 5

Robustness Checks. Table 4 presents several robustness checks to examine the sensitivity of our estimates. The first row shows the baseline results for the full sample for comparison. Panel B shows that excluding DI recipients who are self-employed results in a slightly larger elasticity, suggesting that our results are not driven by the self-employed.[25] We next examine the robustness of our results with respect to the shape of the counterfactual by varying the degree of the polynomial in equation (4). As Panel C shows, elasticity estimates are somewhat smaller (larger) when using a 5th (7th) order polynomial.

Panel D shows results for alternative approaches to estimate the counterfactual earnings density. The point of convergence z^U assumes that in the long-run all beneficiaries in the dominated range move to the SGA threshold. This assumption may lead to an upward-biased estimate of z^U because, as Figure 4 shows, not all beneficiaries in the dominated range move to the SGA threshold over

[24] In contrast, Tazhitdinova (2017) finds substantial bunching in the secondary job at notches in the Mini-Job program for low-income earners in Germany.

[25] Since only 10 percent of DI recipients are self-employed, we cannot examine this group separately.

time either due to low elasticities or career effects. Row 1 in Panel D shows estimates when we shift beneficiaries in the dominated range to different parts of the earnings distribution according to their location five years after entering the DI program.[26] This approach yields a slightly lower earnings response by the marginal buncher of €408 and a slightly lower elasticity of 0.21. Another concern is that the counterfactual density based on equation (4) ignores the potential left shift in the observed distribution above the SGA threshold due to the kink. Following Chetty et al. (2011), we account for such intensive margin responses by shifting the bin counts to the right of z^U upward until the area under the counterfactual and the empirical distribution is identical. Row 2 of panel D shows that incorporating such effects has a small impact on the earnings response and elasticity. Row 3 of panel D shows that the bunching-hole method (see footnote 13) generates a slightly smaller earnings elasticity, consistent with Kleven and Waseem (2013) who argue that this method provides a lower-bound.[27] Finally, we estimate a model that does not depend on the functional form of the underlying utility following Tazhitdinova (2017) and find a slightly smaller elasticity of 0.23 (row 4 of Panel D).[28]

Individuals who are not on the DI program also experience a discontinuous change in tax liability at the SGA threshold because they have to start paying social security taxes on all earnings. Panel E of Table 4 shows that individuals not on the DI program show smaller bunching (b=4.7) and a larger earnings elasticity (e=0.62). As Figure A.6 in Online Appendix A illustrates, the reason is that frictions are large for this group of workers, as there is very little missing mass just above the SGA threshold. Since the change in tax liability at the SGA threshold is smaller for this group, the utility gain from moving to the threshold is lower as well, making it less attractive to adjust earnings if there are adjustment costs.

[26]Specifically, following Panel (b) of 4 we shift 20 percent of beneficiaries in the dominated range to the segment below z^L by increasing each bin proportional to the bin height. Using a similar approach, we shift 30 percent of beneficiaries in the dominated range to the bunching segment and 27 percent to the segment above z^U. We then re-estimate a new counterfactual earnings distribution, bunching response, and earnings elasticity.

[27]The bunching-hole method estimates the earnings response using $\Delta z^* = \frac{B}{(1-f)h_0(z)}$, where $h_0(z)$ is the counterfactual density and f is the fraction of individuals in the dominated range (z^*, z^D) relative to the counterfactual. One difficulty is the determination of the dominated range because z^D varies across DI beneficiaries depending on their benefits. However, there is a minimum dominated range of €90 for all beneficiaries because they have to pay 18 percent social security tax on *all* earnings if earnings exceed the SGA threshold. We therefore set $z^D = 90$.

[28]Specifically, Tazhitdinova (2017) develops a method to estimate an earnings elasticity for a combined kink-notch which is also the case in our setting. The idea is to estimate a counterfactual density that accounts for both missing mass due to the the notch and the left shift above the threshold due to the kink. Assuming that the same elasticity is driving responses to the notch and the kink, it is possible to split the estimated amount of bunching into buching due to the notch and bunching due to the kink. One can then relate each bunching response to the corresponding change in tax parameters to get an estimate for the elasticity.

Table 4

5 Empirical Analysis of Labor Force Participation Response

Since notches introduce a discrete jump in tax liability, they may induce individuals above the threshold to stop working altogether. In this section, we directly estimate the magnitude of the extensive margin response by exploiting a policy change that relaxed the earnings restrictions at the SGA threshold. Prior to July 1993, in the first six months after program entry, DI benefits would be suspended for a month if earnings in that month exceeded the SGA threshold. In July 1993, the Austrian government abolished the earnings restrictions in the first six months for all DI recipients who entered the program before age 55. The earnings restrictions did not change for recipients who entered the program after age 55, because eligibility criteria for DI benefits were relaxed at age 55 and the DI program was primarily used as a gateway for early retirement above this age threshold (see Staubli, 2011).

To assess the impact of the change in the earnings restrictions graphically, Figure 8 plots the fraction of DI recipients who report positive earnings in a month by their age at DI entry over the period July 1991 to June 1995. For each recipient, we keep observations from the first six months on the DI program, because the policy reform changed earnings rules only during this period. Before July 1993, trends in labor force participation are similar among beneficiaries who entered the DI program before and after age 55. In July 1993, labor force participation jumps upward for recipients who entered the DI program before age 55 and then stays fairly constant at the new level. In contrast, labor force participation trends smoothly over time for beneficiaries who entered the DI program after age 55.

Table 7

To estimate the extensive margin response, we use a difference-in-differences design, which exploits the variation in earnings rules by program entry age that was generated by the 1993 reform. Specifically, we estimate the following regression:

$$y_{it} = \alpha + \beta Treat_i + \gamma(Post_t \times Treat_i) + \lambda_t + X'_{it}\delta + \varepsilon_{it}, \tag{5}$$

where i indexes individual, t indexes year-month, y represents an outcome of interest (such as a dummy for having positive earnings), $Treat$ is a dummy which is 0 if an individual enters the DI program between ages 55 and 65 and 1 if the individual enters between ages 20 and 55; $Post$ is a dummy for calendar time after July 1993, λ is a vector of year-month fixed effects, and X is a vector of background characteristics. The coefficient of interest is γ which measures the effect of the liberalization in earnings rules for recipients who entered the DI program before age 55 relative to those who entered after age 55.

Table 5 reports estimates of equation (5) for the full sample (columns 1-2) and when we split the sample by gender (columns 3-4) and by average earnings over the best 15 years (columns 5-6). Panel A shows that the policy change increased labor force participation by 6.5 percentage points. This estimate is robust to controlling for additional background characteristics (column 2 of Panel A). The effects are somewhat larger for women compared to men and about twice as large for high-earners relative to low-earners. To compare the labor supply responses with the policy-induced changes in financial incentives, we calculate an elasticity of labor force nonparticipation with respect to the participation tax rate (Panel B).[29] The results suggest an average elasticity of labor force nonparticipation to the participation tax rate between 0.099 (without controls) and 0.102 (with controls). Consistent with the results in Panel A, the implied elasticities are larger for women relative to men and high-earners relative to low-earners.

Table 5

We next explore the impact of the 1993 policy change over time by replacing $(Post \times Treat)$ in equation (5) with a set of treatment by year-month interaction terms (baseline year-month is July 1991):

$$y_{it} = \alpha + \beta Treat_i + \sum_{j=08/91}^{06/95} \gamma_j (d_j \times Treat_i) + \lambda_t + X_{it}'\delta + \varepsilon_{it}, \tag{6}$$

[29]The elasticity of labor force nonparticipation is defined as $\epsilon = \frac{\Delta(1-LFP)/(1-LFP)}{\Delta PTR/PTR}$, where $\Delta(1-LFP) = -\Delta LFP$ is the change in the labor force nonparticipation rate of the treatment group before and after the policy change, as estimated in Panel A, $(1 - LFP)$ is the mean labor force nonparticipation rate of the treatment group before the policy change, ΔPTR is the difference in the participation tax rate of the treatment group before and after the policy change, evaluated at the pre-policy earnings distribution, and PTR is the mean participation tax rate of the treatment group before the policy change. As argued by Kostol and Mogstad (2014) and others, in the case of a notch the PTR is generally viewed as more relevant to behavioral participation responses than the marginal tax rates. Moreover, the elasticity of labor force nonparticipation it is less sensitive to small changes in the very low labor force participation rate, as compared to the labor force participation elasticity.

where d_j is a dummy that is 1 in year-month j and 0 otherwise. The interaction terms for the period before July 1993 provide pre-treatment specification tests, although they may capture possible anticipation effects. Figure 8 plots the estimated γ-coefficients (the 95 percent confidence interval is shown by dashed lines). The estimated coefficients fluctuate around zero and are insignificant before the 1993 reform became effective (vertical black line), providing evidence that the empirical strategy is not simply picking up differential long-term trends between treated and non-treated individuals. The coefficients turn significantly positive after the reform and this increase in labor force participation among treated individuals persists over time.

Table 8

6 Bunching Estimation with Large Notches

Bunching estimators of notches have been primarily applied to settings with small notches. Much less is known about how well this method works for large notches, as is the case in our setting. In this section, we use numerical simulations to examine the performance of the bunching estimator in our context, including whether extensive margin responses affect the estimation process. Such responses would shift the observed earnings density above the threshold downward, leading to overestimated bunching. We base our simulations on the utility function in equation (2) with the difference that individuals face a fixed cost of labor force participation q that is smoothly distributed across the population:

$$u(c, z) = c - \frac{n}{1 + 1/e} \cdot \left(\frac{z}{n}\right)^{1+1/e} - q. \tag{7}$$

Individuals choose earnings z to maximize equation (7) subject to the budget constraint $c = s + z - T(s, z)$. The fixed cost of participation allows for the possibility that taxes create extensive margin responses. An individual will only participate in the labor force if $q \leq u(c, z) - u_0$ for some $z > 0$, where u_0 denotes the utility from nonparticipation. Bastani and Selin (2014) extend this utility function to allow for income effects. They find, via numerical simulations, that income effects do not bias elasticity estimates even for large kinks. Income effects may also be large for notches, in which case, the estimated elasticity will be a mix of compensated and uncompensated elasticities. Since the uncompensated elasticity is smaller than the compensated elasticity (if leisure is a normal good), the elasticity estimate will be lower in the presence of income effects.

We examine several scenarios that differ in the size of the tax notch $T(s, z)$ and whether individuals face a fixed cost of participation. For each scenario, we follow the same steps. First, we fix an elasticity e and calibrate a vector of ability parameters n such that the distribution of utility-maximizing earnings without the notch resembles the counterfactual earnings distribution in Figure 3.[30] If we allow for extensive margin responses, we additionally calibrate a vector of fixed costs q following Liebman (2002). Specifically, for each individual we randomly draw a fixed cost from a uniform distribution with a lower limit of 0 and an upper limit equal to the difference between the individual's utility at the optimal z without the notch and the utility at zero earnings. These fixed costs are then divided by a scalar to produce an extensive margin response that is consistent with the one estimated in the previous section. Second, we introduce a notch at the SGA threshold and re-simulate the distribution of utility-maximizing earnings choices. With the notch, individuals initially located above the threshold face a higher tax liability and instead bunch at the threshold or stop working altogether. Third, we apply the approach described in section 3 to estimate an earnings elasticity on the simulated data and compare the estimated elasticity with the true underlying elasticity.

The results from the simulation exercise for different scenarios are shown in Table 6 and illustrated graphically in Figures B.1-B.3 in Appendix B. For each scenario, we report the bias in the estimated elasticity relative to the theoretical elasticity in parentheses. The baseline scenario "small notch" rules out extensive margin responses (i.e. $q = 0$) and specifies the notch as a jump in the average tax rate of 8 percent, which is about a third the size of the notch in the Austrian DI program. For this scenario, estimated elasticities are close to the three theoretical elasticities we consider. The bias varies between -3 percent and 3 percent. The second row shows results when we specify the notch to be the same as in the Austrian DI program. In this case, estimated elasticities tend to be larger than for the small notch, but overall the estimation procedure works well. The relative bias is largest for $e = 0.1$ (12 percent), but only 3 percent for $e = 0.2$ and $e = 0.3$. The third row shows that we get a larger upward bias once we allow for extensive margin responses.

[30]We assume that n follows a gamma distribution because this distribution most closely resembles the counterfactual distribution.

The absolute bias increases with the underlying elasticity from 0.017 to 0.034, but the relative bias is modest and varies between 11-17 percent. The last row reports results when we adjust the empirical earnings density for extensive margin responses by adding the simulated extensive response in each bin back to the empirical density. This adjustment of the empirical density lowers the relative upward bias to 2-9 percent.

We can also apply this simulation-based adjustment of the empirical density to our setting. Specifically, we first simulate the extensive margin response using our estimate for the earnings elasticity ($e = 0.27$). In a second step, we add the simulated extensive margin response to the empirical earnings density in Figure 3 and re-estimate the elasticity based on the adjusted earnings density.[31] This adjustment reduces the earnings response Δz from €464 to €392 and the earnings elasticity from 0.27 to 0.20, suggesting that in our context the upward bias from extensive margin responses is small.

Table 6

A caveat is that even though the Monte-Carlo simulations suggest that the bunching approach works well in our context, the same may not be true in other settings. In general, the performance of the bunching estimator for notches will depend on (i) the size of the notch, (ii) the shape of the observed earnings density, and (iii) the size of the extensive margin response. Since larger notches affect the earnings distribution over a wider window, predicting the counterfactual earnings density becomes more difficult, because the estimation relies on earnings bins further away from the threshold. These bins may provide a poor counterfactual for the earnings bins around the notch, especially in settings in which the observed earnings density changes in a very non-linear fashion with earnings. Moreover, the shape of the observed earnings density also matters for whether the observed earnings density above the notch will be distorted by intensive margin responses to the higher marginal tax rate. These intensive margin responses will shift the observed earnings density to the left and, as Kleven (2016) notes, in settings with steep observed earnings densities this left shift can have a significant impact on the estimation. In our context, the large size of the notch and the left-shift in the density are less problematic because the observed earnings density is quite flat above the notch. Finally, bunching estimators will perform better if the extensive margin

[31] Figure A.9 in Online Appendix A shows the resulting earnings distribution when we apply this adjustment.

response is small, which is also the case in our study. With a small extensive margin response, the observed earnings density above the notch will be less distorted, making it easier to estimate the counterfactual earnings density.

7 Fiscal Effects and Policy Implications

This section discusses the fiscal effects of the SGA threshold for the government and the associated policy implications. Using data for the year 2012, we investigate the fiscal impacts of two hypothetical policy changes. Under the first policy, DI beneficiaries would keep full benefits if earnings exceed the SGA threshold. Under the second policy, DI beneficiaries would lose benefits more gradually: They would lose €1 of benefits for every €2 of earnings above the SGA threshold. This policy is currently being tested in the U.S. and is known as the "$1 for $2 benefit offset" (Wittenburg et al. (2015)). In both scenarios recipients would still have to pay social security contributions once earnings exceed the SGA threshold.

We are interested in the long-run impact of each policy on DI benefits paid, payroll taxes received, and government net expenditures. To calculate these effects, we proceed in several steps. First, we calculate the new tax parameters ΔT and Δt under each policy. For example, under the benefit offset policy we have $\Delta T = 0.18 * z^*$ and $\Delta t = 0.5$. Second, we use the new tax parameters and the elasticity estimates to calculate the overall earnings effect of the policy. This effect can be decomposed into an intensive and extensive margin response. For the intensive margin response, we feed the new tax parameters and our estimate of the earnings elasticity ($e = 0.27$) into equation 3 to obtain an estimate of the earnings response $\Delta z^{'}$. This estimate implies that beneficiaries who stop bunching under the new policy will now earn in the interval $(\Delta z^* - \Delta z^{'})$. Additionally, beneficiaries to the right of the SGA threshold increase their earnings, because they face lower tax rates under the new policy.[32] For the extensive response, we use the estimated elasticity of labor force nonparticipation to calculate the number of DI recipients who start to work under the new policy.[33] We assume that beneficiaries who start to work earn the same amount on average as

[32]The change in earnings of recipients to the right of the SGA threshold is calculated as $\Delta z = \epsilon \frac{\Delta t}{(1-t)} z$ where z is the current earnings level, Δt is the change in the marginal tax rate due to the policy change, and $(1-t)$ is the marginal tax rate before the policy change. Since abolishing the notch induces a jump in the average tax rate rather than the marginal tax rate, calculating Δt is not straighforward. We approximate the change in the average tax rate by an equivalent change in the implicit marginal tax rate as in Kleven and Waseem (2013).

[33]More specically, the change in labor force nonparticipation under the new policy is given by $\Delta(1 - LFP) =$

beneficiaries above the SGA threshold. Based on the change in earnings, we can directly calculate the change in payroll tax revenue and DI benefits.

The results for the two hypothetical policy changes are reported in Table 7. The first column shows that under the status quo the government spends €1,024.1 million on DI benefits per year and receives €14.9 million in payroll taxes. As shown in the second column, abolishing the DI notch generates additional DI benefit payments of €7.1 million because beneficiaries who earn above the SGA threshold now receive full benefits.[34] The policy generates additional payroll tax revenues of €16 million, as some beneficiaries start to work while those who already work increase their earnings, and therefore annual net government expenses decrease by €8.9 million. Column 3 shows that the fiscal savings are ten times smaller under the €1 for €2 benefit offset policy. The reason is that this policy induces smaller financial incentives compared to abolishing the notch and therefore generates smaller behavioral responses.

Table 7

Our calculations above ignore the possibility that relaxing the earnings restrictions could induce more program entry by those able to earn above the SGA threshold.[35] To shed light on this issue, we calculate how elastic DI program inflow would need to be to lead to an increase in government net expenditure. Specifically, as in Kostol and Mogstad (2014), we calculate an elasticity of induced entry, defined as the percentage increase in the number of DI beneficiaries relative to the percentage change in disposable income as a DI beneficiary. The abolishment of the DI notch yields an induced entry elasticity of 0.26, while the benefit offset policy yields a smaller induced entry elasticity of 0.09. However, these induced entry elasticities are well below the 1.2 elasticity that Mullen and Staubli (2016) find for Austria, suggesting that after accounting for induced entry responses both policies would increase government net expenses. This finding is consistent with Hoynes and Moffitt (1999) who simulate the labor supply effects of proposed reforms to increase work incentives through changes in the benefit formula and conclude that they are not as effective as expected. They find that non-program based financial incentives such as the Earned Income Tax Credit are more

$\epsilon \frac{\Delta PTR}{PTR}(1 - LFP)$ whereΔPTR measures the policy-induced reduction in the participation tax rate.

[34] In our calculations, we ignore that the increase in DI benefits may induce beneficiaries above the SGA threshold to reduce their earnings (and payroll tax contributions) through an income effect.

[35] Making the earnings rules more generous could also lead to fewer program exits by current beneficiaries. However, this effect is likely to be small given that the DI exit rate is already very low under the current rules.

favorable because they have the potential to increase work and to reduce DI caseloads at the same time.

8 Conclusion

Many countries specify a substantial gainful activity (SGA) threshold in their DI program at which DI beneficiaries lose part or all of their benefits. This rule results in a discontinuous change in tax liability, creating a strong incentive for many beneficiaries to intentionally keep their earnings just below the SGA threshold. In this paper, we have examined whether DI recipients adjust their earnings because of the SGA threshold as well as how elastic their earnings are to changes in financial incentives.

Using a large and salient notch located at the SGA threshold in Austria's DI program, we provide transparent and credible documentation of behavioral earnings responses of DI beneficiaries. We find evidence for large and sharp bunching just below the SGA threshold and missing mass just above the SGA threshold, suggesting that many DI recipients would earn considerably more in the absence of the SGA threshold. Indeed, our estimation approach implies that DI beneficiaries who earn just below the SGA threshold would increase monthly earnings by €196 on average if the notch at the SGA threshold did not exist. This effect represents a substantial 45 percent increase relative to the monthly SGA threshold of €439.

While the earnings responses to the SGA threshold are large, the elasticities driving those responses are not. We estimate that the earnings elasticity with respect to the implicit net-of-tax rate is 0.27, suggesting a relatively low responsiveness of earnings to financial incentives. The reason is that notches create extremely large implicit marginal tax rates and thus behavioral responses are large, even when elasticities are quite small.

Our findings are derived from the Austrian DI program and one needs to exercise caution when applying these conclusions to other countries. The DI program in Austria shares similarities with DI programs in other countries in terms of size and composition of beneficiaries. However, there are also some characteristics that are distinct from other programs, most notably the level of the SGA threshold. This difference is important because our estimation strategy exploits variation in earnings of beneficiaries located around the SGA threshold. If the distribution of people changes as earnings increase, then the elasticity estimated here might be different than an elasticity estimated at a different SGA threshold.

Our framework is useful to shed light on the fiscal effects of policy reforms that encourage work among DI beneficiaries by reducing the implicit tax on earnings. Our calculations suggest that relaxing the earnings restrictions would increase work and reduce government expenditures. However, allowing DI recipients to earn more while keeping benefits may increase the incentive to apply for DI benefits. While we cannot estimate the level of induced entry that would occur if earnings restrictions were relaxed, we instead calculate how elastic entry responses would have to be to increase net expenditure. We find that the elasticity of program inflow to changes in benefits estimated in previous studies is above our break-even elasticity, suggesting that government net expenditures would increase after accounting for induced entry responses.

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Table 1: Summary statistics

	All DI recipients	Working DI recipients	
		All	At notch
Female (percent)	45	45	48
Age at DI entry (years)	48.2 (8.0)	46.6 (9.0)	45.3 (9.1)
Blue-collar (percent)	67	68	62
UI duration last 15 years	1.12 (1.31)	0.93 (1.19)	1.14 (1.21)
Experience last 15 years	9.67 (4.71)	11.1 (4.00)	10.3 (4.00)
Sick leave last 15 years	0.71 (0.79)	0.60 (0.71)	0.69 (0.75)
Monthly DI benefits (in €)			
Full DI benefits	974 (498)	920 (472)	1,040 (490)
Partial DI benefits	964 (507)	688 (584)	1,040 (490)
Monthly gross earnings (in €)			
Last job before DI	3,009 (5,674)	2,411 (3,766)	1,992 (3,916)
While claiming DI	54 (533)	1,179 (2,227)	375 (43)
Health impairment			
Mental disorders (percent)	40	38	44
Musculoskeletal system (percent)	19	16	16
Cardiovascular system (percent)	10	10	8
Other (percent)	31	36	31
No. of individuals	183,168	27,054	7,084
No. of observations	7,562,737	334,461	84,787

Notes: UI duration last 15 years, experience last 15 years and sick leave last 15 years are measured prior to DI entry. Sample standard deviations for continuous variables in parentheses. Monthly DI benefits and monthly gross earnings are measured during DI. Health impairments are only observed for DI spells that were initiated in 2004 or after.

Table 2: Earnings elasticities for pooled sample and by year after program entry

	Bunching b	Earnings response Δz		Elasticity e
		marginal buncher	average response	
A. Full sample	19.1*** (0.7)	464*** (32)	196*** (7)	0.27*** (0.03)
B. Yearly				
1 Year after entry	17.6***(0.82)	488***(44.6)	209***(11.0)	0.27***(0.05)
2 Years after entry	20.4***(1.02)	448***(58.0)	194***(29.4)	0.21***(0.05)
3 Years after entry	22.0***(7.65)	488***(130)	201***(84.7)	0.26***(0.11)
4 Years after entry	19.1***(1.21)	384***(63.9)	170***(35.7)	0.15***(0.06)
5 Years after entry	20.9*(14.2)	448***(163)	184*(127)	0.21*(0.13)
6 Years after entry	23.4***(9.17)	496***(162)	196**(111)	0.25**(0.13)
7 Years after entry	22.4***(3.25)	496**(246)	201*(141)	0.26*(0.19)

Notes: The table presents estimates of bunching, the earnings response of the marginal buncher based on the point of convergence z^U, the average earnings response of individuals who bunch, and the structural earnings elasticity for the full sample and by year after DI entry. The structural elasticity is based on equation (3) using the earnings response of the marginal buncher. Standard errors in parentheses are obtained using a pairs cluster bootstrap that accounts for clustering of errors at the individual level. All estimates are based on a sixth-order polynomial fitted to the empirical earnings distribution. Significance levels: *** = 1%, ** = 5%, * = 10%.

Table 3: Heterogeneity of earnings elasticities

	Bunching b	Earnings response Δz		Elasticity e
		marginal buncher	average response	
A. Age				
< 35	16.7*** (2.4)	496* (324)	171 (137)	0.45 (0.38)
$35-49$	18.9*** (1.0)	448*** (77)	188*** (35)	0.29*** (0.06)
≥ 50	18.8*** (0.8)	432*** (29)	196*** (9)	0.19*** (0.03)
B. Gender				
Men	19.1*** (0.8)	448*** (35)	193*** (9)	0.17*** (0.03)
Women	17.9*** (0.9)	432*** (42)	184*** (10)	0.37*** (0.06)
C. Health impairment				
Mental	16.3*** (1.1)	376*** (44)	169*** (13)	0.21*** (0.05)
Physical	17.9*** (1.4)	400*** (49)	182*** (15)	0.16*** (0.05)
Other	20.6*** (2.2)	528** (233)	216* (141)	0.34** (0.20)
D. Worker status				
Blue-Collar	16.4*** (0.7)	376*** (22)	168*** (8)	0.21*** (0.03)
White-Collar	23.1*** (1.3)	568*** (176)	232*** (77)	0.29** (0.14)
E. Sick days				
Below Median	20.2*** (1.1)	560*** (104)	219*** (63)	0.39*** (0.06)
Above Median	17.8*** (0.8)	392*** (26)	175*** (9)	0.19*** (0.03)
F. Firm switches at DI entry				
Do not switch firm	20.2*** (0.8)	504*** (39)	198*** (9)	0.32*** (0.04)
Switch firm	15.4*** (1.2)	384*** (41)	187*** (14)	0.18*** (0.04)
G. Sector				
Primary/secondary	25.4*** (2.7)	592*** (182)	217** (113)	0.35** (0.15)
Tertiary	19.3*** (1.0)	464*** (47)	187*** (10)	0.28*** (0.05)
Public sector	17.7*** (1.6)	360*** (64)	160*** (16)	0.23*** (0.08)
H. Size of notch				
1st tercile	16.3*** (1.0)	368*** (43)	164*** (11)	0.34*** (0.06)
2nd tercile	18.1*** (1.0)	384*** (27)	177*** (10)	0.24*** (0.03)
3rd tercile	20.8*** (1.4)	504*** (184)	220** (95)	0.13 (0.13)

Notes: The table presents estimates of bunching, the earnings response of the marginal buncher based on the point of convergence z^U, the average earnings response of individuals who bunch, and the structural earnings elasticity by age, gender, health impairment, worker status, sick days, whether beneficiaries switch firm at DI entry, sector, and size of the notch relative to DI benefits. The structural elasticity is based on equation (3) using the earnings response of the marginal buncher. Standard errors in parentheses are obtained using a pairs cluster bootstrap that accounts for clustering of errors at the individual level. All estimates are based on a sixth-order polynomial fitted to the empirical earnings distribution. Significance levels: *** = 1%, ** = 5%, * = 10%.

Table 4: Earnings elasticities, robustness checks

	Bunching b	Earnings response Δz		Elasticity e
		marginal buncher	average response	
A. Main results	19.1*** (0.7)	464*** (32)	196*** (7)	0.27*** (0.03)
B. Without self-employed	19.8*** (0.7)	528*** (56)	195*** (8)	0.35*** (0.06)
C. Alternative polynomials				
5th order polynomial	20.1*** (0.6)	368*** (13)	184*** (5)	0.17*** (0.01)
7th order polynomial	19.5*** (0.7)	528*** (35)	205*** (8)	0.35*** (0.04)
D. Alternative estimation approaches				
Bunching after 5 years	27.7*** (0.8)	408*** (13)	171*** (5)	0.21*** (0.01)
Left shift due to kink	17.6*** (0.7)	384*** (16)	181*** (6)	0.19*** (0.02)
Bunching-hole approach	19.1*** (0.7)	376*** (21)	192*** (11)	0.18*** (0.02)
Reduced-form approach	18.5*** (0.7)	486*** (25)	175*** (6)	0.23*** (0.02)
E. Workers not on DI program	4.7*** (0.7)	336*** (9)	152*** (4)	0.62*** (0.04)

Notes: The table presents estimates of bunching, the earnings response of the marginal buncher based on the point of convergence z^U, the average earnings response of individuals who bunch, and the structural earnings elasticity. The structural elasticity is based on equation (3) using the earnings response of the marginal buncher (except for the reduced-form approach which uses the approach developed by Tazhitdinova, 2017). Standard errors in parentheses are obtained using a pairs cluster bootstrap that accounts for clustering of errors at the individual level. All estimates are based on a sixth-order polynomial fitted to the empirical earnings distribution. Significance levels: *** = 1%, ** = 5%, * = 10%.

Table 5: Estimates of labor force participation and implied elasticity of labor force nonparticipation

	Full sample		Subgroups			
	No controls	With controls	Men	Women	Low-earners	High-earners
A. LFP estimates						
ΔLFP	0.065***	0.067***	0.059***	0.076***	0.044***	0.091***
$(Post \times Treat)$	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)
Age DI entry<55	0.008***	0.002	0.018	0.009	0.001	-0.013
$(Treat)$	(0.001)	(0.015)	(0.020)	(0.032)	(0.023)	(0.021)
Mean LFP	0.028	0.028	0.029	0.027	0.019	0.037
R^2	0.027	0.072	0.059	0.106	0.075	0.075
No. of Obs.	696,169	696,169	488,627	207,542	341,106	355,063
B. Elasticity of labor force nonparticipation						
Mean $(1 - LFP)$	0.972	0.972	0.971	0.973	0.981	0.963
ΔPTR	-0.808	-0.808	-0.859	-0.712	-0.679	-0.868
Mean PTR	1.192	1.192	1.260	1.067	1.022	1.272
Elasticity	0.099***	0.102***	0.090***	0.117***	0.068***	0.141***
	(0.003)	(0.003)	(0.003)	(0.005)	(0.003)	(0.005)

Notes: Panel A reports estimates obtained from regression specification (5). Mean LFP, mean PTR, and mean $(1 - LFP)$ are pre-reform averages for recipients who entered DI before age 55. All specifications include year-month dummies. Additional control variables: gender, age-in-years dummies, average earnings in best 15 years before DI, work experience in 15 years before DI, days unemployed in 15 years before DI, days on sick leave in 15 years before DI, and number of contribution years. Specifications for subgroups include all control variables. Low-earners (high-earners) are below (above) the median in the distribution of average earnings in best 15 years before DI. Panel B reports the elasticity of labor force nonparticipation based on the formula $\epsilon = \frac{\Delta(1-LFP)/(1-LFP)}{\Delta PTR/PTR}$. Standard errors adjusted for clustering at the individual level. Significance levels: *** = 1%, ** = 5%, * = 10%.

Table 6: Simulation exercise to assess robustness of elasticity estimates with a large notch

	e = 0.1	e = 0.2	e = 0.3
Small notch	0.103 (3%)	0.195 (-3%)	0.306 (2%)
Austrian DI notch	0.112 (12%)	0.206 (3%)	0.309 (3%)
With extensive margin response	0.117 (17%)	0.222 (11%)	0.334 (11%)
Simulation-based adjustment	0.109 (9%)	0.204 (2%)	0.308 (3%)

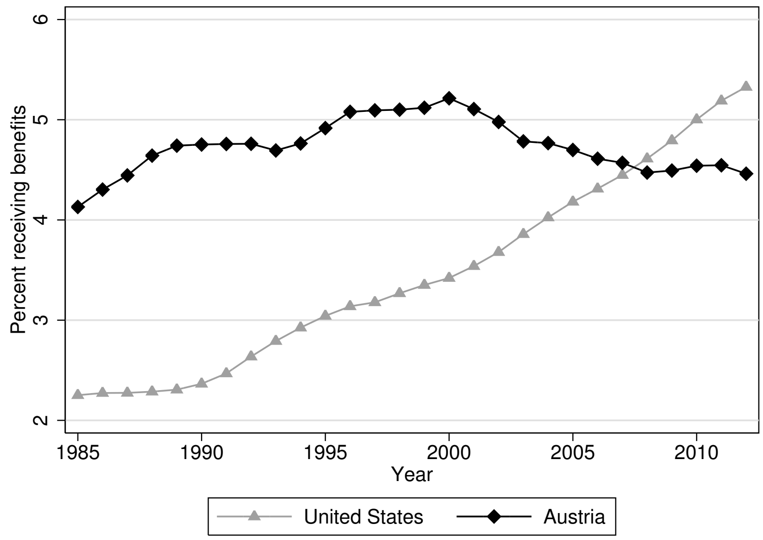
Notes: The table documents elasticity estimates for four different scenarios (rows) and three theoretical elasticities (columns). See text for a description of the different scenarios. In parentheses, we report the bias in the estimated elasticity relative to the theoretical elasticity.

Table 7: Annual Fiscal Effect of Abolishing the Notch

	Status quo (million €)	Abolish DI notch (million €)	€1 for €2 benefit offset (million €)
DI benefits	1024.1	7.1 (0.69%)	0.3 (0.03%)
Payroll tax revenues	14.9	16.0 (107.4%)	1.2 (7.7%)
From intensive response		4.9	0.5
From extensive response		11.1	0.7
Net expenses	1009.2	-8.9 (-0.9%)	-0.9 (0.1%)
Induced entry elasticity		0.26	0.09

Notes: All money amounts are in 2012 euros. Column 1 shows the annual DI benefit payments, annual payroll tax revenues, and annual net expenses for DI beneficiaries below age 57 who are on the DI program in 2012. Columns 2 and 3 show the changes in DI benefits payments, payroll tax revenues, and net expenses in million euros and in percent of the status quo (in parentheses) from two policy experiments: (i) abolishing the DI notch while keeping the notch due to social security payroll taxes (column 2) and (ii) replacing the notch with a kink with €1 for €2 benefit offset (column 3). The induced entry elasticity measures how elastic DI inflow with respect to disposable income would need to be to offset the change in net expenses.

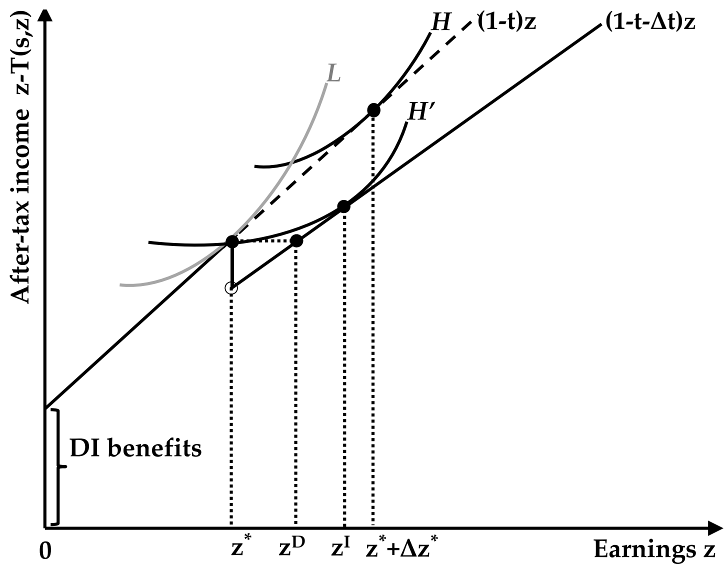
Figure 1: Disability Insurance Recipiency per Adult Ages 25-64



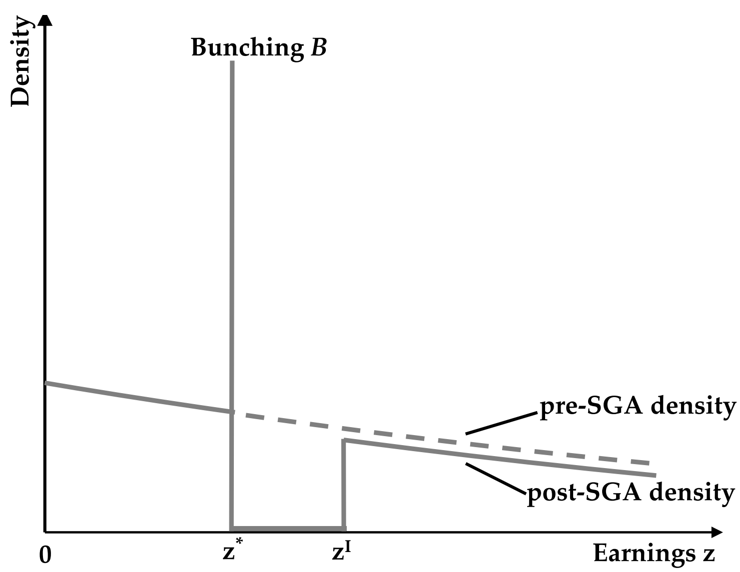
Source for Austria: STATISTIK AUSTRIA population data; statistical supplement published by “Hauptverband der österreichischen Sozialversicherungsträger”. Source for the United States: Social Security Bulletin: Annual Statistical Supplement; Bureau of the Census, Census Population Estimates, available at http://www.census.gov/popest/estimates.html.

Figure 2: Budget sets and density distributions

(a) Budget set

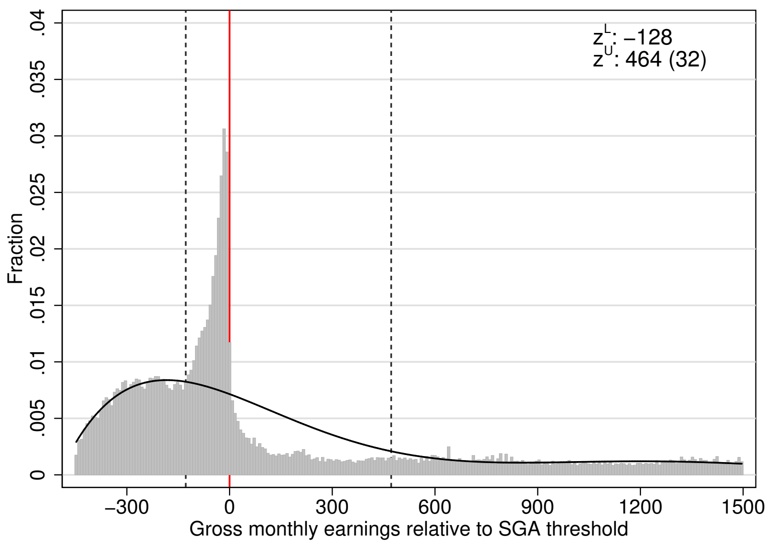


(b) Density distributions



Notes: Panel (a) shows after-tax monthly income as a function of monthly gross earnings without an SGA threshold (dashed line) and with an SGA threshold (solid line); z^* denotes the SGA threshold; z^D denotes the earnings level at which the after-tax income is equal to the after-tax income at the SGA threshold. Panel (b) shows the density distribution without an SGA threshold (dashed line) and with an SGA threshold (solid line).

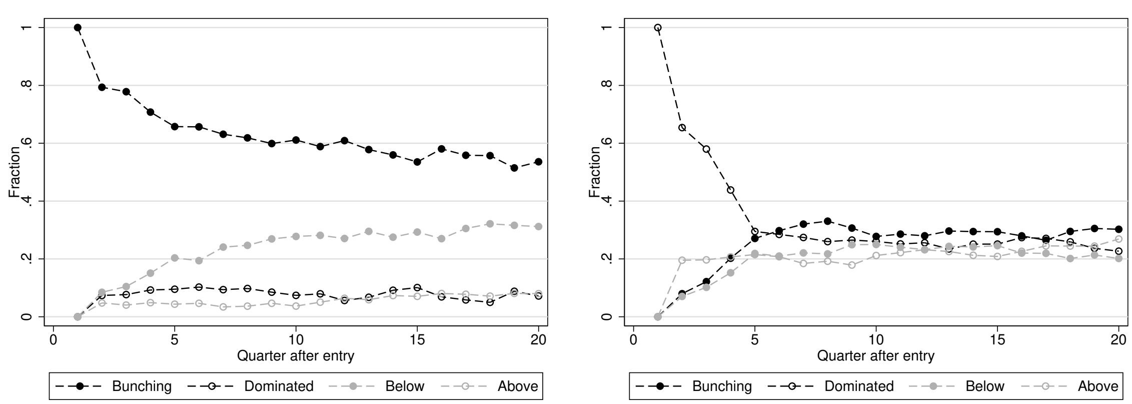
Figure 3: Earnings distribution around the SGA threshold



Notes: The figure shows the distribution of gross monthly earnings relative to the SGA threshold (marked by the vertical solid line) for DI beneficiaries between 2001 and 2012. The histogram bin width is €8. The solid line beneath the empirical distribution is a sixth-degree polynomial fitted to the empirical distribution using equation (4). The excluded range $[z^L, z^U]$ is marked by vertical dotted lines; z^U has been estimated such that missing mass equals bunching mass. Bootstrapped standard errors are shown in parentheses.

Figure 4: Dynamics of bunching and dominated behavior over time

(a) Bunching behavior (b) Dominated behavior

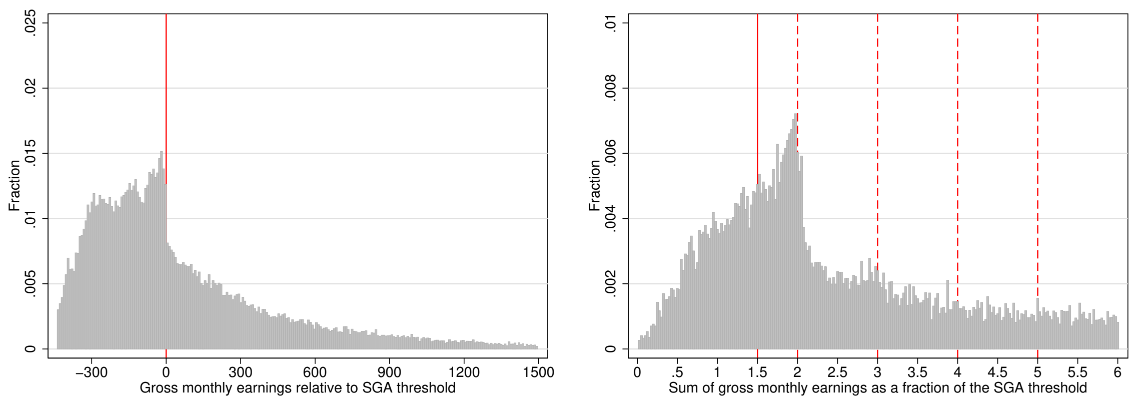


Notes: Panel (a) shows the dynamics of bunching behavior by quarter after DI entry. The sample consists of all DI beneficiaries who are in the bunching segment $[z^L, z^*]$ in the first quarter after DI entry. Panel (b) shows the dynamics of dominated behavior by quarter after DI entry. The sample consists of all DI beneficiaries who are in the range $(z^*, z^U]$ in the first quarter after DI entry. "Below" and "above" denote the earnings intervals $(0, z_L)$ and (z_U, ∞), respectively.

Figure 5: Evidence for firm bunching

(a) Earnings in secondary job

(b) Sum of earnings in a firm of workers with earnings below the SGA threshold

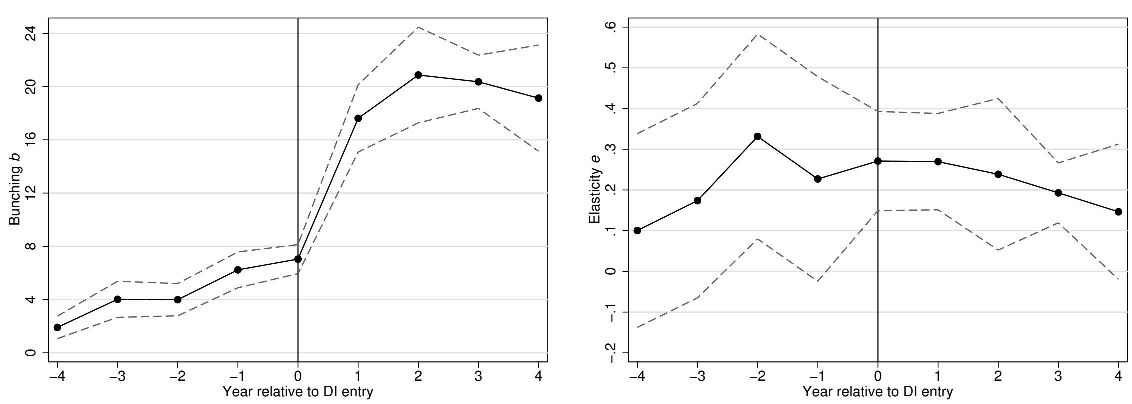


Notes: Panel (a) shows the distribution of monthly gross earnings in a secondary job relative to the SGA threshold (marked by the vertical solid line) for individuals who concurrently hold a second job in addition to the main job, defined as a job that pays more than the SGA threshold. Sample includes DI beneficiaries between 2001 and 2012 who are reported to work in two firms in a month while being on the DI program or up to eight years before entering the DI program. Panel (b) shows the distribution of the sum of gross monthly earnings in a firm of all workers with earnings below the SGA threshold in percent of the SGA threshold. The sample includes all firms which employ at least one DI recipient once between 2001 and 2012 and at least two workers with earnings below the SGA threshold. The histogram bin width is €8 in both panels.

Figure 6: Bunching and earnings elasticity before/after DI entry

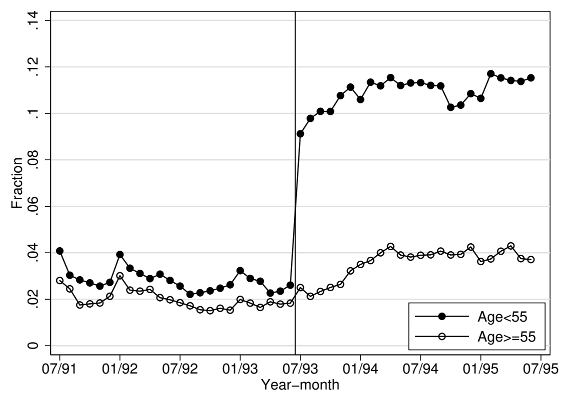
(a) Bunching b

(b) Elasticity e



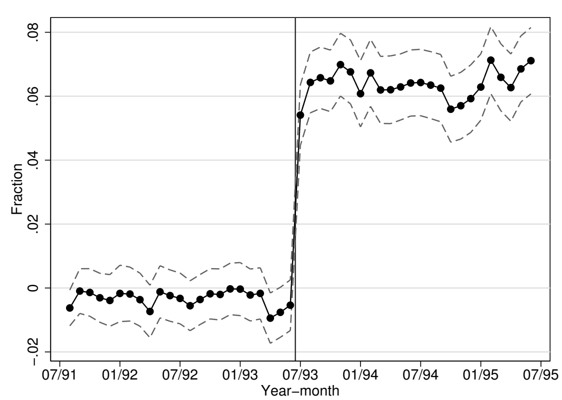
Notes: Panel (a) shows the amount of bunching b and Panel (b) shows the earnings elasticity e using equation (3) for different years before and after DI entry (vertical solid line). The sample consists of DI recipients who are working at least once in the first four years after program entry. The dashed lines denote 95 percent confidence intervals.

Figure 7: Labor force participation for recipients entering DI before and after age 55



Notes: The figure shows the monthly fraction of DI recipient who work by age at DI entry over the period July 1991 to July 1995. For each recipient, we only keep observations from the first six months on the DI program. The black vertical line denotes the month in which the July 1993 reform became effective.

Figure 8: Difference in labor force participation between recipients entering DI before and after age 55



Notes: The figure plots the monthly average difference in the fraction of recipients who work between recipients entering the DI program before and after age 55, obtained from regression specification (6), where controls include gender, age-in-years dummies, average earnings in best 15 years before DI, work experience in 15 years before DI, days unemployed in 15 years before DI, days on sick leave in 15 years before DI, and number of contribution years. The reference year-month is July 1991. The dashed lines denote 95 percent confidence intervals. Standard errors adjusted for clustering at the individual level. The black vertical line denotes the month in which the July 1993 reform became effective. For each recipient, we only keep observations from the first six months on the DI program.

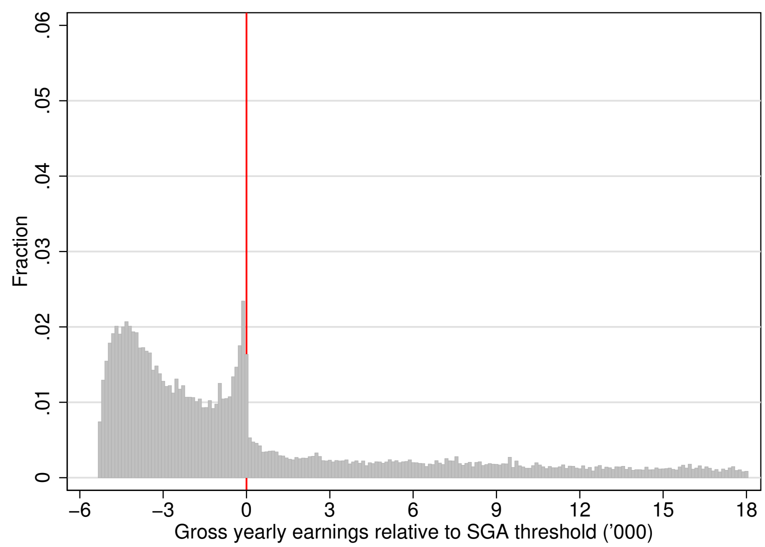
Online Appendix:

Financial Incentives and Earnings of Disability Insurance Recipients: Evidence from a Notch Design

Philippe Ruh and Stefan Staubli

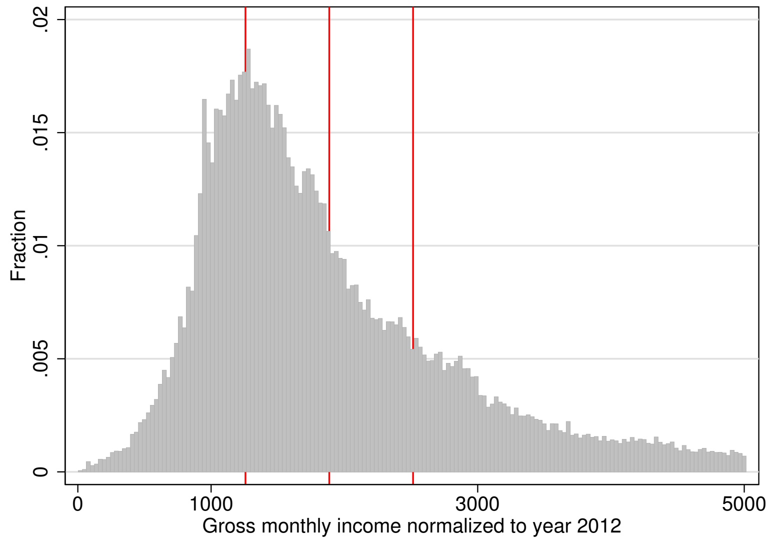
A Appendix: Additional Figures

Figure A.1: Distribution of annual earnings around the SGA threshold



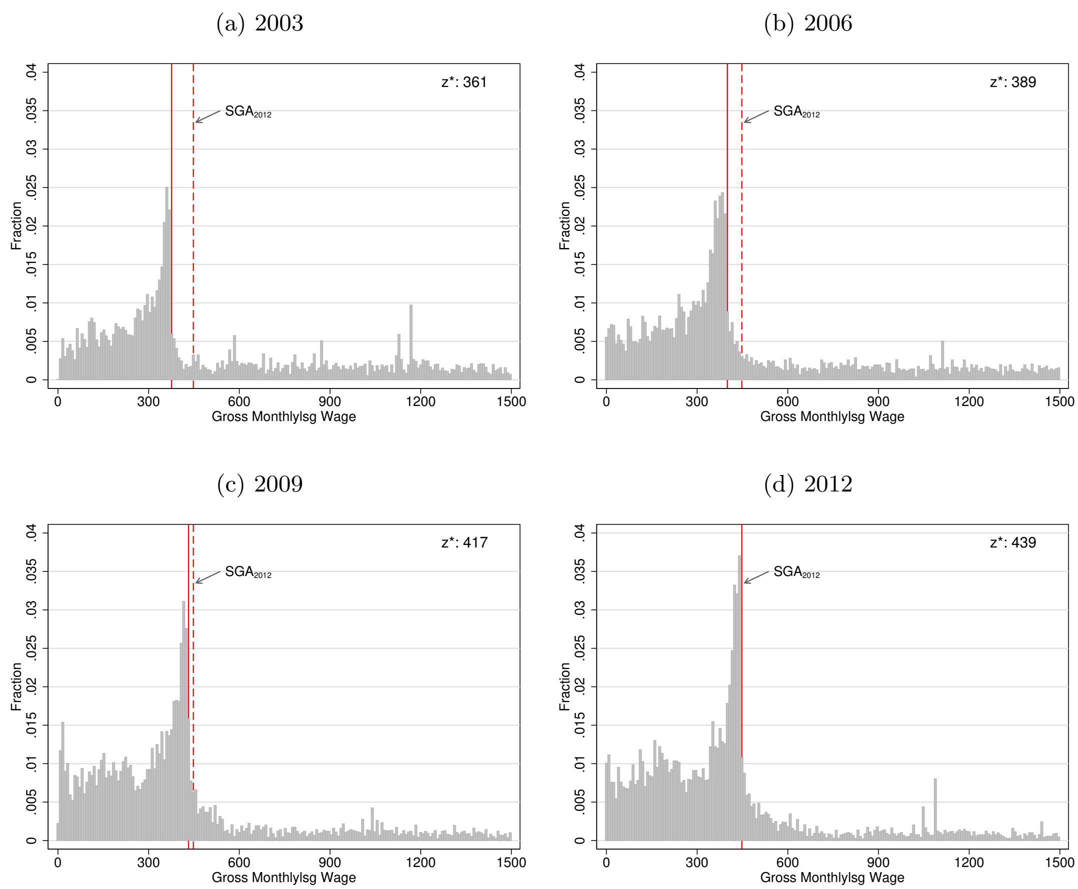
Notes: The figure shows the distribution of annual gross earnings relative to the annual SGA threshold (marked by the vertical solid line) for DI beneficiaries between 2001 and 2012. The histogram bin width is €120.

Figure A.2: Distribution of gross monthly income normalized to year 2012



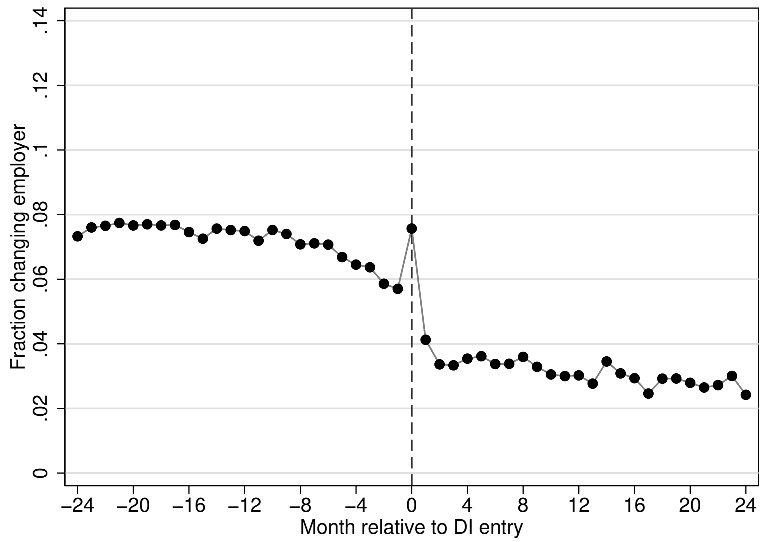
The figure shows the distribution of gross monthly income for DI recipients between 2001 and 2012. Gross monthly incomes are normalized to 2012 with the adjustment factors used to adjust K_1, K_2, and K_3 for inflation. The vertical red lines denote the values for K_1, K_2, and K_3 in the year 2012 (see equation (1) for details). The histogram bin width is €30.

Figure A.3: Earnings distribution around the SGA threshold in 2003, 2006, 2009, and 2012



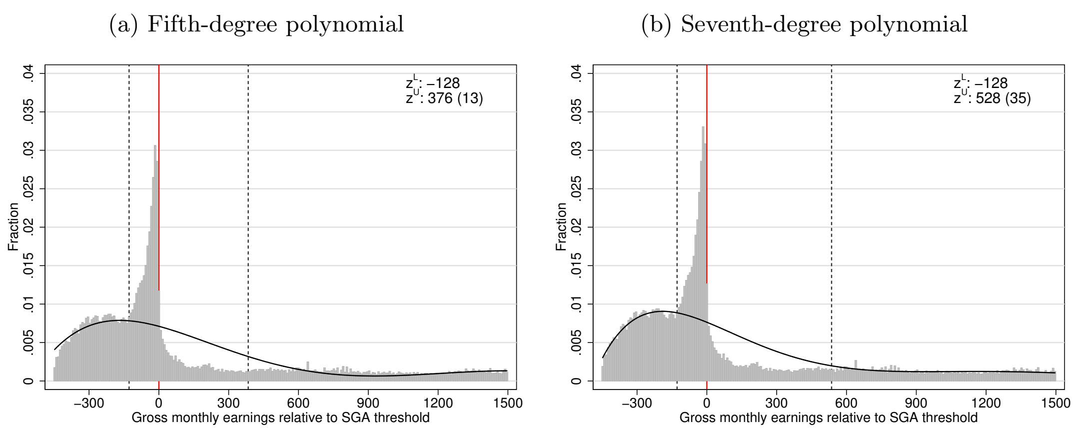
Notes: The figures show the distribution of gross monthly earnings relative to the SGA threshold (marked by the vertical solid line) for DI beneficiaries in the years 2003, 2006, 2009, and 2012. The sample in each figure consists of DI beneficiaries who entered the program in the four-year window before the observation year. The SGA threshold in 2012 is marked by the vertical dashed line. The histogram bin width is €8.

Figure A.4: Fraction of individuals changing the firm by month relative to DI entry



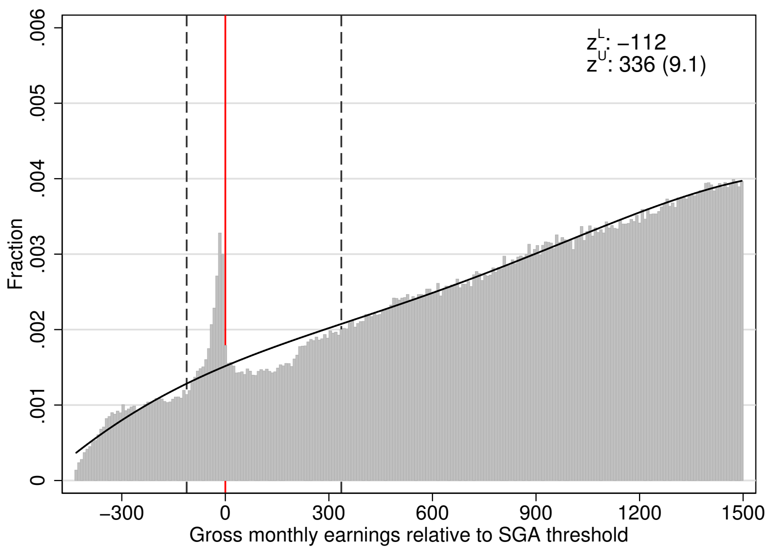
Notes: This figure shows the fraction of individuals who change the firm in different months before and after DI entry (vertical dashed line).

Figure A.5: Estimated counterfactual earnings distributions around the SGA threshold for fifth-degree and seventh-degree



Notes: The figure shows the distribution of monthly gross earnings relative to the SGA threshold (marked by the vertical solid line) for DI beneficiaries between 2001 and 2012. The excluded range $[z^L, z^U]$ is marked by vertical dotted lines. The histogram bin width is €10. The solid line beneath the empirical distribution in the left (right) figure is a fifth-degree (seventh-degree) polynomial fitted to the empirical distribution using equation (4). Bunching b is excess mass in the excluded range below the notch relative to the average counterfactual density in the interval $[z^L, z^*]$ and z^U has been estimated such that missing mass equals bunching mass. Bootstrapped standard errors are shown in parentheses.

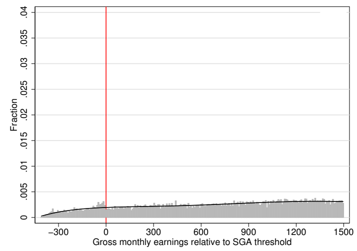
Figure A.6: Earnings distribution around the SGA threshold for workers not on the DI program



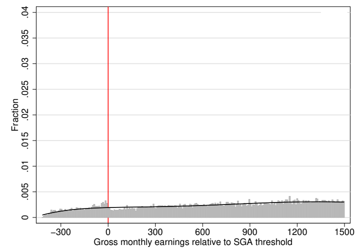
Notes: The figure shows the distribution of monthly gross earnings relative to the SGA threshold (marked by the vertical solid line) for individuals not on the DI program between 2001 and 2012. The excluded range $[z^L, z^U]$ is marked by vertical dotted lines. The histogram bin width is €10. The solid line beneath the empirical distribution is a sixth-degree polynomial fitted to the empirical distribution using equation (4). Bunching b is excess mass in the excluded range below the notch relative to the average counterfactual density in the interval $[z^L, z^*]$ and z^U has been estimated such that missing mass equals bunching mass. Bootstrapped standard errors are shown in parentheses.

Figure A.7: Earnings distribution around the SGA threshold before and after DI entry

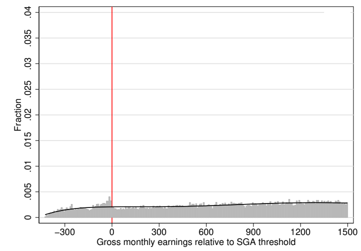
(a) 4 years before entry



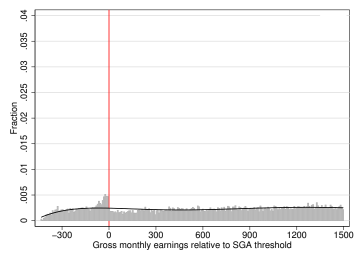
(b) 3 years before entry



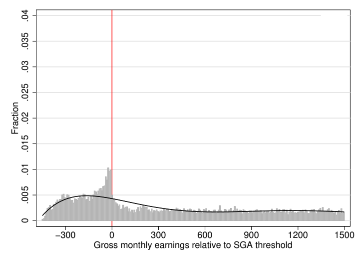
(c) 2 years before entry



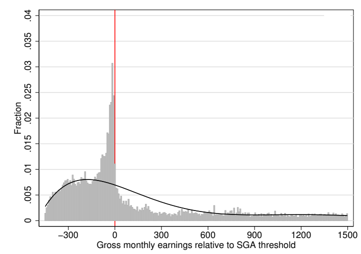
(d) 1 year before entry



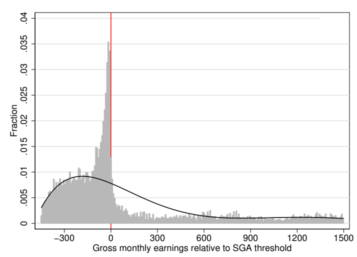
(e) year of entry



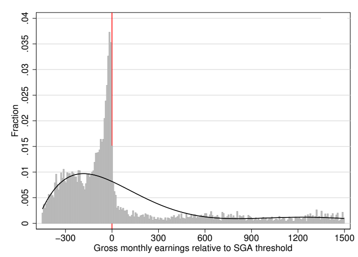
(f) 1 year after entry



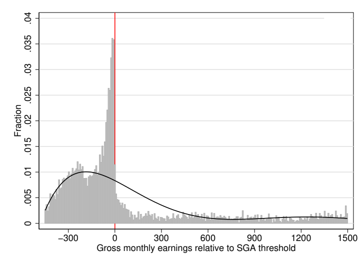
(g) 2 years after entry



(h) 3 years after entry



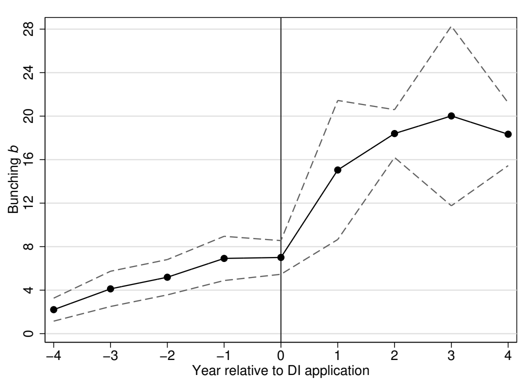
(i) 4 years after entry



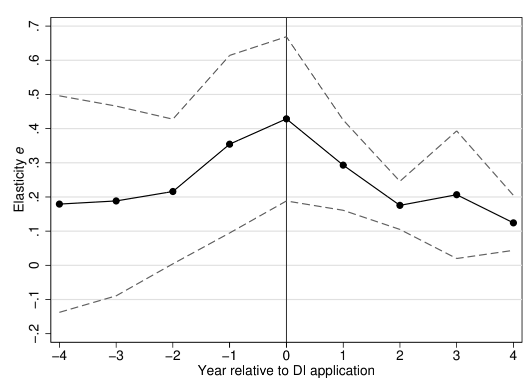
Notes: The figure shows the distribution of monthly gross earnings relative to the SGA threshold (marked by the vertical solid line) for DI beneficiaries each year in the four years before and after DI entry. The sample consists of DI beneficiaries who are working at least once in the first four years after program entry. The histogram bin width is €8. The solid line beneath the empirical distribution is a sixth-degree polynomial fitted to the empirical distribution using equation (4).

Figure A.8: Bunching and earnings elasticity before/after DI application

(a) Bunching b

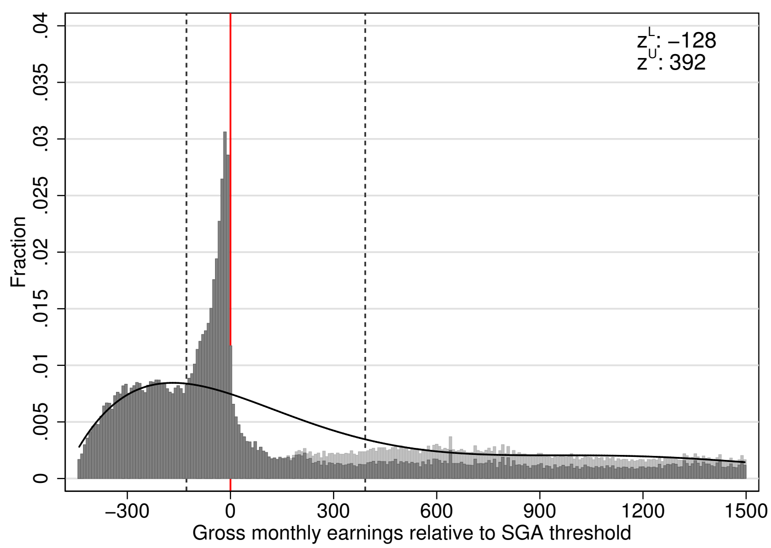


(b) Elasticity e



Notes: Panel (a) shows the amount of bunching b and Panel (b) shows the earnings elasticity e using equation (3) for different years before and after applying for DI benefits (vertical solid line). The sample consists of DI recipients who are working at least once in the first four years after program entry. The dashed lines denote 95 percent confidence intervals.

Figure A.9: Estimated effect on the earnings distribution above the SGA threshold



Notes: The figure shows the distribution of gross monthly earnings relative to the SGA threshold (marked by the vertical solid line) for DI beneficiaries between 2001 and 2012 when we add beneficiaries who would start working without the notch back to the right of the SGA threshold (the difference between the light and the dark gray bars). The histogram bin width is €8. The solid line beneath the empirical distribution is a sixth-degree polynomial fitted to the adjusted empirical distribution (light gray bars) using equation (4). The excluded range $[z^L, z^U]$ is marked by vertical dotted lines; z^U has been estimated such that missing mass equals bunching mass.

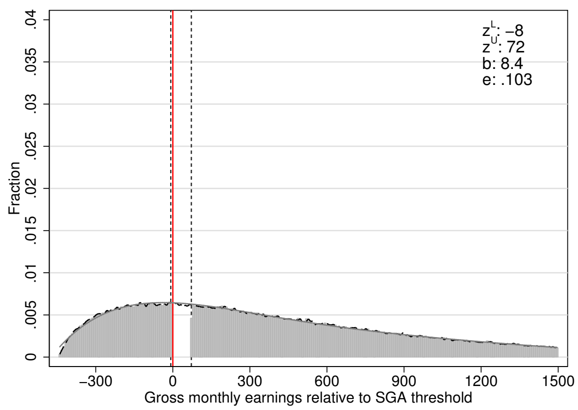
B Graphical illustration of Monte Carlo simulations

Figure B.1 shows the simulated and counterfactual earnings densities under the scenario "small notch," assuming a true underlying elasticity of $e = 0.1$ (Panel a), $e = 0.2$ (Panel b), or $e = 0.3$ (Panel c). Figures B.2 and B.3 display analogous results for the scenario "Austrian DI notch" and "Austrian DI notch with extensive margin response," respectively. In each panel, the black dashed line denotes the simulated earnings density *without* the notch and the gray bars represent the simulated earnings density *with* the notch. The gray solid line denotes the counterfactual earnings density which is obtained by estimating equation (4) on the simulated earnings density with the notch.

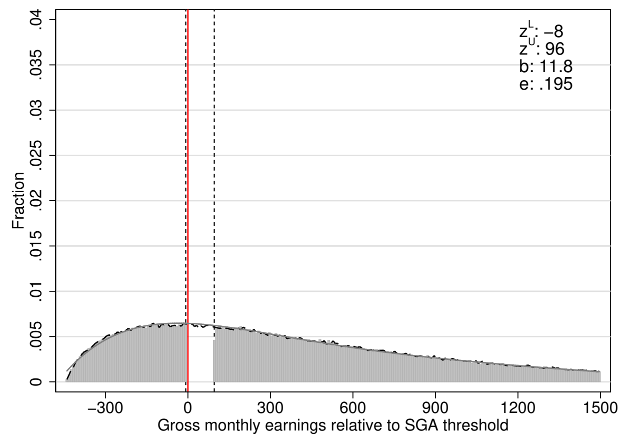
In each panel, we exclude the bin just to the left of the SGA threshold because bunching is so large that including this bin dwarfs all the other bins. The reason is that in the simulations individuals respond to the notch by precisely earning just below the SGA threshold, while in the empirical application bunching is more diffuse around the threshold. Moreover, in the simulations individuals can freely adjust their earnings, while in reality some people may not bunch because of optimization frictions (as discussed in the paper, the estimation strategy takes such frictions into account when estimating the earnings elasticity).

Figure B.1: Simulated and counterfactual densities for small notch

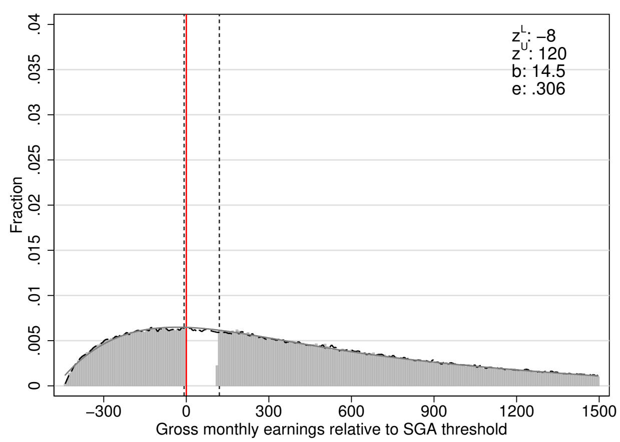
(a) e=0.1



(b) e=0.2



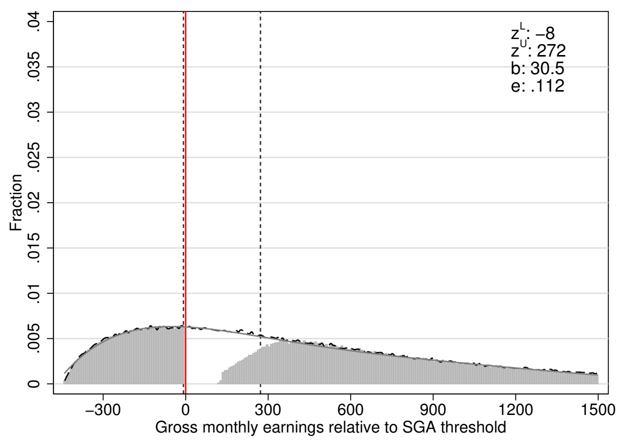
(c) e=0.3



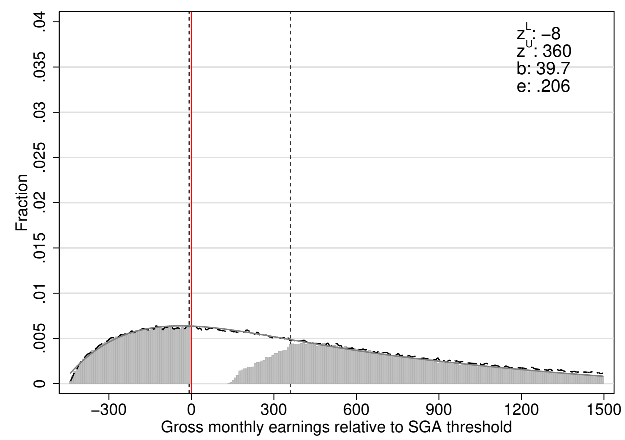
Notes: The figure plots the simulated earnings distributions without the notch (black dashed line) and with the notch (gray bars) for the cases $e = 0.1$, $e = 0.2$, and $e = 0.3$. The bin width of the gray bars is €8. The gray solid line denotes the counterfactual earnings density which is obtained by estimating equation (4) on the simulated earnings distribution with the notch. The bin just to the left of the SGA threshold is excluded in each panel.

Figure B.2: Simulated and counterfactual densities for Austrian DI notch

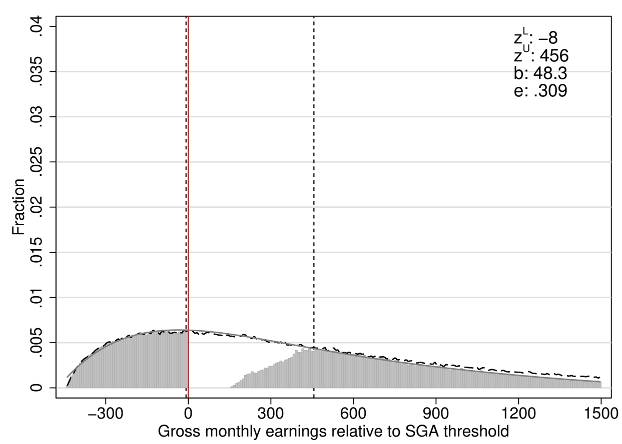
(a) e=0.1



(b) e=0.2



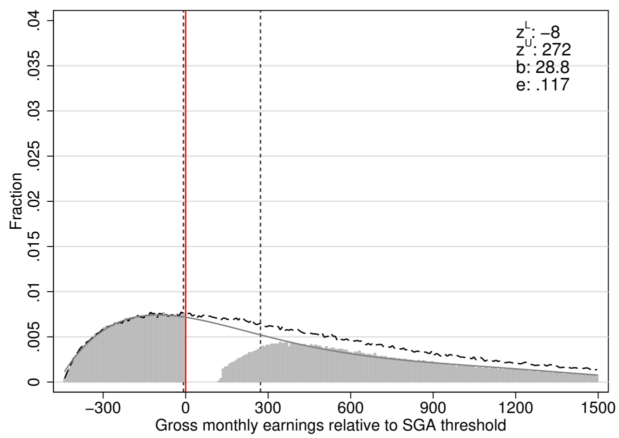
(c) e=0.3



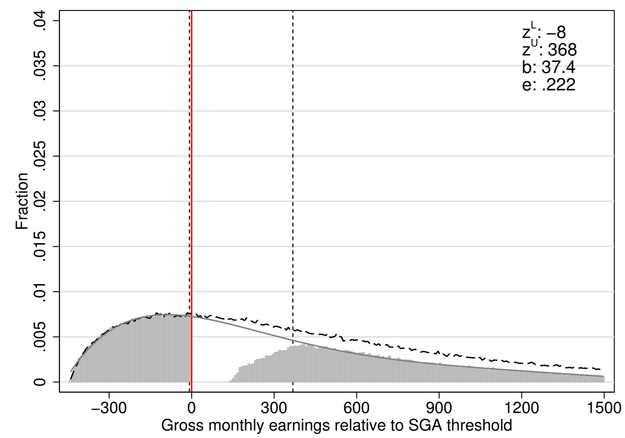
Notes: The figure plots the simulated earnings distributions without the notch (black dashed line) and with the notch (gray bars) for the cases $e = 0.1$, $e = 0.2$, and $e = 0.3$. The bin width of the gray bars is €8. The gray solid line denotes the counterfactual earnings density which is obtained by estimating equation (4) on the simulated earnings distribution with the notch. The bin just to the left of the SGA threshold is excluded in each panel.

Figure B.3: Simulated and counterfactual densities for Austrian DI notch with extensive margin response

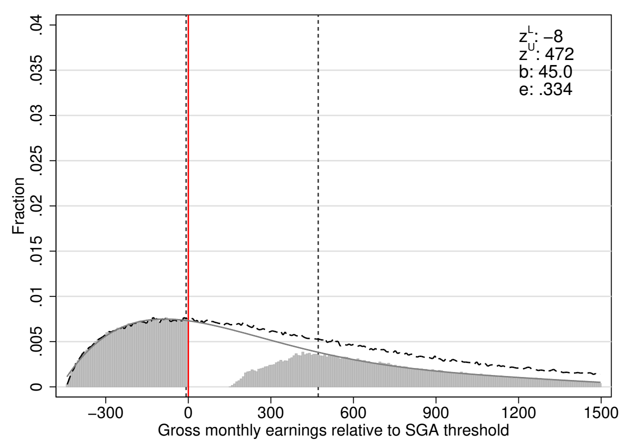
(a) e=0.1



(b) e=0.2



(c) e=0.3



Notes: The figure plots the simulated earnings distributions without the notch (black dashed line) and with the notch (gray bars) for the cases $e = 0.1$, $e = 0.2$, and $e = 0.3$. The bin width of the gray bars is €8. The gray solid line denotes the counterfactual earnings density which is obtained by estimating equation (4) on the simulated earnings distribution with the notch. The bin just to the left of the SGA threshold is excluded in each panel.

C Appendix: Derivation of Equation (3)

This section illustrates the derivation of equation (3). The utility level at the SGA threshold z^* is given by

$$u(z^*) = (1-t)\cdot(s+z^*) - \frac{n^*+\Delta n^*}{1+1/e}\cdot\left(\frac{z^*}{n^*+\Delta n^*}\right)^{1+1/e},$$

where $(n^*+\Delta n^*)$ is the ability level of the DI beneficiary that is indifferent between z^* and z^I. The utility level at the interior point z^I is given by

$$u(z^I) = (1-t)\cdot(s+z^I) - \Delta T - \Delta t\cdot(z^I - z^*) - \frac{n^*+\Delta n^*}{1+1/e}\cdot\left(\frac{z^I}{n^*+\Delta n^*}\right)^{1+1/e}. \qquad (8)$$

Maximizing equation (8) with respect z^I implies that $z^I = (n^*+\Delta n^*)(1-t-\Delta t)^e$. Using this expression, we can write the utility at the interior point z^I as follows

$$u(z^I) = (1-t)s - \Delta T + \Delta t z^* + \frac{1}{1+e}(1-t-\Delta t)^{1+e}(n^*+\Delta n^*).$$

Setting $u(z^I) = u(z^*)$ and using the condition $(n^*+\Delta n^*) = \frac{z^*+\Delta z^*}{(1-t)^e}$, we can rearrange terms so as to obtain equation (3):

$$(1-t)z^* + \Delta T - \Delta t z^* - \tfrac{n^*+\Delta n^*}{1+1/e}\left(\tfrac{z^*}{n^*+\Delta n^*}\right)^{1+1/e} = \tfrac{1}{1+e}(1-t-\Delta t)^{1+e}\left(\tfrac{z^*+\Delta z^*}{(1-t)^e}\right) \Leftrightarrow$$
$$\tfrac{1}{1+\Delta z^*/z^*}\left[1+\tfrac{\Delta T/z^* - \Delta t}{1-t}\right] - \tfrac{1}{1+1/e}\left(\tfrac{1}{1+\Delta z^*/z^*}\right)^{1+1/e} - \tfrac{1}{1+e}\left(1-\tfrac{\Delta t}{1-t}\right)^{1+e} = 0$$