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RESEARCH ARTICLE

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# A kink that makes you sick: The effect of sick pay on absence

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**Summary**
We exploit a regression kink design to estimate the elasticity of the duration of sickness absence with respect to replacement rate. Elasticity is a central parameter in defining the optimal social insurance scheme compensating for lost earnings due to sickness. We use comprehensive administrative data and a kink in the policy rule near the median earnings. We find a statistically significant estimate of the elasticity of the order of one.

## 1 | INTRODUCTION

Absenteeism leads to sizeable losses of working time worldwide. In some OECD countries, nearly 10% of annual working days are lost because of sickness absence (DICE Database, 2017; see Treble & Barmby, 2011). The costs of absenteeism are considerable for individuals themselves, employers, co-workers, and health and benefit systems. A sickness insurance system is designed to protect individuals from earnings losses. Among cash benefits, sickness insurance is one of the most important social protection schemes in Europe (Eurostat, 2017). The key policy parameter of the system is the replacement rate, that is, the ratio of sickness insurance benefits to past earnings.

We examine the effect of the replacement rate of the Finnish sickness insurance on the duration of sickness absence. We find a substantial and robust behavioral response in a universal insurance scheme. The statistically significant point estimate of the elasticity of the duration of sickness absence with respect to the replacement rate is centered around one. Elasticity refers to the intensive margin, that is, the incentive effect conditional on being sick. The point estimate is lower when we exclude long spells.

The elasticity of the duration of sickness absence is a vital parameter of an optimal sickness insurance system, because the replacement rate affects workers' financial incentives to be absent from work through a moral hazard or hidden action effect. In the absence of externalities, an optimal social insurance system balances the marginal costs of more generous payments to the sick, with the welfare gain resulting from the consumption smoothing that the benefits allow, captured in the Baily–Chetty formula (Baily, 1978; Chetty, 2006; Pichler & Ziebarth, 2017).

We use a regression kink design (RKD; see Section 3) to identify the causal effect of the replacement rate. The method is similar to regression discontinuity design, where one exploits level jumps in policy rules, but in the RKD the slope of the policy rule changes and we analyze whether the slope of the behavioral response changes as well. Unlike in most other countries (Frick & Malo, 2008, pp. 510–511), the compensation of sickness insurance in Finland is not a fixed fraction of past earnings. Instead, the policy rule follows a piecewise linear scheme with a replacement rate that decreases with earnings. The institutional setting allows us to use RKD, in which the identification of the effect is based on a predetermined, nonlinear benefit function (Card, Lee, Pei, & Weber, 2012; Nielsen, Sørensen, & Taber, 2010).

Previous research has used policy reforms that provide exogenous variation in the replacement rates to study the effect of sick pay level on absence. Several studies exploit legislative changes in the replacement rates and provide difference-in-difference estimates for Sweden (Henrekson & Persson, 2004; Johansson & Palme, 2005; Pettersson-Lidbom & Skogman Thoursie, 2013). There is also relevant evidence for other countries (De Paola, Scoppa, & Pupo, 2014; Fevang, Markussen, & Røed, 2014; Puhani & Sonderhof, 2010; Ziebarth & Karlsson, 2014). Most other countries, including the USA, have more fragmented sickness insurance schemes, which complicates the analysis (cf. Gruber, 2000). In addition to studies that have exploited policy reforms within countries, there is cross-country evidence on the effect of the replacement rate of sickness insurance on absenteeism (Frick & Malo, 2008).

Evidence shows that the response of absence to the replacement rate is positive but the quantitative size of the effect varies substantially from study to study. However, the comparison of the estimates is not straightforward, since the outcome variables (duration of sickness absence or the number of sickness absence days) and methods are not identical. The elasticity we find using RKD is towards the higher end of estimates in the literature.

Empirical studies based on policy reforms offer a different setup from ours. Reforms are aimed at specific groups, the causal impact takes time to take effect, agents anticipate the upcoming reform, and effects are confounded by simultaneous policy changes or other shocks (cf. Besley & Case, 2000; Pettersson-Lidbom & Skogman Thoursie, 2013, p. 487). The main downside in a valid RKD setting is that the estimate is local around the kink point(s). We discuss the key challenges in our robustness checks.

Our study improves upon previous literature by using a method that allows us to focus on all employees around the kink point in the benefit rule. The kink point provides policy-relevant exogenous variation in the neighborhood of the median earnings (see Section 2). A long-standing quasi-experiment is also likely to reveal equilibrium behavior.

The paper is structured as follows. Section 2 provides an overview of the institutional setting. Section 3 describes RKD. Section 4 introduces the data. Section 5 presents the estimation results. The last section concludes.

## 2 | THE FINNISH SICKNESS INSURANCE SYSTEM

Finland, like the other Nordic countries, has a universal mandatory sickness insurance scheme. It covers all 16- to 67-year-old permanent residents (Kangas, Niemelä, & Varjonen, 2013; Toivonen, 2012). Although admissible by law, there is no private sickness insurance market in Finland. The sickness insurance scheme guarantees compensation for the loss of earnings owing to sickness and illness. Sickness allowances and reimbursements are defined in the Health Insurance Act and Decree. The Social Insurance Institution of Finland (KELA) pays out a sickness allowance (SA) as compensation for the loss of earnings caused by an illness or injury. Sickness insurance is financed by both employers and employees. Insurance contributions are proportional to earnings and unrelated to the benefit rule. The state participates by financing a minimum allowance that is paid to those with no earnings.

Before receiving the SA from KELA, the person must complete a waiting period, which includes the day of onset of work incapacity and the following nine working days. The waiting period includes Saturdays but not Sundays or public holidays. The incapacity for work must be certified by a doctor, and the employer is obliged to notify KELA of the sickness leave. The employee is entitled to the normal full salary during the 9-day waiting period if the employment relationship has lasted for at least a month.[1] Thus the incentive effects related to the payment scheme are only relevant for periods longer than 9 days.

After the 9-day waiting period the employee is eligible to receive an earnings-related SA from KELA. The maximum period for SA is 300 working days (i.e., approximately a full calendar year). All SA days within the last 2 years are counted towards this sum. After the maximum has been reached, there is an assessment of eligibility for a disability pension. The person is eligible to receive the SA again only after having worked for at least a year.

Using the Quality of Work Life Survey by Statistics Finland (Lehto & Sutela, 2009), we have calculated that the proportion of long-term sickness spells (over 10 days) is 15%. Given the average length of 44 days for long spells (see Section 4), and assuming an average length of 5 days for short spells, the share of sickness days for long spells is approximately 60%. The policy relevance of long-term sickness absence spells is timely since they may eventually lead to a permanent withdrawal from the labor market in the form of disability pension (Autor & Duggan, 2003; Kivimäki et al., 2004).

[1]If the employment has lasted less than a month, the beneficiary receives 50% of the salary. KELA fully compensates employers for these payments.

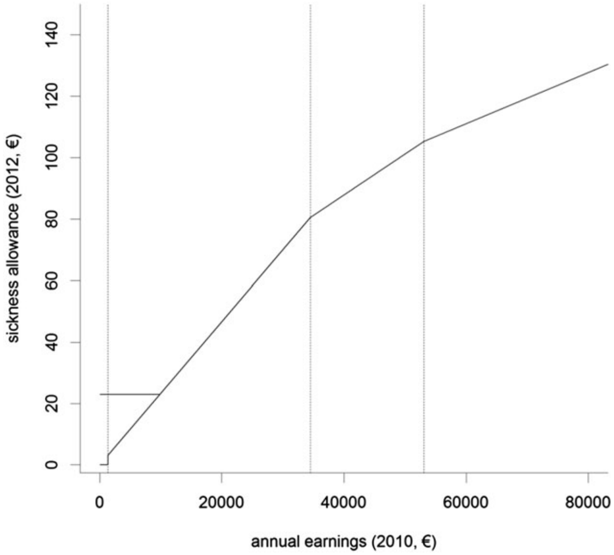


**FIGURE 1** Relationship between prior annual earnings and daily sickness allowance, 2012. The vertical dashed lines represent the discontinuity point at €1,325 and the lower and upper kink points at €34,496 and €53,072, respectively, in 2012

The earnings-related SA has no ceiling. This feature distinguishes the Finnish scheme from those of the other Nordic countries and most other European sickness insurance systems. In 2012, for annual earnings of up to €34,496, the marginal replacement rate was 70%, after which it decreased to 40% and at €53,072 to 25%.

For our purposes, the most important feature of the system is that the replacement rate of the earnings-related SA follows a predetermined, nonlinear policy rule. First, the SA is determined by past taxable annual earnings validated by the tax authorities. The relevant earnings are those earned two calendar years before the claim for sickness insurance is made. For example, in 2012, the SA was calculated based on taxable earnings in 2010.[2] Work-related expenses are deducted from taxable earnings, and an additional deduction is made to account for pension and unemployment insurance contributions.

The second crucial feature of the system is that the benefit formula follows a piecewise linear policy rule in past earnings. These kinks in the system were created in the early 1980s (Kangas et al., 2013, p. 283). The determination of SA for 2012 is illustrated in Figure 1. There are four earnings brackets. The benefit formula for the earnings-related SA exhibits one discontinuity and two kink points, which we define as the lower and upper kink points. Both kink points allow one to use RKD to identify the causal effect of the replacement rate. The discontinuity point cannot be exploited, since those below the threshold receive no compensation and are thus not in the data. The replacement rates are illustrated in Figure 2.

The lower kink point follows the median earnings very closely throughout the period (supporting information Figures A1 and A2 and Table A1). The response estimated around the lower kink point is likely to be similar for a large proportion of the population and thus relevant for policy purposes. The upper kink point is set at a high level (near the 9th decile point of the earnings distribution).

## 3 | REGRESSION KINK DESIGN

### 3.1 | Identification

Card et al. (2012) propose the regression kink design (RKD), which uses a kink or kinks in a policy rule to identify the causal effect of the policy rule on the outcome variable of interest. Intuitively, RKD could be characterized as similar to regression discontinuity design (RDD), with the difference that instead of level changes RKD exploits exogenous changes in the slopes of a policy rule.

A valid RKD setting requires the explanatory variable (in our case, the replacement level) to be a deterministic and known function of an assignment variable (in our case, earnings from 2 years prior). The function also must have at least

[2]The amount of taxable earnings is based on the decision by the Finnish Tax Administration. An index is used to account for a subsequent rise in wage and salary earners' earnings (80% weight) and the cost of living index (20% weight). In 2013 the ratio of sickness allowance benefits to wages and salaries was 1.0%; see Social Insurance Institution (2014) and Statistics Finland: Annual National Accounts.

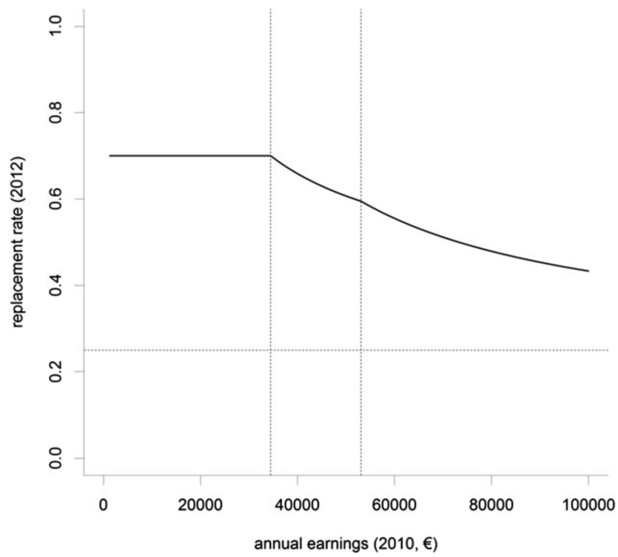


**FIGURE 2** Replacement rates, 2012. The vertical dashed lines represent the lower and upper kink points at €34,496 and €53,072, respectively, in 2012. The horizontal line represents the lowest marginal replacement rate of 0.25

one kink point. This means that the function has segments where it is (continuous and) differentiable, but in at least one point it is continuous but nondifferentiable, having unequal left and right derivatives (Condition 1).

The second condition for a valid RKD setting is that the density of the assignment variable is smooth (Condition 2). Endogenous bunching of observations near kink points (i.e., discontinuities in the derivative of the density function) or nonsmoothness of covariates would invalidate this condition (see Card et al., 2012, for these testable predictions). Additionally, regularity conditions are needed for a valid RKD.

In our setup, Condition 1 holds, since we know exactly how earnings from 2 years prior determine the replacement level. We also have data on the relevant earnings and the replacement level. Also, as Figure 1 shows, the relationship between the assignment variable and the policy variable for the year 2012 is continuous for earnings above €1,325 and has kinks at €34,496 and €53,072. Other years in the data reveal a similar structure.

Condition 2 is not directly verifiable in empirical applications. However, it is unlikely that individuals manipulate the benefit level by altering their earnings in order to be assigned to another segment of the benefit function 2 years later. We can also ascertain that other benefit rules, such as the earnings-related unemployment benefit, do not have kinks or discontinuities at the same points as the sickness benefit, and thus they do not affect the assignment. Furthermore, we can test for whether the distribution of the control variables is smooth in relation to the kink point. If we find this not to be the case, Condition 2 fails, which invalidates the design. This procedure is very similar to what is usually done to validate RDD (for a review, see Imbens & Lemieux, 2008).

## 3.2 | Formal model

Here we show formally the identification of the causal effect of the replacement rate on sickness spell length by exploiting the kink in the benefit scheme. Intuitively, the effect is calculated as the ratio of the change in the slope of the outcome variable (sickness spell length) and the exogenous change in the slope of the policy rule (marginal replacement rate).

Let $S_i$ be sickness days in year $t$, for individual $i \in \{1, 2, ..., n\}$. $Y_i$ is earnings in the year $t-2$ and $B_i$ is the sickness allowance, which follows the deterministic assignment function $B_i = b(Y_i)$, with a kink at $Y_i = y_k$. The parameter of interest is the change in the slope of the conditional expectation function $m(y) = E[S_i | Y_i = y]$, at $y_k$ divided by the change in the slope of the deterministic assignment function $b(y)$ at $y = y_k$.

The general model of interest is of the form

$$S_i = s(Y_i, B_i, \varepsilon_i) \tag{1}$$

where $\varepsilon_i$ is an error term.

Card et al. (2012) show that $\tau$, the average marginal effect of $b(y)$, is identified at $y = y_k$ if $s(Y_i, B_i, \varepsilon_i)$ and its derivatives with respect to $Y_i$ and $B_i$ are continuous, $b(Y_i)$ has a kink (Condition 1), and the density of $Y_i$ is smooth (Condition 2) at $y_k$. Under these assumptions, $E(\varepsilon_i | Y_i = y_k)$ is a smooth function and

$$\tau = \frac{D_+ m(y_k) - D_- m(y_k)}{D_+ b(y_k) - D_- b(y_k)}, \tag{2}$$

where $D_j m(y_k) = \lim_{y \to y_k^j} \frac{\partial m(y)}{\partial y}, D_j b(y_k) = \lim_{y \to y_k^j} \frac{\partial b(y)}{\partial y}, j \in \{+, -\}$. $\tau$ is the weighted average of marginal effects across the population. The weight is the relative likelihood that an individual has $Y_i = y_k$, given $\varepsilon_i$ (see Card et al., 2012, pp. 8–9, for a more detailed discussion).

The numerator in Equation 2 is estimated semi-parametrically as $\beta_1$ using the following local power series expansion:

$$E(S_i | Y_i = y) \approx \alpha_0 + \sum_{p=1}^{P} \left[ \alpha_p (y - y_k)^p + \beta_p D_i (y - y_k)^p \right], \tag{3}$$

where $P$ is the chosen polynomial order of the estimated function and $D_i$ is the treatment status, where 1 means "treated" and 0 means "not treated" ($D_i(z) = 1$, *if* $z > 0, D_i(z) = 0$ otherwise). The power series is a local approximation of $m(y)$. Note that $|y - y_k| \leq h$, where $h$ is the bandwidth chosen for the estimation. The denominator in Equation 2 is the change of slope of the deterministic policy rule $b(y)$ at the kink point.

## 3.3 | Fuzzy setting

In applications, one rarely encounters deterministic policy rules in observed variables. Card et al. (2012, pp. 10–12) distinguish between sharp and fuzzy RKD. A fuzzy design arises when there is a significant difference between the theoretical and observed value of the kink in the policy rule. The difference stems from, for example, measurement errors or the fact that the kink in the policy rule is affected by some unobserved and observed variables in addition to the primary assignment variable. In our setting, a likely source of error is the manner in which variables are defined and classified in the original dataset (see Section 4 and supporting information Figure A3). In a fuzzy setting, the instrumental variable method is used, analogously to a fuzzy RDD setting.

In a fuzzy RKD, $B_i = b(Y_i, \varepsilon_i^B)$. Thus $B_i$ is now determined by unobserved factors, $\varepsilon_i^B$, that might be correlated with the assignment variable. Additional assumptions are also required for identification. Along with some technical assumptions, monotonicity in the assignment function must hold (Condition 3). This condition states that the direction of the kink is either non-negative or non-positive for the entire population. $B_i$ and $Y_i$ are allowed to have specific types of measurement error.

When Conditions 1, 2, and 3 and the necessary technical conditions hold:

$$\tau = \frac{D_+ m(y_k) - D_- m(y_k)}{D_+ b(y_k) - D_- b(y_k)}, \tag{4}$$

where $D_j m(y_k) = \lim_{y \to y_k^j} \frac{\partial m(y)}{\partial y}, D_j b(y_k) = \lim_{y \to y_k^j} \frac{\partial E[B_i | Y_i = y]}{\partial y}, j \in \{+, -\}$. $\tau$, the average marginal effect of $b(y)$ at $y = y_k$ in Equation 4, is weighted by the product of three components (see Card et al., 2012, p. 12). As in a sharp RKD, the first component is the relative likelihood of $Y_i = y_k$. The second is the size of the kink in the benefit rule for individual $i$. The third component is the probability that the assignment variable is correctly measured at $Y_i = y_k$.

For estimation of the expected change of the policy rule, we use the following local power series expansion:

$$E(B_i | Y_i = y) \approx \delta_0 + \sum_{p=1}^{P} \left[ \delta_p (y - y_k)^p + \gamma_p D_i (y - y_k)^p \right], \tag{5}$$

where $\gamma_1$ is the empirical counterpart of the policy rule. The elasticity of interest can be approximated as $\tau \approx \frac{\beta_1}{\gamma_1}$. To obtain the correct point estimate and standard errors for $\tau$, we use instrumental variable (IV) regression, following Card et al. (2012, pp. 20–21). The instrument is the interaction term of past earnings, $y$, and an indicator of earnings above the lower kink point, $D_i(y - y_k)$. The instrumented variable is $B_i$, the received compensation.

### 3.4 | Bandwidth selector

The bandwidth selection is a trade-off between bias and precision. Card et al. (2012, pp. 32–33) use the "rule-of-thumb" bandwidth selector of Fan and Gijbels (1996, equation 3.20, p. 67; henceforth FG):

$$h = C_p \left\{ \frac{\widehat{\sigma}^2(0)}{\left[\widehat{m}^{(p+1)}(0)\right]^2 \widehat{f}(0)} \right\}^{\frac{1}{2p+3}} n^{-\frac{1}{2p+3}}, \tag{6}$$

where $p$ is the order of the polynomial in the main specification; $\widehat{\sigma}^2(0)$ and $\widehat{m}^{(p+1)}(0)$ are, respectively, the estimated error variance and the ($p+1$)th-order derivative of the regression, using a wide-bandwidth polynomial regression of Equation 3;[3] $C_1$ is 2.352 for the boundary case with a uniform kernel; and $\widehat{f}(0)$ is estimated from a global polynomial fit to the histogram of earnings.

Bandwidth choices that are too "large" lead to a non-negligible bias in the estimator of the conditional expectation function. We report the results for multiple bandwidths in the sensitivity analysis and we also use a bandwidth selector proposed by Calonico, Cattaneo, and Titiunik (2014; henceforth CCT). Calonico et al. (2014) build the CCT bandwidth selector upon the FG bandwidth selector.

## 4 | DATA

We use total data on Finnish sickness absence spells over the period 2004–2012. These comprehensive register-based data originate from KELA and are derived from the database that is used to pay out the SA compensations. Therefore, some measurement error might arise from the aggregation of variables when converting the original register for research purposes. In particular, consecutive absence spells that start within 300 days are counted as a single spell if the diagnosis remains the same. Only 0.06% of the spells reach the length of 300 days.

Earnings originate from the comprehensive official tax registers that have been validated by the Finnish tax authorities. The amount of measurement error in earnings should be minimal compared to survey-based measures. However, even the most accurate and comprehensive sources of earnings can contain some amount of measurement error.

The administrative data cover both wage and salary earners and self-employed persons. The data record the start and end dates for all sickness spells and the total amount of SA paid for each person. Annual earnings are deflated to 2012 prices by using the consumer price index.

The data consist of absence spells that last longer than the waiting period of nine full working days. The distribution is right-skewed.[4] Thus longer sickness absences contribute disproportionately to the total days lost and absence costs. The data allow us to concentrate on those absences on which the sickness insurance system payouts are based.

The data record a person's past taxable earnings, which KELA obtains directly from the Finnish tax authorities. KELA uses the same information to calculate the SA for beneficiaries. The data also include useful background information such as a medical diagnosis for sick leave. Diagnoses are important covariates in our setting, because they can be used to test the smoothness condition, which is a critical assumption for the identification of the causal effect using RKD. The initial diagnosis of individuals is documented according to the International Classification of Diseases (ICD-10), which is the standard diagnostic tool for clinical purposes. We have also linked to the data the highest completed education from the Register of Completed Education and Degrees, maintained by Statistics Finland.

The estimations are restricted to those in the labor force who are eligible for sick pay and who are between 16 and 70 years of age. The final sample used in the analysis includes compensated absence spells that are above zero in duration and whose payment criteria and initial diagnoses are known for employees with a single employer during their sickness spell.[5] The final sample around the lower kink point consists of 37,000–41,000 individuals, depending on the year.

[3] We use the data for a very wide window of 0.8 log earnings for this regression, which contains 85% of the total sample. This is done in order to keep the polynomial order within reasonable limits. The polynomial order is chosen to minimize the Akaike information criterion.

[4] The skewness of the distribution is 2.5 and 2.9 for the total sample and for the window of 0.0796 log earnings around the lower kink point, respectively.

[5] A part-time sickness benefit was introduced in Finland at the beginning of 2007. We exclude its recipients from the sample. Only 0.5% of the sample has no known diagnosis. Also, 146 observations with missing compensation data were excluded. We are able to identify entrepreneurs from 2006 onwards. We exclude the 2.3% of the original sample that entrepreneurs represent. In total, we exclude 3.0% of the original data to construct the final sample.

**TABLE 1** Descriptive statistics

| | Panel A: Total sample | | | | Panel B: Sample around the lower kink point | | | | Panel C: Sample around the upper kink point | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Min.** | **Max.** | **Mean** | **SD** | **Min.** | **Max.** | **Mean** | **SD** | **Min.** | **Max.** |
| Duration of sickness absence (days) | 43.76 | 70.73 | 1 | 575 | 36.36 | 60.94 | 1 | 454 | 35.22 | 58.68 | 1 | 458 |
| Duration of sickness absence (log-days) | 2.76 | 1.47 | 0 | 6 | 2.62 | 1.42 | 0 | 6.12 | 2.63 | 1.39 | 0 | 6 |
| Earnings | 26,365 | 16,120 | 0 | 6,120,738 | 33,120 | 1,924 | 29,095 | 37,897 | 50,759 | 3,073 | 44,497 | 58,652 |
| Log earnings | 10.07 | 0.67 | -3.00 | 15.63 | 10.41 | 0.06 | 10.28 | 10.54 | 10.83 | 0.06 | 10.70 | 10.98 |
| Age | 45.13 | 11.35 | 16 | 70 | 46.53 | 10.01 | 17 | 69 | 48.4 | 8.95 | 19 | 68 |
| Female | 0.59 | 0.49 | 0 | 1 | 0.48 | 0.5 | 0 | 1 | 0.31 | 0.46 | 0 | 1 |
| Tertiary level education | 0.14 | 0.34 | 0 | 1 | 0.16 | 0.36 | 0 | 1 | 0.36 | 0.48 | 0 | 1 |
| Helsinki Metropolitan Area | 0.17 | 0.37 | 0 | 1 | 0.19 | 0.39 | 0 | 1 | 0.23 | 0.42 | 0 | 1 |
| Sickness allowance per day (euro) | 54.3 | 23.19 | 0.01 | 4600.56 | 69.16 | 8.26 | 0.02 | 136.21 | 90.5 | 10.77 | 0 | 171 |

**Panel D: Sample size by year**

| **Year** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| Total sample | 344,590 | 352,446 | 346,747 | 341,527 | 339,949 | 317,618 | 309,893 | 309,333 | 313,101 | 2,975,204 |
| Sample around the lower kink point | 39,887 | 41,275 | 41,380 | 40,617 | 40,693 | 38,368 | 37,875 | 37,068 | 37,652 | 354,815 |
| Sample around the upper kink point | 11,480 | 11,903 | 12,102 | 10,923 | 12,061 | 11,446 | 11,533 | 10,661 | 10,914 | 103,023 |

*Note*. The sample around the lower kink point is defined within the FG bandwidth (0.0796 log euro of annual earnings). The diagnoses M, S and F respectively represent 34%, 13%, and 16% of the whole sample and 36%, 14%, and 14% of the sample around the lower kink point. Diagnosis M in ICD-10 refers to diseases of the musculoskeletal system and connective tissue. Diagnosis S refers to injury, poisoning, and certain other consequences of external causes. Diagnosis F refers to mental and behavioral disorders.

Descriptive statistics are reported in Table 1 (duration of sickness absence and background characteristics for persons; see also supporting information Figure A4). A fraction of the insured (13.6%) are compensated according to an eligibility criterion other than prior earnings (e.g., if earnings have changed by more than 20%, the compensation can be claimed based on more recent earnings; see Toivonen, 2012). The results are robust to their exclusion from the sample (see supporting information Table A2, column 3).

We exploit both kink points to identify and estimate the effect of the policy. However, we focus on the lower kink point for two reasons. First, the lower kink point is located close to the median earnings, containing substantial mass to support the estimation of statistically significant effects (supporting information Figures A1 and A2 and Table A1). The large sample size around this kink point shows up as smaller variability in the length of sickness absence within the €800 bins. Second, there is a large change in the replacement rate at the lower kink point (cf. Figure 2).

# 5 | RESULTS

## 5.1 | Baseline estimates

Unless otherwise stated, the results are based on a log-log specification, since the estimates can be interpreted directly as elasticities without a cumbersome conversion. Figure 3 illustrates the duration of sickness absence and annual earnings around the lower kink point.[6] It suggests that there is a significant behavioral response at the kink.

Using the FG bandwidth of 0.0796 log euro for annual earnings, we find clear evidence for the incentive effects (Table 2 and supporting information Table A3). The estimation window in the main specification includes 12% of the

[6]The bandwidth of the bins in Figure 3 was chosen for illustrative purposes to mitigate excessive noise, following the methodological guidance of Lee and Lemieux (2010). The number of bins used coincides with the number given by Sturges' rule (Sturges, 1926), which is a classic method for choosing the optimal number of bins for histograms. The two bins directly above the kink appear to show a discontinuity in the conditional mean. However, adding a dummy to the main specification (Equation 3) shows that the discontinuity is not statistically significant. Also, the point estimate for $\beta_1$ in Table 2 (column 1) changes only from 0.556 to 0.579. See supporting information Figure A5 for the same graph without the fit and confidence interval but illustrating the sample size around the kink point. Supporting information Figures A6 and A7 report the annual graphs.

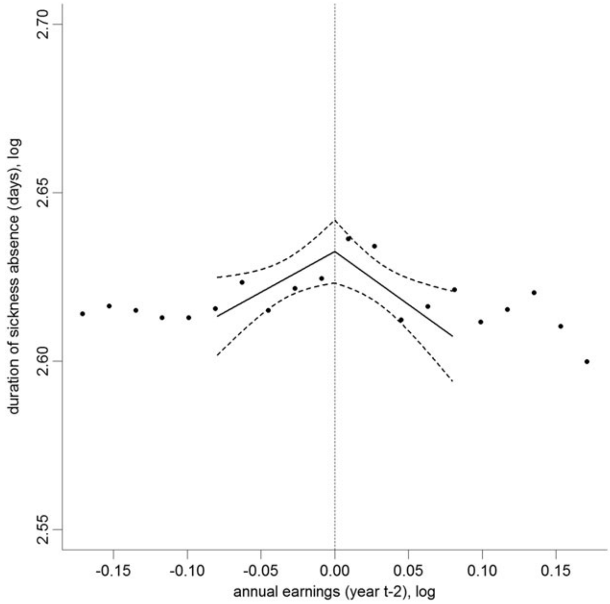


**FIGURE 3** Duration of sickness absence (2004–2012) and annual earnings (2 years prior) around the lower kink point. Annual earnings are deflated to 2012 prices by using the consumer price index. Earnings are in logs and are normalized to zero at the lower kink point. The dots represent the mean duration of sickness absence in bins of 0.018 log euro. The regression fit and 95% confidence interval are shown for the FG bandwidth (0.0796 log euro of annual earnings), which is the main specification bandwidth used in the analysis (cf. Table 2)

**TABLE 2** Regression kink design estimates

| | Linear specification | Quadratic specification | Linear specification, bias-corrected (CCT) |
|---|---|---|---|
| **Panel A: Dependent variable: log duration of sickness absence (days)** | | | |
| Bandwidth | FG bandwidth | FG bandwidth | CCT bandwidth |
| Kernel | Uniform | Uniform | Triangular |
| Change of slope at kink point ($\beta_1$) | −0.556*** (0.208) | −0.353*** (0.119) | — |
| Slope below kink point ($\alpha_1$) | 0.240** (0.112) | 0.162*** (0.06) | — |
| Yearly fixed effects | Y | Y | N |
| Polynomial order | 1 | 2 | 1 (bias correction: 2) |
| $R^2$ (Adj.) | 0.0003 | 0.0002 | — |
| $N$ | 354,800 | 1,326,992 | 635,548 |
| **Panel B: Elasticity of the duration of sickness absence with respect to replacement rate** | | | |
| Change in replacement rate ($\gamma_1$) | −0.394*** (0.021) | −0.318*** (0.086) | −0.393*** (0.012) |
| Elasticity ($\tau \approx \frac{\beta_1}{\gamma_1}$) | 1.411 | 0.830 | — |
| **Panel C: Instrumental variable estimation of elasticity of the duration of sickness absence with respect to replacement rate** | | | |
| Estimated elasticity ($\tau$) | 1.411*** (0.536) | 0.830*** (0.283) | 1.155*** (0.359) |
| $N$ | 354,800 | 1,326,992 | 566,392 |

*Note*. Heteroskedasticity-robust standard errors are reported in parentheses. Statistical significance: $^*p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$. The main specification is shaded in light grey. The estimated model is Equation 3. The FG bandwidth, referring to the "rule-of- thumb" bandwidth described in Fan and Gijbels (1996), is estimated to be 0.0796 and 0.2953 for the linear and quadratic specifications, respectively. The 95% confidence interval for the IV estimated elasticity with a point estimate of 1.41 is [0.36, 2.46] using the linear specification. CCT refers to the bandwidth (0.1416) and bias-corrected estimator proposed by Calonico et al. (2014). The 95% confidence interval for the IV estimated elasticity with a point estimate of 1.16 is [0.45, 1.86] using the linear CCT specification. The instrument is the interaction term of past earnings and an indicator of earnings above the lower kink point. The Angrist–Pischke first-stage $F$-statistic (see Angrist & Pischke, 2009, pp. 217–218) for a test of the hypothesis that the coefficient of the instrument is zero in a regression of the received compensation on the instrument is higher (346) in the linear FG specification than the conventional threshold of 10 for a weak instrument. Clustering standard errors at the level of the individual increases the 95% CI only marginally (1.67%). In the main specification, the standard error with clustering is 0.545.

sample, centered at the median. The result is robust to using levels or logs of the explanatory and dependent variables (supporting information Table A3).

We first assess how observed benefits change at the lower kink point in the benefits–earnings schedule (the first stage in the fuzzy RKD analysis). Above the kink point, daily benefits increase by about one-third of a euro less when daily earnings increase by one euro, compared to below the kink point (point estimates vary from −0.394 to −0.318). These numbers are slightly higher than the strict policy rule of −0.3 (cf. Section 3.3). Using the linear specification, the estimated change of the slope of behavior, the second stage, at the lower kink point is −0.556. The weighted average of the marginal elasticities of the duration of sickness absence, $\tau$, with respect to the replacement rate is 1.41 (95% CI: [0.36, 2.46], Table 2). The point estimate implies a high elasticity.

The quadratic specification ($p = 2$ in Equation 3) gives a point estimate of 0.83 [0.27, 1.38], with the FG bandwidth of 0.2953 also implying a significant behavioral response. Using the CCT (Calonico et al., 2014) bias-corrected estimator and bandwidth (0.1416), we estimate the elasticity to be 1.16. The CCT was estimated using the triangular kernel.[7] The robustness of the result using the CCT estimator is reassuring, since some results have previously been sensitive to the choice of method (e.g., Card, Johnston, Leung, Mas, & Pei, 2015; Card, Pei, Lee, & Weber, 2015).

The wider the bandwidth used, the lower the point estimates become. This result is illustrated in Figure 4. If the functions $E(S_i| Y_i = y)$ and $E(B_i| Y_i = y)$ are piecewise linear and the sample size is sufficiently large, then the point estimate would remain unchanged with all bandwidths; that is, the relationship depicted in Figure 4 would be a horizontal line. Thus deviations from the horizontal line are indicative of curvature in the conditional expectation functions and consequent bias in the local linear estimator.

The choice of bandwidth is a compromise between precision and bias. The main specification uses the FG bandwidth $h$, estimated to be 0.0796 log euro, which fulfills two criteria. First, covariates are linear, whereas they show nonlinearity at wider bandwidths (supporting information Appendix 2) than 0.0796 log euro. Second, the estimates are sufficiently precise, whereas a narrower band would increase estimated standard errors. Precision increases with sample size and variance in the explanatory variable, both of which decrease as the bandwidth narrows. Note that the FG bandwidth we use in the main specification is quite narrow in terms of monthly earnings (~€460 in 2012).

## 5.2 | Sensitivity analyses

Ganong and Jäger (2017) propose that researchers using RKD should present a distribution of placebo estimates in regions without a policy kink. We run 101 placebo regressions (supporting information Figure A8) to test the robustness of the main specification in Table 2. We use the same FG bandwidth (of the true lower kink point) for all these regressions. Of the 94 regressions not around the true kink point, 7 (~7.4%) show a significant estimated effect. This lends strong support to the claim that the result is not spurious.

We confirm the result from the main specification using different sets of controls (supporting information Table A4). The results show a reassuring degree of robustness. Controlling for individual characteristics and the initial diagnosis at the one-letter level (21 different values) gives the same point estimate as the regression with no controls. The adjusted $R^2$ of the model increases from 0.0003 to 0.0781 once all the controls are included, since diagnoses are important determinants per se of the duration of sickness absence spells. The diagnoses also correlate with earnings. The composition of the population is important in one respect: the use of controls eliminates the positive slope below the lower kink point. Demographic characteristics explain the slope.

We also run the estimates by subsample to study the robustness of the effect. When left truncated by sickness spell length (supporting information Figure A9), the point estimate increases until a left truncation of 20 days, after which there is a general decreasing tendency. Right truncation of longer spells also decreases the point estimates (see supporting information Figures A10–A12, for the estimate for right and left truncation at 240 days). The baseline result thus requires the use of the non-truncated sample.

We also show the results for subsamples according to sex, by the SA criterion and keeping only observations where the data year matches the starting year of sickness (supporting information Table A2). When subsampled by diagnosis,

[7]The FG bandwidth depends on the polynomial order. Under the same bandwidth sequence, the variance of the local quadratic estimator with a uniform kernel is 16 times as large as its local linear counterpart (see Card et al., 2012, pp. 15–16). Thus, we focus mainly on the linear specification. Asymptotically, a local quadratic regression using its optimal bandwidth sequence is preferred to the local linear regression with its optimal bandwidth sequence. The asymptotic advantage, however, does not provide finite sample guarantees. Following the recommendation of Gelman and Imbens (2014) for RDD, we do not report results with higher-order polynomials.

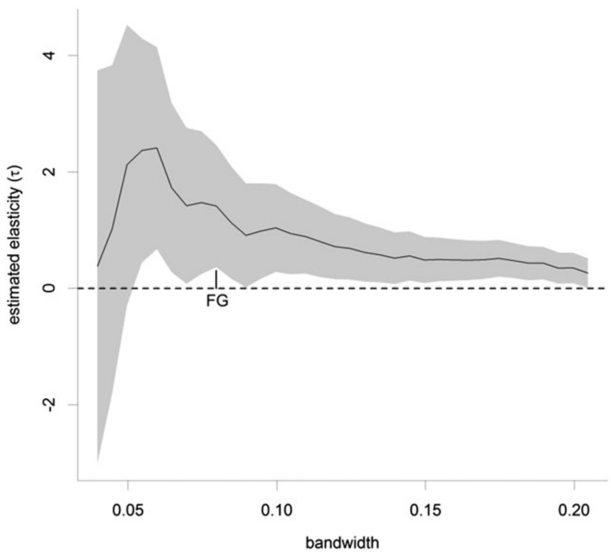


**FIGURE 4** Regression kink design estimates with different bandwidths. The graph represents 33 estimates of elasticity ($\tau$) using the main specification (log sickness absence duration on log earnings with yearly fixed effects) between bandwidths of 0.0396 and 0.1996 at intervals of 0.05 log earnings. The narrowest and widest bandwidths go far beyond optimal levels and are only depicted for illustrative purposes. The point estimates are depicted in black and the 95% confidence intervals in light gray. The FG bandwidth is marked by a short vertical line (cf. notes to Table 2)

the sample sizes drop dramatically and all relevant estimates are insignificant (not reported). The point estimate is larger for men. Using administrative data from a universal mandatory sickness insurance system that very closely resembles the Finnish setting, Johansson and Palme (2005), consistent with our result, also report a larger behavioral response for men. The heterogeneity of behavior by sex or other attributes, however, is of no practical interest unless the policy parameters (i.e., the benefit and contribution rules) are conditioned on these variables.

To implement RKD, it is crucial to check for the smoothness conditions of covariates at the kink point (see Corollary 2 in Card, Pei, et al., 2015, p. 2469). Following Card et al. (2012), we study the smoothness of a covariate index, namely the predicted values of a regression of sickness duration on a set of 31 covariates (sex, age, age squared, living in the Helsinki region, higher education, year, diagnosis at the one-letter level). We find that there is no statistically significant kink at the kink point (see supporting information Figure A13 and Table A5; we examine the covariates individually in supporting information Appendix 2).

Smoothness in the density around the kink is a key testable identification assumption in a valid RKD. We test and find no evidence of non-smoothness in the density function of log earnings around the lower kink point (supporting information Figures A14 and A15).

The estimated effects are insignificant at the upper kink point (supporting information Table A6). There are at least two reasons for the insignificance of the estimate: fewer data points and a smaller slope change.

## 6 | CONCLUSIONS

Using administrative data on sickness absence spells with a large sample size, we find a considerable incentive effect of the benefit rule at the intensive margin in a local quasi-experimental research setting. The point estimate of the elasticity of the duration of sickness absence with respect to the replacement rate is of the order of one and is lower in samples which exclude long spells.

Our estimate of the elasticity is at the high end of estimates obtained in the literature using reforms, which are usually targeted at a specific subset of the population (see Ziebarth & Karlsson, 2014, pp. 209–210). The effect in a subset of the population might differ from that of the total population. Compared to these difference-in-difference studies, our estimates are based on a different set of assumptions. We evaluate the validity of the setting thoroughly.

The research design builds on exogenous variation, which can be exploited for coherent causal inference. The result is robust even with multiple controls, including sickness diagnoses. Exogeneity is ensured by the fact that the sickness benefit is determined by earnings 2 years prior. Thus our research provides a clean application of the regression kink design. An extensive battery of checks was run on a number of variables which might influence our results at the kink point. Since the estimates are obtained around the earnings level close to the median earnings of full-time workers (within 1% in all years), the response is likely to be similar for a large proportion of the population.

We deliver a compelling estimate with strong internal validity on a vital policy parameter in a social insurance system. The result we find is useful for policymakers who aim to improve the mandatory sickness insurance. Future research should study the response at the extensive margin.

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## SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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