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The Effect of Plant Downsizing on Disability Pension Utilization

Abstract:
We investigate the impact of plant downsizing on disability pension utilization in Norway. Plant downsizing substantially increases the disability entry rate of workers in affected plants. Workers originally employed in plants that closed between 1993 and 1998 were 27.9 percent more likely to utilize disability pensions in 1999 than comparable workers in non-downsizing plants. The effect of downsizing is non-linear, with workers originally employed in plants downsizing 65-95 percent of their workforce more likely to enter disability than workers in fully closing plants. This is consistent with the signaling story of Gibbons and Katz (1991). We also estimate significant effects of downsizing on future earnings and mortality, suggesting the increase in disability participation could be driven by an adverse effect of downsizing on the economic opportunities or health of affected workers.

Keywords: disability, social insurance, downsizing, layoffs, plant closings

JEL classification: H55, I12, I38, J63, J65

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1. Introduction

Dramatic growth in disability rolls has become an increasing concern for many OECD countries (OECD, 2003). Between 1980 and 1999, the share of non-elderly adults receiving disability benefits in the United States increased 60 percent to 4.7 percent.[1] Across the OECD as a whole, disability participation rates increased 36 percent over the period, to 6.4 percent. The growth in disability participation rates has important implications in terms of national productivity and the public financing of disability benefit programs. In 1999, disability benefit payments comprised 1.4 percent of GDP in the U.S. and 2.5 percent of GDP across countries in the European Union. Thus, understanding the determinants of disability participation is an increasingly important issue for policy makers.[2]

The current paper investigates the impact of plant downsizing (i.e. reductions in plant employment levels) on disability entry rates.[3] Downsizing events are an endemic feature of market economies, as producers periodically re-optimize in response to changing market conditions. If such events have only temporary effects on the productivity of affected workers, it is reasonable to assume that the long-term productivity gains outweigh any short-term losses. However, if downsizing events increase disability entry rates, the lost production of at least some affected workers might not be short-term due to hysteresis in disability participation. Only about one percent of disability recipients leave the rolls each year due to recovery or work resumption (OECD, 2003, p. 58). As a result, the productivity losses associated with downsizing events could be prolonged and quite large, depending on the extent that disability entry rates are affected.

Downsizing can affect the likelihood of applying for disability through at least two different channels: expected future earnings or health. Downsizing typically involves laying off some fraction of a plant's workforce. Assuming there exists some cost associated with re-entering the workforce (e.g. job search costs), being "downsized" reduces expected future earnings, lowering the opportunity cost of entering disability. Additionally, downsizing could affect workers' health, leading to depression or stress-related health problems. The adverse health effects of downsizing could increase the effort cost of remaining in the workforce and/or increase the likelihood a disability pension application is successful.

We investigate the relationship between plant downsizing and disability participation using a comprehensive, longitudinal database containing annual records for every person in Norway,

[1] Statistics on disability program use and expenditures obtained from OECD (2003).

[2] Throughout this paper, we employ the colloquial expressions "on disability" and "disability participation" to refer to the utilization of disability pension benefits.

[3] By "plant" we are referring to the establishment at which a worker is employed. Plants are therefore distinct from a worker's firm in cases where a firm operates multiple establishments.

combined with a dataset containing employment spell records for workers in all Norwegian plants. Merging these datasets, we calculate employment counts by plant and year, allowing us to identify workers originally employed in plants that subsequently downsized. Our effect estimates are based on comparisons of covariate adjusted disability entry rates across workers originally employed in downsizing and non-downsizing plants. Such estimates are potentially biased if downsizing plants are concentrated in industries or geographic areas with unusually high (or low) rates of disability entry. The richness of our register data allows us to include industry, municipality and neighborhood fixed effects to address these sources of bias. We are also able to conduct robustness checks to test for unobserved differences across workers in downsizing and non-downsizing plants.

Our empirical results suggest that plant downsizing has a substantial effect on the disability entry rate of workers in Norway. Workers originally employed in plants that closed between 1993 and 1998 were 27.9 percent more likely to utilize disability pensions in 1999 than comparable workers in non-downsizing plants. We also estimate a large and statistically significant negative impact of plant downsizing on workers' future earnings and likelihood of employment. These findings are consistent with the hypothesis that the effect of plant downsizing on disability entry is driven by its effect on expected future earnings. However, our findings also suggest that the downsizing effect on disability entry could be driven by its effect on workers' health. We estimate a large and statistically significant impact of plant downsizing on workers' mortality rates. Workers originally employed in plants that close during 1993-1998 have a 15.6 percent increase in mortality rates estimated over 1999-2002. Moreover, we find that diagnoses of mental disorders, a category capturing depression and many stress-related conditions, are more prevalent among disability entrants following downsizing.

Interestingly, we find that workers originally employed in plants downsizing 65-95 percent of their workforce are more likely to enter disability than workers in fully closing plants. This non-linear relationship is consistent with the signaling story of Gibbons and Katz (1991). If "partially" downsizing plants select to lay off less productive workers, then prospective employers may infer these workers to be of lower quality than those laid off due to a plant closure. As a result, workers laid off as part of a partial downsizing could face more difficult labor market conditions than workers laid off due to a plant closure. Consistent with the signaling story, we find that future earnings and likelihood of employment are higher for workers originally employed in closing plants than for those in plants downsizing by 65-95 percent.

The current paper contributes to a stream of empirical investigations suggesting that economic conditions affect disability participation, including two excellent recent studies that appear to establish a causal link (Black, Daniel, and Sanders, 2002, and Autor and Duggan, 2003).[4] Analyzing county-level data from coal-producing U.S. states, Black, Daniel, and Sanders (2002) demonstrate that the coal boom and subsequent bust had a large impact on disability participation among residents of coal-rich counties. Autor and Duggan (2003) find that decreasing demand for low skilled workers combined with unforeseen increases in the earning replacement rate substantially increased the likelihood low-skilled workers entered disability following an adverse labor market shock.

The richness of our dataset allows us to conduct numerous analyses that are new to this literature. First, using individual level data we are able to establish a direct link between plant downsizing and disability pension entry. Our estimates suggest that the aggregate effect of downsizing events (workforce reductions of more than 5 percent) increased disability participation in 1999 by 14.3 percent among workers employed full-time in 1993. Therefore, the role of plant downsizing in disability participation is substantively important. Second, we are able to investigate the plausibility of different channels through which the effect of downsizing on disability participation may operate. The existing literature generally assumes that adverse economic conditions affect disability entry by increasing the earnings replacement rate. Our results support the plausibility of this channel, but also indicate that downsizing could increase disability entry by adversely affecting workers' health. Third, we are able to identify a non-linear relationship between plant downsizing and disability entry, a finding of practical relevance to policy makers and noteworthy for its consistency with the signaling story of Gibbons and Katz (1991).

The remainder of the paper is laid out as follows. Section 2 describes the Disability Pension program in Norway. Section 3 provides a theoretical framework for understanding the impact of plant downsizing on disability entry. Section 4 discusses our empirical strategy. Section 5 describes our dataset. Section 6 presents and discusses our empirical results, and section 7 concludes.

2. Disability Pension Program in Norway

All Norwegian residents and non-resident Norwegian employees are covered under Norway's National Insurance Program.[5] Any insured person aged 18 to 67 is entitled to a disability pension if his or her "work capacity" is permanently reduced by 50% or more due to illness, injury or defect and the person has been insured at least three years immediately before the disability occurs. The disability benefit is meant to serve as a replacement for earned income lost as result of the disability.

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[4] Other important papers in this literature include Parsons (1980), Haveman and Wolfe (1984), Bound (1989), Haveman, De Jong, and Wolfe (1991), Bound and Waidman (1992), Rupp and Stapleton (1995), Aarts, Burkhauser, and De Jong (1996), Gruber and Kubik (1997), Gruber (2000), and Duggan and Imberman (forthcoming).

[5] Excluded from the program are foreign citizens who are paid employees of a foreign state or international organization.

Disability pensions are comprised of three components: a basic pension, a supplementary pension and a special supplement.[6] The basic pension is currently set to NOK 58,778 (about 9,000 U.S. dollars) and adjusted annually to account for changes in prices and aggregate income levels.[7] The basic pension is reduced by 25 percent if the person's spouse has an income exceeding twice the basic pension amount or receives a pension. The supplementary pension is designed to ensure that a recipient can maintain a standard of living comparable to the standard he had before becoming disabled. This amount is calculated as a complicated (concave and capped) function of prior earnings. Thus, the supplementary pension generally increases with prior earnings, but at a decreasing rate. The special supplement essentially establishes a minimum for the supplementary pension to ensure that each disabled person has a reasonable standard of living. This minimum is calculated as a fixed percentage of the basic pension amount, with the percentage varying with family composition. For instance, the percentage applied for single persons is 79.33, establishing a minimum supplementary pension of NOK 46,629. Thus, a typical single worker who becomes 100 percent disabled is entitled to a *minimum* total annual pension of NOK 105,408 (about $16,600).

The total pension amount will be larger for persons with even modest earnings. For instance, in 2002 the average annual income for workers in the lowest quintile of the income distribution was NOK 240,000. At this income level, a single worker becoming 100 percent disabled is entitled to a total pension of NOK 131,709. In addition, pension recipients are allowed to earn up to NOK 58,778 while on disability and also pay lower income taxes. Due to concavity in the supplementary pension calculation, the earnings replacement rate declines for higher earnings levels.

Norway's disability pension program serves a similar function as the combined disability programs of Social Security Disability Insurance (SSDI) and Supplemental Security Income (SSI) in the U.S. The basic and supplementary pensions provide a benefit that is increasing and concave in prior earnings similar to SSDI, and the special supplement ensures a minimum benefit amount similar to SSI. An important difference between the Norwegian and U.S. programs is that the Norwegian program allows workers to apply for disability pension while still employed. As a result, it is common for Norwegian workers to receive "sick money" prior to transitioning from employment onto disability

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[6] In addition to the basic pension, supplementary pension and special supplement, there are means-tested supplements for disability pensioners with a dependent spouse or child.

[7] The basic pension is reduced for beneficiaries with fewer than 40 insurance coverage years (e.g. a person with 20 coverage years would receive a basic pension half this amount). Since all Norwegian employees are covered and coverage years are calculated up to the person's 67th birthday, this reduction only applies to a small fraction of beneficiaries who spent a large part of their adult life abroad.

without ever being unemployed.[8] The replacement rate for low-income earners is also higher in Norway than in the U.S.

3. Theoretical Framework

The following presents a simple model illustrating how plant downsizing can affect a worker's decision to apply for disability benefits.[9] In particular, it demonstrates how downsizing can affect the likelihood of applying for disability either by affecting expected future earnings or by affecting health. Let a worker's health be denoted by h, where h is uniformly distributed on [0,1]. Let $s = \{d, w\}$ denote the alternative states of drawing a disability pension (d) and being in the workforce (w). Let the utility of being in the workforce be denoted by $u(e,h)$, where e is expected earnings. We assume that the "effort cost" of work is decreasing in health, so that the utility of working is increasing in both health and expected earnings. For simplicity, we assume that the utility of receiving disability benefits has a fixed value given by V_d.[10]

Let C represent the effort cost of filing an application and $p(h)$ the probability of application success. We assume that $p'<0$, reflecting that the likelihood of application success is higher for applicants of poorer health. The expected utility from *applying* for disability can then be written as:[11]

(1) $$EU = \left(1 - p(h)\right)u(e,h) + p(h)V_d - C$$

Hence, workers maximize expected utility by applying for disability benefits when the following condition is met:

(2) $$p(h)\left(V_d - u(e,h)\right) > C$$

Equation (2) says that a worker will apply for disability benefits if the expected net benefit of being a disability pension recipient is higher than the application cost.

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[8] "Sick money" is a temporary benefit that replaces the earnings of incapacitated workers. While receiving sick money, recipients cannot be dismissed by their employer and are considered employed for reporting purposes.

[9] This model draws on Diamond and Sheshinski (1995) and Autor and Duggan (2003).

[10] For simplicity, we have assumed that V_d is independent of health. Our results would prevail even if V_d was dependent on health as long as the net benefit of becoming a disability recipient is decreasing in health.

[11] Recall that the Norway program allows workers to apply for disability pension while employed.

Downsizing often involves laying off some fraction of a plant's workforce. Let e_w and e_l denote future expected earnings of a retained and a laid off worker, respectively. We assume that $e_w > e_l$, reflecting the cost associated with re-entering the workforce following a layoff (e.g. lost earnings due to unemployment or having to accept lower wage). This is consistent with the literature on job displacement showing that displacement reduces future earnings and likelihood of employment (see survey by Kletzer, 1998). Let h_w (and h_l) denote the level of health at which a retained (and laid off) worker is indifferent between applying and not applying for disability benefits. That is, h_w and h_l are defined implicitly by $p(h_w)(V_d - u(e_w, h_w)) = C$ and $p(h_l)(V_d - u(e_l, h_l)) = C$. Note that $h_w < h_l$ follows from $e_w > e_l$.

Figure 1. People's labor supply choices

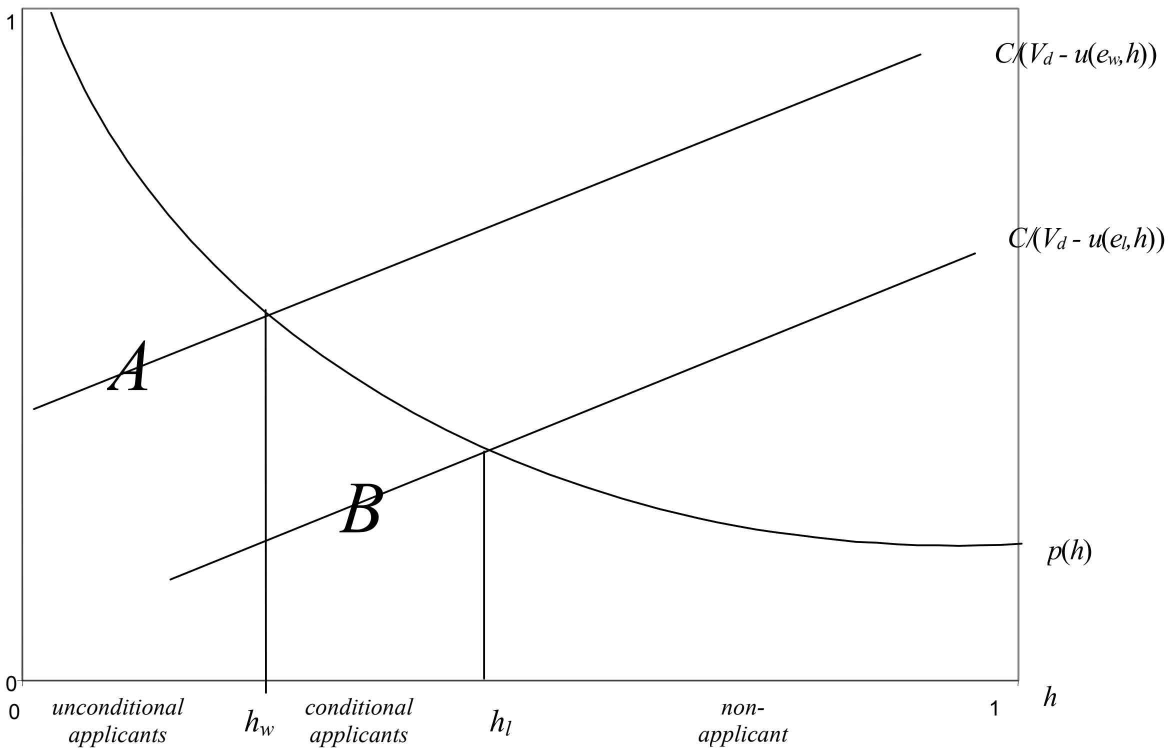

Figure 1 illustrates the relationship between worker health, expected earnings, and entry onto disability under this simple model. We refer to workers with health $h < h_w$ as *unconditional* applicants since such workers will apply for disability independent of their workforce status (retained versus laid off). A worker with health $h_w < h < h_l$ is a *conditional* applicant, meaning he will apply for disability insurance if and only if he is laid off. Finally, a worker with health $h > h_l$ is a *non-applicant*, meaning that he will not apply for disability insurance regardless of being laid off. Recall that *h* is uniformly distributed on [0,1]. Thus, the area *A* represents the likelihood that a random worker who is retained becomes a disability pension recipient, while the area *A*+*B* represents the likelihood that a random worker who has been laid off becomes a disability pension recipient.

In this simple model, downsizing can affect the likelihood of applying for disability either by affecting expected future earnings or by affecting health:

Expected future earnings: If downsizing forces plants to layoff workers, this increases the number of conditional applicants. Figure 1 illustrates how conditional applicants are more likely to become disability recipients because of lower expected future earnings $(e_l < e_h)$. The literature on job displacement (see survey by Kletzer, 1998) suggests that the decrease in expected future earnings is larger for workers with more plant specific skills. Thus, area *B* is likely larger for workers with plant specific skills, suggesting these workers are more likely to enter disability following a layoff than workers with more general skills. Assuming workers with longer job tenure, lower education levels, and older ages have more plant specific skills, we are able to test this implication empirically.

If downsizing plants have some discretion with respect to whom they lay off and tend to lay off workers of lower productivity, then being laid off can signal low productivity to future employers (Gibbons and Katz, 1991). As such, expected future earnings are potentially lower (i.e. e_l is smaller and area *B* larger) for workers displaced as one of a few than workers displaced as one of many. If so, workers displaced because of a partial downsizing are more likely to enter disability than those displaced because of a plant closure.

Note that downsizing can also decrease expected future earnings of retained workers (i.e. e_w is smaller and area *A* larger). Downsizing events may, for example, affect workers' perceptions regarding local labor market opportunities, reducing perceived job security and expectations about future wages. These factors can affect retained workers who are on the margin for entering disability.

Health effect: Plant downsizing could affect the health of workers. The epidemiological literature has linked stress and depression associated with job loss to cardiovascular disease and diseases of the digestive system (see survey by Kasl and Jones, 2002). Thus, the stress of experiencing a job loss could be a direct cause of disabling health problems. In addition, a recent paper by Snyder and Evans (2002) suggests that working has a positive effect on health, measured by differences in mortality rates.[12] We find that downsizing has a sizable negative effect on the future labor force participation of affected workers, which could adversely affect their health.

There is also evidence from the epidemiological literature that downsizing could affect the health of retained workers by imposing stress or affecting perceptions of job security (see e.g. Dragano, Verde, and Siegrist, 2005, Kivimaki et al., 2000, Vahtera and Kivimaki, 1997). Alternatively, the consequence of downsizing may be more work for retained workers, leading to physical or mental exhaustion. Notably, Røed and Fevang (2005) find that major downsizing events in the Norwegian health care and social services sectors raised the level of sickness-related absenteeism among workers in affected institutions.

Figure 1 illustrates how adverse health effects resulting from plant downsizing events will increase a worker's likelihood of disability benefit utilization. An adverse health effect (decrease in h) will increase the worker's likelihood of being an unconditional or conditional applicant, as well as increase the probability an application is successful.

4. Empirical Strategy

Our empirical analysis focuses on the effect of downsizing events on both retained and laid off workers. There are two important reasons for this approach. First, there are identification issues in estimating the effect of layoffs on disability pension utilization. Workers selected to be laid off are likely different in unobservable ways than retained workers. Moreover, our theoretical model suggests that downsizing could also affect the disability entry rate of retained workers. For this reason, the effect of downsizing events over both laid off and non-laid off workers is probably more relevant to policy makers than the effect of layoffs in isolation. As a practical matter, we are also prevented from isolating the effect of layoffs because we cannot identify which workers were laid off with any precision.[13]

Our dataset allows us to measure plant downsizing by looking at changes in employment levels by plant and year. We will refer to the *plant downsizing rate* (PDR) as the maximum percentage

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[12] However, a study by Ruhm (2000) found that temporary decreases in employment rates *decreased* mortality rates. See Ruhm (forthcoming) for an excellent survey on how macroeconomic conditions affect health.

[13] Under Norwegian law, workers must be notified a minimum of one month prior to an impending layoff. Workers notified of their impending layoff might enter a new job without ever receiving unemployment and would not appear to have been laid off. The problem is even more severe for workers who exit jobs onto disability. Since workers commonly receive sick money prior to entering disability, and because workers cannot be dismissed from employment while receiving sick money, a worker who intends to enter disability in response to an impending layoff will commonly be observed as transitioning directly from employment onto disability. There is no way to determine with any precision when such transitions are associated with an impending layoff.

reduction in employment between 1993 and 1998. More precisely, the plant downsizing rate in plant *k* is given by

$$(3) \qquad PDR_k = \max\left\{ \frac{x_{i,k} - x_{j,k}}{x_{i,k}} \;\middle|\; 93 \le i < j \le 98 \right\},$$

where $x_{i,k}$ denotes number of workers (full-time equivalents) in plant *k* at the end of year *i.*[14]

We estimate the following linear probability model[15] for the probability that a worker employed full-time in 1993 receives a disability pension in 1999:

$$(4) \qquad A_{i,99} = \alpha_0 + \eta PDR_{p(i)} + \alpha_P X_{p(i)} + \alpha_X X_i + u_i$$

where

$A_{i,99}$	~	indicator that worker *i* is a disability pension participant in year 1999
$PDR_{p(i)}$	~	plant downsizing rate of the plant in which *i* was employed in 1993
$X_{p(i)}$	~	vector of 1993 characteristics of *i*'s plant
X_i	~	vector of 1993 characteristics of *i*
u_i	~	Error term with mean zero

The parameter of interest in equation (4) is η, which captures the impact of plant downsizing on *i*'s likelihood of entering disability. Estimation of equation (4) will produce unbiased estimates of η provided that plant downsizing events are determined by exogenous economic shocks and are independent of unobservable determinants of disability entry. This assumption may be difficult to defend for several reasons. For example, some industries may be laying off more workers than other industries. If workers are more likely to become disabled in these industries (e.g. heavy industry), estimate of η will be biased upwards. Downsizing plants may also be concentrated in neighborhoods or municipalities with poor labor market conditions. If so, our estimate of η may capture the effect of difficult local labor market conditions on disability entry. Finally, a worker may be more likely to enter disability if more of their neighbors are utilizing disability benefits (see e.g. Moffit 1983, Lindbeck, Nyberg, and Weibull, 1999, Bertrand, Luttmer, and Mullainathan, 2000). If downsizing

[14] We also estimated models calculating the PDR as the percentage change in plant employment between 1993 and 1998 (as opposed to the maximum percentage reduction). The estimates produced under these models were very similar to those reported here, but slightly less precisely estimated.

[15] Logit models were also estimated (when possible) and produced similar marginal effect estimates. However, we were unable to estimate logit models for specifications including neighborhood fixed effects.

plants are concentrated in neighborhoods with high disability participation rates, social interaction effects in disability participation could bias our estimate of η. In our empirical analysis, we address these potential sources of bias by including industry, municipality and neighborhood fixed effects.

Estimates of η could also be biased if unobserved determinants of disability entry are correlated with the downsizing experience of workers' plants, for instance, if workers of marginal health are concentrated in failing plants. If true, we might expect higher rates of sick money use in 1992 among workers in downsizing plants. Similarly, we might expect higher rates of disability entry among workers in downsizing plants even prior to the downsizing event. We are able to test both of these possibilities.

Disability entry rates could also vary across plants if adverse health events are correlated within plants. For instance, a plant may never recover after a plant accident injuring a lot of workers, or a plant may have bad environmental conditions that hurt both its workers' health and plant performance. We investigate this potential source of bias by looking at the diagnoses on which workers enter disability. If downsizing is frequently caused by plant-specific "health shocks," then a higher fraction of disability entrants from downsizing plants should enter with an injury- or pollution-related diagnosis relative to entrants from non-downsizing plants. To investigate this possibility, we estimate a worker's probability of entering disability on a particular diagnosis, restricting the sample to those on disability in 1999. For different diagnosis categories, we estimate the following logit model:

$$\text{(5)} \qquad \Pr\left(B_{i,99}=1\right)=\Lambda\left(\alpha_0+\gamma PDR_{p(i)}+\alpha_P X_{p(i)}+\alpha_X X_i\right)$$

where $B_{i,99}$ is an indicator that entrant i has a certain diagnosis (e.g. injury- or pollution-related). If we find no significant relationship between plant downsizing and injury- or pollution-related diagnoses, this suggests that estimates of η are probably not biased from a higher incidence of "health shocks" in downsizing plants.

Our diagnosis-related results can also shed some light on the potential health effects of downsizing. Certain health conditions (e.g. mental disorders, diseases of the circulatory system) are more plausibly affected by downsizing than others (e.g. neoplasms, diseases of the musculoskeletal system). If downsizing increases disability entry rates by adversely affecting workers' health, we should expect a higher fraction of disability entrants from downsizing plants entering for the prior types of conditions.

It should be noted that, absent the sources of omitted variable bias identified above, our results potentially under-estimate the impact of downsizing on disability entry since our downsizing measure is based on a worker's original plant of employment. Job mobility across downsizing and non-downsizing plants would therefore tend to attenuate our estimates.

5. Dataset Description

Our empirical analysis utilizes two databases provided by Statistics Norway: a register database called *FD-trygd* and an employment spell database. The FD-trygd database contains employment and disability pension records for every Norwegian from 1992 to 2000.[16] In addition, this database contains a rich array of individual demographic and socio-economic variables (e.g. marital status, education, income/wealth), as well as geographic identifiers for municipality and neighborhood of residence.

The employment spell database allows us to calculate the number of employees in any given plant at the end of each calendar year. Due to uncertainty regarding the "end date" of employment spells, we counted as employed only those persons whose employment status was confirmed in FD-trygd.[17] The count of workers in each plant-year is based on the number of "full-time equivalents" (FTEs), with part-time workers counted as 0.67 FTEs and minor part-time workers counted as 0.33 FTEs. From these counts, we derived the downsizing rate for each plant as defined in equation (3).[18]

Individuals identified as employed full-time in the FD-trygd database were matched to their plant of employment in 1993 to form the basis of our analytic sample.[19] A number of exclusion criteria were applied to create our final sample of full-time workers. First, since our primary outcome is disability participation at the end of 1999, we omitted any workers who died or emigrated prior to the end of 1999. Second, we restricted our sample to workers age 30 to 60 in 1993. Disability participants are automatically transferred to the elderly pension program at the age of 67, so that workers over age 60 in 1993 cannot receive a disability pension in 1999. Third, we excluded those with less than one year of tenure in their plant, including any workers receiving assistance in 1993 that should have precluded full-time employment (i.e. disability pension, rehabilitation pension, unemployment benefits, social assistance). Since the personal income variable in FD-trygd includes both earnings and governmental assistance, this restriction ensures that personal income consistently captures annual earnings in 1993, though it potentially includes earnings from more than one

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[16] We are using 1993 as the base year because of missing income variables in 1992.

[17] In FD-trygd, employment status is confirmed by the presence of positive earnings related to the employment spell.

[18] We also estimated models using only the count of full-time workers to construct PDR (as opposed to FTEs). The estimates produced under these models were very similar to those reported here, but less precisely estimated.

[19] In some cases, workers appeared to have simultaneous full-time employment spells in more than one plant. In such cases, the main plant of employment was selected based on the employment spell with most recent start date.

employment source. Fourth, we excluded any workers receiving sick money at the end of 1993, and similarly excluded such workers from the annual plant employment counts on which our downsizing variables are based. Since workers commonly receive sick money prior to entering disability, failure to do this could contribute to spurious correlation between plant downsizing and disability entry.[20] Finally, to reduce noise in our measure of plant downsizing, we restrict our sample to workers employed in plants with at least ten FTEs in 1993.

Applying the above restrictions provides us a sample of 496,961 workers living in 12,217 neighborhoods (434 municipalities) and working in each of the 33 different industries.[21] Table 1 presents summary statistics for our sample. Note that the 1999 disability entry rate among workers in plants with a low PDR (less than 35 percent) is 4.3 percent, while the disability entry rate among workers in high PDR plants is 5.4 percent. Workers employed in high PDR plants differ from those in low PDR plants in a number of potentially important dimensions, though the differences are not substantively large. Overall, workers in high PDR plants tend to be less well educated, have lower incomes and household wealth, and are employed in smaller plants. Workers in low PDR plants tend to be somewhat older. The age differences are less than the tenure differences, suggesting that employment is historically more stable in low PDR plants.

[20] For instance, if workers who exit a plant onto disability are not replaced, a plant with a higher fraction of sick money recipients will have a larger downsizing rate when more of those recipients exit onto disability.

[21] Industries are coded at the two-digit level of the Standard Industrial Classification, the industry coding system used by Statistics Norway in 1993.

Table 1. Summary statistics

variables	all	PDR < 35	PDR > 35
on DP 1999	.046	.043	.054
female	.351	.346	.364
age			
30-40	.360	.352	.380
40-50	.391	.397	.376
50-61	.249	.251	.244
years of schooling			
less than 9	.355	.348	.376
9-13	.112	.112	.111
13-15	.338	.340	.332
more than 16	.195	.200	.181
years of tenure			
1-3	.203	.188	.243
3-5	.147	.149	.143
5-10	.280	.282	.275
more than 10	.370	.381	.339
plant size (workers)			
10-25	.208	.201	.227
25-50	.177	.179	.173
50-100	.169	.171	.163
100-500	.277	.274	.285
more than 500	.169	.175	.152
income			
personal income	252721 (111751)	254083 (112658)	248915 (109085)
household income	508225 (3747687)	508303 (3703050)	508007 (3869767)
household wealth	131718 (6204367)	133418 (6269549)	126963 (6018409)
PDR			
less than 5%	.250		
5-35%	.486		
35-65%	.077		
65-95%	.037		
95-100%	.150		
# observations	496961	366036	130925

Note: Standard errors are in parenthesis.

In our estimation models, the estimated effect of PDR is captured through inclusion of four categorical dummies indicating original employment in a plant downsizing 5-35, 35-65, 65-95, or 95-100 percent ("fully closed").[22] The PDR coefficients therefore capture the incremental increase in disability participation relative to workers in non-downsizing plants (less than 5 percent). Based on characteristics in 1993, a large number of individual- and plant-level covariates were included in all models:

- sex and year-of-birth: 62 categories
- marital status: 4 categories (never married, married, divorced, widowed)
- number of children: 4 categories (0, 1, 2-3, ≥4)
- received sick in money in 1993: indicator
- years of education: 4 categories (<9, 9-12, 13-15, ≥16)
- years of tenure in plant: 4 categories (1-3, 3-5, 5-10, ≥10)
- personal earnings: linear and quadratic
- household income: linear and quadratic
- household wealth: linear and quadratic
- plant size: 5 categories (10-25, 25-50, 50-100, 100-500, ≥500)
- share of plant workers, age ≥50: linear
- share of plant workers, education ≥16: linear
- share of plant workers, tenure ≥5: linear
- share of plant workers, received sick money in 1993: linear
- mean income of plant workers: linear

6. Empirical Results

6.1. Effect of Plant Downsizing on Disability Pension Entry

Table 2 presents linear probability (OLS) estimates for the effect of the plant downsizing rate (PDR) on the probability a worker originally employed in the plant (in 1993) receives disability benefits in 1999. Standard errors in Table 2 (and subsequent tables) are corrected for heteroskedasticity and non-independence of residuals across workers originally employed in the same plant.[23] Omitting industry

[22] In alternative specifications (not presented), we estimated the effect of downsizing using either continuous PDR covariates (linear and quadratic terms) or finer PDR categories. The results from these specifications confirm those presented here. In particular, the continuous specification indicated that disability entry rates were highest among workers in plants downsizing 90-95 percent. Results using finer categories were qualitatively similar to those presented but produced very imprecise estimates for several downsizing categories due to the small number of plants in those categories.

[23] Using the "robust cluster(.)" option in Stata 8.0.

and geographic fixed effects (see Model 1), we find that working in a plant that closed between 1993 and 1998 increased the likelihood a worker entered disability by 1.4 percentage points. Interestingly, the relationship between the PDR and disability entry is non-linear, with a pronounced "hump" in the entry rate for workers in plants downsizing 65-95 percent. We provide further exploration of this relationship below.

Table 2. Main results

	Model 1	Model 2	Model 3	Model 4
Dependent variable: DP recipient in 1999				
PDR				
5-35%	.0051**	.0056**	.0048**	.0047**
	(.0010)	(.0009)	(.0009)	(.0009)
35-65%	.0121**	.0120**	.0107**	.0103**
	(.0021)	(.0021)	(.0019)	(.0019)
65-95%	.0274**	.0277**	.0266**	.0267**
	(.0035)	(.0034)	(.0032)	(.0032)
95-100%	.0138**	.0117**	.0114**	.0112**
	(.0015)	(.0015)	(.0014)	(.0014)
F-test (p-value)	.0000	.0000	.0000	.0000
Included covars				
Industry FEs		X	X	X
Municipality FEs			X	
Neighborhood FEs				X
mean	.0459	.0459	.0459	.0459
N	496961	496961	496961	496961

Note: * and ** denote significance at the 5 and 1 percent level. Robust standard error in parenthesis, corrected for non-independent residuals within plant. All estimates adjust for individual and plant 1993 characteristics (described in text). F-test refers to test of joint significance for the four PDR coefficients.

As discussed in section 4, an important concern for our empirical strategy is that downsizing events might be concentrated in industries with hazardous work conditions or in geographic areas with poor labor market conditions. If so, controlling for industry and geographic area effects would be expected to reduce the estimated effect of the PDR covariates. Inclusion of fixed effects for industry (see Model 2) has only a modest impact on our estimates, with no significant differences across estimates in the two models. Only in the case of fully closing plants does the estimate move in the direction consistent with omitted variable bias. Estimates do systematically decline in magnitude when municipality or neighborhood fixed effects are included (see Models 3 and

4), though again the differences are fairly modest. We nonetheless view the estimates including both industry and neighborhood fixed effects as our preferred estimates (Model 4). These results suggest that disability participation rates are 1.1 percentage points higher among workers originally employed in fully closing plants and 2.7 percentage points higher among workers employed in plants downsizing 65-95 percent.

Table 3 reports alternative estimates of the downsizing effect as well as results of several robustness tests. For comparison, the first column (Model 1) repeats our preferred estimates from Table 2. When the outcome is changed to DP participation in 1998 (Model 2), effect estimates decline slightly in magnitude. This would be expected since responses to downsizing events might take time to materialize. When the outcome is changed to DP participation in 2000 (Model 3), estimates are similar to our original estimates. Models 4 and 5 replicate our preferred model altering the years over which PDRs are calculated (calculated over 1993-97 in Model 4 and 1993-96 in Model 5). This has the effect of recategorizing some plants experiencing employment declines in latter years. As a result, effect estimates are slightly larger in the lower PDR categories and modestly lower in the higher PDR categories. Model 6 replicates our preferred model but constructs the PDR categories based strictly on the change in plant employment levels (FTEs) between 1993 and 1998. Again, the results are similar to our original estimates, though slightly smaller in magnitude.

The non-linear effect of downsizing on disability entry is a persistent finding across all models, with workers in fully closing plants demonstrating substantially lower disability entry rates relative to those in plants downsizing 65-95 percent. We were concerned that this might reflect a problem with the employment spell data. For instance, if plant identifiers changed over time for some fraction of plants, this would lead us to mis-categorize those plants as fully closing, biasing the estimated effect of full closure towards zero. To investigate this possibility, we re-estimated our original model dropping workers in fully closing plants where more than 50 percent of the exiting workers were subsequently re-employed in the same next plant. The results in Model 7 show that dropping workers in these plants had minimal effect on our estimates.

Table 3: Robustness checks

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Dependent variable:	DP recipient 1999	DP recipient 1998	DP recipient 2000	DP recipient 1999	DP recipient 1999	DP recipient 1999	DP recipient 1999	DP recipient 1999	DP recipient 94/95	Sick money recipient 92
Measure of downsizing:	*PDR* 93-98	*PDR* 93-98	*PDR* 93-98	*PDR* 93-97	*PDR* 93-96	ΔFTE 93-98	*PDR* 93-98	*PDR* 95-98	*PDR* 95-98	*PDR* 93-98
5-35%	.0047** (.0009)	.0045** (.0007)	.0051** (.0010)	.0053** (.0008)	.0051** (.0008)	.0037** (.0009)	.0048** (.0009)	.0054** (.0011)	.0003 (.0003)	-.0010 (.0015)
35-65%	.0103** (.0019)	.0093** (.0014)	.0122** (.0020)	.0144** (.0026)	.0109** (.0028)	.0103** (.0024)	.0103** (.0019)	.0120** (.0037)	.0005 (.0007)	-.0005 (.0024)
65-95%	.0267** (.0032)	.0231** (.0029)	.0265** (.0030)	.0213** (.0028)	.0221** (.0035)	.0257** (.0034)	.0269** (.0031)	.0147** (.0035)	.0009 (.0009)	.0025 (.0031)
95-100%	.0112** (.0014)	.0099** (.0011)	.0117** (.0016)	.0097** (.0015)	.0100** (.0017)	.0089** (.0013)	.0118** (.0018)	.0109** (.0027)	.0002 (.0005)	-.0024 (.0021)
F-test (p-value)	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.6992	.5617
Sample restriction:							Excludes workers in plants with PDR 93-98 > 95% & > 50% in same next plant	Excludes workers in plants with PDR 93-95 > 5%	Excludes workers in plants with PDR 93-95 > 5%	
mean	.0459	.0325	.0558	.0459	.0459	.0459	.0457	.0433	.0032	.1171
N	496961	496961	496961	496961	496961	496961	469316	270575	270575	496961

Note: * and ** denote significance at the 5 and 1 percent level. Robust standard error in parenthesis, corrected for non-independent residuals within plant. All estimates adjust for individual and plant 1993 characteristics, with industry and neighborhood fixed effects. F-test refers to test of joint significance for the four PDR coefficients.

Another potential concern regarding our estimates is that they are driven by disability entry from plants with persistently unstable employment levels. It is possible that workers employed in less stable plants are different in unobservable ways from those employed in more stable plants, biasing the downsizing effect estimates. To investigate this, we restricted our sample to workers in plants with stable employment levels over 1993-95, specifically, plants either growing or experiencing no more than 5 percent downsizing over 1993-95. Over the remaining sample, we then estimated the relationship between disability entry and the plant downsizing rates over 1995-98. Model 8 presents the results of this analysis. Notably, the estimated effect of originally working in a plant downsizing 65-95 percent is significantly and substantially smaller than our original estimate. Overall, though, we cannot conclude that our original estimates were biased by workers in unstable plants, since the other PDR estimates remain unchanged or grow slightly in magnitude. It does appear, however, that among plants downsizing 65-95 percent, the plants that began downsizing earlier had higher rates of disability entry.

Model 9 tests whether workers in downsizing plants have similar propensities to enter disability as those in non-downsizing plants. If true, workers in downsizing plants should not demonstrate increased disability entry rates until the downsizing event occurs. To test this, we again restrict our sample to workers in plants with no downsizing prior to 1995, and estimate the relationship between PDR and disability participation in 1994 or 1995. The results demonstrate no significant relationship, supporting our assumption that unobserved propensities to enter disability are independent of plant downsizing rates.

Model 10 provides a similar robustness check, focusing on unobserved differences in health across workers in downsizing and non-downsizing plants. Using our full sample, Model 10 estimates the relationship between PDR and the probability of receiving sick money in 1992. We find no relationship between sick money use in 1992 and the subsequent downsizing rate of a worker's plant, suggesting no unobserved differences in health across downsizing and non-downsizing plants prior to the downsizing events.

6.2. Sub-sample Analyses

Tables 4-6 investigate the impact of downsizing over different sub-samples of workers under our preferred specification. Our theoretical model provides a number of implications in this regard. First, workers who respond to a layoff by entering disability are likely those of marginal health. To the extent that age or prior use of sick money is associated with poorer health, we therefore expect the downsizing effect to be larger among older workers and those with a prior history of sick money use. The same reasoning would also predict higher responsiveness to downsizing in more physically demanding jobs, such as manufacturing and construction. Second, workers differentially respond to layoffs when the effect of layoffs on future employment and earnings is larger. The literature on job displacement indicates that the effect of layoffs on future employment and income depends on tenure, education and age (see survey by Kletzer, 1998). An important explanation for this result is that people with long tenure, low education and old age have more plant-specific human capital (see e.g. Becker 1975) which is lost when a worker is displaced. We therefore predict greater responsiveness to downsizing among workers who have longer tenure and less education. The effect of downsizing is expected to be less severe among workers in industries involving less plant-specific human capital, such as the financial services industry. Third, progressivity in the earnings replacement rate suggests that the opportunity cost of exiting the job market to enter disability will be lower among low earners. As a result, workers with lower initial earnings are expected to be more responsive to downsizing events.

Table 4 presents estimates of the downsizing effect broken down along two dimensions: sick money use in 1992-93 and income in 1993. Note that in "partially" downsizing plants, the differences across sub-samples could be driven by the selection of which workers a downsizing plant lays off. For example, a plant undergoing a partial downsizing might selectively layoff its least healthy or least productive workers which could exaggerate the difference in estimates across partially closing plants. Therefore, the estimated effects of "full closure" (95-100 percent) provide the most meaningful comparisons across the sub-samples for analyzing differential effects. We find that workers with a history of sick money use are more than twice as likely to respond to plant closure by entering disability. Low earners, defined as those with incomes below 225,000 NOK (roughly the median for our sample), are more than 50 percent more likely to respond to plant closure by entering disability than those with higher incomes.[24]

[24] The sick money results also support the hypothesis that less healthy workers are disproportionately affected by partial downsizing episodes, as the relative difference in effect estimates is larger in the lower PDR categories.

Table 4: Estimates for sub-samples: received sick money and earnings

Dependent variable: DP recipient in 1999				
	Received sick money 92/93		earnings	
	recipient	non-recipient	<225000	>225000
PDR				
5-35%	.0132**	.0028**	.0063**	.0033**
	(.0028)	(.0008)	(.0015)	(.0009)
35-65%	.0313**	.0052**	.0124**	.0074**
	(.0054)	(.0017)	(.0027)	(.0019)
65-95%	.0492**	.0207**	.0329**	.0186**
	(.0071)	(.0031)	(.0042)	(.0034)
95-100%	.0203**	.0093**	.0138**	.0090**
	(.0045)	(.0013)	(.0023)	(.0015)
F-test (p-value)	.0000	.0000	.0000	.0000
mean	.1086	.0322	.0664	.0268
N	89298	407663	239441	257520

Note: * and ** denote significance at the 5 and 1 percent level. Robust standard error in parenthesis, corrected for non-independent residuals within plant. All estimates adjust for individual and plant 1993 characteristics (described in text). F-test refers to test of joint significance for the four PDR coefficients.

Table 5 presents downsizing effect estimates broken down by age, education and tenure. Again, the results for “full closure” represent the most meaningful comparisons for evaluating differential effects. Consistent with the literature on job displacement and assumptions about plant-specific human capital, we find that the effect of plant closure is strongest for workers of older age, longer tenure and lower education level.

Table 6 presents estimates broken down along two plant characteristics, industry and plant size, to determine if disability entry is more sensitive to downsizing episodes in certain types of plants. Our findings suggest that they are. Over the six most heavily populated major industries, disability entry is most sensitive to downsizing among workers in manufacturing, construction, and transport, storage and communication. The first two of these categories are characterized by physically demanding work. In contrast, no significant effects were estimated for the category of finance, insurance, real estate and business services. We expected smaller effects for this industry category since the jobs are not physically demanding and the skills required for such jobs are likely less plant-specific than in the other industries considered. The effect of downsizing on disability entry appears strongest in smaller plants, however, the magnitudes are large and statistically significant even for workers in plants employing 100 to 500 FTEs. Among the largest plants (>500 FTEs), estimates are somewhat smaller and not statistically significant. This finding is somewhat at odds with the plant-specific human capital story, as we might expect a higher degree of specialization in the largest plants. However, this finding could also reflect unobservable differences in the types of workers originally employed in large plants.

Table 5: Estimates for sub-samples: age, education and tenure

Dependent variable: DP recipient in 1999

	30-40 years					40-50 years					50-60 years				
	all	education		tenure		all	education		tenure		all	education		tenure	
PDR		<13	>13	<5	>5		<13	>13	<5	>5		<13	>13	<5	>5
5-35%	.0010 (.0007)	.0021 (.0015)	.0003 (.0006)	.0003 (.0009)	.0013 (.0009)	.0039** (.0010)	.0043* (.0019)	.0035** (.0011)	.0020 (.0019)	.0042** (.0012)	.0117** (.0027)	.0164** (.0040)	.0072* (.0034)	.0066 (.0057)	.0148** (.0031)
35-65%	.0017 (.0011)	.0026 (.0025)	.0003 (.0010)	.0005 (.0015)	.0026 (.0015)	.0075** (.0020)	.0088** (.0033)	.0056** (.0021)	-.0008 (.0030)	.0116** (.0026)	.0243** (.0054)	.0373** (.0080)	.0083 (.0055)	.0191* (.0097)	.0255** (.0065)
65-95%	.0022 (.0015)	.0033 (.0032)	.0019 (.0015)	.0014 (.0019)	.0030 (.0021)	.0154** (.0030)	.0253** (.0055)	.0073** (.0027)	.0041 (.0044)	.0203** (.0038)	.0773** (.0092)	.1057** (.0131)	.0403** (.0089)	.0912** (.0136)	.0721** (.0119)
95-100%	.0029** (.0010)	.0046* (.0021)	.0020* (.0009)	.0033* (.0013)	.0027 (.0014)	.0086** (.0018)	.0149** (.0033)	.0032* (.0016)	.0052 (.0028)	.0092** (.0022)	.0274** (.0042)	.0383** (.0064)	.0169** (.0049)	.0195* (.0082)	.0311** (.0049)
F-test (p-value)	.0387	.2832	.2000	.1139	.2129	.0000	.0000	.0014	.3353	.0000	.0000	.0000	.0000	.0000	.0000
mean	.0106	.0178	.0061	.0100	.0110	.0320	.0469	.0180	.0315	.0323	.1187	.1504	.0784	.1120	.1209
N	178703	68578	110125	79016	99687	194434	94154	100280	63910	130524	123824	69305	54519	30989	92835

Note: * and ** denote significance at the 5 and 1 percent level. Robust standard error in parenthesis, corrected for non-independent residuals within plant. Estimates adjust for individual and plant 1993 characteristics, with neighborhood and industry fixed effects. F-test refers to test of joint significance for the four PDR coefficients.

Table 6: Estimates by industry and plant size

Dependent variable: DP recipient in 1999

	Industry						Plant size				
	manu-facturing	con-struction	wholesale and retail trade, restaurants and hotels	transport, storage and communi-cation	financing, insurance, real estate and business services	Community, social and personal services	10-25 workers	25-50 workers	50-100 workers	100-500 workers	>500 workers
PDR											
5-35%	.0065**	.0087*	.0020	.0095**	-.0006	.0047**	.0061**	.0055**	.0060**	.0039*	.0042
	(.0020)	(.0041)	(.0026)	(.0035)	(.0023)	(.0015)	(.0018)	(.0020)	(.0022)	(.0017)	(.0023)
35-65%	.0060	.0233	.0159**	.0175*	.0025	.0082**	.0141**	.0136**	.0122**	.0102*	.0006
	(.0044)	(.0140)	(.0041)	(.0069)	(.0035)	(.0031)	(.0028)	(.0034)	(.0040)	(.0044)	(.0037)
65-95%	.0422**	.0523*	.0153**	.0423**	.0051	.0239**	.0332**	.0281**	.0204**	.0301**	.0207
	(.0101)	(.0209)	(.0052)	(.0131)	(.0061)	(.0032)	(.0048)	(.0054)	(.0047)	(.0067)	(.0125)
95-100%	.0135**	.0137	.0142**	.0168**	.0065	.0085**	.0152**	.0157**	.0038	.0122**	.0083
	(.0038)	(.0077)	(.0037)	(.0064)	(.0036)	(.0023)	(.0025)	(.0030)	(.0033)	(.0032)	(.0043)
F-test (p-value)	.0000	.0440	.0000	.0025	.2499	.0000	.0000	.0000	.0000	.0000	.1620
Mean	.0491	.0438	.0408	.0525	.0269	.0501	.0465	.0495	.0487	.0456	.0390
N	104042	26922	48515	53567	45208	194771	103620	88026	83864	137639	83812

Note: * and ** denote significance at the 5 and 1 percent level. Robust standard error in parenthesis, corrected for non-independent residuals within plant. All estimates adjust for individual and plant 1993 characteristics, with industry and neighborhood fixed effects. We report results for the 6 major industrial categories with the highest population of workers. F-test refers to test of joint significance for the four PDR coefficients.

6.3. Effect of Plant Downsizing on Employment, Earnings and Health

The above results suggest that downsizing events increase disability entry rates of affected workers but do not indicate the mechanism through which disability entry rates increase. As our theoretical model suggests, downsizing could affect disability entry by reducing future expected earnings or by adversely affecting health. Determining the relative importance of these mechanisms is complicated by the fact that employment outcomes and health are endogenous. That is, if workers in downsizing plants have poorer subsequent employment outcomes *and* poorer health, it is impossible (without longitudinal health data) to determine the extent that these outcomes cause one another. The following analysis therefore only investigates the *plausibility* of these two mechanisms in contributing to the downsizing effect on disability entry.

The first two panels of Table 7 present estimates of the downsizing effect on workers' employment and log income in 1999. We estimate a strong effect of downsizing on the subsequent employment of workers in our sample, with full-time employment rates 10.6 percentage points lower among workers originally employed in plants downsizing 65-95 percent. Consistent with our disability entry results, we find a distinct "hump" in the downsizing effect on subsequent employment. The effects are smaller in magnitude but remain very large when disability entrants are omitted from the sample. A similar pattern is observed for the estimated effect of downsizing on log income. Not surprisingly, the income effects are smaller when the sample is limited to those full-time employed in 1999. Interestingly, we continue to estimate a negative effect of downsizing on log income even when we limit our sample to workers still employed in their 1993 plant, indicating that the negative effect of downsizing on future earnings extends to retained workers. The non-linear effect of downsizing on future employment outcomes and income is consistent with the signaling story of Gibbons and Katz (1991), and suggests that expectations of future earnings contribute to the effect of downsizing on disability entry.

The remaining panel in Table 7 presents the estimates of the effect of downsizing on subsequent mortality rates over the period 1999-2002. Over our entire sample, downsizing demonstrates a statistically significant positive effect on the mortality of workers. Again, the "hump" prevails, with the estimated mortality effect smaller for fully closed plants than plants downsizing 65-95 percent. Much of the mortality effect is apparently driven by workers in downsizing plants who entered disability, as the estimates decrease in magnitude when disability entrants are omitted. Restricting the sample to those employed full-time in 1999, the estimates decrease further and are no longer statistically significant. While these findings are supportive of the possibility that downsizing directly affects the health of affected workers, we cannot conclude this with any certainty. The mortality results appear to be primarily driven by persons suffering poorer work outcomes in 1999, with a non-linear pattern similar to the employment results. Thus, the higher mortality rates in downsizing plants could reflect the impact of labor force participation on health (as in Snyder and Evans, 2002) rather than a direct effect of downsizing on health.

Analyzing the diagnoses for which workers enter disability provides another opportunity for investigating whether the effect of downsizing on disability entry is plausibly explained by a direct health effect, as certain health conditions are more plausibly associated with downsizing than others. Table 8 presents logit (odds-ratio) estimates for the probability a disability participant entered with a given diagnosis.[25] Results for the seven most common diagnoses are presented.[26] If downsizing increases disability participation by adversely affecting health, we would expect to observe a disproportionate share of disability entrants from downsizing plants diagnosed for "mental and behavioral disorders" and "diseases of the circulatory system." The former of these captures a number of conditions related to stress and depression, potentially affected by job loss. The epidemiological literature has linked stress and depression associated with job loss to heart disease (Kasl and Jones, 2002), captured by the latter category. Our results partially support the hypothesis that downsizing events have a direct adverse effect on health, with a significantly higher fraction of disability entrants from downsizing plants having been diagnosed with a mental or behavioral disorder. However, no such difference was observed for diseases of the circulatory system.

An alternative interpretation for the relatively high fraction of mental disorders among entrants from downsizing plants is that such diagnoses are more easily manipulated by workers, and might therefore be indicative of system "abuse" by workers not truly disabled. If entrants from downsizing plants were engaging in such abuse, we would also expect a relatively higher fraction of disability entrants from downsizing plants to enter for "diseases of the musculoskeletal system and connective tissue," the category that includes conditions such as rheumatism. The extent that such conditions impede work depends entirely on the amount of pain suffered by the worker – something a physician cannot observe and therefore potentially subject to manipulation. Of particular concern within this category is the diagnosis of fibromyalgia, characterized by muscle pain and fatigue but devoid of objectively verifiable symptoms. However, we find no evidence that disability entrants from downsizing plants are more commonly diagnosed with fibromyalgia or other musculoskeletal

[25] These models were estimated without municipality or neighborhood fixed effects. Logit models could not be estimated with neighborhood fixed effects. Including municipality fixed effects produced estimates similar to those presented but led to a large number of dropped observations (i.e. when no entrants from a given municipality were associated with a particular diagnosis category).

[26] The diagnosis categories were defined by "chapters" in the International Classification of Diseases (10th revision).

system/connective tissue conditions. Thus, the increase in mental and behavioral conditions associated with downsizing appears to capture an adverse health effect rather than system abuse.

Finally, our downsizing estimates are potentially biased if plant downsizing events are the result of plant-specific "health shocks." In particular, dangerous work conditions or poor air quality in a plant could contribute to *both* higher rates of disability entry and declines in plant employment, leading to biased estimates of the downsizing effect. However, we find no evidence that disability entrants from downsizing plants were more likely to enter with an injury-related diagnosis. The evidence for "diseases of the respiratory system" is mixed. A significantly higher than expected fraction of entrants from plants downsizing 65-95 percent were diagnosed with a respiratory condition, and a significantly *lower* fraction from plants downsizing 35-65 percent. Overall, then, it does not appear that our estimates are driven by plant-specific health shocks, though such shocks could potentially be biasing the estimated effect associated with plants downsizing 65-95 percent.

Table 7: Estimates for alternative dependent variables

Dependent variable	employed ft 1999		log income 1999				dies 1999-2002			
PDR										
5-35%	-.0279**	-.0239**	-.0332**	-.0316**	-.0154**	-.0141**	.0010*	.0005	.0003	.0006
	(.0029)	(.0027)	(.0034)	(.0034)	(.0022)	(.0023)	(.0004)	(.0003)	(.0003)	(.0004)
35-65%	-.0811**	-.0745**	-.0763**	-.0736**	-.0236**	-.0170**	.0018**	.0004	.0004	.0010
	(.0050)	(.0051)	(.0064)	(.0064)	(.0044)	(.0046)	(.0007)	(.0005)	(.0006)	(.0008)
65-95%	-.1062**	-.0878**	-.0996**	-.0929**	-.0237**	-.0321**	.0024**	.0015*	.0010	.0022
	(.0084)	(.0078)	(.0105)	(.0102)	(.0043)	(.0065)	(.0009)	(.0007)	(.0007)	(.0015)
95-100%	-.0705**	-.0614**	-.0577**	-.0541**	-.0170**	-	.0018**	.0010*	.0007	-
	(.0043)	(.0040)	(.0060)	(.0058)	(.0047)		(.0006)	(.0005)	(.0005)	
F-test (p-value)	.0000	.0000	.0000	.0000	.0000	.0000	.0022	.1177	.5786	.2477
Sample restriction										
not on dp 1993-2000		X		X	X	X		X	X	X
empl ft 99					X	X			X	X
empl same plant 93/99						X				X
mean	.7976	.8334	12.549	12.560	12.657	12.664	.0125	.0080	.0070	.0065
N	496961	467297	466975	458924	389168	240089	498898	467297	389436	240143

Note: * and ** denote significance at the 5 and 1 percent level. Robust standard error in parenthesis, corrected for non-independent residuals within plant. Estimates adjust for individual and plant 1993 characteristics, with neighborhood and industry fixed effects. Observations with missing dependent variable are dropped. The sample sizes are larger in the mortality regressions because these include workers dying in 1999. F-test refers to test of joint significance for the four PDR coefficients.

Table 8: Diagnoses

Dependent variable: DP recipient in 1999 with specified diagnoses (Logit Estimates)

	Diseases of the musculoskeletal system and connective tissue		Mental and behavioral disorders	Diseases of the circulatory system	Diseases of the nervous system	Injury and poisoning	Neoplasms	Diseases of the respiratory system
	All	Fibromyalgia						
PDR								
5-35%	.962	.975	1.057	1.031	.932	1.030	.840*	.992
	(.040)	(.100)	(.058)	(.057)	(.071)	(.095)	(.071)	(.105)
35-65%	.995	1.104	1.084	1.032	.961	1.084	.800	.703*
	(.064)	(.167)	(.088)	(.085)	(.112)	(.141)	(.110)	(.107)
65-95%	.947	.849	1.232*	.943	.886	.895	.770	1.456*
	(.073)	(.162)	(.114)	(.094)	(.130)	(.149)	(.128)	(.223)
95-100%	.895	.860	1.294**	1.038	.878	.795	.902	.983
	(.056)	(.127)	(.092)	(.081)	(.094)	(.103)	(.109)	(.134)
LR-test (p-value)	.2793	.6092	.0017	.8516	.7573	.1568	.2517	.0031
Mean	.378	.031	.152	.142	.058	.043	.041	.040
N	22806	22496	22795	22806	22720	22796	22738	22720

Note: * and ** denote significance at the 5 and 1 percent level. Sample restriction: Individuals on disability pension in 1999. Odds-ratio coefficients reported for logit models. Robust standard error in parenthesis, corrected for non-independent residuals within plant. All estimates adjust for individual and plant 1993 characteristics, with industry fixed effects. Including municipal fixed effects produced similar results but led to a larger number of dropped observations. To reduce number of dropped observations, the sex-age dummy covariates were replaced with continuous, fourth-order age covariates interacted with sex. The Likelihood Ratio (LR) test refers to test of joint significance for the four PDR coefficients and were performed without robust standard errors (required by Stata). The Table reports results for the seven most common diagnosis categories (based on ICD10 chapters) among disability entrants in 1998 and 1999. See appendix for coding of diagnoses.

7. Conclusion

In this paper, we investigate the impact of plant downsizing on disability pension entry rates in Norway. Our results suggest that plant downsizing substantially increases the likelihood of disability pension entry by workers in affected plants. Plant closure between 1993 and 1998 increased a worker's likelihood of receiving a disability pension in 1999 by 27.9 percent. Our estimates suggest that the aggregate effect of downsizing events increased disability participation in 1999 by 14.3 percent among workers employed full-time in 1993. Thus, downsizing events appear to play an important role in determining aggregate disability participation rates. Indeed, our estimates likely understate the impact of downsizing on disability entry since our downsizing variable is based on workers' original plant of employment. Of particular interest, we find that the relationship between plant downsizing and disability entry is non-linear. Workers originally employed in plants downsizing 65-95 percent of their workforce were more likely to enter disability than workers in fully closing plants.

At least some of the downsizing effect on disability entry appears to be driven by an adverse effect of downsizing on expected future earnings. Plant downsizing was associated with substantial reductions in workers' future earnings and likelihood of employment. These effects were also non-linear, with workers originally employed in plants downsizing 65-95 percent demonstrating worse labor market outcomes than those in fully closing plants. The non-linear effect on earnings and employment is consistent with the signaling story of Gibbons and Katz (2001). If downsizing plants have discretion over whom to lay off, prospective employers may infer that a worker displaced as one of a few is of lower productivity than a worker displaced as one of many. As a result, workers displaced due to a partial downsizing may face poorer employment opportunities than workers displaced due to plant closure, reducing their opportunity cost of exiting the workforce relative to workers in closing plants. This can explain the non-linear relationship between plant downsizing and disability entry.

However, we also find that downsizing has an adverse effect on workers' health. Among workers observed entering disability, those originally employed in downsizing plants were more likely to be diagnosed with mental and behavioral conditions, plausibly related to the stress of job displacement. Moreover, we estimate significant effects of downsizing on mortality. Interestingly, the non-linear relationship referred to above prevails in the mortality estimates. Job displacement has been linked to both stress and depression (Kletzer 1998). The non-linearity may reflect that it is and it is more stressful or depressing to lose your job as one of a few than as one of many. Alternatively, it suggests that the adverse health effect of downsizing could be related to the poor employment outcomes of workers in downsizing plants (Snyder and Evans, 2002).

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Coding of Diagnosis

The dataset contains International Classification of Diseases (ICD) codes for all disability pension recipients. Disability pension entries prior to December 1998 are coded with ICD9. Entries in December 1998 and thereafter are coded with ICD10. In Table 8, we report results for the seven most common diagnosis categories on which people entered onto disability pension during 1998 and 1999. These categories were defined based on chapters in the ICD10. The specific diagnosis codes within each category are listed in the table below.

Table A1: Coding of Diagnosis

Title of chapter/diagnosis (from ICD10)	ICD10	ICD9
ChapterII: Neoplasms	C00-D48	140-239
ChapterV: Mental and behavioral disorders	F00-F99	290-319
Chapter VI: Diseases of the nervous system	G00-G99	320-359
Chapter IX: Diseases of the circulatory system	I00-I99	390-459
Chapter X: Diseases of the respiratory system	J00-J99	460-519
Chapter XIII: Diseases of the musculoskeletal system and connective tissue	M00-M99	710-739
- Fibromyalgia	M790	7290
Chapter XIX: Injury, poisoning and certain other consequences of external causes	S00-T98	800-999

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